IBM

Enabling z/OS Applications for SOA

- Learn how to use patterns to help you modernize your applications
- Use our samples of a selection of patterns to get started
- Understand integration and modernization

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This edition applies to a large variety of software versions and releases. Refer to the respective chapters for exact information regarding product versions and releases.

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Preface

The objective of this IBM® Redbooks® publication is to demonstrate ways of enabling existing applications and data on z/OS® for integration into service-oriented architecture (SOA). The focus is on solutions using Web Services as the underlying technology for this integration.

This book describes a variety of patterns that can be applied to enabling z/OS applications for SOA. We explain many of these patterns by means of a sample. Each sample is included in the additional material of this book. For instructions to access the additional material, go to Appendix B, “Additional material” on page 485.

The team that wrote this book

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Ulrich Seelbach is an IT Architect based in Frankfurt, Germany. He has been with IBM for twelve years. He started working on IBM mainframes in 1999 and never looked back. His main areas of expertise include everything related to Java on z/OS and its major subsystems, including WebSphere for z/OS, DB2, WebSphere MQ, and CICS Transaction Server. In the last eight years, he has supported various clients, mainly in the banking and insurance sectors, by designing and implementing solutions based on these technologies.
By his birth name, Ulrich Gehlert, he has coauthored *DB2 for z/OS and OS/390: Ready for Java*, SG24-6435, and *Java Application Development for CICS*, SG24-5275. He holds a degree in Computer Science from University of Erlangen, Germany.

Figure 0-1 The team that wrote the book from left to right: Alex, Uli, Naveed, Wilbert, Aki, and Roy (Geoff is standing at the far right and Subhajit is missing)

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1

Introduction

The benefits that can be derived from a service-oriented architecture (SOA) are accepted by both the Information Technology (IT) community and the business community that it serves. The high-level Qualities of Service (QoS) associated with running enterprise applications on the z/OS system are also acknowledged and proven in the technical community.

This book assumes that you have already embraced SOA and are looking to leverage your existing z/OS applications so that these applications form part of your SOA. A typical challenge you will face is knowing where to start. This decision can be specially daunting in light of the myriad of applications ranging from simple to complex that were developed many years ago and have been maintained by multiple software professionals over many years.

As you identify candidate services from your existing application portfolio, you will face the additional challenge of melding the existing application interfaces to the service interfaces. You will also determine that certain applications might need to be re-architected for reasons related to the proper separation of concerns, elimination of redundant business logic, reduction of application complexity, and so forth.

We term this set of application renovation activities *application modernization.*

In this chapter, we talk about the objectives, scope, and organization of this book and describe the target audience.

1.1 Objectives

In this book, we review the impetus behind SOA, a strategy to attain SOA, and in the context of z/OS applications, approaches that you can take to transform or modernize these applications to enable optimal business agility and flexibility. We also talk about common scenarios involved in application modernization and identify patterns for those scenarios. Lastly, we provide examples for several of the scenarios and patterns and show you the approach that we took toward integrating existing applications into an SOA environment.

1.2 Challenges to application modernization

There are challenges to application modernization, which we can broadly categorize into three areas:

- Malleability of existing applications
- Extensibility and availability of skills
- Multitude of platforms and middleware

1.2.1 Malleability of existing applications

Many z/OS applications, especially those applications that have been around for many years, were not written with reuse in mind and are classified as what the industry terms as *monolithic* applications. These applications are typically tightly coupled with strong cohesion and incur high costs of maintenance and enhancement, with the costs taking a large share of the limited IT budget. Industry experts have estimated that 70% to 80% of an organization's IT budget is typically spent on maintenance.

While these applications encode a lot of business knowledge, they are hard to repurpose to fulfill new business requirements. Often, this difficulty in repurposing applications leads to decisions about whether to rewrite the applications so that you can make them more flexible and easy to extend. But rewriting might not always be the best option, when you consider the amount of rewriting that needs to take place and the repercussions to interdependent applications during the rewrite. You also face the dilemma of having to consider the operating platform and the programming language so that you will not be in a similar "boxed-in" position when the newly rewritten applications become older applications.

1.2.2 Extensibility and availability of skills

We have three distinct challenges in the area of skills.

One challenge is that developers are usually specialized, and their skills are not portable across projects because they often only program on one platform (for example, the CICS developers do not create Web programs and the Web developers do not create CICS applications). They also use different tools, programming languages, and processes. Thus, there is a lot of fragmentation and suboptimal governance in an IT development organization.

The second challenge is that a lot of business savvy people do not know that new technologies are hard and costly and that it takes a long time to retrain the existing development staff to effectively adopt these new technologies.

The third challenge is that the “baby boomers,” the people who can handle the existing application platforms, are disappearing. They cannot be replaced by new generations who do not understand or have interest in the older technologies, which forces IT managers to consider outsourcing, stabilizing, end of life planning, rewrite, and so forth. All of these choices are difficult and costly.

Developing software is slow, repetitive, and error prone. Many existing applications are written in RPG, COBOL, PL/I, 4GL, and so forth. New applications require Java, Java Enterprise Edition, and other skills related to Web 2.0 technologies. The development paradigm usually differs between the procedure-oriented existing languages as compared to the object-oriented Java language. Many times, retraining a COBOL programmer to become a Java developer might not be an option due to the high costs associated with retraining and the possibility that the COBOL programmer might not be able to become a Java programmer. Furthermore, business pressures to deliver results quickly might force you to avoid retraining.

1.2.3 Multitude of platforms and middleware

With mergers and acquisitions, the need for business information to be used in new and consolidated ways presents a unique challenge in that you now have to deal with disparate, heterogeneous computing platforms and middleware. These consolidations might result in a fragmentation of skills needed to support these platforms and middleware and add to the complexity of interfaces among the disparate applications, which tends to slow down development.

These challenges often translate to high costs, hamper the ability to quickly respond to business requirements and deliver solutions, and often lead to compromising into building what the development team is capable of building rather than what the business asks for and needs.

1.3 Case for application modernization

Despite the challenges we have enumerated, there are many reasons to transform and modernize existing applications:

- They run the business and contain critical business logic that is unique, difficult, and costly to replicate.
- Modernizing existing applications allows you to reuse critical business assets and leverage an investment that you have already made.
- These systems are not necessarily broken, but they are restrictive and limit business agility and flexibility.
- It is absolutely feasible (doable) to modernize these systems in a timely, cost-effective manner.

1.4 Styles of application modernization

There are four styles for application modernization or transformation:

- **Transform the user experience**
  Change the current character-based user interface to an interface that gives the user a consolidated Web look and feel, which is fairly simple and cost-effective to undertake and does not change the underlying code.
- **Transform the application connectivity**
  Change the way that users or client applications can connect with the existing application, which can working with Java connectors and creating Java wrappers. It can also involve exposing Web service interfaces.
- **Transform the application architecture**
  Change the way that the application is constructed by making it more modular and making it easier to compose business services with the right level of granularity. These services represent mission-critical application components.
- **Transform the application code**
  This transformation involves the actual process of transforming the underlying application code to a new, modern language that supports deployment to any platform using whatever user interface (UI) is deemed necessary (Web, rich client platform (RCP), or text user interface (TUI) or traditional “green screen” for any type of processing (online or batch) or service creation. It is a strategic move forward.

Note on *service granularity*:

When designing service components, consider the granularity of the service. Typically, the discussion revolves around *coarse-grained* and *fine-grained* services. The differences in these services are:

- *Coarse-grained service:*
  - The goal is to reduce the number of invocations related to a service.
  - This service results in fewer services with one service implementing more functions.
  - The client in general will need to pass more information to the service and might need more intelligence.
- *Fine-grained service:*
  - This service produces better reusability, because each service maps to a single function.
  - The result is more services that are smaller and have less functionality.
  - The client in general passes less information to a service but will need more service invocations to accomplish its task.

1.5 The case for application modernization on System z

There are many reasons to modernize your applications on System z, which include:

- Many business rules are currently implemented on System z with a quality that cannot be matched by any other platform. It is the combination of the System z hardware and operating system (OS) attributes and the transaction and database managers that have matured over many decades that drive this extraordinary quality.
- Those business rules can be made more reusable with a relatively low investment while adhering to the principles of an SOA. Tools and technologies are in place for all major software products on z/OS.
- Modernized applications on z/OS will deliver the promises of SOA through better business and IT alignment, better time to market, and better manageability while keeping the original qualities of service (QoS) that are associated with System z.

1.6 SOA best practices

In general, you perform appropriate planning to identify the correct services. You might want to consider the use of methodologies, such as *Component Business Modeling (CBM)* or *Service-Oriented Modeling and Architecture (SOMA)*. It is important to note that not every component, module, or program interface has to become a service. You might also want to consider technologies that facilitate the management and use of services, such as *Enterprise Service Bus (ESB)* or *process choreography*. Last but not least, SOA governance must be addressed.

In particular to System z, there is a tendency to think of the System z applications as service providers. In fact, System z applications can be service consumers. In SOA, every component can be both provider and consumer; restricting System z components as only providers pushes up unnecessary service choreography. Another thing to note is that layering or the proper separation of concerns is good architecture applicable to System z components. When creating new or renovating existing CICS or IMS applications, consider a layering approach by separating programs and modules into presentation, business logic, and data access parts. Lastly, a good test bed and process are important for all SOA work, which is worth mentioning for the System z because of a dearth in this area for many System z organizations.

1.7 Critical success factors

Frequently, the critical success factors have more to do with business than with technology:

- Businesses must be motivated to embrace change through the adoption of more dynamic processes and a desire to optimize business through better metrics or *Key Performance Indicators (KPIs)*.
- Businesses must establish an SOA governance process that focuses on the lifecycle of services and composite applications so that decision rights for the development, deployment, and management of new services are rightly established and that the proper monitoring and reporting of governance results exist.
- Businesses must take an incremental approach to projects that are prioritized by expected business benefits.
- Businesses must be willing to fund both infrastructure upgrades and new technology in support of SOA.

1.8 How this book is organized

This book is organized into two parts:

- In Part 1, “SOA application enablement patterns for z/OS” on page 25, we discuss a comprehensive range of patterns from which you can choose to accomplish an SOA modernization task on z/OS. The patterns are organized in the following groups:
  - Integrating data on z/OS in SOA, which is discussed in Chapter 3, “Accessing data on z/OS as a service” on page 27
  - Integrating existing z/OS applications into SOA, which is discussed in Chapter 4, “Accessing programs on z/OS as a service” on page 55
  - Integrating external services with existing z/OS applications, which is discussed in Chapter 5, “Integrating external services in existing z/OS applications” on page 105
- In Part 2, “Samples” on page 127, we describe samples of a selection of patterns. The following samples are included in this book:
  - Exposing VSAM data as Web Services
  - Exposing data as a service by using IBM WebSphere Message Broker
  - Exposing DB2 data as a service
  - Exposing IMS data as a service
  - Exposing an IMS application as a Web service
  - Building composite CICS services using the Service Flow Feature
  - Integrating an external Web service with a CICS application
  - Integrating an external Web service into an IMS application
  - Using DB2 as a Web service requester
  - Using an external Web service in batch applications

1.9 The audience for this book

This book is written for both the IT Architect or solution designer and the IT Specialist. Part 1, “SOA application enablement patterns for z/OS” on page 25, might be of particular interest to the IT architect, because it is written from an architectural point of view and is a starting point for SOA-enabling z/OS applications. Part 2, “Samples” on page 127, might be of particular interest to the IT implementation specialist, because it provides technical details of solution approaches and how-to implementation steps.

2

Analysis, design, and architecture

Organizations that run the IBM System z platform have unique business requirements. Their commitment to this highly available server platform demonstrates their need for an environment that can support high-volume transaction processing with demanding batch windows and large, critical application portfolios.

More commercial transactions are processed on IBM mainframes than on any other platform. It is estimated that there are approximately 200 billion lines of COBOL code running on mainframes today with several billions of lines of code added annually. Rewriting or replacing this functionality involves considerable time, expense, and risk. An alternative to the rip-and-replace approach is to modernize IT systems using service-oriented architecture (SOA) as a strategic means to extend the value of existing mainframe assets.

Making the transition to an SOA offers significant benefits including reusing the investment in the application assets that support the business. This chapter presents an architectural overview of how an SOA implementation can be effectively achieved.

In this chapter:

- In 2.1, “IBM SOA strategy and the SOA lifecycle” on page 11, we present the SOA concepts and architectural principles.
- In 2.2, “Choosing a development and design approach” on page 13, we present the three general approaches to SOA analysis and design.
- In 2.3, “Hosting the SOA infrastructure on System z” on page 14, we present the benefits of deploying the SOA infrastructure on the mainframe.
- In 2.4, “SOA infrastructure components” on page 14, we present the building blocks necessary to support an SOA environment.
- Finally, in 2.5, “Integrating existing mainframe applications in an SOA” on page 19, we provide a strategy for determining what System z assets might be candidates for an SOA implementation and provide three transformation styles for both a tactical and strategic SOA integration.

2.1 IBM SOA strategy and the SOA lifecycle

The SOA lifecycle is the framework of the IBM SOA strategy. As Figure 2-1 shows, the SOA lifecycle consists of four stages:

- **Model**: Use modeling tools to define the business process at a business level and model the actual services that will be part of an assembled, composite application.
- **Assemble**: Assemble the individual services and write the code that is needed to implement the business rules for the application. Preexisting services can be reused, and new services can be developed, or both.
- **Deploy**: Deploy the services to runtime environments, such as transaction management engines, such as WebSphere Application Server, CICS, IMS, and so forth. Use integration components primarily and enterprise service bus (ESB) to link together the various services that are needed for the composite application.
- **Manage**: Implement the management infrastructure for monitoring and managing the services and the service infrastructure, which includes not only IT management tools, but also business management and monitoring tools to measure actual business activities.

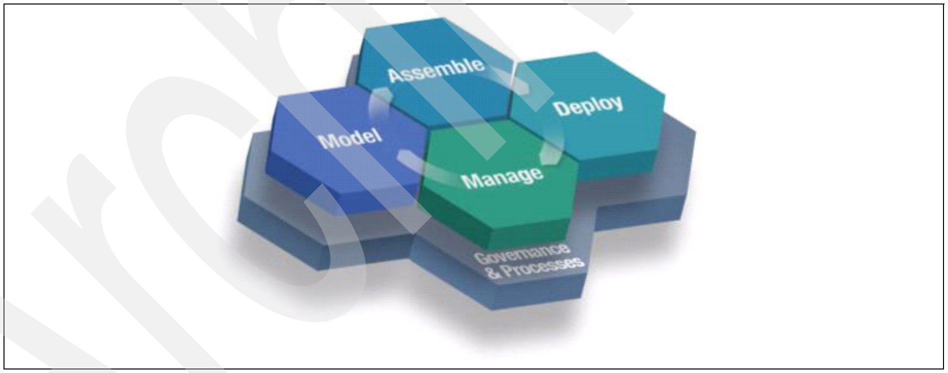


Figure 2-1 IBM SOA Lifecycle

Because this approach is a lifecycle, it implies a closed loop, meaning that at the end of the cycle, the Manage stage feeds information back to the Model stage. Results from the runtime management tool can be fed into the modeling tools to provide feedback for refinement of the business processes that are being instantiated into services and composite applications.

Underlying the four phases of the lifecycle is the function of governance. Governance of the SOA implementation is critical to the integrity of the architecture. Governance can ensure the consistency of the service development strategy and adherence to the policies and procedures of the SOA implementation.

The SOA lifecycle is not an entirely new concept. Many application development models, including those models for developing mainframe applications, have evolved the same concepts. However, there are several aspects of SOA that make this particular lifecycle unique:

- SOA involves modeling business processes, not just the modeling of the applications themselves. With SOA, the business process is modeled first, and the results of the model are fed to additional development tools that produce the *Business Process Execution Language (BPEL)*. The BPEL artifacts are then passed to other tooling that is designed to enable the construction of composite applications that consist of multiple, orchestrated services.
- SOA applications are assembled from multiple services that can be logically connected using orchestration and process management tools.
- In a full SOA implementation, the individual services are deployed to a run time, just like a “traditional” transactional system. However, the composite applications are represented in and “executed” from a flow engine, and that runtime engine takes care of calling the services in the proper sequence, based upon what is specified in the BPEL (the input to the flow engine).
- While the logical linkage between the services is represented by the flows that execute under the control of a flow engine, the physical linkage between deployed services is typically implemented in an *Enterprise Service Bus (ESB)*. The ESB is the abstraction layer that is designed to eliminate the point-to-point connectivity between specific services.
- In previous application architectures (mainframe and other), monitoring is traditionally only done at the IT level. Organizations are often concerned about the number of transactions per second being executed, what the user response time is, application server utilization, and so forth. In the SOA lifecycle, there is a keen interest in the business performance. For example, Bank A might be interested in how many new accounts were opened last week, or how many ATM withdrawals occurred, rather than what the average response time was for the ATM transactions. This kind of business information is fed into the business modeling tool to refine the business process.
- The sharp focus on governance by IBM is unique in this model. While architectural governance (including security) has always been an important facet of IT and architectural management, it is particularly critical in SOA due to the loosely coupled nature of services.

2.2 Choosing a development and design approach

One of the more interesting philosophical discussions in SOA is “Where do we start?” This discussion is particularly lively when mainframe assets are involved, because few companies are willing to simply discard working applications that contain valuable intellectual capital. The general approaches to SOA analysis and design tend to center on three philosophies:

- **Top-down**: This top-down approach is usually considered the “purist” approach to SOA. The top-down approach begins with analysis and understanding of the business environment and the services that make up the functions of the business. The business model is decomposed into the elementary components that represent business services. Those business services are eventually represented by IT services. This analysis is accompanied by the documentation of the processes that link together the various business services.

  You can follow the IBM *Component Business Modeling (CBM)* to discover the business architecture. When a model is developed, the strategically important parts of the business architecture can be identified and fed into the process of service modeling so that IT services can be created from them.

- **Bottom-up**: The bottom-up approach involves exposing existing applications as services, which are then used to create new, composite applications that are developed using techniques, such as business modeling and development with process orchestration tools.

  When a bottom-up approach is used, concerns often emerge regarding the granularity of the services. With existing mainframe systems, an interesting situation often arises: Older mainframe systems are frequently well suited for SOA, because the applications themselves already represent discrete business functions.

- **Meet-in-the-middle**: The meet-in-the-middle approach is a compromise that employs techniques from both top-down and bottom-up methodologies. It affirms that there is considerable value in existing assets that needs to be reused when appropriate, and it also utilizes top-down service identification and decomposition techniques.

This summary shows the need to address SOA analysis and design from both the top and the bottom. In a mainframe environment, where there is a pre-existing inventory of mature, high-performance business applications, it only makes sense to try to reuse as much as possible.

2.3 Hosting the SOA infrastructure on System z

As organizations adopt SOA as the guiding architectural framework for development of enterprise applications, the newly deployed services quickly become business-critical components of the application infrastructure. Therefore, services must be treated as business-critical components of the application infrastructure and must be deployed on a robust, scalable, secure, and high performance platform. Along with the services, the SOA infrastructure middleware and tools must also reside on such a platform. The mainframe, z/OS in particular, is the premier IBM computing environment for providing ultra-high qualities of service for enterprise applications.

The advantages of using System z and z/OS for SOA can be seen in three broad categories:

- **Quality of service (QoS)**: A framework that incorporates SOA capabilities exploits well proven System z features, such as high scalability, availability, reliability, and security. System z clustering is provided through Parallel Sysplex® technology and workload management.
- **Core system transaction capabilities for SOA**: The source of most services that service requesters call upon are likely core systems, such as CICS and IMS transactions. The positioning of these systems within a System z environment means that performance is enhanced.
- **Total Cost of Ownership**: The centralized architecture of the mainframe helps to avoid many of the costs associated with distributed systems. The total cost of ownership for System z is also reduced with new virtualization technology and System z specialty engines.

2.4 SOA infrastructure components

The IBM SOA reference architecture, which is shown in Figure 2-2 on page 15, defines the necessary building blocks to support an SOA environment. This section includes a brief description of the following core components of the logical architecture.

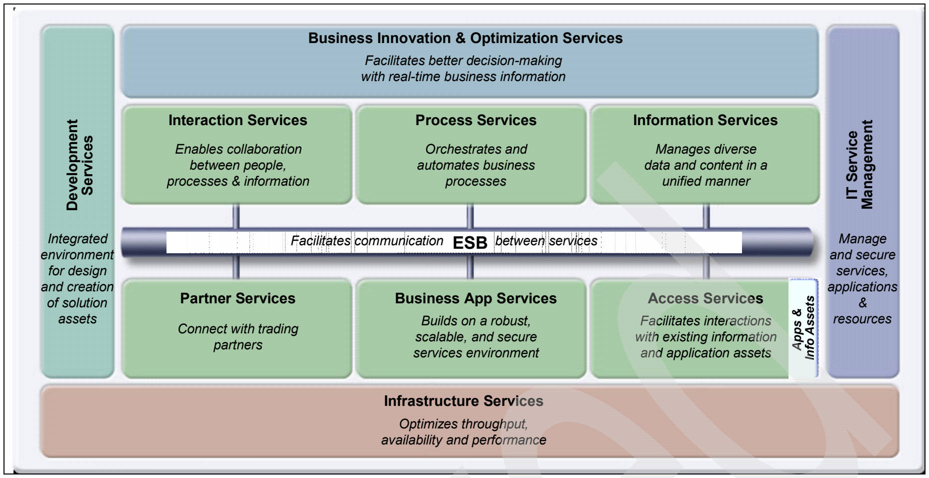

Business Innovation & Optimization Services
Facilitates better decision-making with real-time business information
Development Services
Integrated environment for design and creation of solution assets
Interaction Services
Enables collaboration between people, processes & information
Process Services
Orchestrates and automates business processes
Information Services
Manages diverse data and content in a unified manner
IT Service Management
Manage and secure services, applications & resources
Facilitates communication ESB between services
Partner Services
Connect with trading partners
Business App Services
Builds on a robust, scalable, and secure services environment
Access Services
Facilitates interactions with existing information and application assets
Apps & Info Assets
Infrastructure Services
Optimizes throughput, availability and performance

Figure 2-2 IBM SOA foundation reference architecture

2.4.1 Interaction Services

The *Interaction Services* component provides the user interface to the SOA application. A key principle of SOA is the abstraction of application layers. In this case, the application's user interface (UI) is exposed in a separate layer from the business logic. Interaction services are commonly thought of as the *portal layer*, because the UI for many SOA applications is provided by a portal, although this component is not mandatory. The portal not only provides abstraction for the UI, but it also provides a standard set of services to give the user a customized, personalized user experience.

2.4.2 Process Services

A key attribute of an application in an SOA is that it is often a "composite application," meaning an application that is constructed from several discrete services, all connected via a type of orchestration engine. The *Process Services* components provide the orchestration and workflow services that are required to meld multiple services into a single, composite business application. This application can be a single transaction, or it can be a series of transactions joined together into a business process.

2.4.3 Information Services

The *Information Services* component provides SOA-based access to the data repositories through techniques, such as accessing stored procedures as Web services, providing standardized interfaces to non-relational data repositories, and other access mechanisms that return Information As A Service (IAAS). Because data or information is not executable, infrastructure is required to expose that data to applications, such as SOAP, that use SOA standards.

2.4.4 Partner Services

The *Partner Services* component is the interface to outside business partners. Exposing enterprise services to the outside world and invoking external services pose challenges to the integrity and security of the SOA. Services must be exposed in a manner that maintains the security and scalability of the service, which makes the usage patterns for the service much less predictable and controllable than if they were being accessed exclusively in-house.

2.4.5 Business Application Services

Newly developed services reside in the *Business Application Services* component. These new services are generally deployed on servers, such as IBM WebSphere Application Server, which is a transaction manager for Java 2 Enterprise Edition (J2EE™) applications. The WebSphere Application Server can be used for full-function applications (presentation, business logic, and data logic), or it can host business services that have the other functions abstracted to other portions of the reference architecture.

2.4.6 Access Services

The *Access Services* component is particularly interesting to most mainframe clients. It is the linkage to existing applications, both on and off the mainframe. The functionality here provides the connectivity to applications on IMS, CICS, SAP®, PeopleSoft®, and so forth, using various connector and adapter technologies.

2.4.7 Enterprise Service Bus (ESB)

This section includes a description of the supporting components of the SOA foundation logical architecture used in support of the core components. At the center of this reference architecture is the ESB (Figure 2-2 on page 15). Surrounding the ESB are the key services needed to support the SOA runtime environment: Interaction Services, Process Services, Information Services, Partner Services, Business Application Services, and Access Services. Along with those core services, the surrounding boxes describe the other functions that are necessary to support the services before, during, and after their deployment.

The ESB provides an infrastructure that removes the direct connection dependency between service consumers and providers. Consumers connect to the ESB and not to the provider that actually implements the service. The ESB provides the abstraction layer between the service requester and the service provider.

The IBM definition of an ESB is that of an architectural construct rather than a specific product. The ESB supports four primary functions. The ESB handles routing messages between services, removing the direct one-to-one relationship between endpoints. It also handles the conversion of transport protocols between the requester and the service, for example, SOAP to MQ, FTP to EXCI, and so forth. The ESB handles the transformation of message formats, for instance, the transformation of XML to binary. And, the ESB handles events from disparate sources. Events are received from the ESB endpoints and correlated to trigger new events based upon decisions in the ESB.

The connectivity between applications is one of the key benefits of implementing an SOA. The ESB establishes the connection between services without requiring a unique connection. Figure 2-3 shows the evolution of application connectivity.

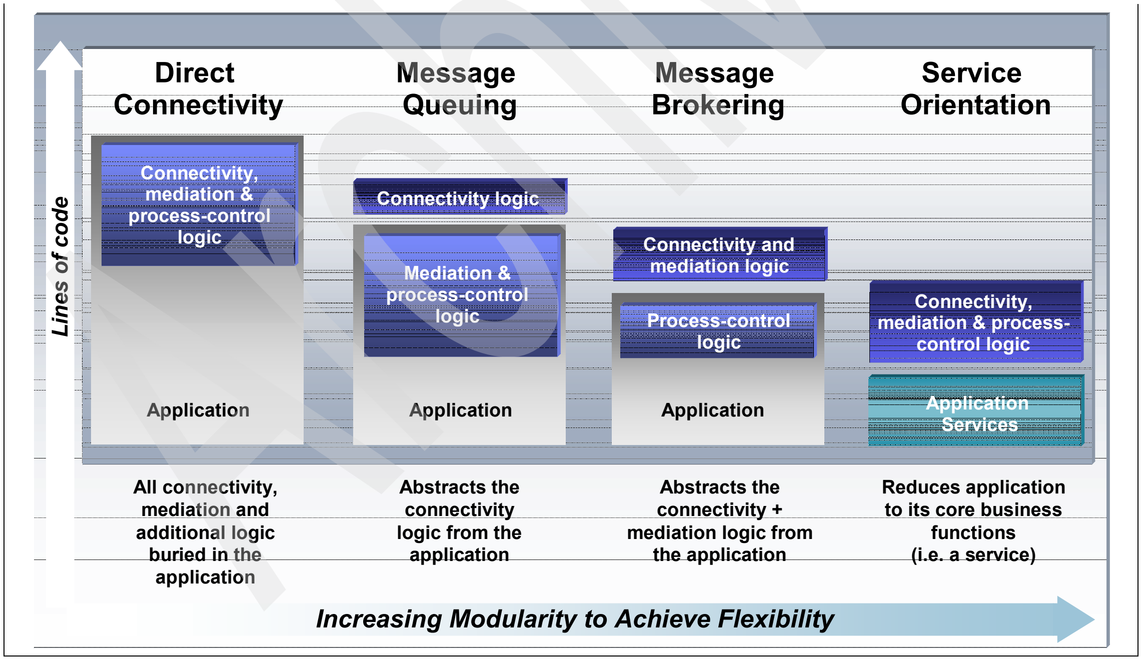

Lines of code
Direct Connectivity
Message Queuing
Message Brokering
Service Orientation
Connectivity, mediation & process-control logic
Application
Connectivity logic
Mediation & process-control logic
Application
Connectivity and mediation logic
Process-control logic
Application
Connectivity, mediation & process-control logic
Application Services
All connectivity, mediation and additional logic buried in the application
Abstracts the connectivity logic from the application
Abstracts the connectivity + mediation logic from the application
Reduces application to its core business functions (i.e. a service)
Increasing Modularity to Achieve Flexibility

Figure 2-3 Evolution of the SOA connectivity challenge

2.4.8 Business Innovation and Optimization Services

While the IT infrastructure is monitored and managed through the IT service management components, what about the business services? An organization can ensure proper levels of system and application performance, but what about business performance? The *Business Innovation and Optimization Services* component provides the functionality to effectively monitor and record what is happening in the enterprise from a purely business perspective. Business Innovation and Optimization Services exist in the architecture to help capture, encode, analyze, and iteratively refine the business design. The services also include tools to help simulate the business design. The results are used to predict the effect of the design, including the changes that the design has on the business.

2.4.9 Development Services

Development Services encompass the entire suite of architecture tools, development tools, visual composition tools, assembly tools, methodologies, debugging aids, instrumentation tools, asset repositories, discovery agents, and publishing mechanisms that are needed to construct an SOA-based application. Modeling consists of the modeling of the business process and the modeling of the actual services and the business logic within them. The tools might be higher level tools suitable for business analysts and architects or lower level tools, such as those tools used for object-oriented development. The output from these tools consists of artifacts, such as Uniform Modeling Language (UML) models, actual application source code in a variety of languages from Java to COBOL, and also markup languages, including XML and Business Process Execution Language (BPEL).

2.4.10 IT Service Management

The SOA infrastructure components consist primarily of middleware software. An SOA implementation requires adequate levels of monitoring and the management of the middleware and applications to ensure proper levels of system performance and security. The *IT Service Management* component in the SOA reference architecture includes those monitoring, management, and security tools. The IT Service Management component is particularly important in an SOA-based system, because the infrastructure that is required to support an SOA is significantly more complex than traditional mainframe transaction systems, such as CICS, which are relatively self-contained. The SOA has more components, making the monitoring and management tasks more complex.

2.4.11 Infrastructure Services

At the base of the SOA is the platform for deployment, which includes the deployment of hardware and software for the actual business services and service infrastructure. A production environment usually requires the highest degree of quality of service (QoS), and the Infrastructure Services component provides the QoS. Services at this layer can include operating system functions, security, and hardware functions.

2.5 Integrating existing mainframe applications in an SOA

Most mainframe users have a keen interest in the method that is used to integrate existing applications into an SOA, which generally means that they intend to expose existing transactions or data via a service interface. Exposing applications as services is the primary goal of the bottom-up SOA design model. But if there are drawbacks to the bottom-up style, why pursue that model rather than simply rewriting existing applications? Clients are often concerned that if their existing applications are written in COBOL or PL/I, they need to eliminate them. However, many studies have shown that significant savings can be realized by reusing existing code rather than rewriting. An often-quoted statistic states that it is up to five times more expensive to rewrite an application than to reuse existing code to achieve the same functionality. Reuse becomes a very attractive strategy to harvest existing code assets and save money during an SOA implementation.

The IBM enterprise transformation strategy is a path that you can follow to assist you in integrating mainframe applications into an SOA.

2.5.1 The discovery phase

Enterprise transformation often starts with a discovery phase. Many existing applications lack documentation, or the documentation is out-of-date, or it is in someone's head and that person has left the company. In such situations, before modernization activities begin, it is necessary to discover the location of the application code, what it does, which applications and components it interacts with, and so forth.

Discovery tools are designed to assist in documenting relationships among applications and subroutines and creating visual representations that show asset relationships effectively and efficiently. These tools are intended to extract components and associated data items from existing code, simplifying the difficult and time-consuming task of building components manually. Discovery tools can also perform impact analysis to understand data movement and application interaction during run time and record the results for use in future application development and test. Both static (code-based) and dynamic (runtime-based) analyses are supported. The discovery tools include:

- *Rational Asset Analyzer (RAA®)* and *WebSphere Asset Analyzer* are static analysis tools designed to assist in maintaining and extending existing assets through impact analysis, connector builder assistance, and graphical application understanding.
- Relativity's *Application Portfolio Manager (APM)* centralizes business and technical intelligence for applications across mainframe, midrange, and distributed environments. APM allows for rapid construction of operations from a top-down as well as a bottom-up approach. The generated models can be transferred to third-party business process management technologies.

After a client understands existing business assets and the impact of changes to those assets, development tools can be used to more effectively develop new business applications. Most tools support extending existing applications to business without modifying existing code. This rapid development and deployment capability enables a quick return on investment while more substantial development projects are under way that might involve the creation of a more complete SOA.

2.5.2 Enterprise transformation strategy: Improve, adapt, and innovate

SOA focuses on the concept of *reusability*, which means that application components must be built in a way that facilitates reuse and avoids creating components from scratch when existing assets can satisfy the requirements. The combination of existing data and applications on the mainframe and the concept of reuse through transformation leads to a fast startup into the SOA model, which is the concept of *enterprise transformation*.

Enterprise transformation and application modernization are critical to an enterprise's application development strategy, because the high cost and risk of rewriting existing applications is often an inhibitor. If a company can reuse existing well tuned and proven code that has been implementing business function satisfactorily for years, savings can be significant. Aside from the high cost and risk of migration of these applications, performance, reliability, and scalability requirements often make the current environment the best choice. When considering reuse of existing assets, developers experienced in traditional languages must be considered an important part of the overall business development team. As the availability of these development skills continues to tighten in the marketplace, it becomes more critical to create a development environment where existing assets can be maintained and extended using current development approaches and available skills.

SOA has particular importance in the enterprise transformation practice, because it has the power to unlock existing applications and data and expose them as services, therefore, providing extended value to the business. Considering the investments that companies have made in developing applications and the importance that those applications have to the core business, service enablement using standard-based interfaces helps to extend the lifecycle of those applications and leverages existing investments.

The move toward SOA is not going to happen overnight. It is not an appliance to be installed on top of an existing infrastructure, thus making it SOA ready. The implementation process is a set of granular changes applied to the existing architecture and the exploitation of new technologies that will gradually make the environment SOA ready.

The IBM enterprise transformation strategy supports this gradual, granular process that will help to enable existing assets as services. It defines three solution frameworks, sometimes referred to as *styles of transformation*, to help clients convert IT assets from siloed applications to shared resources, and then to interdependent software components and services.

The strategic goal is to innovate by enabling the creation of new software components that have strategic business value and support an on-demand environment. But, that takes time, effort, and money. So, more immediate and tactical solutions are required as well. For example, the ability to transform siloed applications to shared resources can enable better ways of interacting with customers, partners, and suppliers. Certain changes to applications will require immediate solutions that can drive business value, but they might not be as flexible in adapting to future changes in the business process. The three transformation styles, *Improve*, *Adapt*, and *Innovate*, address both tactical and strategic service enablement solutions.

While IBM identifies these three approaches for modernizing a client's enterprise, an IT organization will likely not use just one style. Businesses often choose multiple styles of modernization for various types of solutions, so the deployment scenario is determined case by case.

The three transformation styles of Improve, Adapt, and Innovate cover both tactical and strategic service-enablement solutions. This section presents a more detailed look at these styles.

Improve

The Improve style is characterized by the use of new technologies to Web-enable or service-enable applications at the user interface level without changing those applications and with minor changes or additions to the middleware infrastructure. Improve is often the first step toward SOA, where clients simply enable existing applications with SOAP or MQ protocols to facilitate integration. This style concentrates on transforming the user experience by providing a more sophisticated and productive user interface for applications.

Adapt

Adapt goes a bit farther in terms of application transformation and enhancement of the existing infrastructure. Adapt comes closer to full SOA architecture, but it requires more investment in business componentization and in IT services. The result is more flexibility for the business and the value that this flexibility represents.

Adapting existing connectivity enables broader application integration and provides the ability to incorporate core applications into more modern application flows. Adapting allows clients to leverage existing applications to develop better customer, partner, and supplier relationships. But the connection of many existing applications to new applications and new architectures poses a compatibility problem: Data formats, communication protocols, and existing programs frequently cannot communicate without an intermediary.

The requirement emerges for an intermediate broker to be used for data mediation, protocol transformation, message routing, and so forth. This functionality is where the requirement for an ESB usually emerges. The ESB is not a direct component of the Adapt transformation style, but it does serve as the hub to connect the applications, transactions, and services that are transformed using the adapt techniques. Other elements of the SOA reference architecture are also involved in this phase, including information and access services. The service management infrastructure is often planned and designed during this phase.

Innovate

The Innovate style of modernization is characterized by the creation of new applications that are fully compliant with the SOA model. Accordingly, with reference to SOA strategic approaches, this style is mostly top-down, where business processes are modeled using a modeling tool. Deployed applications invoke a service or services (applications) that make up the composite business applications or processes. This style might require that a totally new service or application be developed, or it might involve the transformation and reuse of an existing application to meet the business requirements.

Transforming the application structure and architecture requires the highest degree of investment, but it pays off with the greatest business value and process flexibility. In this Innovate style of transformation, core applications are restructured to provide the greatest amount of business benefit. This restructuring allows clients to more rapidly innovate and change their business processes using existing IT applications to create new and differentiated market solutions. In order to innovate, tools are required to design and deploy new applications, and a server is needed to orchestrate and direct the newly created business processes.

Another significant value that SOA brings to companies is an architecture that is programming language-neutral, thereby allowing companies to continue to develop new applications using traditional languages, which leverages existing skills, tools, and investments. Being able to use traditional languages is important to mainframe shops, because senior application developers can continue to use their preferred languages and tools, providing improvements in productivity and economics.

Part 1

SOA application enablement patterns for z/OS

In this part of the book, we have grouped patterns in three scenarios. Each scenario represents a certain driver for service-oriented architecture (SOA) enablement. We discuss the following scenarios:

- Accessing data on z/OS as a service
- Accessing programs on z/OS as a service
- Integrating external services in existing z/OS applications

We describe each of the patterns within those scenarios using a standard structure. We discuss the following aspects for each pattern:

- **Initial state**
  The *initial state* covers the current maturity of the application in terms of complexity for SOA framework qualification criteria, for example, the extent to which service-level agreement (SLA) goals are currently being met and the nature of the application, such as simple, complex, hybrid, rigid, monolithic,

and so on. Quality of service (QoS) aspects also play a role. The initial state will tell us how much work needs to be done to become somewhat SOA compliant.

- **Current architecture**
  The current architecture depicts the current architecture diagram of the system that includes both the infrastructure and application level.
- **Solution strategy**
  The solution strategy covers a planned approach to a solution, taking into consideration the SOA features and QoS features of the mainframe, which require a well designed methodology. Also, there might be situations that need a quick development time or turnaround time in deploying a solution or solutions. In this case, there might be an approach to a solution that takes into consideration the short-term benefits only and has the guidelines (instead of a methodology) that need to be put in place for a smooth SOA transition in phases.
- **Solutions**
  For each solution, we discuss:
  - **Target architecture**
    Using the adopted methodology, we arrive at a target architecture diagram that includes both an infrastructure and an application perspective.
  - **Runtime software prerequisites**
    Runtime software prerequisites include the required software products to run the target architecture. We do not mention prerequisites at the level of the operating system, but we focus on the middleware level.
  - **Development tools**
    In this section, we mention the development tools that are required or recommended.
  - **Advantages**
    Under this heading, we mention the particular advantages of the solutions.
  - **Limitations**
    If there any important limitations, we mention those limitations.
  - **Guidelines**
    Under this heading, we mention any noteworthy guidelines for using the solution.

This information gives the reader an idea of what to expect in the forthcoming chapters. The patterns that we describe can be a good starting point for an architect to identify the available options and correlate the options with their own situation. There might be more than one solution for a pattern. The objective of this book is to provide almost all the possible solutions for a pattern and we expect the reader to make a decision that best suits their enterprise.

3

Accessing data on z/OS as a service

One of the first steps in a migration to service-oriented architecture (SOA) might be to offer an enterprise-wide, technology-neutral way of providing access to mission-critical business data. This concept is *information as a service*, and there are many ways to implement this idea. In this book, we look at at a number of options from an application perspective. In this chapter, we discuss the following patterns involving data integration:

- Accessing VSAM data as a service
- Accessing DB2 data as a service
- Accessing IMS data as a service

Note: IBM provides rich set of Information Management solutions that can help you access data in an SOA and help you build a sophisticated Information Management architecture. In this book, however, we focus on solutions that exploit the capabilities of z/OS, VSAM, DB2, and IMS.

3.1 Accessing VSAM data as a service

The scenario presented in this chapter applies to anyone with a need to access data stored in VSAM files in an SOA. The service consumer with this need might reside on z/OS, but it can also reside elsewhere. The service consumer can be implemented in J2EE, CICS, .Net, and so on. With all of the scenarios in this book, a structural difference between technologies, such as having a .Net consumer and data stored in a VSAM file on z/OS, does not need to be any problem due to the richness of the SOA-enabling technology that is available these days. Be aware, though, that in the case of VSAM, the possible options are not that common and you might even initially think it is not possible to access VSAM through a (data access) service.

Important: There is not really a direct need to migrate data from VSAM to a relational database for the sake of improving integration and accessibility. In this chapter, we present three architectures to access VSAM data SOA-style. They are not equally pure and you can debate about each architecture's SOA maturity, but they do the job of SOA integration.

One of the reasons, though, to migrate part of the data to a relational database, such as DB2, might be to benefit from the capability to parse and store XML inside DB2 tables. IMS supports storage of XML as well.

3.1.1 Initial state

A fictional company has been maintaining data over the last decades in VSAM key-sequenced data set (KSDS) files, and the company wants to enable real-time access to this data for a variety of business partner applications. Their business partners run their applications predominantly on distributed systems, and the master data from the VSAM files is currently replicated in an asynchronous manner. Multiple components are involved in this process. An issue with this replication process is that databases between the fictional company and their business partners are not always in sync at any given point of time except for the beginning of a business day, because the data sync process between the databases happens only during the overnight batch window. In order to avoid this complexity, the fictional company has made a decision to integrate the VSAM data with business partners' applications in a real-time manner using open standards.

3.1.2 Current architecture

Figure 3-1 represents the current architecture diagram in a simplified form. The cloud represents a replication mechanism between the VSAM data and the Java and .Net client applications. At the same time, the data in the VSAM files is accessible through CICS transactions and batch programs running on z/OS.

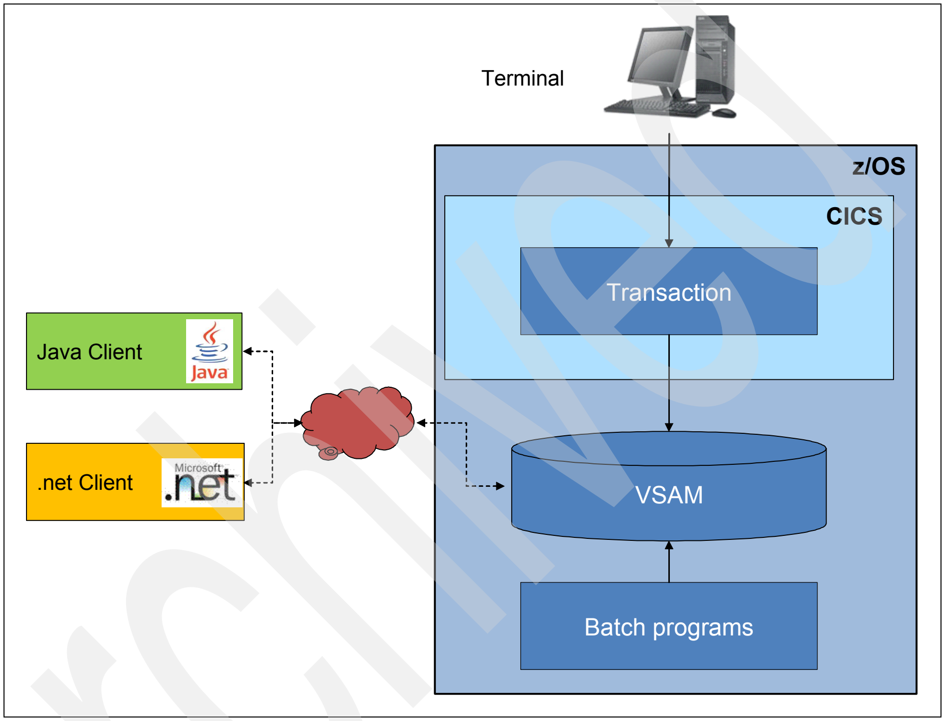


Figure 3-1 Current architecture for VSAM access on z/OS

3.1.3 Solution strategy

The chosen solution depends upon requirements and factors, such as cost, time, and flexibility. If there is only a need for an easy, simple and inexpensive way of providing access to VSAM data and the business partners prefer to use Web Services (SOAP) over HTTP or MQ only, “Accessing VSAM data through an existing program” on page 301 is appropriate.

Assuming that there is a need for a more flexible, scalable, and platform-independent or software-independent infrastructure and the business partners use a wide range of transmission protocols, such as Java Message Service (JMS), MQ, HTTP, HTTPS, TCP/IP, SOAP, or other transmission protocols, “Accessing VSAM data through WebSphere Message Broker” on page 34 or “Accessing VSAM data using JZOS and WebSphere Application Server” on page 37 will be more appropriate.

Benefits

The benefits of the solution strategy are:

- The issue of maintaining redundant data can be avoided.
- All the data sync issues can be eliminated, because this solution provides a single data store.
- Data is available in real time for both the fictional company and its business partners at the same time.
- Future (business partner) applications can reuse the same solution architecture.
- The cost, time, and effort to maintain the batch window for keeping the databases in sync have been eliminated.
- “Accessing VSAM data through WebSphere Message Broker” on page 34 has the following additional benefits:
  - Sources and destinations can be of any format, and they are independent of each other.
  - It provides better business and IT flexibility.
  - The integration is much easier to perform.
  - Message logging and exception handling facilities are available.
  - This solution is highly scalable.

3.1.4 Solutions

We discuss the following solutions:

- Accessing VSAM data through an existing program
- Accessing VSAM data through WebSphere Message Broker
- Accessing VSAM data using JZOS and WebSphere Application Server

Accessing VSAM data through an existing program

The easiest and quickest way to integrate VSAM data through Web Services is to expose the existing z/OS program that currently accesses the VSAM data as a Web service. If no such program currently exists, a new program might need to be built. The Web service can then be invoked by a Java application, a .Net application, or any other application that is capable of using Web Services as a protocol.

Assuming that a CICS program is used to access the VSAM data, then CICS Transaction Server Version 3.1 or 3.2 can be used to expose the existing CICS program as a Web service. The COMMAREA that contains the structure related to the VSAM record needs to be converted to a Web Services Description Language (WSDL) file using tools, such as *Rational Developer for System z (RDz)* or the *CICS Web Services Assistant (WSA)*. The WSDL file can then be published to the Java client or .Net client application to invoke the Web service.

CICS TS Version 3.1 and 3.2 provide new resource definitions, such as PIPELINE, URIMAP, and TCPIPSERVICE, that are used to define a CICS program as a Web service. Refer to Section 2.3.1 of *Application Development for CICS Web Services,* SG24-7126, to understand the concept of CICS as a service provider.

Note: The existing program can also be an IMS program. In that case, the IMS SOAP Gateway can be used instead of CICS Web Services. Refer to “IMS Web Services” on page 82 for more details.

Target architecture

Refer to Figure 3-2 on page 32, which depicts the process of exposing VSAM data to Web service consumers via CICS Web Services.

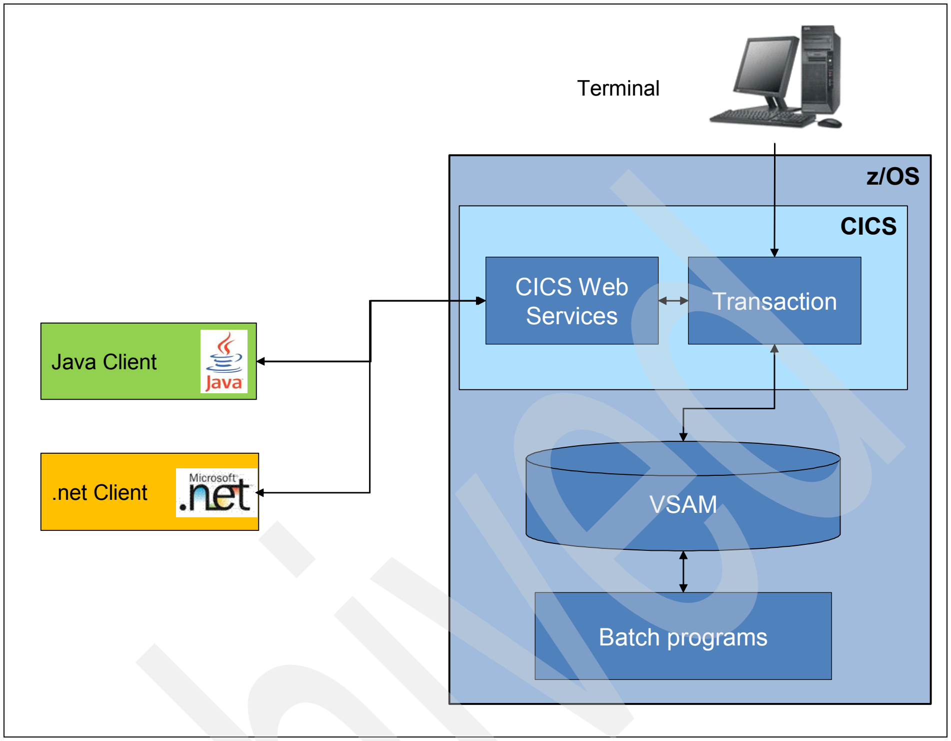


Figure 3-2 Target architecture for VSAM access through an existing program

Runtime software prerequisites

The following software prerequisites exist for accessing VSAM through a Web service-enabled program on z/OS:

- CICS Transaction Server Version 3.1 or higher in the case of a CICS program
- IMS Version 10 or higher, in combination with IMS SOAP Gateway Version 10.1 or higher, and IMS Connect Version 10 or higher, in the case of an IMS program

Development tools

It is difficult, if not impossible, to develop this scenario without proper tooling. We recommend that you use Rational Developer for System z (RDz) for both the CICS and IMS variation. In the case of CICS, the CICS Web Services Assistant (WSA) can be used as an alternative to RDz.

Advantages

Several of the advantages of this solution are:

- Reuse of existing assets (CICS or IMS program) and, in many cases, no need to develop new logic
- Robust data access through CICS or IMS (transactional, recoverable, fast, and secure)
- No data migration needed, because the data can remain inside VSAM files

Limitations

Limitations of this solution are:

- No loose coupling between the program and data layer
- VSAM not providing support for XML natively, although adapters and connectors exist to access VSAM XML-style

Guidelines

The guidelines are:

- Prioritize the process of identifying either an existing CICS or an existing IMS program that accesses the VSAM data, or prioritize the creation of a new program.
- Be careful to avoid creating Web services with the wrong granularity. For example, a Web service per VSAM file might result in too many fine-grained services. A better design is to implement data integration inside the new service.
- Pay attention to the security aspects when external applications gain direct access to a CICS or IMS Web service. For CICS, for example, you can take these measures:
  - Having the user ID as part of the application data header and having the program defined in the CICS PIPELINE configuration file to use the user ID to check with RACF® or other security products, such as ACF/2
  - Using the security authentication validation features of the TCPIPSERVICE definition
  - Defining the TCPIPSERVICE to use Secure Sockets Layer (SSL) transport

  Refer to *Securing Access to CICS Within an SOA*, SG24-5756, for an extensive discussion of CICS Web Services security.

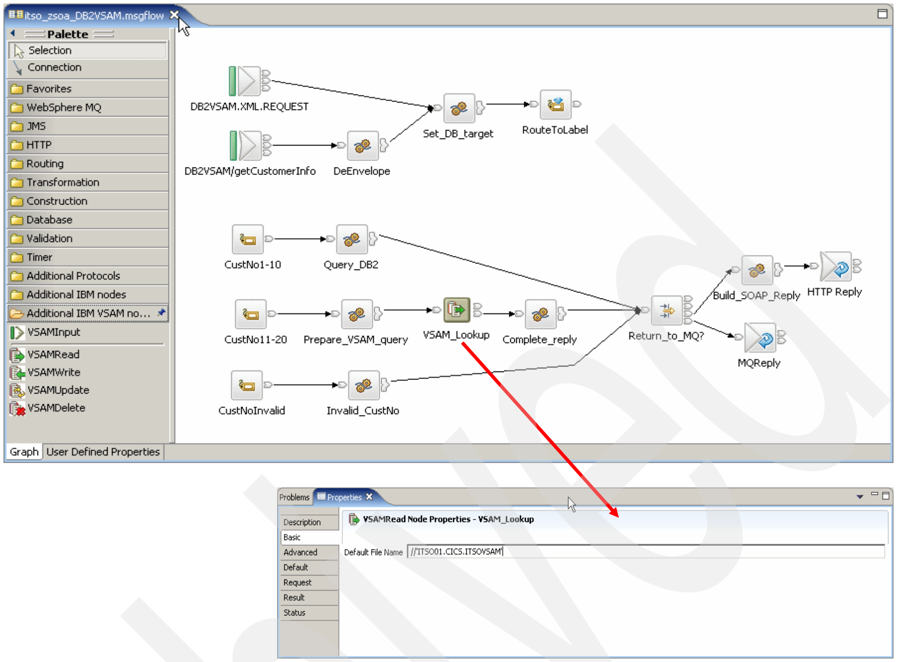
Accessing VSAM data through WebSphere Message Broker

This solution is based on using an enterprise service bus (ESB) concept to access VSAM data. We have chosen to discuss the WebSphere Message Broker for z/OS product, because WebSphere Message Broker for z/OS provides specific VSAM *nodes*. *WebSphere Message Broker* is an advanced version of an ESB. An ESB offers many advantages in a service-oriented architecture framework. An ESB offers the advantage of stateless data transformations between the source and target message formats and, as a result, the avoidance of changes to source and target application programs.

With regard to VSAM data integration, WebSphere Message Broker provides a number of nodes to access VSAM data sets as part of a *message flow*:

- *VSAMInput* to read records from a VSAM data set
- *VSAMRead* to read a record from a VSAM dataset
- *VSAMWrite* to write a record to a VSAM dataset
- *VSAMUpdate* to update a record to a VSAM dataset
- *VSAMDelete* to delete a record from the dataset

These nodes can be used to construct a *message flow.* Figure 3-3 on page 35 shows an example of a message flow.



VSAMRead Node Properties - VSAM_Lookup

Default File Name //ITSO01.CICS.ITSOVSAM

Figure 3-3 Example of WebSphere Message Broker message flow with VSAM access

Target architecture

Figure 3-4 on page 36 depicts the target architecture when using WebSphere Message Broker to access VSAM data.

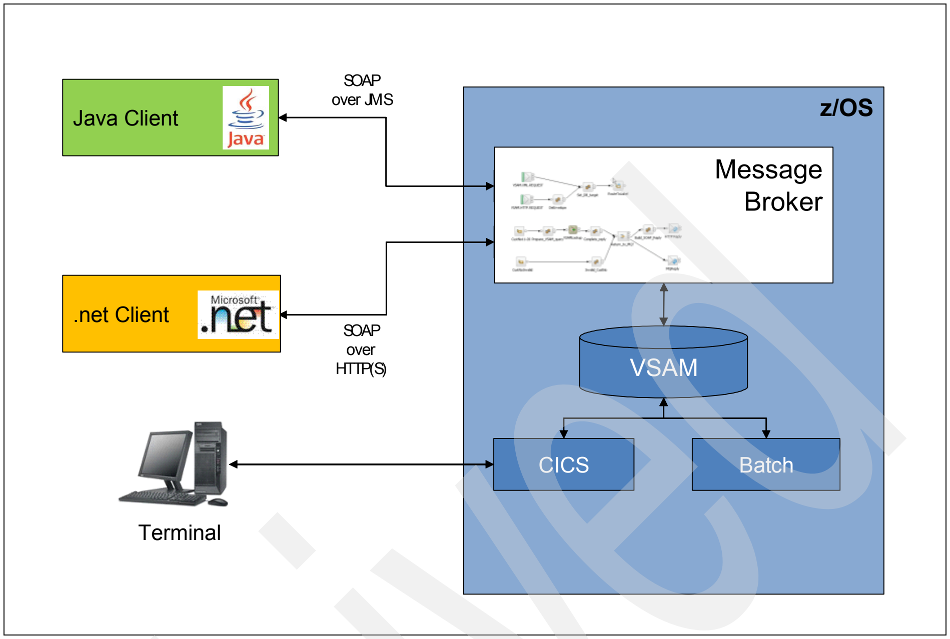


Figure 3-4 Target architecture for VSAM access using VSAM nodes in WebSphere Message Broker

Runtime software prerequisites

The following runtime software prerequisites exist for this solution on z/OS:

- WebSphere Message Broker Version 5 or higher
- VSAM node SupportPac (IA13) for WebSphere Message Broker

Development tools

Message flows in WebSphere Message Broker are developed using WebSphere Message Broker Toolkit. We recommend that the level of the Message Broker Toolkit corresponds with the level of the WebSphere Message Broker run time. However, in certain cases combinations of different levels are supported.

Advantages

The advantages of this solution are:

- Usage of an ESB providing SOA benefits, such as loose coupling
- Data access that is fully transparent for client applications

Limitation

The limitation of this solution is that ESB might introduce overhead because of the transformation.

Guidelines

In this scenario, SOA characteristics, such as business-IT complexity, loose coupling, and flexibility, can really only be achieved with this solution.

Example

We describe a sample of this scenario in Chapter 9, “Exposing data as a service by using IBM WebSphere Message Broker” on page 217.

Accessing VSAM data using JZOS and WebSphere Application Server

This solution uses the *JZOS* toolkit, which is a set of utility classes for access to z/OS services from Java applications, including the ability to use “traditional” MVS data sets, such as VSAM files. So, the approach here is to create a Java application, which then is exposed as a Web service in WebSphere Application Server.

Target architecture

The target architecture is depicted in Figure 3-4 on page 36. The Web service in WebSphere Application Server is accessible by any Web Services client program. The WebSphere Application Server Web service wraps the JZOS access to the VSAM data. This scenario is a direct and standard-based solution that uses Java and Web Services.

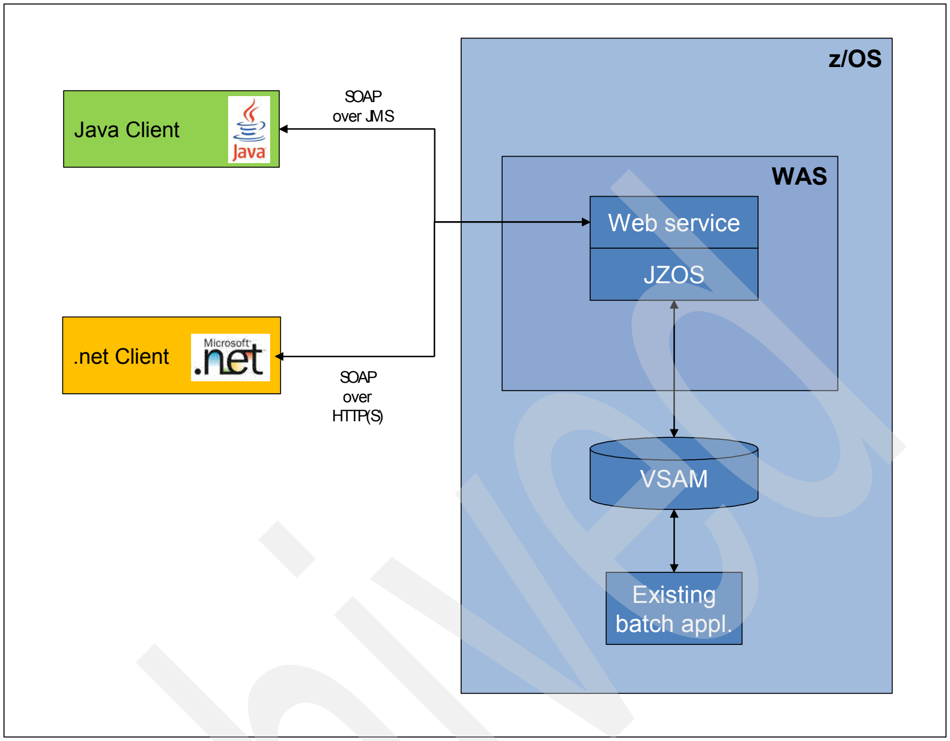


Figure 3-5 Target architecture for VSAM access using JZOS in WebSphere Application Server

Runtime software prerequisites

The following runtime software prerequisites exist for using JZOS on z/OS:

- JZOS toolkit.
  We have tested this solution with JZOS included in the Java Software Developer Kit (SDK) on z/OS.

> **Note:** Starting with SDK™ Version 1.4 for z/OS, the JZOS toolkit is part of the z/OS SDK. It is available to all Java applications running on a z/OS JVM™, because it is a standard extension.

- WebSphere Application Server for z/OS.
  We have tested this solution with WebSphere Application Server Version 6.1.

Development tools

Web services running in WebSphere Application Server can be developed using IBM Rational Application Developer (RAD) or any other tool that supports the appropriate levels of J2EE and Web Services.

Advantages

The advantages of this solution are:

- Web service hosted in J2EE server, which provides a highly standardized environment for hosting and accessing a Web service
- Data access to VSAM local on z/OS, providing fast and secure access

Limitation

JZOS and WebSphere Application Server are not a mainstream technology combination, such as, for example, Java Database Connectivity (JDBC™).

Guidelines

Just as with any data-centric solution for service enablement, be careful that you ensure a reasonable service granularity.

Example

We provide a sample for this scenario in Chapter 6, “Exposing VSAM data as Web Services” on page 129.

3.2 Accessing DB2 data as a service

This scenario is similar to the scenario that we discussed in 3.1, “Accessing VSAM data as a service” on page 28. The data is on z/OS, but this time, the data is in an hierarchical database management system (DBMS). DB2 by nature has been more open and more easily accessed from distributed applications than VSAM data sets. Java DataBase Connectivity Type 4 drivers and the DB2 *Distributed Remote Data Access (DRDA®)* protocol are commonly used protocols for remote access to DB2 on z/OS. However, with SOA techniques, we can still advance further.

3.2.1 Initial state

The initial state of this scenario is a DB2 database on z/OS and various traditional programs (CICS and IMS) on z/OS accessing this data. The DB2 database is also accessed by batch programs. Certain distributed applications access the database using JDBC.

3.2.2 Solution strategy

The data needs to be exposed as a service, which accelerates the reuse of the data and helps to access the data using common queries. In addition to data access, stored procedures also need to be callable using a Web Services call.

Benefits

The benefits of the new solution strategy are:

- All data remains on z/OS.
- You can run common queries, which means that heterogeneous client applications do not need to know any specifics about how to run SQL for a DB2 database on z/OS.
- Client applications are not confronted with DB2 on z/OS specific data types.

3.2.3 Current architecture

Figure 3-6 depicts the architecture of the current state.

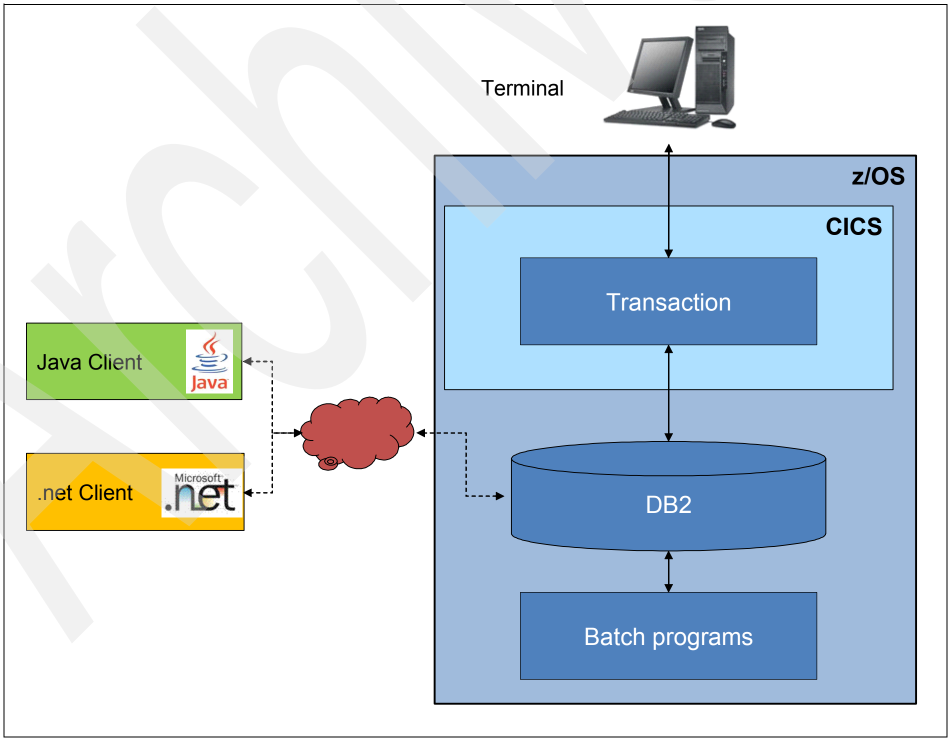


Figure 3-6 Current architecture for DB2 access on z/OS

3.2.4 Solutions

We discuss the following solutions:

- Accessing DB2 on z/OS using Data Web Services (DWS)
- Accessing DB2 on z/OS using custom data access
- Accessing DB2 on z/OS using WebSphere Message Broker

Accessing DB2 on z/OS using Data Web Services (DWS)

Data Web Services (DWS) can be used to expose existing SQL statements as Web services. These statements can be (and typically *will* be) parameterized, that is, they contain host variables, which become parameters of the Web service to be created.

For more details and an example, refer to 7.2, “Using Data Web Services (DWS)” on page 160.

Target architecture

Figure 3-7 on page 42 depicts the target architecture for this solution. The Web service in this solution is deployed to a J2EE server, such as WebSphere Application Server. In our example, WebSphere Application Server runs on z/OS. The deployed Web service accesses DB2 using Java DataBase Connectivity (JDBC), either locally on the same logical partition (LPAR) using a JDBC Type 2 driver or on another LPAR using a JDBC Type 4 driver. This solution works for both SQL queries and calling stored procedures.

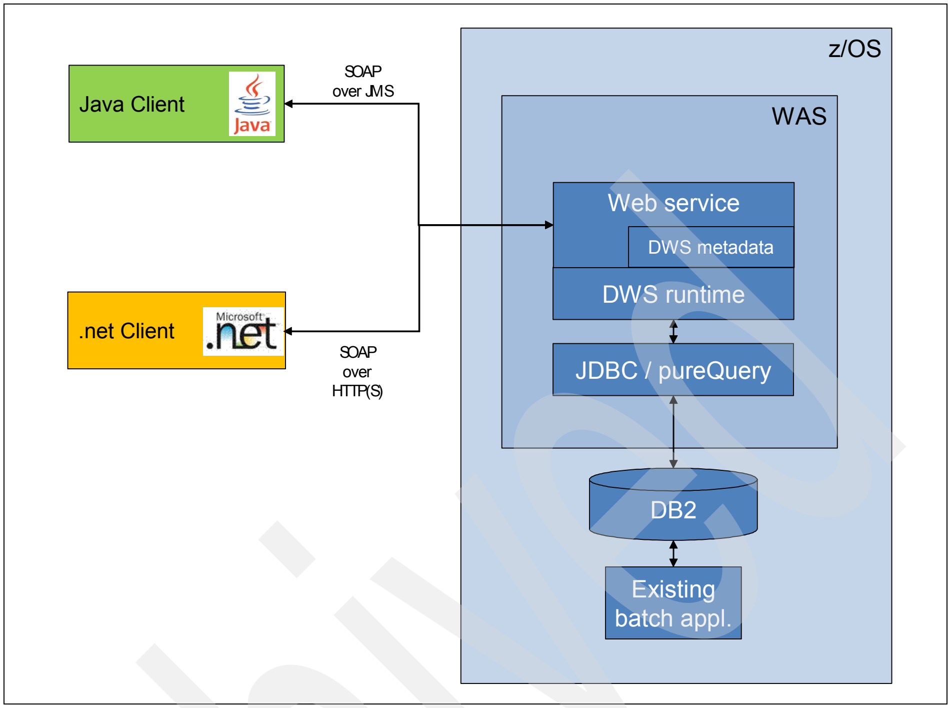


Figure 3-7 Target architecture for exposing DB2 using DWS

Runtime software prerequisite

The runtime software prerequisite for using DWS on z/OS is WebSphere Application Server. We have tested this scenario with WebSphere Application Server Version 6.1.

Development tool

The development tool that was used for this solution is IBM Data Studio Developer. The latest version is Version 2.1, but we used Version 1.2.

Advantages

The advantages of this solution are:

- Extremely easy to use
- Support for static SQL using *pureQuery*
- Support for SOAP over both HTTP(S) and JMS
- Existing queries can easily be reused

Limitations

The limitations of this solution are:

- Separate tool required
- Additional tier required in the form of a J2EE server to host the Web service
- Only basic create, read, update, and delete functionality is exposed
- Purely data-centric, not necessarily business-centric
- No enforcement of business rules (except by the database itself, in the form of constraints)

Guidelines

The guidelines for this solution are:

- Read-only access (queries) work as long as they expose a business view of the data. Be careful about modifying services, and especially, be sure to consider service granularity and business rules enforcement.
- Database constraints are an excellent vehicle for enforcement of business rules.

Example

Refer to 7.2, “Using Data Web Services (DWS)” on page 160.

Accessing DB2 on z/OS using custom data access

The essence of this solution is the usage of hand-written (or tool-generated) SQL statements to access DB2 from a J2EE application. This J2EE application is then exposed as a Web service, and a J2EE application server is then used to host this Web service.

Various technology and tooling options are available for this scenario:

- Hand-coded JDBC or SQLJ access
- Use of pureQuery
- Container-Managed Persistence Entity JavaBeans™ (CMP EJBs)
- An Object-Relational Mapping (ORM) tool, such as *Hibernate*™

Target architecture

Figure 3-8 on page 44 shows the target architecture of this solution. In the diagram, a Web service is implemented in WebSphere Application Server. This Web service can use any of the techniques previously mentioned to access DB2. The protocol to access DB2 is Java DataBase Connectivity (JDBC) or SQLJ. This scenario can be used for SQL queries and stored procedures.

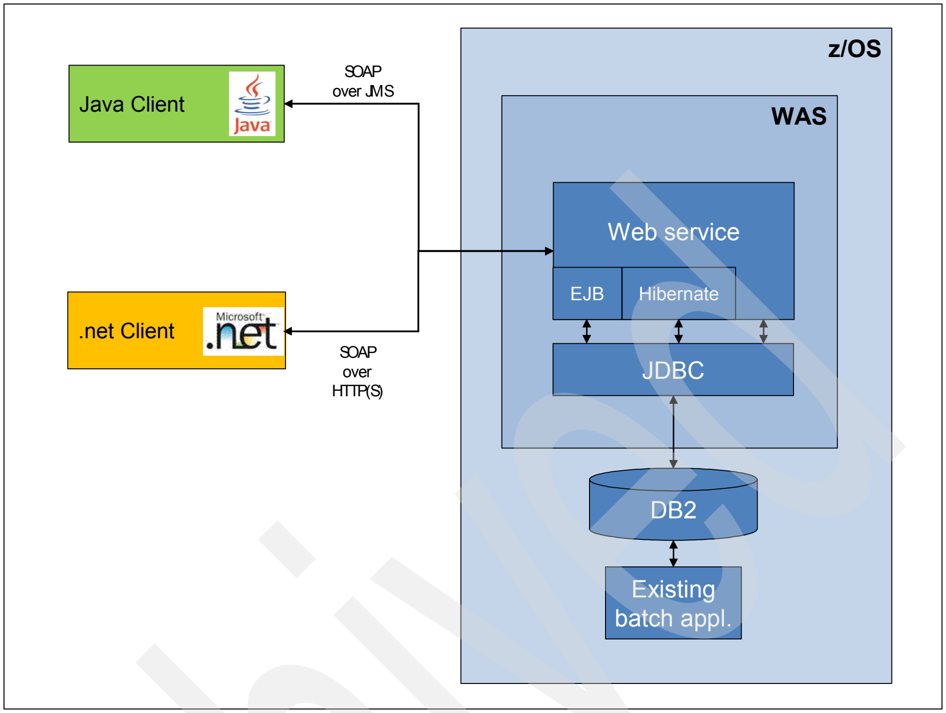


Figure 3-8 Target architecture for custom data access hosted in WebSphere Application Server

Runtime software prerequisites

WebSphere Application Server or an equivalent J2EE application server is the runtime software prerequisite that exists for custom data access on z/OS.

Development tools

IBM Rational Application Developer (RAD), Eclipse, or any development tool that supports developing J2EE applications and Web services can be used for this solution.

Advantages

The advantages of this solution are:

- In contrast to “Accessing DB2 on z/OS using Data Web Services (DWS)” on page 41, you have the option to add business functionality and to enforce business rules.
- ORM tools allow a high degree of flexibility when defining and evolving the object model.

Limitations

The limitations of this solution are:

- Hand-coding JDBC or SQLJ data access is error prone. Consider tool support and a utility framework, such as Spring.
- ORM tools add another level of complexity, and they have a considerable initial learning curve.

Accessing DB2 on z/OS using WebSphere Message Broker

By using WebSphere Message Broker, DB2 on z/OS can be accessed using an ESB approach. WebSphere Message Broker provides a number of nodes specifically for database access, but database access can also be manually programmed inside a so-called *Compute node*. WebSphere Message Broker provides a generic Compute node and a Java Compute node. The generic Compute node uses the Open Database Connectivity (ODBC) protocol to access DB2, and the Java Compute node uses JDBC to access DB2.

Target architecture

Figure 3-9 on page 46 depicts the target architecture for using WebSphere Message Broker to access DB2 on z/OS. A typical message flow in WebSphere Message Broker consists of an HTTP or JMS input node to receive the request from the client application. This input can also be in the form of a SOAP request. Eventual transformation nodes are executed to prepare the input for the database calls. One or several database nodes are used to perform create, read, update, and delete actions on the data. In the case of extremely complex database access, Compute nodes or Java Compute nodes are added. After the database access has been completed, transformation is typically required again before building a reply back to the client application.

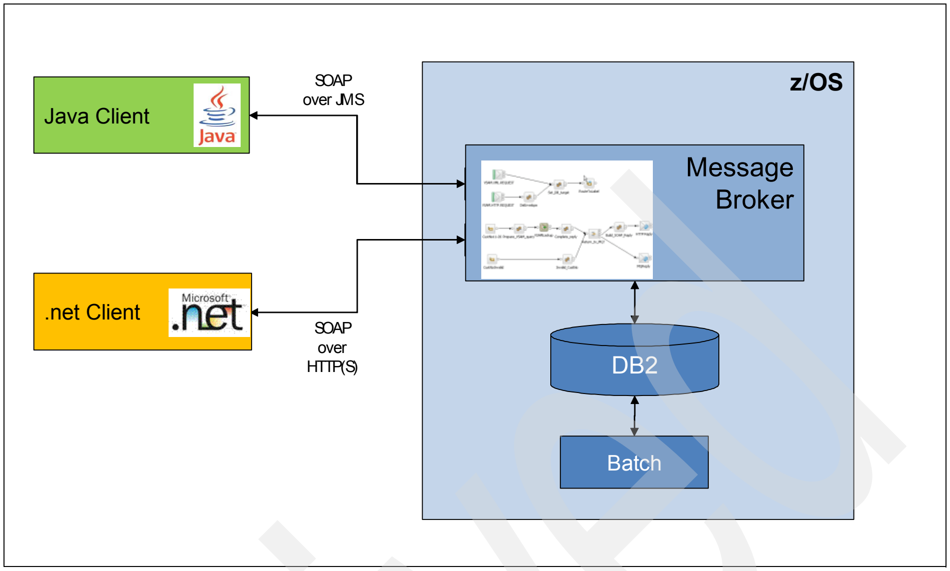


Figure 3-9 Target architecture for accessing DB2 on z/OS using WebSphere Message Broker

Runtime software prerequisite

WebSphere Message Broker is the prerequisite for accessing DB2 on z/OS using WebSphere Message Broker.

Development tool

WebSphere Message Broker Toolkit is the development tool that is used for this solution.

Advantages

The advantages of using this solution are:

- Using an ESB provides SOA benefits, such as loose coupling.
- Data access is fully transparent for client applications.

Limitation

ESB might introduce overhead because of transformation.

3.3 Accessing IMS data as a service

This scenario is similar to the scenario that is discussed in 3.1, “Accessing VSAM data as a service” on page 28 and 3.2, “Accessing DB2 data as a service” on page 39. The data is on z/OS, but this time, the data is in an IMS database. IMS databases are highly efficient, but have a specific organization. In the past, you were only able to access IMS databases on MVS and OS/390® using native protocols. Over the past few years, this restriction has changed, and now, you can access IMS databases directly from outside. Also, IMS databases can be accessed in a relational style using SQL.

3.3.1 Initial state

In this example, the initial state is similar to the scenario that is described in 3.1, “Accessing VSAM data as a service” on page 28, but the master data is now kept in IMS databases.

3.3.2 Current architecture

Figure 3-10 on page 48 represents the current architecture diagram in an extremely simplified form. The cloud represents a replication mechanism between the IMS data and the Java and .Net client applications. At the same time, the data in the IMS databases is accessible through IMS transactions and batch programs running on z/OS.

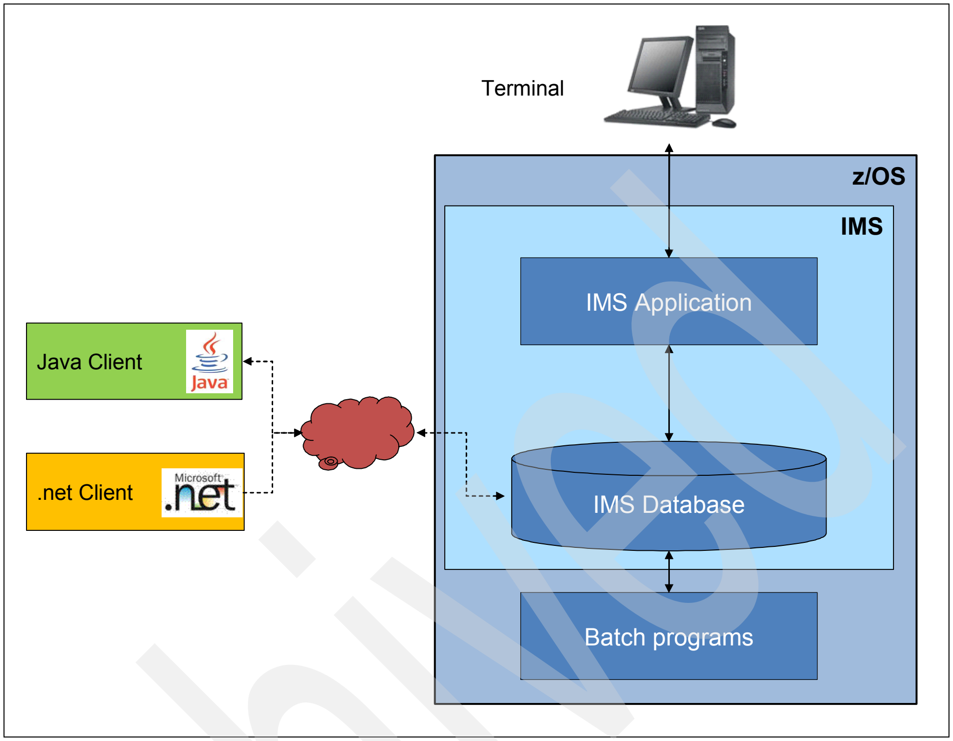


Figure 3-10 Current architecture for IMS database access on z/OS

3.3.3 Solution strategy

The chosen solution depends on requirements and factors, such as cost, time, and flexibility. If you only need an easy, simple, and inexpensive way to provide access to the IMS data and the client applications and prefer to use Web Services (SOAP) over HTTP, "Accessing IMS databases through an existing program" on page 491 is appropriate.

If you need a more flexible, scalable, platform-independent, and software-independent infrastructure and the client applications use a wide range of transmission protocols, such as JMS, MQ, HTTP, HTTPS, TCP/IP, SOAP, or other transmission protocols, "Accessing IMS databases using JDBC" on page 51 is more appropriate.

Benefits

The benefits of the solution strategy are:

- The issue of maintaining redundant data can be avoided.

- All the data sync issues can be eliminated, because this solution provides a single data store.
- Data is available in real time for both the fictional company and its business partners at the same time.
- Future (business partner) applications can reuse the same solution architecture.
- The cost, time, and effort to maintain the batch window for keeping the databases in sync has been eliminated.

3.3.4 Solutions

We discuss the following solutions:

- Accessing IMS databases through an existing program
- Accessing IMS databases using JDBC

Accessing IMS databases through an existing program

This solution focuses on using an existing IMS (or CICS) program to access the IMS database. This existing program will then be exposed as a Web service. If the program is an IMS program, follow the approach that is explained in “IMS Web Services” on page 82. If the program is a CICS program, follow the approach that is explained in “CICS Web Services” on page 59.

Target architecture

Figure 3-11 on page 50 shows a diagram of the architecture of this solution. In this case, we assume that the existing program is an IMS program. The vehicle that is used to access the IMS program as a Web service is the IMS SOAP Gateway. At the same time, you can continue to use the existing program from a 3270 terminal.

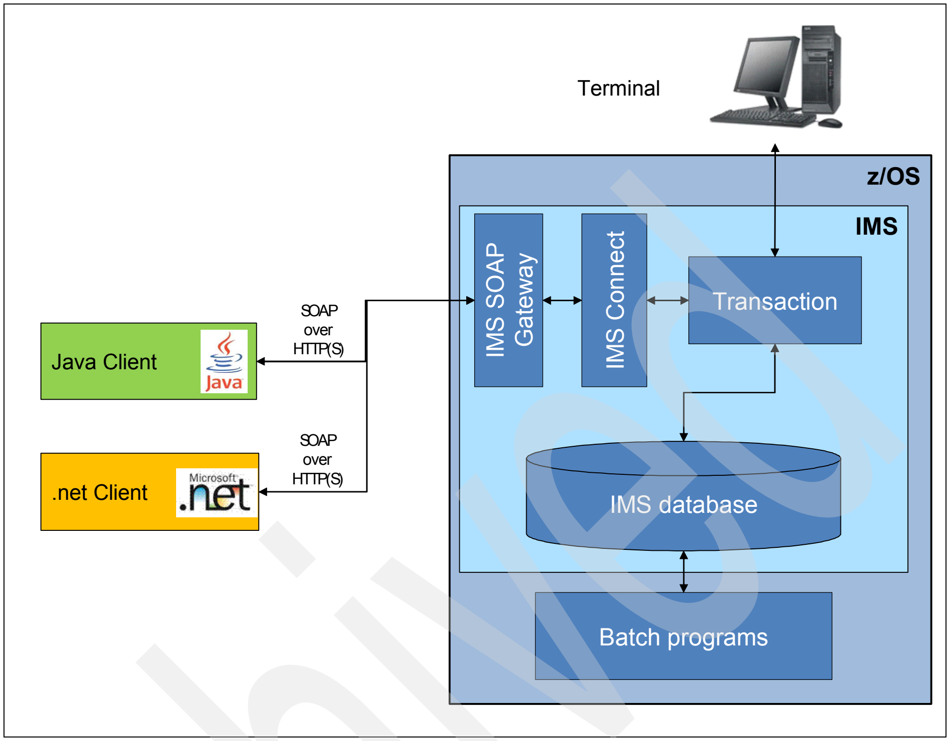


Figure 3-11 Target architecture for accessing IMS databases through an existing program

Runtime software prerequisites

The following runtime software prerequisites exist for this solution:

- IMS Version 10 or higher
- IMS Connect Version 10 or higher
- IMS SOAP Gateway Version 10.1 or higher

Development tool

We used Rational Developer for z (RDz) Version 7.1.1 (or higher) for this solution.

Advantages

The advantages of this solution are:

- This solution is a simple and easy way to service-enable IMS transactions accessing IMS databases.
- You can retain your existing transactions, which have been proven, secure, reliable, and scalable.

Limitations

The limitations of this solution are:

- Only non-conversational transactions are supported.
- Only commit mode 1, sync level NONE processing is supported.
- Two-phase commit is not supported.

Accessing IMS databases using JDBC

This solution is quite sophisticated. Again, we assume that we need a Web service that is reusable by the enterprise. In this solution we implement the Web service in a J2EE server, WebSphere Application Server. Then, we use a resource adapter to connect to the IMS database.

Target architecture

In this architecture, we do not use IMS Transaction Manager and IMS Connect. We access the IMS database directly from WebSphere Application Server on z/OS. You can write Java applications that run on WebSphere Application Server for z/OS and access IMS databases when WebSphere Application Server for z/OS and IMS are on the same logical partition (LPAR). JDBC or IMS hierarchical database interface for Java calls are passed to the IMS DB resource adapter, which converts the calls to DL/I calls. The IMS DB resource adapter passes these calls to Open Database Access (ODBA), which uses the database resource adapter (DRA) to access the DL/I region in IMS.

In order for a Java application to access an IMS database, it needs information about that database. The *DLIModel utility* allows you to transform your IMS database information (program specification blocks, database descriptions, and COBOL copybooks) into application-independent metadata.

Figure 3-12 on page 52 shows the target architecture for this solution.

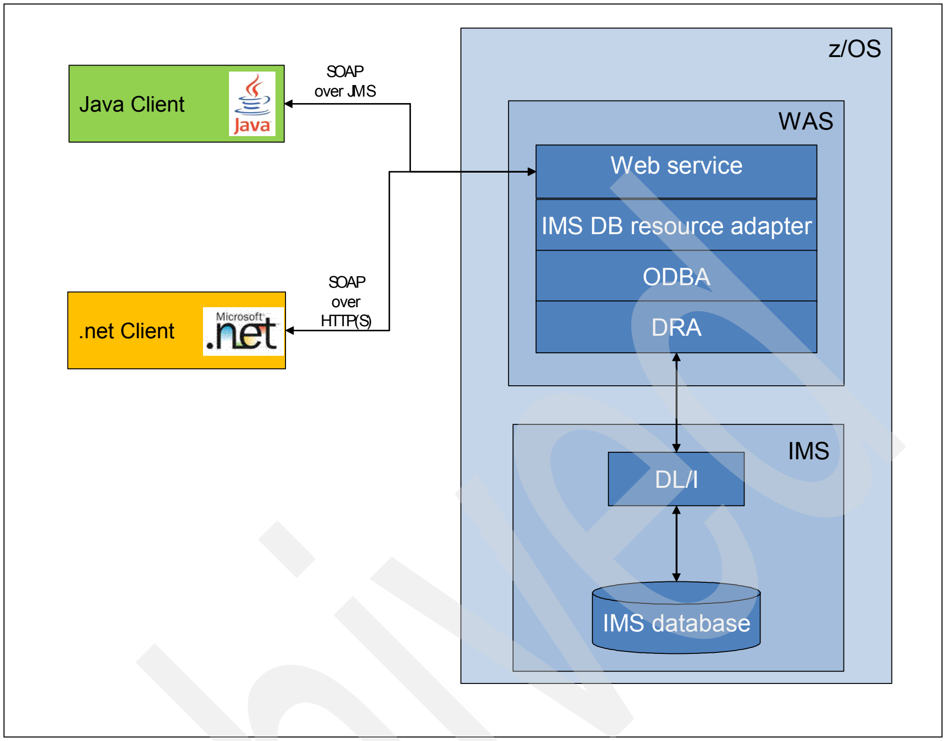


Figure 3-12 Target architecture for accessing an IMS database using ODBA

Runtime software prerequisite

IMS Version 10 or higher is the prerequisite to access an IMS database using ODBA.

Development tools

We used the following development tools for this solution:

- Rational Developer for System z (RDz)
- DLIModel utility

Advantages

The advantages of this solution are:

- WebSphere Application Server is used as the container for the data access programs. WebSphere Application Server provides a common environment that is easily accessible from outside applications.
- The development process is relatively easy, considering that we are accessing an IMS database.

- Even though the database is hierarchical by nature, we can use JDBC statements to access the database.
- When WebSphere Application Server and the IMS DB are on the same LPAR, a high quality of service (QoS) is achieved.
- The IMS implementation of JDBC supports a selected subset of the full facilities of the JDBC 2.0 application programming interface (API). This subset allows you to perform all the tasks that traditional IMS applications using DL/I calls can perform. You can also use the IMS Java hierarchical database interface for lower level access to IMS databases.

Limitations

The limitations of this solution are:

- You cannot use the DLIModel utility to modify a data structure in IMS on the mainframe.
- This solution does not support:
  - Main storage database (MSDB), hierarchical sequential access method (HSAM), and simple hierarchical sequential access method (SHSAM) databases
  - Shared secondary indexes
  - The processing option to make an application sensitive to only the segment key of a segment (PROCOPT=K option) in a PSB SENSEG statement

Guidelines

Refer to the following sources for guidelines:

- Chapter 8, "Configuring WebSphere Application Server for z/OS," in *IMS Communications and Connection Guide Version 10*, SC18-9703
- Chapter 25, "Developing Java applications that work with IMS," in *IMS Application Programing Guide Version 10*, SC18-9698
- Chapter 12, "Java class libraries for IMS," in *IMS Application Programing API Reference Version 10*, SC18-9699
- The DLIModel utility Web site at:

  `http://www-306.ibm.com/software/data/ims/toolkit/dlimodelutility/`

Example

Refer to the example with a step-by-step technical explanation in Chapter 8, "Exposing IMS data as a service" on page 179.

4

Accessing programs on z/OS as a service

This chapter explains most of the technology solutions that are available today to integrate existing z/OS programs into a service-oriented architecture (SOA) infrastructure.

We discuss the following patterns:

- Accessing a CICS program on z/OS as a service
- Accessing a complex CICS application as a service
- Accessing IMS programs as a service
- Accessing a CICS application as a composite service
- Accessing DB2 stored procedures on z/OS as a service
- Accessing presentation logic as a service

4.1 Accessing a CICS program on z/OS as a service

An example of this pattern is a company whose application portfolio comprises well designed CICS applications. The programs generally have their presentation and business logic layers clearly demarcated. The applications contain several programs with business logic in high demand for reuse throughout the company. The company is looking for solutions to provide an alternate user interface to the 3270 displays, as well as a solution for providing broad access to certain CICS business logic programs. This access ideally includes business partners. These vendors possess a wide variety of distributed systems and several vendors also use System z.

4.1.1 Initial state

The company has a large number of CICS-based applications that use traditional character-based 3270 interfaces using CICS *Basic Mapping Support (BMS)* maps as an interface to send and receive the data that is entered. The process of sending and receiving the COMMAREA data is contained separately within programs, and the data is passed to other CICS programs containing the core business logic.

The application portfolio also contains programs that are a mix of stand-alone business logic and terminal-based CICS programs that take input from the users.

4.1.2 Current architecture

Figure 4-1 on page 57 shows the current application architecture at a high level.

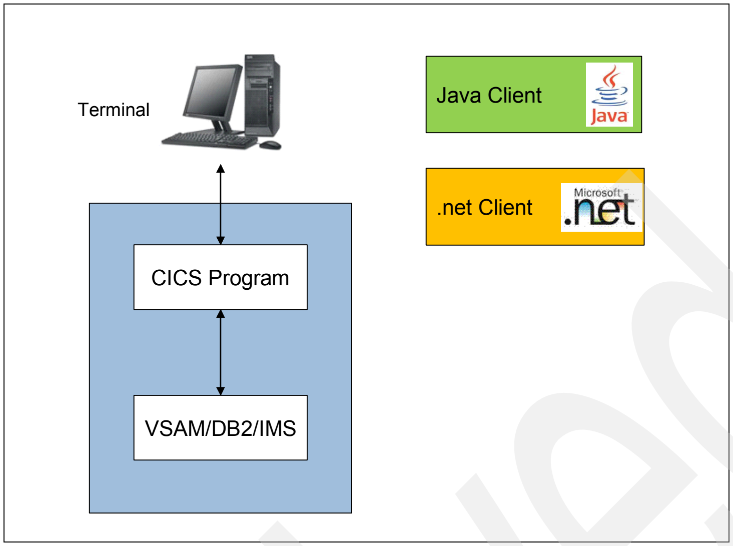


Figure 4-1 High-level view of the current application architecture

Figure 4-2 shows a more detailed view of the current architecture.

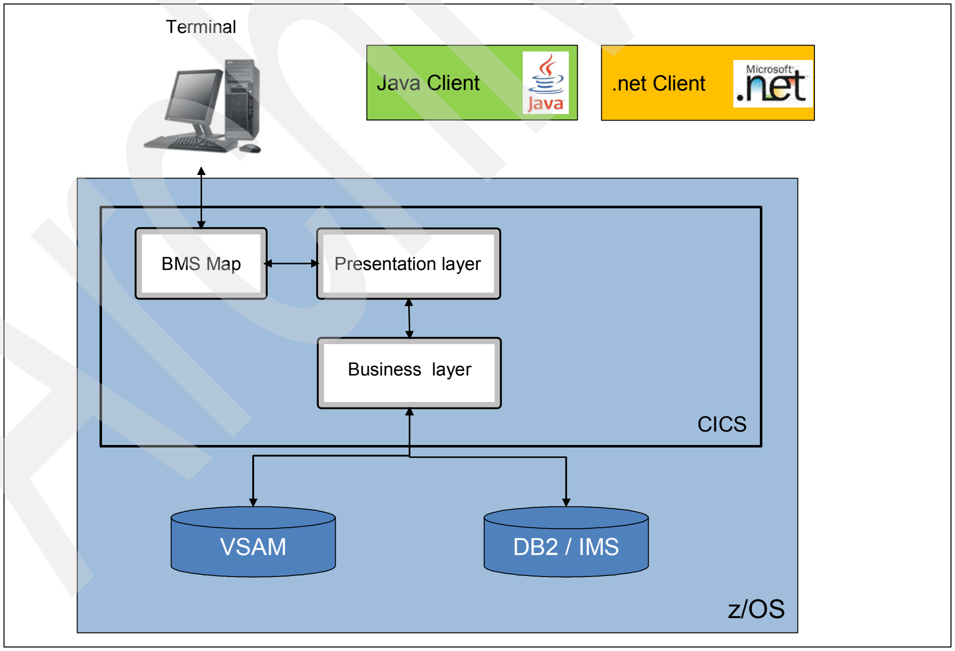


Figure 4-2 More detailed view of the current application architecture

4.1.3 Solution strategy

The solution strategy is to make the business logic programs accessible for a broad variety of potential client programs in a standardized way. The quality of service (QoS) plays an important role, too. At this point, you can make one of three architectural decisions:

- Web service-enable selected CICS business logic programs and provide the Web Services Description Language (WSDL) to those individuals who want to access those service (directly).
- Do not Web service-enable the CICS business logic program, but implement a Web service interface in WebSphere Application Server and access the CICS program from WebSphere Application Server through any of the supported protocols and connectors, for example, J2EE Connector architecture (J2C) or WebSphere MQ.
- Do not Web service-enable the CICS business logic programs, but provide an enterprise service bus (ESB) layer with access to those CICS programs using native/traditional access methods, such as external CICS interface (EXCI) and WebSphere MQ. The access point for those CICS programs for clients will then be in the ESB.

All solution directions can be considered standardized and SOA-compliant. However, the ESB direction is a better architecture, providing advantages in the area of governance, flexibility, quality of service (QoS), and more. After all, just providing a Web Services interface without using an ESB remains a “point to point” solution, but just with an another interface protocol.

In 4.1.4, “Solutions” on page 59, we discuss solutions of all categories.

Benefits

The benefits of providing broader and more standardized access to CICS business logic programs are:

- Leverage robust and proven business logic with high performing native data access
- Avoid building redundant programs throughout the company that perform the same functions as the CICS programs, but usually with lower quality of service

4.1.4 Solutions

We discuss the following solutions:

- CICS Web Services
- Web service interface in WebSphere Application Server and J2C to CICS
- Web service interface in WebSphere Enterprise Service Bus and J2C to CICS
- Web service interface in WebSphere Enterprise Service Bus and WebSphere MQ to CICS
- Web service interface in WebSphere Enterprise Service Bus and SOAP/JMS to CICS
- Web service interface in WebSphere Message Broker and EXCI to CICS
- Web service interface in WebSphere Message Broker and WebSphere MQ to CICS
- Web service interface in WebSphere Message Broker and SOAP/JMS to CICS

CICS Web Services

One of the first solutions to consider is to use CICS Web Services support, which is part of CICS TS Version 3.1 and Version 3.2, to expose the CICS business logic programs as a Web service. A lot of detailed information with regard to CICS Web Services is already available. For example, refer Section 2.3.1 in *Application Development for CICS Web Services,* SG24-7126.

Target architecture

Figure 4-3 on page 60 shows the target architecture when using CICS Web Services. After a CICS Web service is implemented using CICS Web Services support, it is accessible from a Web service consumer using Web Services protocols. The consumer can exchange SOAP messages with CICS over HTTP or Java Message Service (JMS).

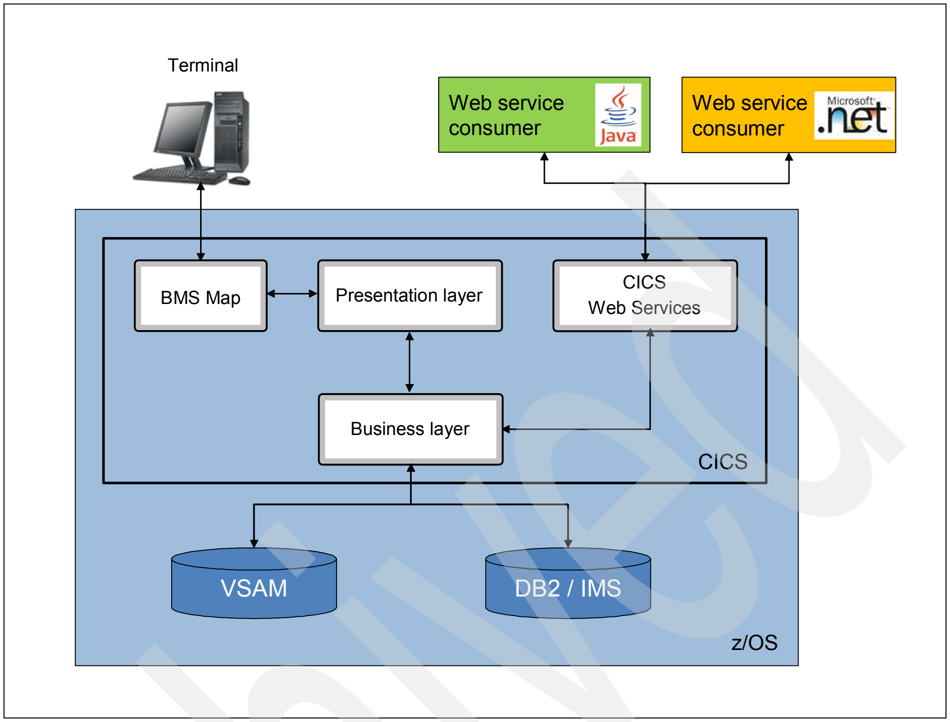


Figure 4-3 Target architecture using CICS Web Services

Runtime software prerequisite

CICS Transaction Server Version 3.1 or Version 3.2 is the runtime software prerequisite exist for this solution.

Development tools

Use either Rational Developer for System z (RDz) or CICS Web Services Assistant to Web service-enable CICS programs.

Advantages

This solution has the following advantages:

- Simple and easy way to service-enable CICS programs
- Existing programs, which have been proven, secure, reliable, and scalable, retained
- Excellent tooling support
- Standard protocols

Limitation

If the CICS Web Services Assistant DFHLS2WS utility is used to generate the Web service artifacts, such as the wsdl file, only basic support is available. Copybook fields, such as COMP and arrays, are not supported.

Guidelines

Guidelines for this solution include:

- You can use Rational Developer for z (RDz) to generate the Web service artifacts, covering all possible data definitions.
- You need to carefully consider the security aspects when external applications gain direct access to a CICS Web service. Examples of security measures that can be taken are:
  - Having user ID as part of the application data header and having the program defined in the CICS PIPELINE configuration file to use the user ID to check with RACF or other security products, such as ACF/2
  - Using the security authentication validation features of the TCPIPSERVICE definition
  - Defining the TCPIPSERVICE to use Secure Sockets Layer (SSL) transport

  Refer to *Securing Access to CICS Within an SOA*, SG24-5756, for an extensive discussion of CICS Web Services security.

Web service interface in WebSphere Application Server and J2C to CICS

In this approach, a Web service is developed and implemented in WebSphere Application Server. This Web service then uses a J2C connector, in this case, the resource adapter for the CICS Transaction Gateway. You can use any J2EE server that supports this resource adapter. Alternatively, you can use WebSphere MQ as well between WebSphere Application Server and CICS.

The Web service can be developed with a tool, such as Rational Application Developer (RAD). RAD contains wizards to easily create a J2C-based Web service that connects to a CICS program. In this approach, CICS Web Services support is not used, and no additional definitions need to be created in CICS.

You can use the RAD's J2C wizard to create a J2C bean. Mapping COMMAREA data with Java data types is part of this process. When the J2C bean is ready, a Web service can be generated that will use that J2C bean. The Web Service is then deployed to the J2EE application server, such as the WebSphere Application Server on z/OS.

Refer to Chapter 6 in *WebSphere for z/OS V6 Connectivity Handbook,* SG24-7064, for technical hands-on instructions.

Target architecture

Refer to Figure 4-4 for a diagram of the target architecture. After the Web service is implemented in WebSphere Application Server, it can be accessed directly from a Web service consumer using the Web Service protocols. In principle, this approach means exchanging SOAP messages over HTTP or JMS. A browser can also access the Web service in WebSphere Application Server using REST.

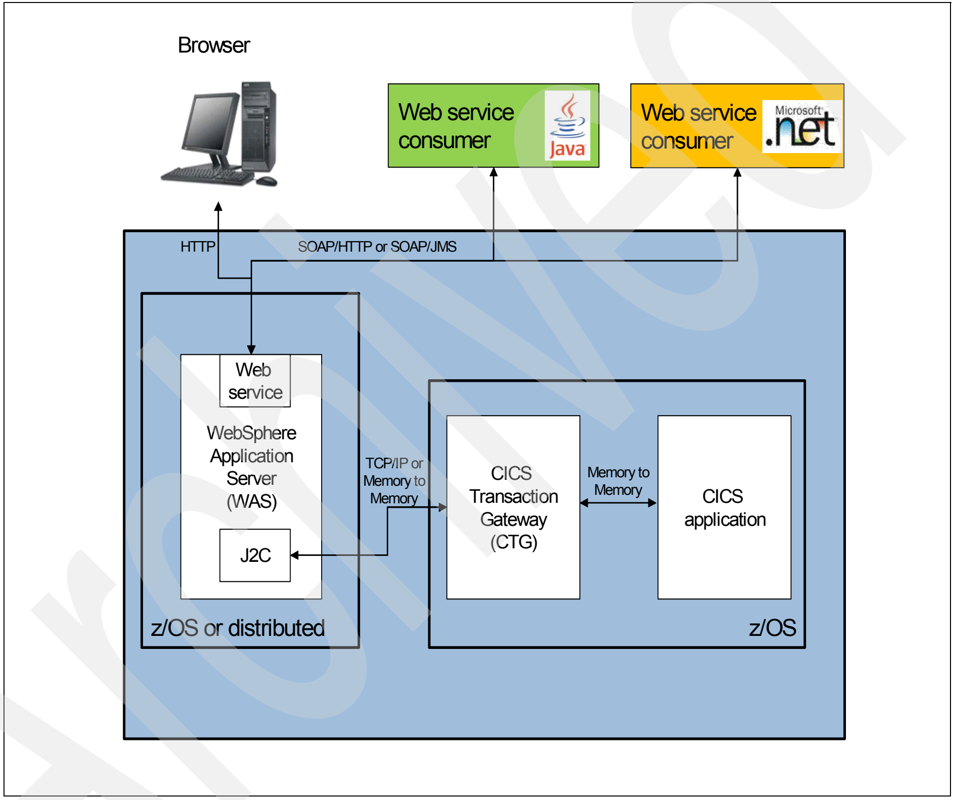


Figure 4-4 Target architecture using WebSphere Application Server and J2C

Runtime software prerequisites

This solution requires the following software:

- CICS Transaction Server
- CICS Transaction Gateway (CICS TG) on z/OS
- WebSphere Application Server or a J2EE server supporting the CICS TG resource adapter

Both CICS TG and WebSphere Application Server can run on z/OS or the distributed platform. In our pattern, we assume they run on z/OS. If WebSphere Application Server and CICS TG run on the same z/OS logical partition (LPAR), the communication is cross-memory.

Development tool

This solution requires Rational Application Developer (RAD) for developing WebSphere Application Server Web services and J2C beans.

Advantages

The advantages of this solution are:

- Applications can be created quickly using the wizards that are provided for Web services and J2C beans in RAD.
- CICS TG is a mature connector supporting two-phase commit, advanced security, and systems management.
- No changes to the existing CICS programs are required, and no additional definitions are required in CICS, apart from the setup for using the EXCI protocol.
- In terms of performance, this solution rates extremely high, especially when WebSphere Application Server, CICS TG, and CICS all run on z/OS.
- WebSphere Application Server provides extensive support for Web Services, including Universal Description, Discovery, and Integration (UDDI), IBM WebSphere Service Registry and Repository (WSRR), and many of the Web Services standards (security, reliability, and so forth).

Limitation

The connection between WebSphere Application Server and CICS is not entirely loosely coupled; this solution is more oriented toward a peer-to-peer connection. Transformation, although generated using the tools at development time, is integrated into the new Web service application in WebSphere Application Server.

Guidelines

For guidelines about how to develop this solution, refer to Chapter 6 of *WebSphere for z/OS V6 Connectivity Handbook,* SG24-7064, for technical hands-on samples.

Web service interface in WebSphere Enterprise Service Bus and J2C to CICS

In this solution, you use the combination of WebSphere Enterprise Service Bus and a J2C adapter to integrate existing CICS programs into the SOA. ESB functions of WebSphere Enterprise Bus, such as data format and transport protocol transformation, service virtualization, and quality of service (QoS) features are leveraged to make this solution more comprehensive. In this solution, WebSphere Integration Developer is used to create a mediation with a J2C connection to CICS. WebSphere Integration Developer is used to create mediation modules that are deployed to the run time of WebSphere Enterprise Service Bus. The J2C connector used between WebSphere Enterprise Service Bus and CICS is the CICS Transaction Gateway.

Target architecture

Refer to Figure 4-5.

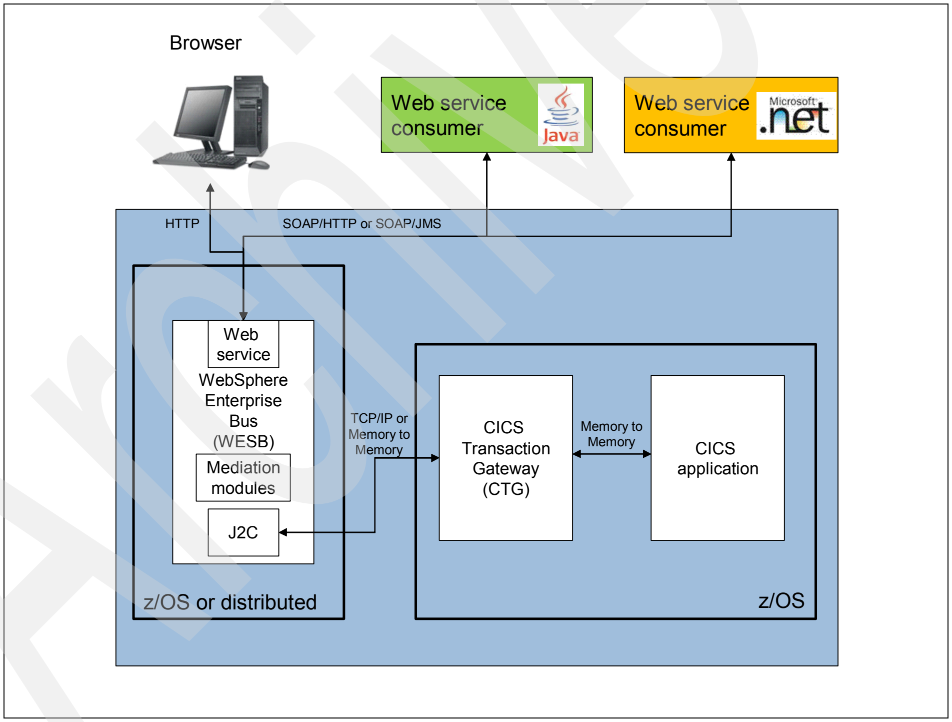


Figure 4-5 Target architecture: WebSphere Enterprise Service Bus, J2C, and CICS TG

Runtime software prerequisites

This solution requires the following runtime software:

- CICS Transaction Server
- CICS Transaction Gateway (CICS TG) on z/OS
- WebSphere Enterprise Service Bus on z/OS

Both CICS TG and WebSphere Enterprise Service Bus can run on z/OS or the distributed platform. In our pattern, we assume that they run on z/OS. If WebSphere Enterprise Service Bus and CICS TG run on the same z/OS LPAR, the communication is cross-memory.

Development tool

This solution requires WebSphere Integration Developer for developing mediation modules and mediation flows.

Advantages

The advantages of this solution are:

- Rich data format transformation functionality is available in WebSphere Enterprise Service Bus, allowing the service requestor to use a standard data format, such as XML or HTML, which is independent of the COMMAREA that is delivered to CICS.
- Transport protocol transformation is available in WebSphere Enterprise Service Bus. The service requestor can use a variety of standard protocols, such as JMS, HTTP, SOAP over HTTP, and SOAP over JMS.
- CICS TG is a mature connector supporting two-phase commit, advanced security, and systems management.
- There are no changes required to the existing CICS programs, and there are no additional definitions required in CICS other than the setup for using the EXCI protocol.
- In terms of performance, this solution rates extremely high, especially when WebSphere Application Server, CICS TG, and CICS all run on z/OS.

Limitations

No real limitations exist for this solution.

Guidelines

- There are many books already available with more details about how to use WebSphere Enterprise Service Bus. Refer to:
  - *Implementing an ESB using IBM WebSphere Message Broker V6 and WebSphere ESB V6 on z/OS,* SG24-7335
  - *Patterns: SOA Design Using WebSphere Message Broker and WebSphere ESB,* SG24-7369

Web service interface in WebSphere Enterprise Service Bus and WebSphere MQ to CICS

In this solution, WebSphere Enterprise Service Bus is used for the ESB, and WebSphere MQ is used as a transport layer between WebSphere Enterprise Service Bus and CICS. No Web Services protocol is used between WebSphere Enterprise Service Bus and CICS, but a WebSphere MQ message gets created using JMS in WebSphere Enterprise Service Bus. A CICS program that is already used to work with WebSphere MQ messages does not need to be changed.

Target architecture

Refer to Figure 4-6 on page 67 for the target architecture. WebSphere Enterprise Service Bus receives the request from the Web service consumer, performs the necessary mediation, creates a JMS message, and forwards it to a WebSphere MQ queue. CICS receives the MQ messages through the CICS-MQ Bridge and triggers the CICS program.

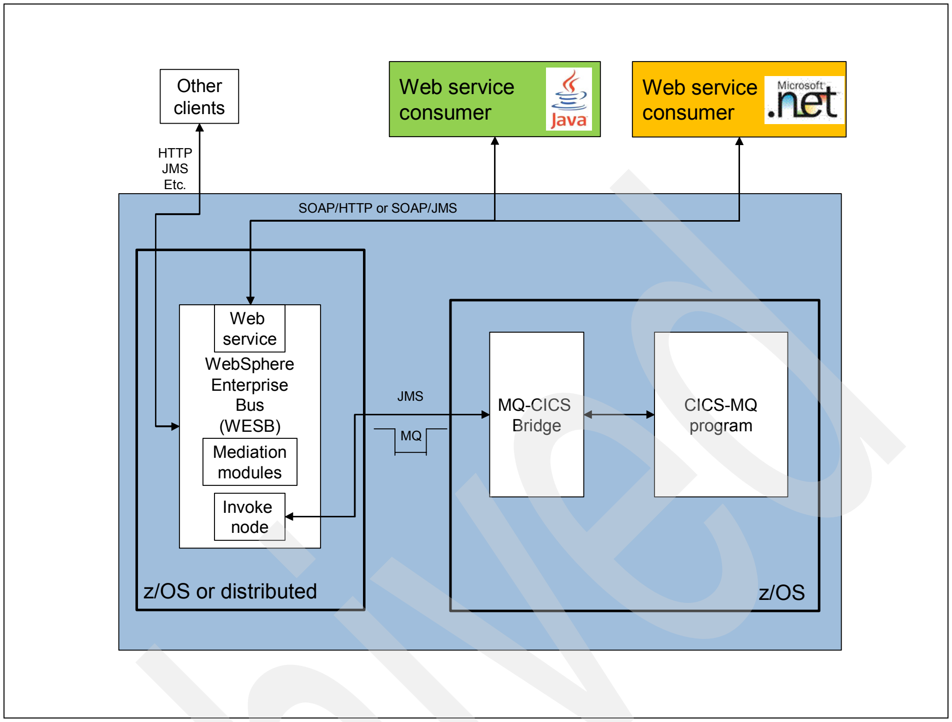


Figure 4-6 Target architecture: WebSphere Enterprise Service Bus, JMS, and WebSphere MQ

Runtime software prerequisites

The following runtime software prerequisites apply:

- CICS Transaction Server
- WebSphere Enterprise Service Bus
- WebSphere MQ

WebSphere Enterprise Service Bus can run on z/OS, Linux on System z ,or in a distributed environment. A local WebSphere MQ must exist, however, on z/OS to deliver the message to CICS.

Development tool

We used WebSphere Integration Developer to develop mediation modules and mediation flows for this solution.

Advantages

The advantages of this solution are:

- Rich data format transformation functionality is available in WebSphere Enterprise Service Bus, allowing the service requestor to use a standard data format, such as XML or HTML, which is independent of the MQ message that is delivered to CICS.
- Transport protocol transformation is available in WebSphere Enterprise Service Bus. The service requestor can use a variety of standard protocols, such as JMS, HTTP, SOAP over HTTP, and SOAP over JMS.
- The usage of WebSphere MQ between WebSphere Enterprise Service Bus and CICS provides an industry standard and a proven method of transport.
- If the CICS program is already MQ-enabled, no changes are required on the CICS side.

Limitations

No real limitations exist for this solution.

Guidelines

We recommend:

- For more technical hands-on samples, refer to *Implementing an ESB using IBM WebSphere Message Broker V6 and WebSphere ESB V6 on z/OS,* SG24-7335
- You can also refer to the following developerWorks article, “Building an Enterprise Service Bus using WebSphere ESB, Part 4” by Rachel Reinitz and Andre Tost, 28 February 2006:

  http://www.ibm.com/developerworks/websphere/techjournal/0702_reinitz/0702_reinitz.html

Web service interface in WebSphere Enterprise Service Bus and SOAP/JMS to CICS

The solution is similar to the solution that we discussed in “Web service interface in WebSphere Enterprise Service Bus and WebSphere MQ to CICS” on page 66. However, instead of using a JMS message that gets delivered to CICS as an MQ message using the CICS-MQ Bridge, we now use a SOAP message packaged inside a JMS message. Because we now use a SOAP message, the SOAP message can be delivered to CICS using the CICS Web Services support. The CICS program that is accessed needs to be Web service-enabled.

Target architecture

Refer to Figure 4-7 on page 69 for an architectural diagram of this solution.

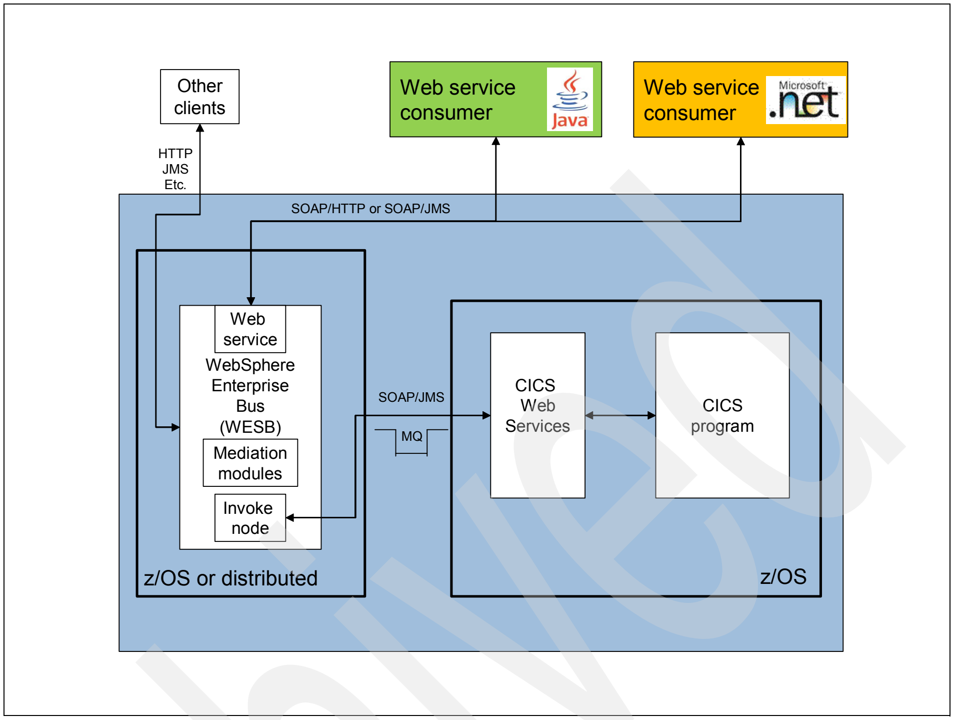


Figure 4-7 Target architecture using WebSphere Enterprise Service Bus, SOAP/JMS, and CICS Web Services

Runtime software prerequisites

The following runtime software is needed for this solution:

- CICS Transaction Server Version 3.1 or Version 3.2 with CICS Web Services configured
- WebSphere Enterprise Service Bus
- WebSphere MQ

WebSphere Enterprise Service Bus can run on z/OS, Linux on System z, or in a distributed environment. A local WebSphere MQ must exist, however, on z/OS.

Development tools

We used the following tools to develop this solution:

- WebSphere Integration Developer for developing mediation modules and mediation flows
- Rational Developer for System z (RDz) or CICS Web Services Assistant to Web service-enable CICS programs

Advantages

The advantages of this solution are:

- Rich data format transformation functionality is available in WebSphere Enterprise Service Bus, allowing the service requestor to use a standard data format, such as XML or HTML, which is independent of the SOAP/JMS message delivered to CICS.
- Transport protocol transformation is available in WebSphere Enterprise Service Bus. The service requestor can use a variety of standard protocols, such as JMS, HTTP, SOAP over HTTP, and SOAP over JMS.
- The usage of WebSphere MQ between WebSphere Enterprise Service Bus and CICS provides an industry standard and proven method of transport.
- After the CICS program is Web Service-enabled, it can also be accessed from sources other than WebSphere Enterprise Service Bus (refer to “CICS Web Services” on page 59).

Limitations

No real limitations exist for this solution.

Guidelines

We recommend:

- For more technical hands-on samples, refer to *Implementing an ESB using IBM WebSphere Message Broker V6 and WebSphere ESB V6 on z/OS,* SG24-7335
- You can also refer to the following developerWorks article, “Building an Enterprise Service Bus using WebSphere ESB, Part 4” by Rachel Reinitz and Andre Tost, 28 February 2006:

  http://www.ibm.com/developerworks/websphere/techjournal/0702_reinitz/0702_reinitz.html

Web service interface in WebSphere Message Broker and EXCI to CICS

In this solution, access to CICS programs takes places through an Enterprise Service Bus (ESB), such as in “Web service interface in WebSphere Enterprise Service Bus and J2C to CICS” on page 64. However, in this solution WebSphere Message Broker is used for the ESB. WebSphere Message Broker provides a special node to access CICS synchronously using the CICS EXCI protocol. WebSphere Message Broker provides broad functionality for routing and data format and transport protocol conversion. The architecture, along with its advantages and limitations, is generally the same as the WebSphere Enterprise Service Bus architecture.

The Web service consumer sends the request to WebSphere Message Broker, and WebSphere Message Broker forwards the request to CICS using the EXCI node. Eventually, transformation takes place, and logic can be executed before actually accessing CICS.

Target architecture

Figure 4-8 shows the architecture of this solution. Web service clients access WebSphere Message Broker using Web service requests. Other clients can access WebSphere Message Broker too using non-Web Services protocols, such as FTP, JMS, and HTTP.

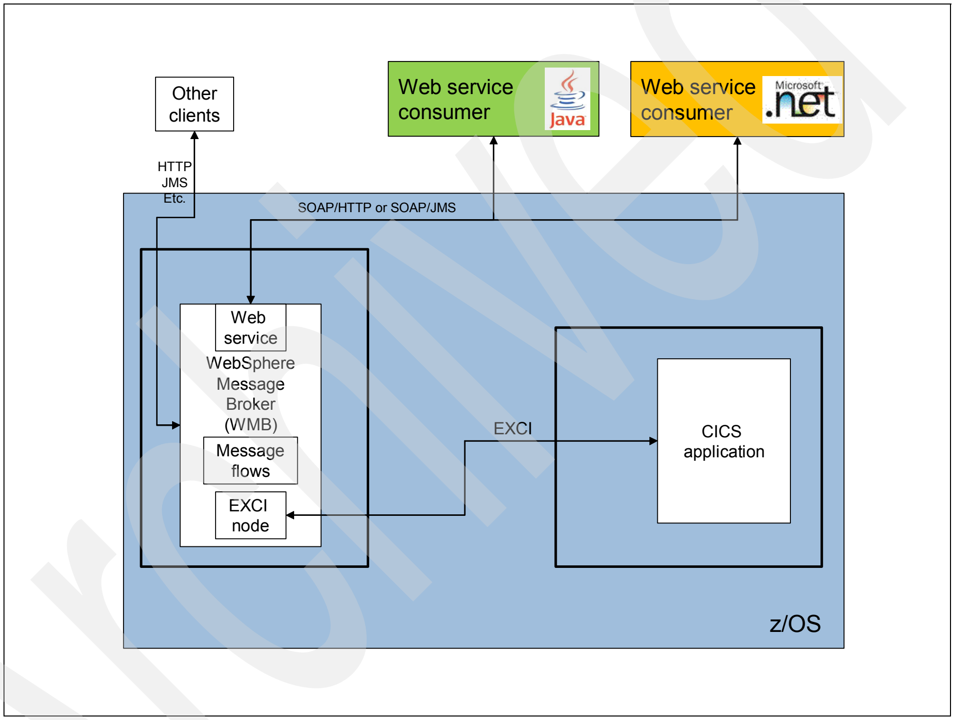


Figure 4-8 Target architecture using WebSphere Message Broker and EXCI

Runtime software prerequisites

The following runtime software prerequisites apply to this solution:

- CICS Transaction Server with EXCI configured
- WebSphere Message Broker on z/OS

Note that the EXCI node is not supported in WebSphere Message Broker on platforms other than z/OS. To use this solution, the Broker needs to run on z/OS, on the same LPAR, or in another LPAR in the same sysplex with CICS.

Development tool

We used WebSphere Message Broker Toolkit for developing message flows to run in WebSphere Message Broker.

Advantages

The advantages of this solution are:

- Data format transformation functionality is available, allowing the service requestor to use a standard data format, such as XML or HTML, which is independent of the MQ message that is sent to CICS.
- Transport protocol transformation is available. The service requestor can use a variety of standard protocols, such as JMS, HTTP, SOAP over HTTP, and SOAP over JMS.
- EXCI is a CICS native protocol supporting two-phase commit and cross-memory.
- No changes to the existing CICS programs are required, and no additional definitions are required in CICS, apart from the setup for using the EXCI protocol.
- In terms of performance, this solution rates extremely high.

Limitations

There are no real limitations with this solution.

Guidelines

For additional information about using WebSphere Message Broker, refer to:

- *WebSphere Message Broker Basics,* SG24-7137
- *Patterns: SOA Design Using WebSphere Message Broker and WebSphere ESB,* SG24-7369

Web service interface in WebSphere Message Broker and WebSphere MQ to CICS

This solution is similar to the solution that we discussed in "Web service interface in WebSphere Message Broker and EXCI to CICS" on page 70. However, this scenario uses another communication technique between the Broker and CICS. Instead of the EXCI node, WebSphere MQ is used to integrate with CICS.

Target architecture

Figure 4-9 on page 73 shows the target architecture of this solution. The original request can be sent to WebSphere Message Broker using a variety of protocols, including SOAP over HTTP and SOAP over JMS. Also, you can use non-Web Services protocols, such as HTTP, JMS, and FTP. In our solution, we are mainly interested in the usage of standard Web Services protocols. After the necessary transformation and routing logic in WebSphere Message Broker, the request is put on an MQ queue. This queue is then used to trigger further processing in CICS.

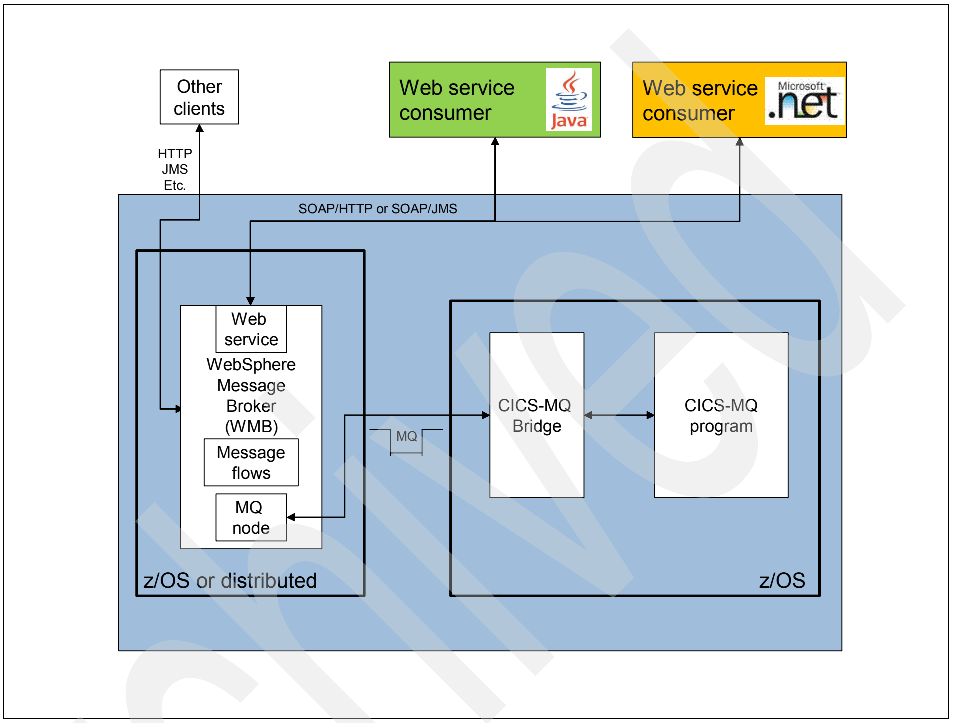


Figure 4-9 Target architecture using WebSphere Message Broker, WebSphere MQ, and CICS-MQ Bridge

Runtime software prerequisites

The following software prerequisites apply to this solution:

- WebSphere Message Broker
- WebSphere MQ
- CICS Transaction Server with the CICS-MQ Bridge configured

In this solution, WebSphere Message Broker can run on z/OS, Linux on System z, or in a distributed environment. Messages can be placed on a queue remotely.

Development tool

This solution uses WebSphere Message Broker Toolkit for developing message flows to run in WebSphere Message Broker.

Advantages

This solution has the following advantages:

- All of the benefits from using WebSphere Message Broker as an ESB
- Proven communication mechanism between WebSphere Message Broker and CICS
- Loosely coupled

Limitations

There are no real limitations with this solution.

Guidelines

For more technical hands-on samples, refer to *Implementing an ESB using IBM WebSphere Message Broker V6 and WebSphere ESB V6 on z/OS,* SG24-7335.

You can refer to *WebSphere Business Integration Message Broker Basics,* SG24-7090, for the simple basics of Message Broker.

Web service interface in WebSphere Message Broker and SOAP/JMS to CICS

This solution is a mix of the solution that was discussed in “CICS Web Services” on page 59 and the solution that was discussed in “Web service interface in WebSphere Message Broker and WebSphere MQ to CICS” on page 72. A SOAP message is sent over WebSphere MQ from the Broker to CICS, and CICS Web Services support will receive, parse, and convert the SOAP message. CICS Web Services must be configured, and Web Services definitions have to be made in CICS for the CICS program that is being accessed.

Target architecture

The target architecture is shown in Figure 4-10 on page 75. Requests can be sent to WebSphere Message Broker using any of the protocols supported. After the necessary routing and transformation logic in the WebSphere Message Broker, a SOAP message gets built that is being transported to CICS through WebSphere MQ. CICS will receive this message as a JMS message, strips of the JMS, and a SOAP header and delivers the message in a COMMAREA format to the program.

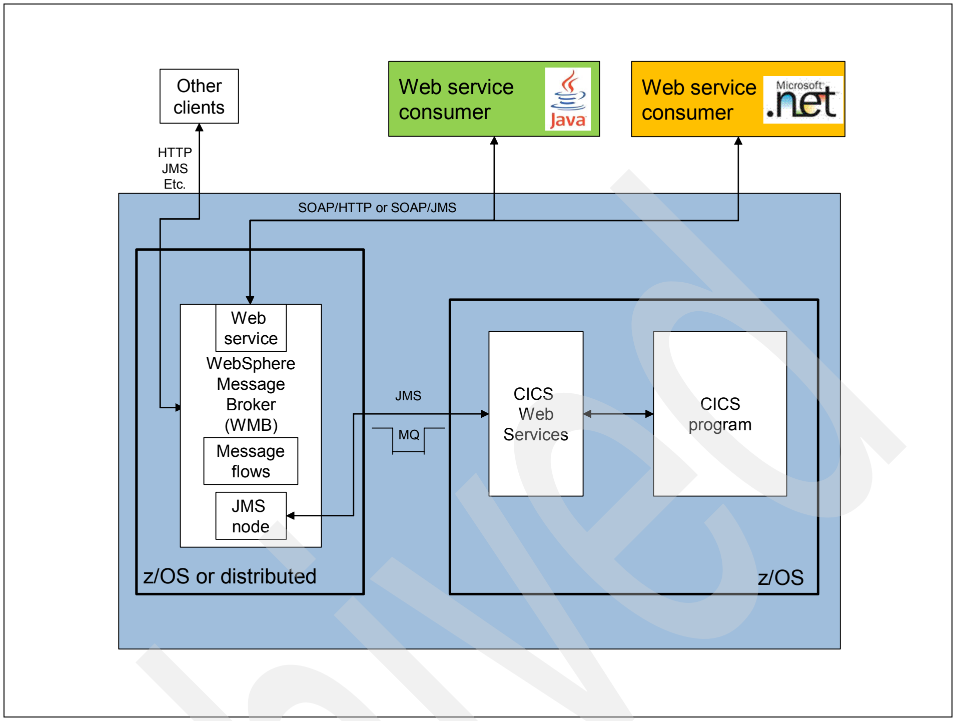


Figure 4-10 Target architecture using WebSphere Message Broker, WebSphere MQ, JMS, and CICS Web Services

Runtime software prerequisites

The following runtime software prerequisites exist for this solution:

- CICS Transaction Server V3.1 or V3.2 with CICS Web Services configured
- WebSphere MQ
- WebSphere Message Broker

Tools

This solution is developed using the following tools:

- WebSphere Message Broker Toolkit for developing the message flows for the Broker
- Rational Developer for System z or the CICS Web Services Assistant for defining the Web service in CICS

Advantages

This solution has the following advantages:

- All of the benefits from using WebSphere Message Broker as an ESB
- Proven communication mechanism between WebSphere Message Broker and CICS, that is, WebSphere MQ
- Loosely coupled

Limitations

For limitations, refer to "Limitation" on page 61 regarding CICS Web Services and "Limitations" on page 74 regarding WebSphere MQ.

Guidelines

For more information about using WebSphere Message Broker:

- For more technical hands-on samples, refer to *Implementing an ESB using IBM WebSphere Message Broker V6 and WebSphere ESB V6 on z/OS,* SG24-7335.
- You can refer to *WebSphere Business Integration Message Broker Basics,* SG24-7090, for the simple basics of WebSphere Message Broker.

4.2 Accessing a complex CICS application as a service

An example of this pattern is a company with a large base of CICS applications, which were designed and built without much focus on the demarcation of types of logic and without focus on future service granularity.

4.2.1 Initial state

The existing applications are complex, rigid, and volatile with presentation, business, and data access layers all scattered around in hundreds of programs and copybooks. Due to the nature of these applications, maintenance and enhancement of the business functionality have become difficult and expensive. The business functionality is mixed with one or multiple complex CICS panels, that is, basic mapping support (BMS maps). In particular, the new users of the system find it hard to navigate through the panels and have to remember complex panel flows. The impact of any new change to a panel or a database causes issues with regard to the development, testing, and integration of the changes.

4.2.2 Current architecture

Figure 4-11 shows a simplified diagram of the current state.

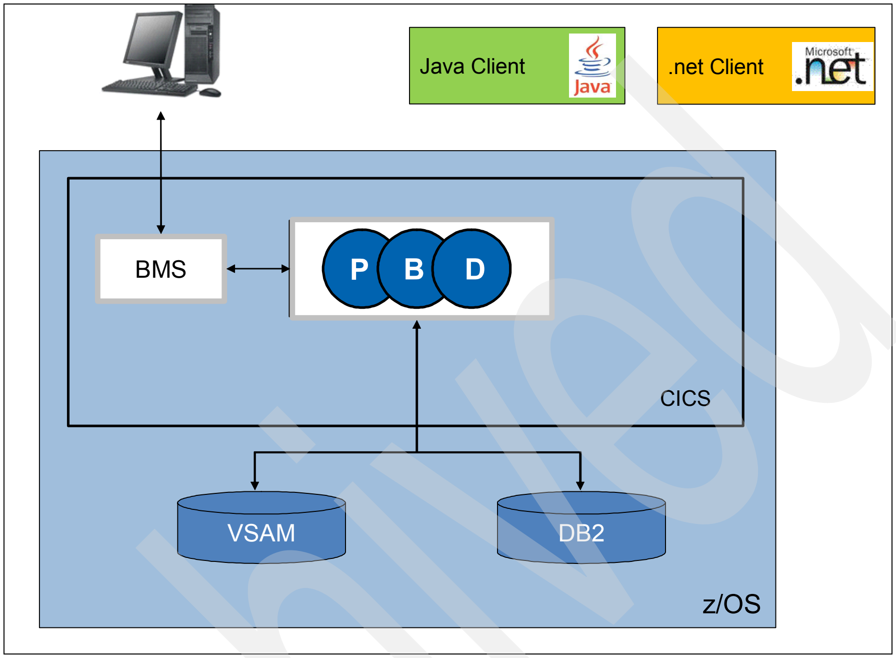


Figure 4-11 Current application architecture

4.2.3 Solution using code refactoring

This solution targets a better demarcation of types of logic and eventually a better organization of business logic. When the business logic is better organized, maintenance improves significantly and the integration of business logic into an SOA becomes much more effective. The solution for this pattern can be executed in phases and ideally involves a good refactoring tool. A tool, such as *IBM Rational Asset Analyzer (RAA)* and *CICS Interdependency Analyzer (IA),* can help you to obtain an organized view of the existing code and get an understanding of how components relate to each other.

After the code has been reorganized, Web services can be created from the business layer programs that can be consumed by other distributed and mainframe applications.

You collect an inventory of all the elements and analyze the source code. The data analyzed is then used to identify those programs that contain the mix of presentation, business, and data layers. You then extract the code and create simple COMMAREA-based programs. Those programs can then be easily exposed as a CICS service provider using Rational Developer for System z (RDz) and the CICS Web Services functionality in CICS Transaction Server Version 3.1 or 3.2 (refer to Figure 4-12 on page 78).

You can adopt any one of the approaches that was explained in 4.1.4, “Solutions” on page 59 to “Web service interface in WebSphere Enterprise Service Bus and SOAP/JMS to CICS” on page 68 for enabling the refactored CICS code as a Web service provider.

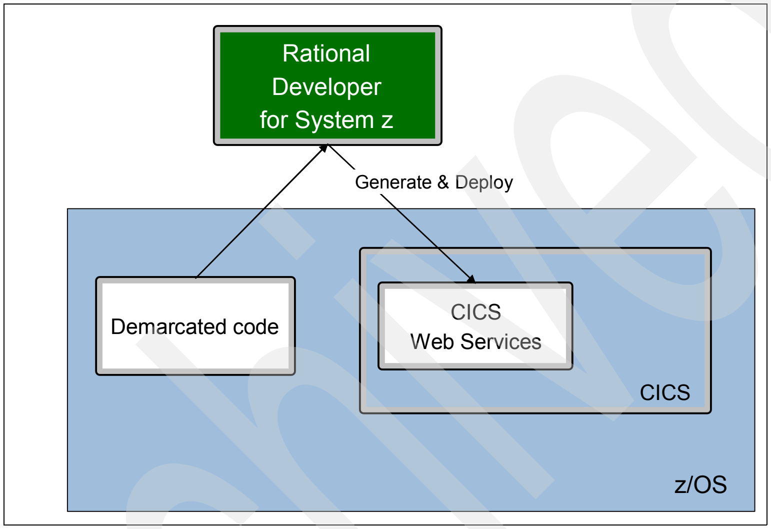


Figure 4-12 Rational Developer for z: Generate and deploy CICS Web Services

Target architecture

After the code refactoring process, separate Web Services exist with the desired granularity. Certain business logic programs might still have their BMS map. Refer to Figure 4-13.

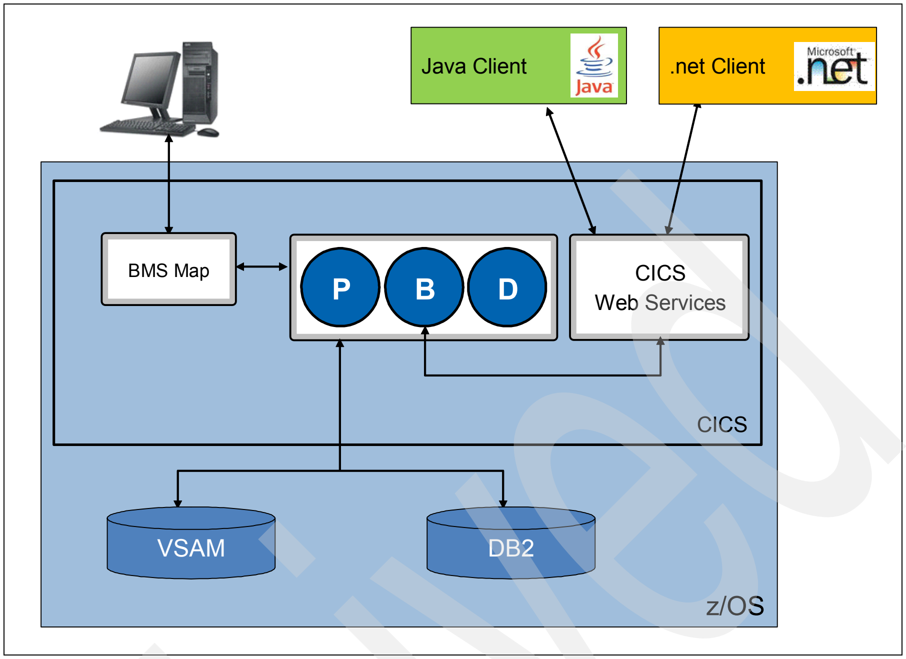


Figure 4-13 Demarcated CICS business logic program as CICS Service provider

Runtime software prerequisites

The following runtime software prerequisites exist for this solution:

- CICS Transaction Server V3.1 or V3.2 with CICS Web Services configured
- WebSphere Application Server 6.1(optional; only for RAA)
- DB2 V 7.0 or higher (optional; only for RAA)

Development tools

This solution is developed using the following tools:

- Rational Developer for System z (RDz) Version 7.1

  Use Rational Developer for System z for Web service-enabling CICS programs.
- Optionally, Rational Asset Analyzer (RAA) Version 5.5

Advantages

This solution has the following advantages:

- Better strategic reuse of existing assets with a better demarcation and better application architecture
- Effective tooling to help analyze and reproduce quality code

- Continuing leverage of proven and robust programs

Limitations

We cannot really call this a limitation, but there is no tool that just converts an existing “spaghetti” application into a beautiful SOA-capable set of reusable services. In this solution, you have to factor in manual coding and lots of testing.

4.3 Accessing IMS programs as a service

One example of the pattern that we present here is a manufacturing company whose application portfolio comprises well designed IMS applications containing programs that have their presentation and business logic layers clearly demarcated and also contain stand-alone business modules. The company is looking for solutions that help its users avoid using the mainframe terminal displays and that also provide access to its existing IMS business logic programs from other sources, such as vendors who provide the necessary raw materials required for the manufacturing process. The vendors possess a wide variety of distributed systems as well as several mainframe systems.

4.3.1 Initial state

The company contains a good number of IMS-based applications that use traditional character-based displays or “green screens” using Message Format Service (MFS) as an interface for sending and receiving the data. There is a need for the reuse of business logic and interfacing between IMS business logic programs and vendor programs for Enterprise Resource Planning (ERP) purposes.

4.3.2 Current architecture

Figure 4-14 shows a simplified view of the initial architecture. There are 3270 terminal-based IMS applications accessing IMS databases, and there are numerous other applications in the company, such as Java and .Net.

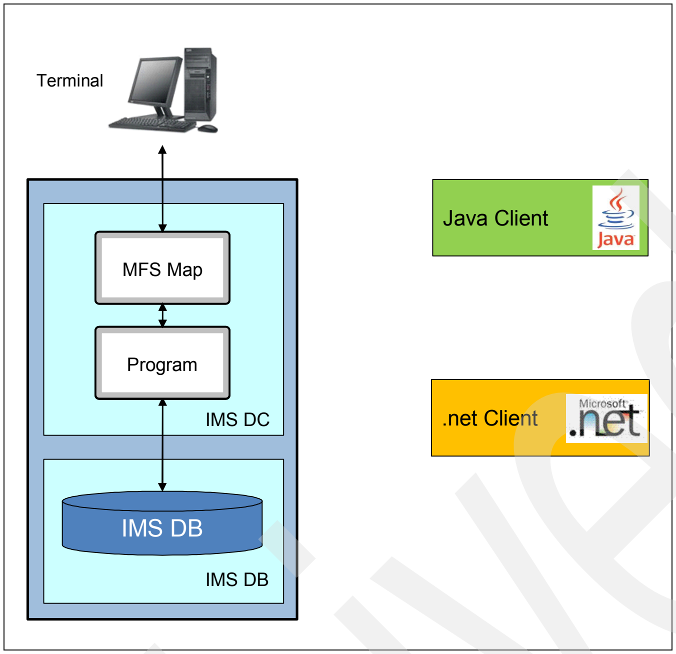


Figure 4-14 Current architecture

4.3.3 Solution strategy

The solution strategy is to make the business logic programs accessible for a broad variety of potential client programs in a standardized way. Quality of service (QoS) plays an important role, too. At this point, you can make one of roughly three architectural decisions:

- Web service-enable selected IMS business logic programs and provide the Web Services Description Language (WSDL) to those individuals who want to access those services (directly).
- Do not Web service-enable the IMS business logic program, but implement a Web service interface in WebSphere Application Server and access the IMS program from WebSphere Application Server through any of the supported protocols and connectors, for example, J2C or WebSphere MQ.
- Do not Web service-enable the IMS business logic programs, but provide an ESB layer with access to those IMS programs using native or traditional access methods, such as Open Transaction Manager Access (OTMA) and WebSphere MQ. The access point for those IMS programs for clients will then be in the ESB.

All solution directions can be considered standardized and SOA-compliant. However, the ESB direction is a better architecture, providing advantages in the area of governance, flexibility, quality of service, and more. After all, just providing a Web Services interface without using an ESB remains a “point to point” solution, but just with an another interface protocol.

In 4.3.4, “Solutions” on page 82, we discuss solutions of all categories.

Benefits

The benefits of providing broader and more standardized access to IMS business logic programs are:

- Leverage robust and proven business logic with high performing native data access
- Avoid building redundant programs throughout the company that perform the same functions as the IMS programs, but usually with a lower quality of service

4.3.4 Solutions

We discuss the following solutions:

- IMS Web Services
- WebSphere Application Server and the IMS TM Resource Adapter
- WebSphere Enterprise Service Bus and IMS TM Resource Adapter
- WebSphere Message Broker and IMS TM Resource Adapter
- WebSphere Message Broker and WebSphere MQ-IMS Bridge
- WebSphere Enterprise Service Bus and WebSphere MQ-IMS Bridge

IMS Web Services

An easy solution is to use the IMS SOAP Gateway to expose the IMS business logic programs as Web services. IMS SOAP Gateway is a solution that enables IMS applications to interoperate outside of the IMS environment through the SOAP protocol to provide and request services that are independent of platform, environment, application language, or programing model.

In the case where IMS acts as a service provider, various types of client applications, such as Microsoft® .NET, Java, and third-party applications, can submit SOAP requests to IMS SOAP Gateway to drive business logic. In conjunction with the IMS Connect XML adapter, you can enable your IMS application to become a Web service without the need of changing the back-end IMS application. A step-by-step technical hands-on implementation for IMS as a service provider is available in Chapter 10, “Exposing an IMS application as a Web service” on page 289.

Target architecture

Figure 4-15 shows the target architecture for the solution using IMS SOAP Gateway.

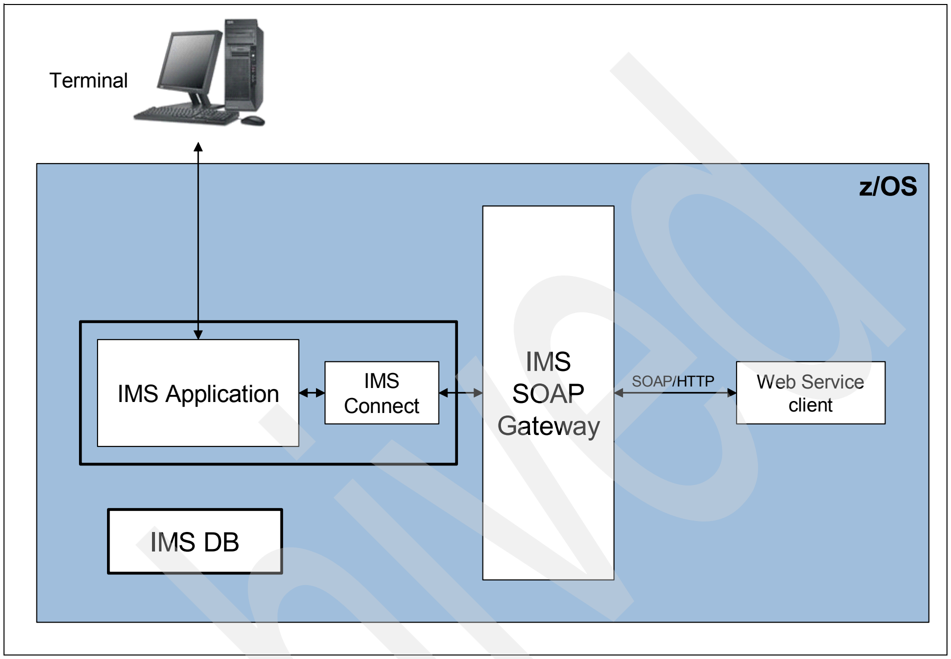


Figure 4-15 Target architecture using IMS SOAP Gateway on z/OS

Runtime software prerequisites

The following runtime software requirements exist for this solution:

- IMS Version 10 or higher
- IMS Connect Version 10 or higher
- IMS SOAP Gateway Version 10.1 or higher

Development tool

We used Rational Developer for z (RDz) Version 7.1.1 (or higher) to develop this solution.

Refer to the following Web site for details regarding the required level of development tooling:

http://www-01.ibm.com/software/data/ims/soap/

Advantages

The advantages of this solution are:

- This solution is a simple and easy way to service-enable IMS transactions.
- Existing transactions, which have been proven, secure, reliable, and scalable for many years, can still be retained.

Limitations

IMS SOAP Gateway has the following limitations:

- Only non-conversational transactions are supported.
- Only commit mode 1, sync level NONE processing is supported.
- MFS-based transactions are not supported.
- Two-phase commit is not supported.

Guidelines

You can use tools, such as Rational Developer for z (RDz), to generate the Web Service artifacts that cover all possible data definitions.

Example

Refer to Chapter 10, “Exposing an IMS application as a Web service” on page 289 for a hands-on example of this solution.

WebSphere Application Server and the IMS TM Resource Adapter

The *IBM IMS TM Resource Adapter* is used by Java applications, Java 2 Platform, Enterprise Edition (J2EE) applications, or Web services to access IMS transactions that are running on host IMS systems. In addition, the IMS TM Resource Adapter implements the J2C *Common Client Interface (CCI)*, a programming interface that allows your application to communicate with IMS Transaction Manager. The IMS TM Resource Adapter can be used with a J2EE server, such as IBM WebSphere Application Server. The IMS TM Resource Adapter also enables an IMS application to act as a client to invoke applications in a J2EE server.

Target architecture

The architecture of this solution is depicted in Figure 4-16 on page 85.

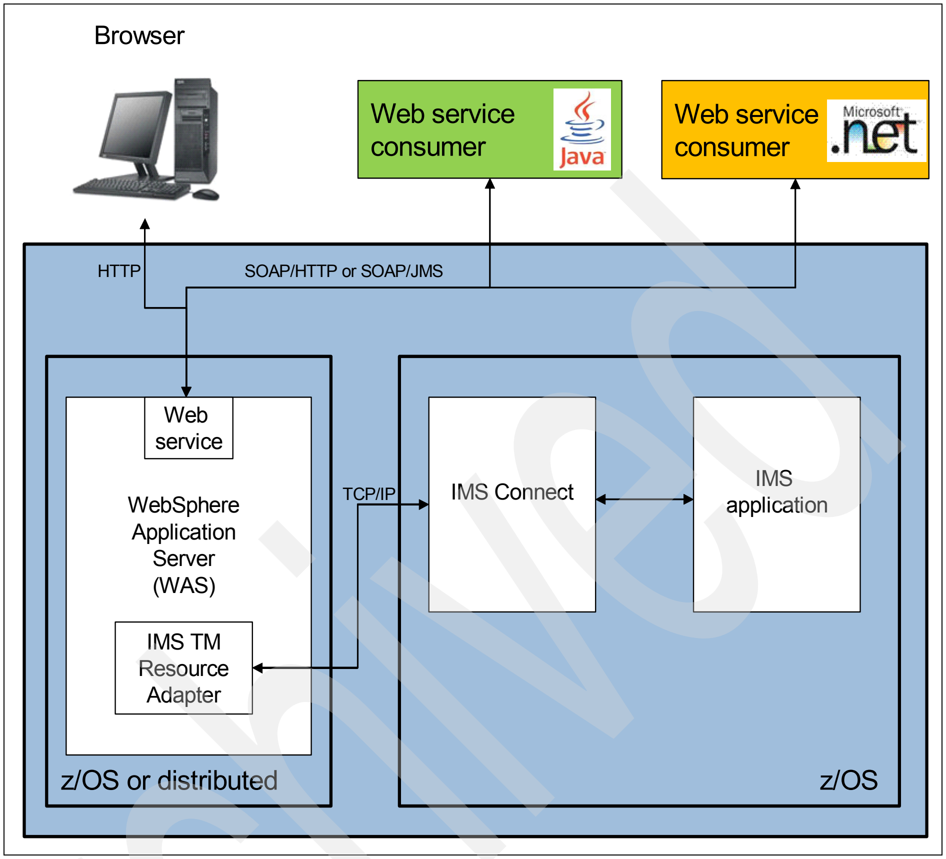


Figure 4-16 Target architecture: WebSphere Application Server and IMS TM Resource Adapter

Runtime software prerequisites

The runtime software prerequisites for this solution are:

- IMS Version 9 or higher
- IMS Connect Version 9 or higher
- WebSphere Application Server Version 6 or higher on z/OS or in a distributed environment

Refer to the following Web site for the exact details regarding software levels:

http://www-01.ibm.com/software/data/ims/ims/components/tm-resource-adapter.html#sysreqs

Development tool

This solution can be developed using Rational Application Developer (RAD) Version 6.

Refer to the following Web site for the exact details regarding the supported combinations of development tools and runtime software:

http://www-01.ibm.com/software/data/ims/ims/components/tm-resource-adapter.html#sysreqs

Advantages

Advantages of this solution are:

- A quick way of creating J2C applications
- Two-phase commit support offered by WebSphere Application Server, the IMS TM Resource Adapter, and IMS Connect
- No change to existing IMS transactions

Limitation

A limitation of this solution is that it is still tightly coupled; this solution is more oriented to a peer-to-peer communication environment.

Guidelines

For guidelines, refer to *IMS TM Resource Adapter User's Guide and Reference Version 9, Version 10*, SC19-1211.

WebSphere Enterprise Service Bus and IMS TM Resource Adapter

This solution is similar to the solution that we discussed in "WebSphere Application Server and the IMS TM Resource Adapter" on page 84. In this solution, however, the Web service interface is implemented in WebSphere Enterprise Service Bus instead of WebSphere Application Server. The development process differs slightly though, because WebSphere Enterprise Service Bus requires WebSphere Integration Developer as a development tool. For WebSphere Application Server, a Web service interface is developed as a J2EE application, but a mediation module is developed for WebSphere Enterprise Service Bus.

Target architecture

Figure 4-17 on page 87 depicts the architecture of this solution.

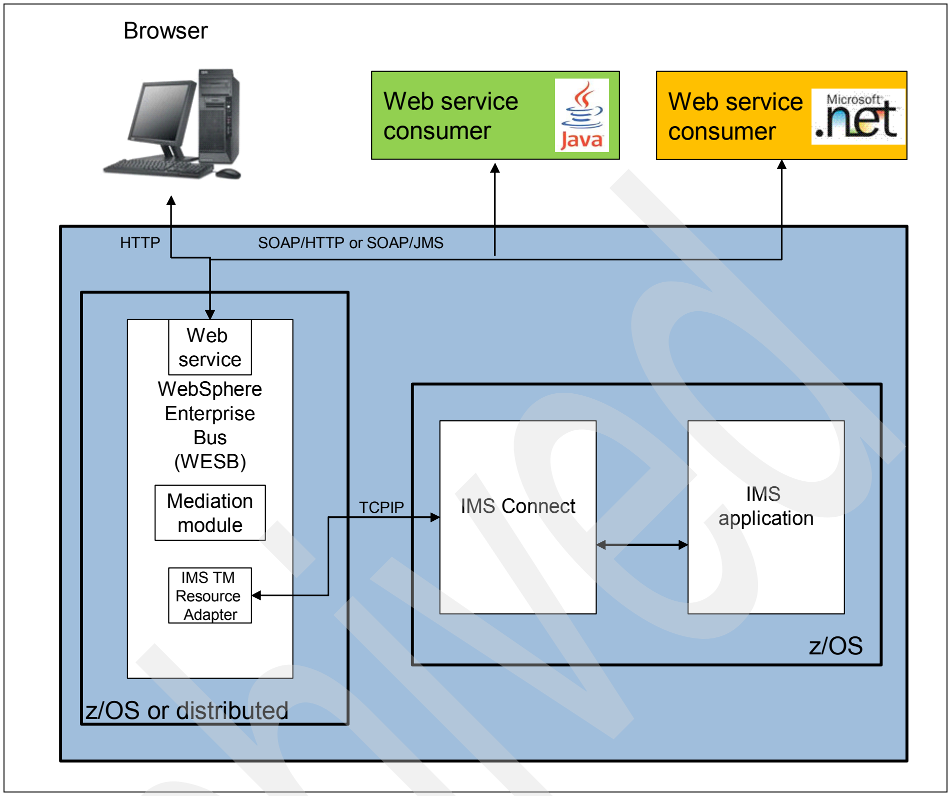


Figure 4-17 Target architecture: WebSphere Enterprise Service Bus and IMS TM Resource Adapter

Runtime software prerequisites

The following runtime software prerequisites exist for this solution:

- IMS Version 9 or higher
- IMS Version 9 or higher
- WebSphere Enterprise Service Bus Version 6 or higher on z/OS or in a distributed environment

Refer to the following Web site for the exact details regarding software levels:

`http://www-01.ibm.com/software/data/ims/ims/components/tm-resource-adapter.html#sysreqs`

Development tool

This solution is developed using WebSphere Integration Developer Version 6 or higher.

Advantages

The advantages of this solution are:

- Data format transformation provided by WebSphere Enterprise Service Bus
- Transport protocol transformation provided by WebSphere Enterprise Service Bus
- Two-phase commit support offered by WebSphere Application Server, the IMS TM Resource Adapter, and IMS Connect
- No change to existing IMS transactions

Limitation

This solution does not have any real limitations.

Guidelines

There are many books that are already available containing more details about WebSphere Enterprise Service Bus:

- *Implementing an ESB using IBM WebSphere Message Broker V6 and WebSphere ESB V6 on z/OS,* SG24-7335
- *Patterns: SOA Design Using WebSphere Message Broker and WebSphere ESB,* SG24-7369

WebSphere Message Broker and IMS TM Resource Adapter

This solution is similar to the solution that we discussed in "WebSphere Enterprise Service Bus and IMS TM Resource Adapter" on page 86. In this solution, however, the Web service interface is implemented in WebSphere Message Broker instead of WebSphere Enterprise Service Bus. The development process differs slightly though, because WebSphere Message Broker requires WebSphere Message Broker Toolkit as a development tool. For WebSphere Enterprise Service Bus, a Web service interface is developed as a mediation module, but a message flow is developed for WebSphere Message Broker.

Target architecture

Figure 4-18 on page 89 depicts the architecture of this solution.

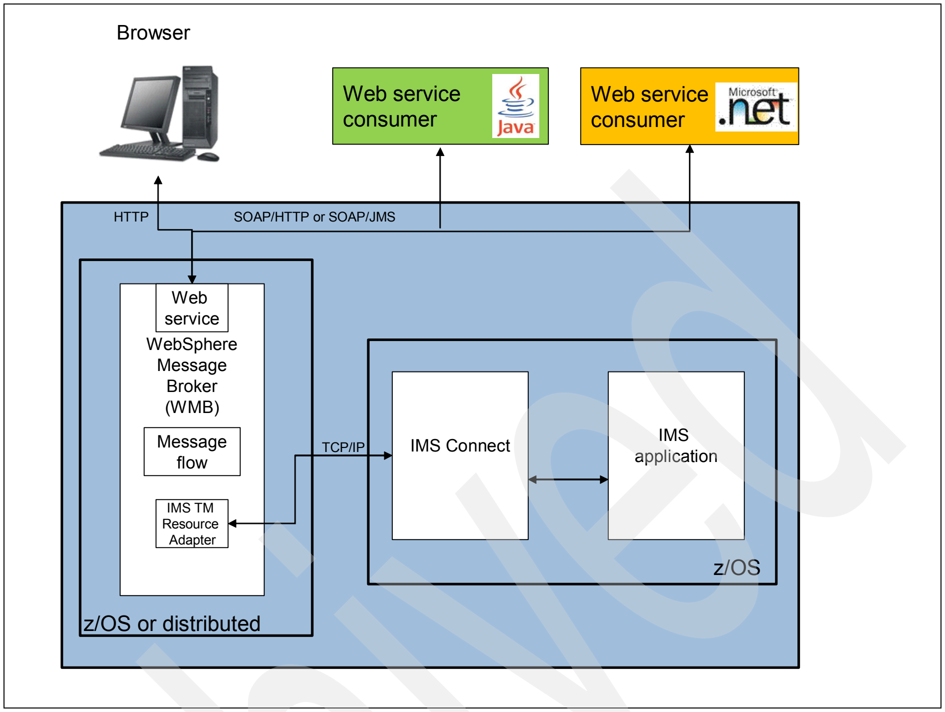


Figure 4-18   Target architecture: WebSphere Message Broker and IMS TM Resource Adapter

Runtime software prerequisites

The following runtime software prerequisites exist for this solution:

- IMS Version 10 or higher
- IMS Version 10 or higher
- WebSphere Message Broker Version 6.1.0.3 or later

Refer to the following Web site for the exact details regarding software levels:

http://www-01.ibm.com/software/data/ims/ims/components/tm-resource-adapter.html#sysreqs

Development tool

This solution is developed using WebSphere Message Broker Toolkit Version 6.1.0.3 or later.

Advantages

The advantages of this solution are:

- Data format transformation provided by WebSphere Message Broker

- Transport protocol transformation provided by WebSphere Message Broker
- Two-phase commit support offered by WebSphere Message Broker, the IMS TM Resource Adapter, and IMS Connect
- No change to existing IMS transactions

Limitations

This solution does not have any real limitations.

Guidelines

There are many books already available that contain more details about WebSphere Enterprise Service Bus:

- *Implementing an ESB using IBM WebSphere Message Broker V6 and WebSphere ESB V6 on z/OS,* SG24-7335
- *Patterns: SOA Design Using WebSphere Message Broker and WebSphere ESB,* SG24-7369

WebSphere Message Broker and WebSphere MQ-IMS Bridge

This solution integrates existing IMS MQ-based applications and exposes them as a Web service. IBM MQSeries®, which WebSphere MQ was previously called, has brought the first stage of loosely coupled applications to IMS. Combined with the WebSphere MQ-IMS Bridge, IMS applications can now integrate with external applications asynchronously. This principle is taken to the next stage with WebSphere Message Broker by adding broad functionality in the area of routing and conversion.

In those environments where the WebSphere MQ-IMS Bridge is already in place, WebSphere Message Broker can be added without changing anything in the IMS environment. WebSphere Message Broker will just insert messages into the (existing) queue, and IMS MQ applications consume these messages as usual. WebSphere Message Broker takes over the role of the MQ client application.

Figure 4-19 on page 91 shows the new target architecture.

Target architecture

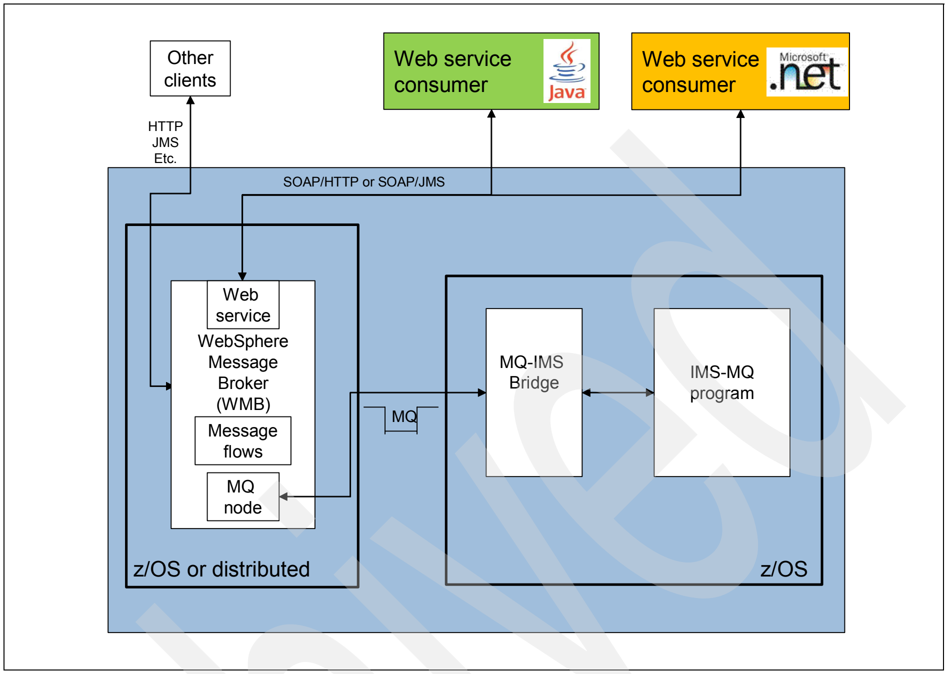


Figure 4-19 Target architecture for WebSphere Message Broker and MQ IMS-Bridge

Runtime software prerequisites

The following software prerequisites exist for this solution:

- WebSphere MQ
- WebSphere Message Broker on z/OS or in a distributed environment
- WebSphere MQ-IMS Bridge, which includes the triggering mechanism of IMS transactions with local queues defined on z/OS

Development tool

This solution is developed using WebSphere Message Broker Toolkit.

Advantages

This solution offers the following advantages:

- Flexible communication
- Simplified communication
- Loosely coupled
- Solution not impacted by the complexity of the infrastructure

Limitations

There are limitations when you import the COBOL files in the wizard, such as the DEPENDING-ON clause, and hexadecimal binary values are not supported. Refer to the WebSphere Message Broker toolkit documentation.

Guidelines

We recommend:

- For more technical hands-on samples, refer to *Implementing an ESB using IBM WebSphere Message Broker V6 and WebSphere ESB V6 on z/OS,* SG24-7335.
- You can refer to *WebSphere Business Integration Message Broker Basics,* SG24-7090, for an introduction to WebSphere Message Broker.

WebSphere Enterprise Service Bus and WebSphere MQ-IMS Bridge

This solution is similar to the solution that was discussed in "WebSphere Message Broker and WebSphere MQ-IMS Bridge" on page 90. The difference is that another ESB product is used to implement the service interface. The process for developing the solution is similar too, but another tool is used and various types of components are developed, that is, mediation modules for WebSphere ESB as opposed to message flows for WebSphere Message Broker.

Figure 4-20 on page 93 shows the architecture of this solution.

Target architecture

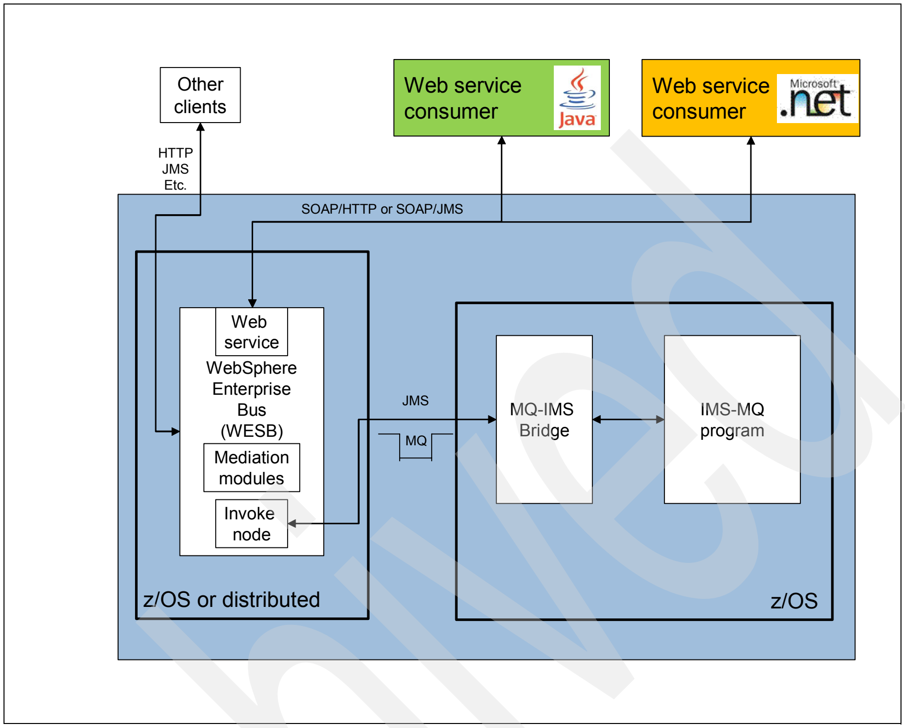


Figure 4-20 Target architecture: WebSphere ESB and WebSphere MQ-IMS Bridge

Runtime software prerequisites

The following software prerequisites exist for this solution:

- WebSphere MQ
- WebSphere Enterprise Service Bus on z/OS or in a distributed environment
- WebSphere MQ-IMS Bridge, which includes the triggering mechanism of IMS transactions with local queues defined on z/OS

Development tool

This solution is developed using WebSphere Integration Developer.

Advantages

This solution offers similar advantages to the solution that was discussed in “Web service interface in WebSphere Message Broker and WebSphere MQ to CICS” on page 72.

Limitations

There are no real limitations for this solution.

Guidelines

- You can also refer to this journal article “Building an Enterprise Service Bus using WebSphere ESB, Part 4” by Rachel Reinitz and Andre Tost, 28 February 2006:

  `http://www.ibm.com/developerworks/websphere/techjournal/0702_reinitz/0702_reinitz.html`

4.4 Accessing a CICS application as a composite service

As companies move to more closely align their IT investments with their business priorities and strategies, many companies find that a service-oriented architecture (SOA) provides the desired resiliency and flexibility that enables their IT organizations to more rapidly respond to a changing competitive and regulatory landscape in a more robust and scalable manner. These companies have also embarked on endeavors to map their business processes to their IT applications. Often, they find that their existing applications can become building blocks or nodes, which can be built into a new application to support those processes. As part of this effort, they also find that external applications that provide common industry functionalities can be utilized to optimize software development cycles. Being able to create a composite application that coordinates the invocation of internal applications and external services is the ideal solution.

4.4.1 Initial state

A fictional company contains multiple CICS applications that are 3270 terminal-based and COMMAREA-based. In addition, the fictional company has a requirement to call an external service provider to obtain information that is needed to support a prescribed business process.

4.4.2 Current architecture

A client application is written to support a business process. This application leverages existing CICS applications and also makes a call to an external Web service provider. The CICS applications are both 3270 terminal-based and COMMAREA-based. The client application has to make multiple invocations to the CICS system and one Web service call. It then aggregates the data that is returned from these sources into a consolidated result. While this process achieves the desired result, it is expensive and involves longer instruction path lengths because of the multiple invocations. The client application developer also needs to be immersed in the complexity of writing controlling logic that coordinates the various invocations and aggregates the varied results.

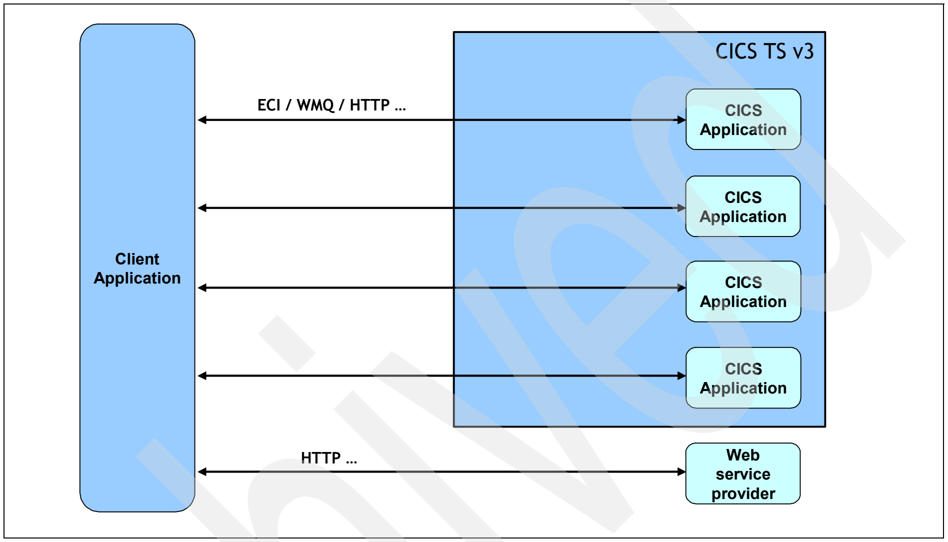


Figure 4-21 Client application with multiple invocations

4.4.3 Solution

Next, we describe the solution for this scenario.

Target architecture

The CICS Service Flow feature consists of both development tooling and run time. The development tooling is provided as part of Rational Developer for System z (RDz) and provides the environment where processes can be modeled graphically with nodes representing CICS applications and outbound Web service calls. After these processes are modeled, the Service Flow modeling component of RDz can be used to generate a Service Flow application and attendant artifacts that are then deployed to the CICS Service Flow run time running on CICS Transaction Server on z/OS. The deploy Service Flow application can be accessed just as any CICS COMMAREA-based application, or a service interface can be described and implemented that enables various types of client applications to be written to perform a single service invocation to obtain the results that were aggregated on the CICS system.

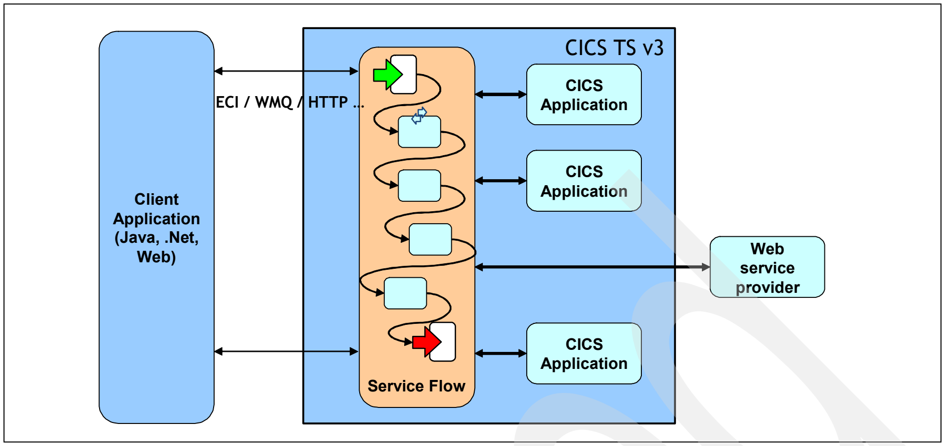


Figure 4-22 Using Service Flow to aggregate CICS applications and Web service calls

Runtime software prerequisites

This solution requires IBM CICS Transaction Server for z/OS V3.1 or V3.2 with the Service Flow Feature configured.

Development tool

Service Flow applications are developed using IBM Rational Developer for System z V7.1 or higher.

Advantages

This solution has the following advantages:

- Process integration and coordination within CICS
- Reuse of existing CICS applications without the need to change them
- Simplification of the integration of CICS applications into an SOA by aggregating service invocations

Guidelines

Refer to the following publications for guidelines:

- *Developing CICS Web Services*, SG24-7126
- *Implementing CICS Web Services*, SG24-7206

Example

We describe a detailed example in Chapter 11, “Building composite CICS services using the Service Flow Feature” on page 307.

4.5 Accessing DB2 stored procedures on z/OS as a service

Next, we describe accessing DB2 stored procedures on z/OS as a service.

4.5.1 Initial state

DB2 stored procedures are an excellent way to implement business logic in a single, centralized place, namely, in the database rather than in application programs.

You have existing DB2 stored procedures that encapsulate business logic. You want to make this business logic available within the enterprise, but you want to avoid coupling the users to a specific technology, or even making them aware of the underlying technology.

4.5.2 Solution

As of now, DB2 by itself cannot act as a Web service provider. Therefore, the service has to be hosted in an application server, such as CICS or WebSphere.

An easy way to expose a DB2 stored procedure is to use Data Web Services tooling, which produces a J2EE-compliant Web archive (WAR) file that can be deployed to any supported application server.

Target architecture

Figure 4-23 on page 98 shows the target architecture for this solution.

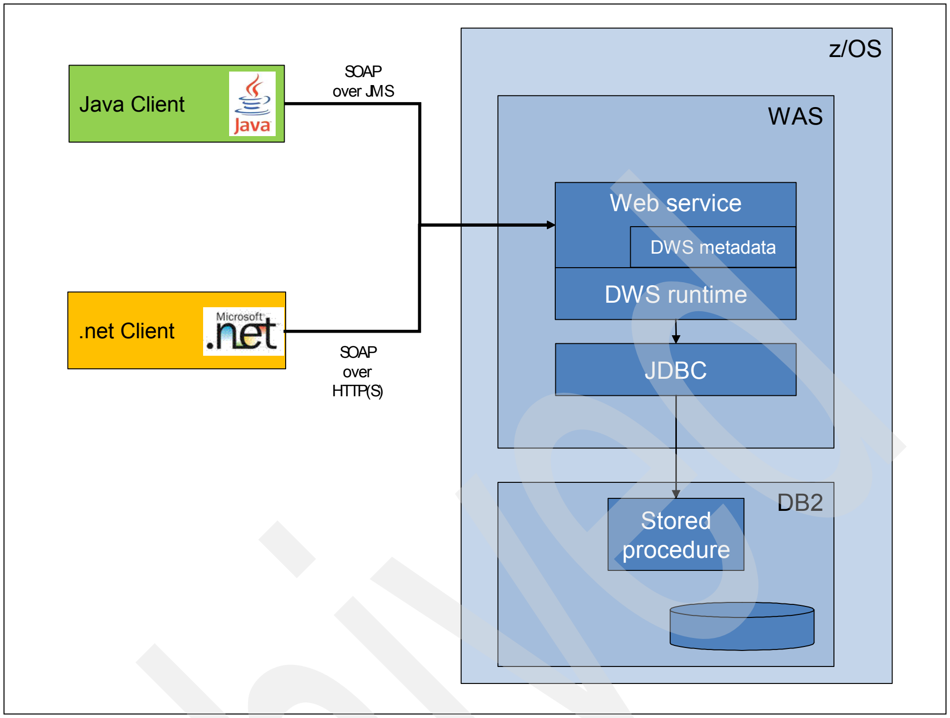


Figure 4-23 Target architecture exposing a DB2 stored procedure as a Web service

Runtime software prerequisites

The following runtime software prerequisites exist for this solution:

- Data Web Services run time
- J2EE application server supported by Data Web Services (might not be on z/OS)

Development tool

This solution is developed using IBM Data Studio Developer Version 1.2 or higher.

Example

We show an example for this solution in 7.3, “Exposing a DB2 stored procedure as a service” on page 172.

4.6 Accessing presentation logic as a service

An example of the pattern that we present here is a company that has many 3270 terminal-based applications that have traditionally been accessed only by internal users from the internal network of the company. Customer service representatives have to access multiple applications in order to effectively respond to customer service requests. With the ubiquity of Web browsers and the relative ease of access to information on the Internet, providing customers access to their information through self-service applications has become a standard business practice for many companies and a standard customer expectation. This capability requires transforming the 3270 terminal-based user interface of these applications into Web-based user interface. In addition, to facilitate potential interactions between other partners, providing a Web service interface is also necessary for optimal interoperability.

4.6.1 Initial state

This company has a set of 3270 terminal-based applications that run on CICS and IMS. The user interface is primarily through CICS BMS-based and IMS MFS-based displays that are accessed through 3270 terminals or emulated sessions. A user might have to access multiple applications to obtain all the needed information. Navigation is thus not limited to multiple panels within one application but likely through multiple applications that are accessed through multiple terminals or sessions.

4.6.2 Current architecture

Figure 4-24 on page 100 depicts the current architecture.

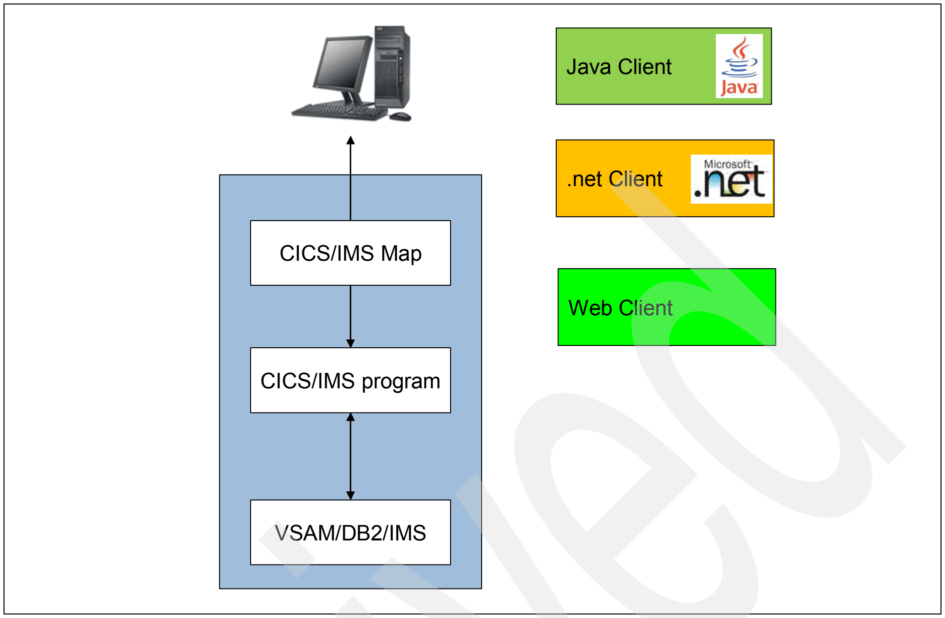


Figure 4-24 Current application architecture

4.6.3 Solution: Using HATS as a service enabler

For competitive and tactical reasons, the solution for this scenario needs to be delivered in a short time frame. In addition, the existing 3270-based terminal interface needs to be maintained in order to minimize operational disruptions. This requirement precludes the wholesale replacement of existing systems through either a rewrite or the adoption of a package solution. A quick, tactical solution with a shorter time to application delivery is to use a user interface transformation technology, such as *IBM Rational Host Access Transformation Services (HATS)*.

HATS enables the transformation of terminal applications quickly and easily. With HATS, 3270-based and 5250-based applications can be extended to the Web, to a portlet, to a rich client, or to browsers on mobile devices with low risk. With HATS, you can also:

- Improve the workflow and navigation of your host 3270 and 5250 applications, without any access or modification to the application source code.
- Create service-oriented architecture (SOA) assets from logic that is contained in your terminal applications.

- Support a variety of mobile devices, such as cell phones, data collection terminals, and personal digital assistants (PDAs).
- Create portlets that conform to the Java Portlet Specification (JSR) 168.

The enterprise applications that are built with HATS are deployed to and run on either IBM WebSphere Application Server or IBM WebSphere Portal.

To facilitate the development of HATS applications, the IBM Rational HATS Toolkit is a set of plug-ins for the Eclipse-based IBM Rational Software Delivery Platform. The HATS Toolkit lets you develop a new application that generates a GUI for your 3270 and 5250 applications. These applications can be developed one step at a time. Over time, the HATS application can be streamlined, making it easier to use than the host applications whose data it presents.

The development process for building HATS applications that are accessed from a browser, portal, rich client, and mobile device is similar. The GUI that you create can be customized to suit your business needs and standards. You can hide unnecessary information, organize data into tables, or display only required input fields. You can provide a drop-down list of valid values for an input field, change the size and location of certain text, and provide navigation buttons.

In addition to the basic customization capabilities, you can create HATS macros to provide streamlined navigation through multiple host panels or combine data from several host panels. From these HATS macros, you can then generate *HATS integration objects*, which are Java beans that encapsulate interactions with a host application. These integration objects can then be used to create Web pages and Web services.

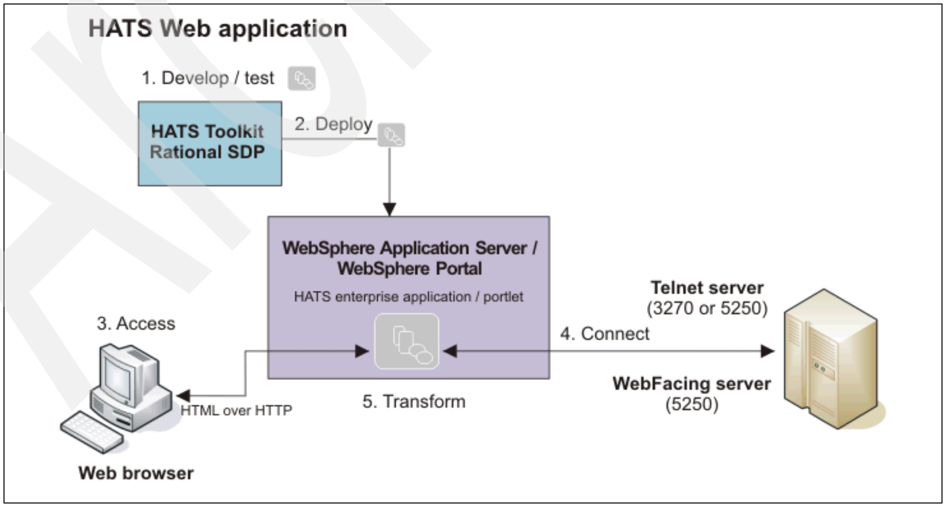


Figure 4-25 HATS Web application

Target architecture

The target architecture is shown in Figure 4-26.

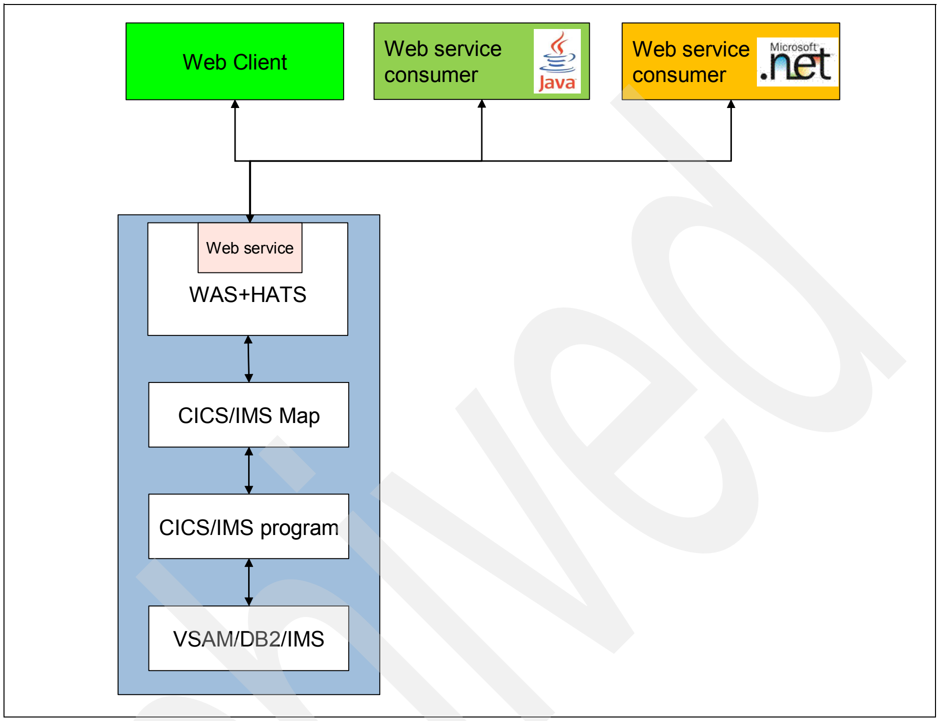


Figure 4-26 Target architecture using HATS

Runtime software prerequisites

This solution has the following runtime software prerequisites:

- IBM Rational Host Access Transformation Services for Multiplatforms V7.1 or higher
- IBM WebSphere Application Server V6.0 or higher

Development tools

The following tools are used for development:

- IBM Rational HATS Toolkit V7.1 or higher
- One of the following software delivery platforms:
  - IBM Rational Application Developer for WebSphere Software V7.1 or higher
  - IBM Rational Software Architect for WebSphere Software V7.1 or higher

  - IBM Rational Developer for System z for SOA Construction with EGL V7.1 or higher
  - IBM Rational Developer for System z for SOA Construction with Java V7.1 or higher
  - IBM Rational Business Developer V7.1 or higher

Advantages

The advantages of this solution are:

- Shortened application delivery time
- Minimal operational disruption
- Improved productivity from reducing the number of panel interactions and application navigations
- Reduced training costs

Limitations

Limitations of this solution are:

- Requires IBM WebSphere Application Server, introducing an additional middleware layer in certain cases
- Integrates only panel-based applications

Best practices

The best practices or guidelines for this solution are:

- Design the user interface from the requirements perspective, which applies to most development projects that involve a human interface. Determine how information is to be presented to the user before you start creating the interface.
- Identify any established Web page templates or conventions that are used within your company.
- Document conventions for:
  - Layout of Web pages
  - Expressing names, addresses, phone number, currency, and so forth
  - Format headers
  - Breaking up logically grouped form data
  - Where and when to use radio buttons, check boxes, or drop-down lists for various kinds of input data
  - Code formatting and other settings

- Create a story board for panel flows, which is especially important when you are controlling process flows.
- Identify panels that can be modified to make them easier to transform.
- Identify panels that are the same but with differences in authorized inputs based on login credentials.
- Identify all static data that can be string-replaced in the tool as compared to codes or inputs that defy hard-coded transformations.
- Identify panels that will be combined as early as possible.
- Create the HTML layouts of each window before putting in the host components or widgets, because moving HATS components or widgets around on the window is in many cases easier than rearranging the base layout.
- Use a source control management system, which is especially critical when you have a team of developers.
- Divide a project into component ownership areas for easier development.

5

Integrating external services in existing z/OS applications

In this chapter, we describe patterns with technology solutions to reuse existing or new external services by integrating them into existing z/OS applications.

We discuss the following patterns:

- In Integrating external Web Services into CICS applications, we discuss patterns to integrate external services into CICS applications:
  - Using CICS outbound Web Services support
  - Using an enterprise service bus
  - Using DB2 outbound Web Services support
- In Integrating external Web services with IMS applications, we discuss a pattern to integrate external services into IMS applications:
  - Using IMS asynchronous callout support
- In Integrating external services into batch applications, we discuss patterns to integrate external services into z/OS batch applications:
  - Using messaging
  - Using messaging over an ESB
  - Using Web services over JMS transport
  - Using a Java Web services client
  - Using DB2 outbound Web Services support

5.1 Integrating external Web Services into CICS applications

An example of the pattern explained here is a company whose application portfolio includes both z/OS CICS applications and non-mainframe applications to support key supply chain processes. The z/OS CICS applications strongly benefit from having access to external services inside and outside the company, which is especially true for those CICS applications that use input from vendor applications and provide output to client applications. Traditionally, input has been entered into CICS panels manually based on vendor information and output has been provided through a batch interface process.

5.1.1 Initial state

In this pattern, the CICS applications are used for internal use only, but they are frequently maintained to include new functionality. It is recognized that, in certain cases, the new functionality that is required in these CICS applications exists elsewhere in the company, typically in other environments or on other platforms. New service-oriented architecture (SOA) technology and features in CICS make it easy now to reuse functionality outside CICS.

As mentioned earlier, certain input from vendors is still entered manually through 3270 terminals.

5.1.2 Current architecture

Figure 5-1 on page 107 depicts the current architecture.

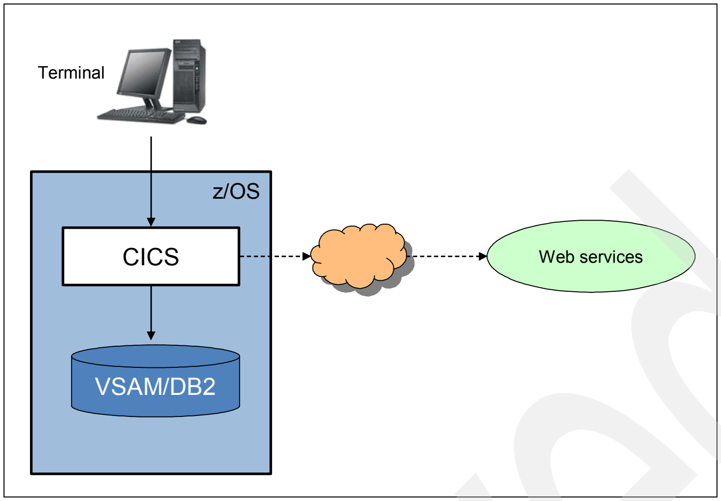


Figure 5-1 Non-integrated current architecture

5.1.3 Solution strategy

The solution strategy lies in providing access to external services from existing CICS applications. We will look at the primary outbound connectors in CICS, including Web Services support and WebSphere MQ.

Special attention needs to be paid to the transactional behavior and the quality of service (QoS) of the CICS transactions. An outbound service call must not jeopardize the existing service level of the current CICS transactions.

5.1.4 Solutions

We discuss the following solutions:

- Using CICS outbound Web Services support
- Using an enterprise service bus
- Using DB2 outbound Web Services support

Using CICS outbound Web Services support

In this solution, the Web Services Description Language (WSDL) file of the existing Web service is used to convert the XML interface structure of the distributed service into a COBOL copybook structure using Rational Developer for System z (RDz) or the CICS Web Services Assistant (WSA). RDz and WSA create both the request and response structures in the form of a COBOL copybook. RDz can assist you to create a CICS Web Services requestor program that can be updated with the simple basics of a CICS program, such as populating request and response structures and validating error messages. RDz-generated artifacts, such as the service requestor program and WSBind file, are then deployed to z/OS. The external Web service can be hosted in many places. Refer to Figure 5-2.

Target architecture

Figure 5-2 depicts the target architecture of this solution.

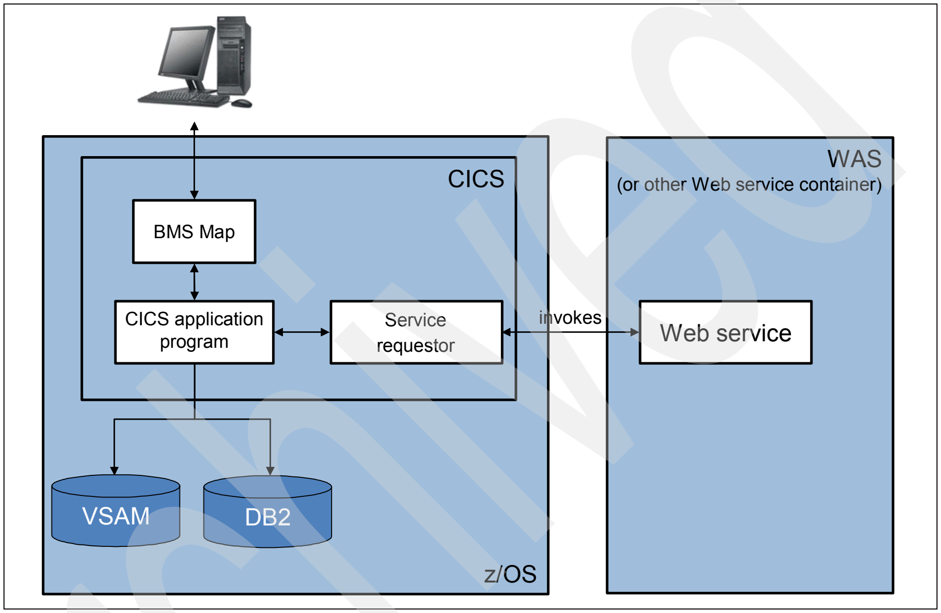


Figure 5-2 Target architecture: Integration of CICS application and external Web services

Runtime software prerequisites

The following software is required:

- CICS Transaction Server Version 3.1 or 3.2
- WebSphere Application Server or other Web service container

Development tool

You can develop this solution with either Rational Developer for System z (RDz) or CICS Web Service Assistant (WSA)

Advantages

This solution has the following advantages:

- This solution is a simple and easy way to integrate CICS applications with external Web services.
- There is no impact to the existing CICS applications.
- The CICS service requestor solution can be extended to use an enterprise service bus (ESB) to get more benefits.

Limitations

There are no additional restrictions in this solution other than the limitation that is explained in 12.9, “Handling complex CICS COMMAREA structures” on page 415, which is not a solution limitation but is due to a COBOL language limitation.

Guidelines

We recommend:

- Use Rational Developer for System z (RDz) instead of CICS-supplied JCL utilities to generate CICS Web Service artifacts.
- In cases where you have a complex-type structure defined in the XML data structure of the external Web Service WSDL file, refer to the instructions in “Handling complex CICS COMMAREA structures” on page 415.
- In situations where you need only part of the existing CICS program integrated into the external Web service, you need to write a wrapper program. Refer to “Using an enterprise service bus” on page 109.

Example

Refer to Chapter 12, “Integrating an external Web service with a CICS application” on page 385 for a hands-on example.

Note: To understand more of the concepts of CICS as a service requestor, refer to Chapter 6 of *Application Development for CICS Web Services,* SG24-7126.

Using an enterprise service bus

Another approach to integrate external services into existing CICS applications is to use an enterprise service bus (ESB). You can use mediation components to perform transformation and routing between the CICS requestor and the Web service. An ESB supports multiple data and transport protocols, such as SOAP, Java Message Service (JMS), MQ, HTTP, and HTTPS. Refer to Figure 5-3 on page 110.

Target architecture

Figure 5-3 shows the target architecture. Note that the protocol that is used between the service requestor in CICS and the ESB can be any of the protocols that are supported by both CICS and the ESB. In most cases, those protocols are SOAP over HTTP or JMS, JMS, or WebSphere MQ.

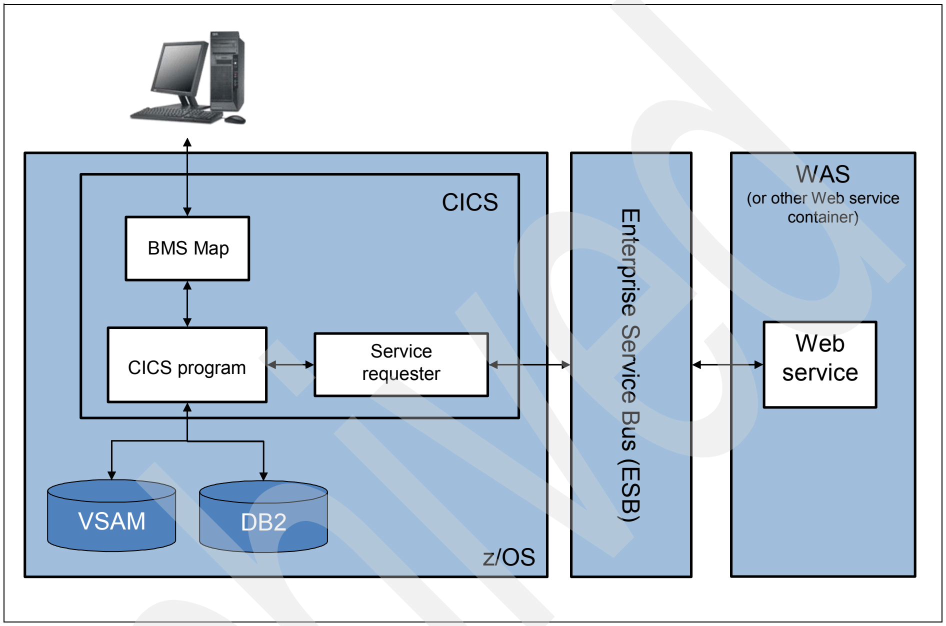


Figure 5-3 Integration of CICS application and external Web Services using an ESB

For a more detailed understanding of WebSphere Message Broker and WebSphere ESB, refer to *Patterns: SOA Design Using WebSphere Message Broker and WebSphere ESB,* SG24-7369.

In order to provide more flexibility in these solutions, the Web services can be published using a registry, such as WebSphere Service Registry and Repository, which eliminates any dependency on the endpoints. For example, a service requestor does need not know the service provider location. For a detailed understanding of WebSphere Service Registry and Repository, refer to *WebSphere Service Registry and Repository Handbook*, SG24-7386.

Runtime software prerequisites

This solution requires the following software products:

- CICS Transaction Server Version 3.1 or 3.2 with Web Services support configured
- Enterprise Service Bus (ESB) product on z/OS or in a distributed environment

Development tools

This solution is developed using the following tools:

- Rational Developer for System z (RDz) or CICS Web Service Assistant (WSA)
- Development tool for the ESB to be used

Advantages

This solution has the following advantages:

- Flexibility from the usage of the ESB
- No major changes to existing CICS applications

Limitations

No real limitations exist for this solution.

Guidelines

Refer to *Implementing an ESB using IBM WebSphere Message Broker V6 and WebSphere ESB V6 on z/OS,* SG24-7335.

Using DB2 outbound Web Services support

As an alternative to CICS as a service requestor, if you have CICS DB2-based applications, you can use DB2 outbound Web Services support to invoke external Web services. In this case, DB2 even takes care of XML parsing (refer to Figure 5-4 on page 112).

Target architecture

Figure 5-4 on page 112 shows the target architecture for this solution.

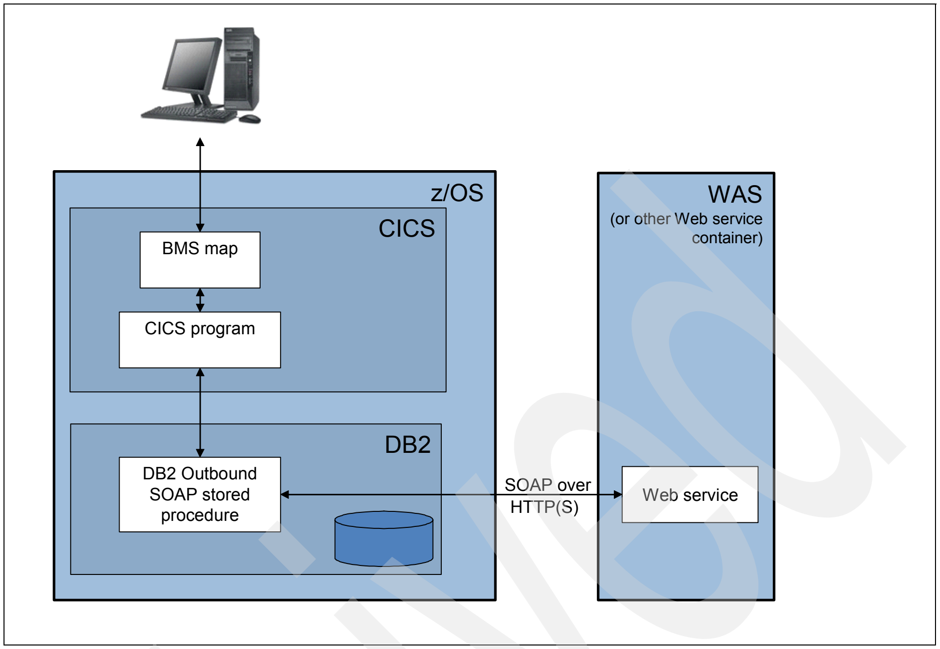

z/OS
CICS
BMS map
CICS program
DB2
DB2 Outbound SOAP stored procedure
SOAP over HTTP(S)
WAS
(or other Web service container)
Web service

Figure 5-4 Integration of CICS application and external Web services using DB2 outbound service

Runtime software prerequisites

Refer to Chapter 14, "Using DB2 as a Web service requester" on page 455 for details about the runtime software prerequisites.

Development tools

Refer to Chapter 14, "Using DB2 as a Web service requester" on page 455 for details about the development tools.

Advantages

An advantage of this solution is that you do not need to implement any additional outbound communication channels from a CICS perspective.

Limitations

Refer to "Using DB2 outbound Web Services support" on page 123 for limitations in the DB2 outbound Web service support.

Guidelines

We explain all of the guidelines in the technical hands-on example in Chapter 12, "Integrating an external Web service with a CICS application" on page 385.

Example

Refer to Chapter 14, “Using DB2 as a Web service requester” on page 455 for an example.

5.2 Integrating external Web services with IMS applications

An example of the pattern that we explain here is a company whose application portfolio includes both z/OS IMS applications and non-mainframe applications to support key supply chain processes. The z/OS IMS applications will strongly benefit from having access to external services inside and outside the company, which is especially true for those IMS applications that use input from vendor applications and provide output to client applications. Traditionally, input has been entered into IMS panels manually based on vendor information and output has been provided through a batch interface process.

5.2.1 Initial state

In this pattern, the IMS applications are used for internal use only, but they are frequently maintained to include new functionality. It is recognized that, in certain cases, the new functionality that is required in these IMS applications exists elsewhere in the company, typically in other environments or on other platforms. New SOA technology and features in IMS make it easy now to reuse functionality outside IMS.

As mentioned earlier, certain input from vendors is still entered manually through 3270 terminals.

5.2.2 Current architecture

Figure 5-5 on page 114 shows the current architecture of this scenario.

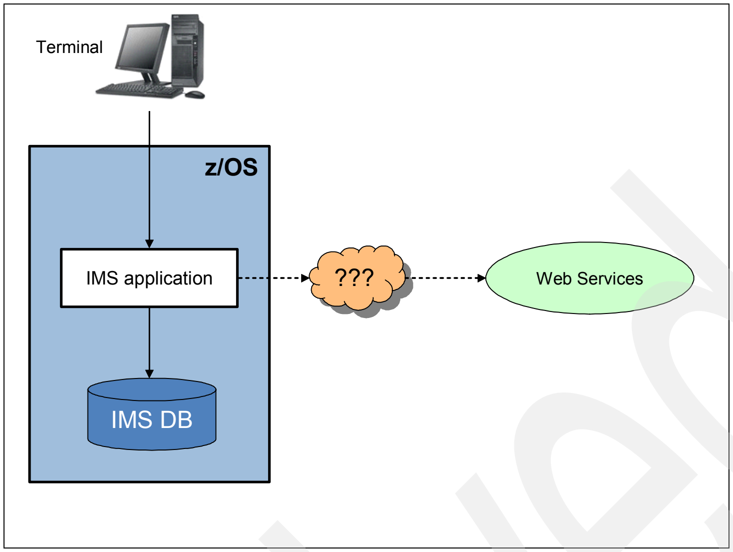


Figure 5-5 Non-integrated current architecture

5.2.3 Solution strategy

The solution strategy lies in providing access to external services from existing IMS applications. We will look at the primary outbound connectors in IMS, including IMS Callout support and WebSphere MQ.

Special attention needs to be paid to the transactional behavior and the quality of service (QoS) of the IMS transactions. An outbound service call must not jeopardize the service level of these existing CICS transactions.

5.2.4 Solutions

The solutions for IMS are similar to those solutions for CICS. There are three principal solutions:

- Using IMS asynchronous callout support
- Use an enterprise service bus (ESB), similar to “Using an enterprise service bus” on page 109 and not discussed again
- Use DB2 Outbound Web Services support, similar to “Using DB2 outbound Web Services support” on page 111 and not discussed again

Using IMS asynchronous callout support

IMS SOAP Gateway is a lightweight Web Services solution that enables IMS applications to interoperate in a service-oriented architecture (SOA). IMS asynchronous callout support can be used to access a Web service through the IMS SOAP Gateway. With this function, users can develop new applications or extend their existing IMS applications to access new business logic or data outside IMS using Web Services protocols.

The IMS SOAP Gateway enables IMS applications to make asynchronous callout requests to external Web services and optionally receive responses back.

Rational Developer for System z (RDz) provides wizards that generate the XML converter and the correlator files needed to enable the IMS application to run as a Web service consumer.

Target architecture

Figure 5-6 shows the target architecture for an IMS application using asynchronous callout to access a Web service.

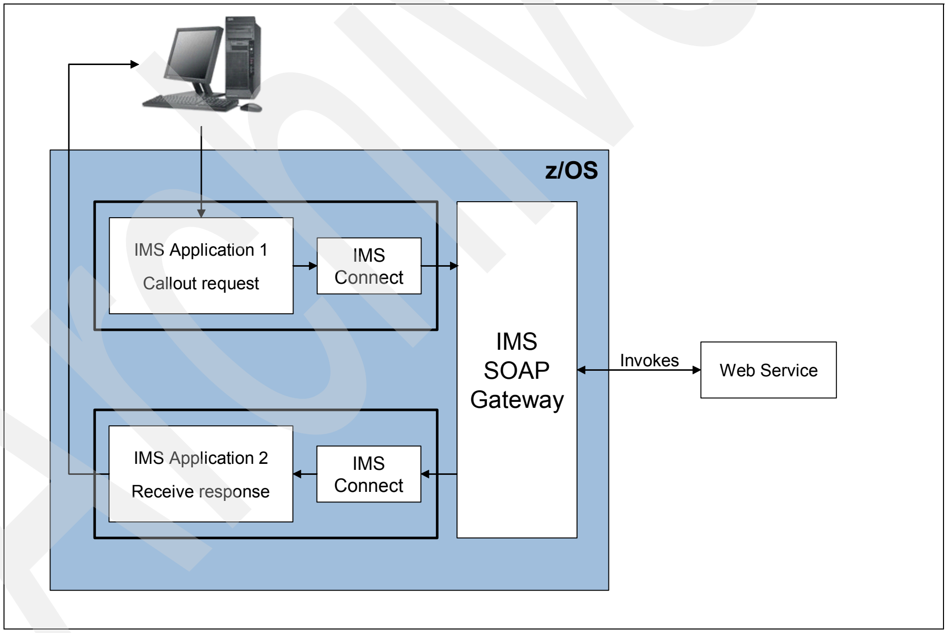


Figure 5-6 Integration of IMS application and external Web services

Runtime software prerequisites

The following software is required on z/OS to implement an asynchronous callout solution:

- IMS Version 10 or higher
- IMS Connect Version 10 or higher
- IMS SOAP Gateway Version 10 or higher

Development tool

Rational Developer for System z (RDz) Version 7.1.1 or higher is used for development.

Advantages

This solution has the following advantages:

- This solution is a simple and a easy way to integrate IMS applications with external Web Services.
- The time to develop these solutions is quicker than other approaches.
- The IMS Service requestor solution can be extended to use ESB or a Message Broker to get more benefits.

Limitations

IMS SOAP Gateway Version 10 has the following limitations:

- Only non-conversational transactions are supported.
- Only commit mode 1, sync level NONE processing is supported.
- Message Format Service (MFS)-based transactions are not supported.
- Two-phase commit is not supported.

Guidelines

We provide more detailed guidance in Chapter 13, “Integrating an external Web service into an IMS application” on page 419, but important considerations are:

- You must modify or create your IMS application for sending callout requests and receiving response messages from an external Web service if necessary.
- Optionally, an IMS database is needed to store the data necessary to correlate the callout response to the initiating IMS client, for example, the LTERM name of the initiating IMS client.
- The Open Transaction Manager Access (OTMA) destination routing descriptor enables an IMS application to route callout requests to services that are accessible to the IMS SOAP Gateway without the need to code routing exits.

Example

We provide a technical hands-on example in Chapter 13, “Integrating an external Web service into an IMS application” on page 419.

5.3 Integrating external services into batch applications

The setting for this pattern is a typical z/OS environment with daily, weekly, and monthly batch jobs and cycles. Many of these jobs perform functions in which they can benefit from accessing certain services directly. Traditionally, batch applications access data directly and write output to files, printers, or databases again. Batch applications can also take input from WebSphere MQ queues.

5.3.1 Initial state

You have an existing batch application, which is written in a traditional language, such as COBOL or PL/I, that needs to be enhanced by integrating an external service. For example, you might need to integrate a credit card validation service that is hosted on a distributed platform.

5.3.2 Solution strategy

The solution strategy involves providing access to external services from existing batch applications. Because batch applications are carefully designed to fit a certain processing window, outbound service calls need to be carefully evaluated and designed. Performing an outbound service call and waiting for a response message back is usually many times slower than a direct database call. Also, when batch applications involve high volumes, outbound service calls are not an obvious choice. We only recommend looking into this pattern if:

- The data accessed in the external Web service is not available locally in a database.
- The amount of outbound service calls is reasonable in the context of the batch program processing time and its successor programs’ processing times.

5.3.3 Solutions

The solutions that we discuss for performing outbound Web service calls from batch applications are:

- Using messaging
- Using messaging over an ESB
- Using Web services over JMS transport
- Using a Java Web services client
- Using DB2 outbound Web Services support

Using messaging

A traditional way to solve this problem is to establish a messaging connection between the two applications, that is, connecting the applications via WebSphere MQ. For example, the application providing the service can be exposed as a Message-Driven Bean (MDB) hosted in WebSphere Application Server.

Target architecture

The solution in this case is a batch program that inserts messages into a WebSphere MQ queue and a target service that retrieves those messages from the queue. If needed, the service sends a response message back either with full data in certain cases and in other cases perhaps with just a return code. WebSphere MQ does not provide protocol conversion or data format conversion, so the message needs to be sent in the format in which the target service expects it. If the service is a Web service, the expected format is likely to be SOAP over JMS. The batch program needs to insert SOAP messages into the WebSphere MQ queue, which most batch programs that are written in traditional languages cannot easily do. The least intrusive method for an existing batch program is to insert plain MQ messages into a queue and let another layer (Java 2 Platform, Enterprise Edition (J2EE) layer or an ESB) sort out eventual conversion issues.

Runtime software prerequisite

This architecture requires WebSphere MQ.

Development tools

The development tool to be used for this pattern depends on the programming language in use for the existing batch application. If plain MQ messages are used, you can continue to use your existing development tooling for your batch environment.

Advantages

Advantages of this solution are:

- Easy and proven way to connect two applications
- In most cases, no additional software required

Limitations

Limitations of this solution are:

- Most traditional batch applications that are written in languages, such as PL/1 and COBOL, cannot easily send SOAP/JMS messages.
- Batch applications might slow down significantly if many messages are being exchanged with an outside service and if the program has to wait for a response message each time.
- There might be loose runtime coupling between applications but high development-time coupling, because the applications have to agree on a common message format.
- A homegrown message format might prevent reuse, especially when using a binary format, such as COBOL data structures (as opposed to an XML-based format, for example).
- There is a risk of a high amount of coupling between the two applications, creating “MQ spaghetti.”

Using messaging over an ESB

In this solution, the interface to the Web service is exposed as a “traditional” COBOL or PL/I language structure. The application uses WebSphere MQ messaging to put the request structure to a queue. An ESB retrieves the request messages from the queue and converts them to the format that is expected by the target service (for example, a SOAP request message) using its transformation capabilities. It then invokes the target service and converts the response back to an appropriate language structure.

This solution is similar to the previous simple messaging solution. The major advantage is that it leverages the “messaging switchboard” capabilities of the ESB, avoiding the tight coupling between service consumer and service provider.

Target architecture

In this solution, the batch program inserts request messages into a WebSphere MQ queue, ideally, structures that fit the existing programming language being used for the batch program. The messages are delivered to an MQ or JMS input node of an ESB solution, such as WebSphere Message Broker or WebSphere ESB. The ESB performs protocol conversion, data format conversion, service lookups, and eventual routing functions. A traditional MQ message can thus be converted and delivered in SOAP/XML to a target Web service in any environment and on any platform. The response messages will follow the reverse path back to the batch program.

Runtime software prerequisites

This architecture requires an ESB product, such WebSphere ESB or WebSphere Message Broker.

Development tools

The development tool to use for this pattern depends on the programming language in use for the existing batch application and on the ESB product that is chosen.

Advantages

The advantages of this solution are:

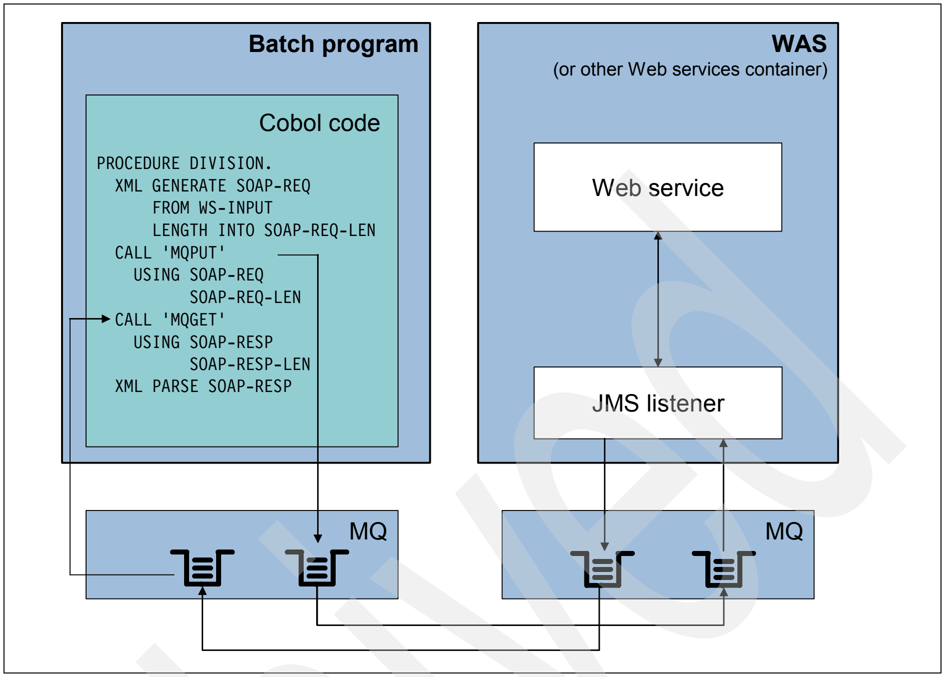
- Loose coupling between applications, both at run time and at development time
- Minimum impact for the calling batch applications, because they do not necessarily need to use the message format required by the service provider
- Central point of administration and control

Using Web services over JMS transport

At the time of writing this book, there is no predefined, ready to use support for Web Services calls from pure COBOL (or PL/I) over HTTP or HTTPS. However, SOAP over JMS transport is a feasible approach. Enterprise COBOL has built-in support for XML generation and parsing, and sending and receiving messages via WebSphere MQ is daily business for most COBOL programmers.

Target architecture

The target architecture for this solution is shown in Figure 5-7 on page 121. The batch service consumer sends SOAP messages to a WebSphere MQ queue, and the service provider processes these messages. The SOAP reply message is sent back from the service provider to the batch program.



```
PROCEDURE DIVISION.
  XML GENERATE SOAP-REQ
      FROM WS-INPUT
      LENGTH INTO SOAP-REQ-LEN
  CALL 'MQPUT'
    USING SOAP-REQ
          SOAP-REQ-LEN
  CALL 'MQGET'
    USING SOAP-RESP
          SOAP-RESP-LEN
  XML PARSE SOAP-RESP
```

Figure 5-7 Web service call from COBOL via JMS transport

Runtime software prerequisite

Enterprise COBOL or Enterprise PL/1 is required on z/OS for XML parsing.

Development tool

You can use your existing COBOL (or PL/1) development workbench to develop these types of applications.

Advantages

The advantage of this solution is that it is a pure language solution and does not require any additional middleware.

Limitations

The limitations include:

- XML parsing in Enterprise COBOL is event-driven (Simple API for XML (SAX) style), which is more difficult to handle than tree-style parsing.
- Namespace support for XML generation and parsing is only available with Enterprise COBOL V4.1 and later.

- As with all asynchronous loosely coupled integration solutions, waiting time is consumed between sending a message and receiving the reply. In most cases, this wait time is not a problem in an online transaction processing (OLTP) one message at a time environment, but in a batch job, this solution is only possible in limited cases. Refer to “Solution strategy” on page 117 for considerations.

Using a Java Web services client

This solution is similar to the solution discussed in “Using Web services over JMS transport” on page 120, but in this case, you use the COBOL/Java interoperability features of Enterprise COBOL. You create a Web services client stub in Java and call that stub from COBOL, as depicted in Figure 5-8. The Java part of the application has the responsibility of communicating with the service provider using either SOAP over HTTP or SOAP over JMS. So, one of the advantages of this solution over the solution discussed in “Using Web services over JMS transport” on page 120 is that you can now also use HTTP as the transport protocol. In addition, Java provides much more functionality and flexibility in terms of using Web Services standards.

Target architecture

Figure 5-8 shows the target architecture of this solution.

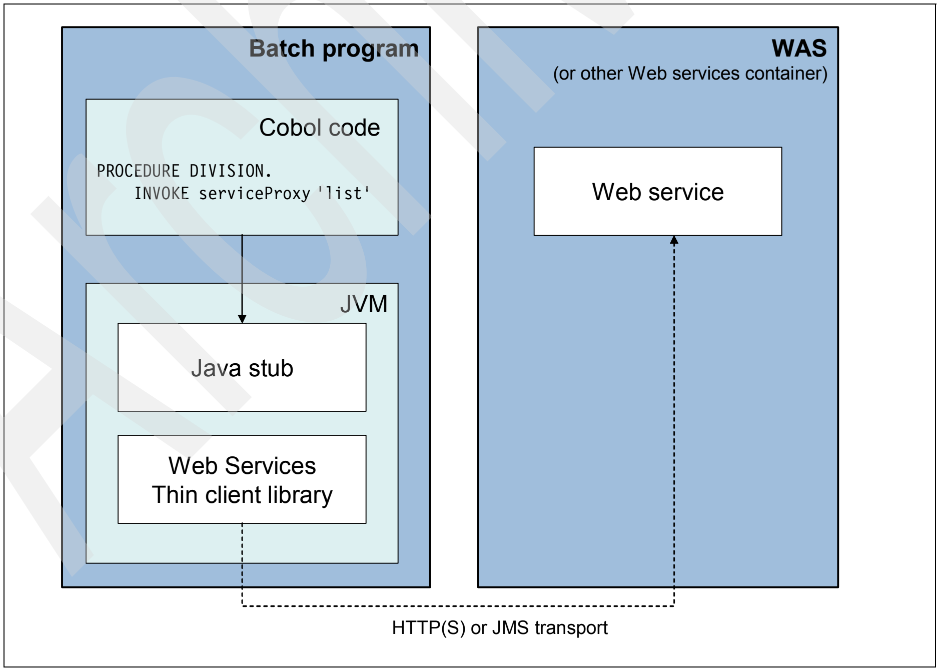


Figure 5-8 Calling a Web service from COBOL via Java

Runtime software prerequisite

Enterprise COBOL is required on z/OS for XML parsing.

Development tools

You can use your existing COBOL development workbench to adapt the COBOL. In addition, you need a simple Java development tool to develop the Java classes for the Web Services calls.

Advantages

The advantages of this solution are:

- Almost seamless integration
- COBOL does not have to consider the SOAP message format
- Common code base if you also have Java-based clients

Limitations

Limitations are:

- JVM creation incurs a significant startup cost. Therefore, this solution might be unsuitable for "small" job steps.
- As in all mixed-language solutions, the build and deployment procedures might be more difficult.

Example

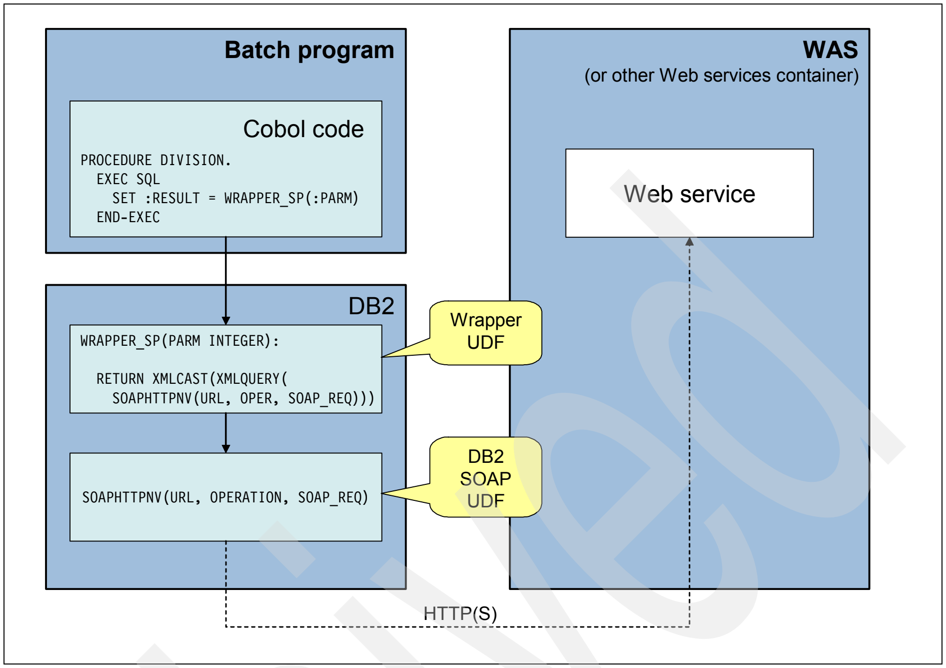
Refer to 15.3, "Calling a Java client from Enterprise COBOL" on page 471 for an example.

Using DB2 outbound Web Services support

DB2 outbound Web Services support is an extremely attractive solution, because it isolates your application code from the intricacies of the HTTP protocol. Taking it one step further, you can wrap the call to the SOAP-enablement user-defined functions (UDFs) into a UDF (or stored procedure) of your own, thus hiding the details of SOAP request building and SOAP response parsing from the application. Using this technique, calling a Web service from a DB2 application program can be made to look like a call to a local stored procedure or UDF.

Target architecture

Figure 5-9 on page 124 shows the target architecture.



```
PROCEDURE DIVISION.
  EXEC SQL
    SET :RESULT = WRAPPER_SP(:PARM)
  END-EXEC
```

```
WRAPPER_SP(PARM INTEGER):

  RETURN XMLCAST(XMLQUERY(
    SOAPHTTPNV(URL, OPER, SOAP_REQ)))
```

```
SOAPHTTPNV(URL, OPERATION, SOAP_REQ)
```

Figure 5-9 Call Web service via DB2 outbound Web service support

Runtime software prerequisite

The only prerequisite of this solution is to have DB2 on z/OS with UDFs installed.

Development tool

There is no need for a specific development tool.

Advantages

The advantages of this solution are:

- Web Services calls are completely transparent to the application program.
- The response can be presented to the application program in familiar tabular format.
- Maintenance is centralized when using wrapper UDFs.

Limitations

Limitations of this solution are:

- As of DB2 Version 9 for z/OS, only HTTP and HTTPS are supported as transport protocols; there is no support for JMS transport.

- You need a good understanding of DB2 XML support, XQuery syntax, and so forth.
- Problem determination can be more difficult, because communication and XML parsing are handled by DB2 and are outside the control of the application program.

Example

We provide a sample for this solution in Chapter 14, “Using DB2 as a Web service requester” on page 455.

Part 2

Samples

In this part of the book, we show you a number of samples of scenarios that were introduced in Part 1, “SOA application enablement patterns for z/OS” on page 25.

We discuss the following samples in detail:

- Exposing VSAM data as Web Services
- Exposing DB2 data as a service
- Exposing IMS data as a service
- Exposing data as a service by using IBM WebSphere Message Broker
- Exposing an IMS application as a Web service
- Building composite CICS services using the Service Flow Feature
- Using DB2 as a Web service requester
- Using an external Web service in batch applications

6

Exposing VSAM data as Web Services

In this chapter, we first develop a generic Web service that is written in Java to access existing VSAM data. We then deploy the Web service to WebSphere Application Server for z/OS and explore several ways to test and invoke it.

We then show building a less generic but more business-oriented Web service that exposes a structured view of the data but not the raw data. We use the JZOS Record Generator tool to create Java classes for conversion from and to COBOL record layouts.

6.1 Introduction

In this section, we first develop a simple Java bean to access a VSAM key-sequenced data set (KSDS) file. We use the JZOS library to perform the file operations (inserting, updating, deleting, and listing records). We then create a Web service that wraps those operations and then deploys the service to WebSphere on z/OS.

6.2 The JZOS toolkit and library

One of the weak points in the adoption of Java technology on the mainframe in the beginning was that access to z/OS-specific system services was not possible, or at least not without considerable effort. Most importantly, Java did not have access to the “traditional” MVS file system (specifically, sequential and partitioned access methods and VSAM).

With the advent of JZOS, things have changed. It originally was offered as a free download from Dovetailed technologies, which was later acquired by IBM. JZOS is now part of the IBM SDK for z/OS and is constantly being improved and functionally enhanced. The latest versions are published on the IBM developerWorks Web site before they are integrated into one of the next SDK maintenance levels.

JZOS actually consists of two parts:

- *JZOS launcher* is a utility program to invoke Java applications in MVS batch (that is, from JCL). Because the launcher is not relevant to this discussion, we do not go into more detail here. Refer to *JZOS Batch Launcher and Toolkit Installation and User’s Guide,* SA23-2245, for more information.
- *JZOS library* is a set of utility classes that provide access to traditional z/OS data and z/OS system services directly from Java applications.

In this section of the book, we use the *ZFile class,* which provides access to traditional MVS data, such as sequential and partitioned data sets, as well as VSAM files, extensively. In fact, the ZFile class is just a thin wrapper around the C/C++ standard library functions for file I/O, which can be used to access both traditional and z/OS UNIX® data.

First, we create a generic VSAM service that can be used to access any VSAM file regardless of its structure.

6.3 Creating the generic VSAM access bean

In this step, we create a simple Java bean that wraps part of the ZFile class, exposing only the ZFile methods that are relevant for VSAM-related operations:

1. In *Rational Developer for System z (RDz)* or IBM Rational Application Developer (RAD), create a new Project (select **File** → **New** → **Project** → **Java Project**). Enter `VsamAccess` as the project name.
2. First, we need to bring the JZOS library into the workspace and add it to the project's classpath. In the project, create a folder named `lib` (select **File** → **New** → **Folder**). Now, you need to copy `ibmjzos.jar` from the SDK installation directory on z/OS into that folder. You can use either FTP or the Uniform Symbol Specification file access tooling in RDz. Finally, add it to the project's classpath by right-clicking the project and selecting **Properties** → **Java Build Path** → **Libraries** → **Add JARs**. Navigate to `lib/ibmjzos.jar` and click **OK**.

   > **Tip:** The `ibmjzos.jar` file can be found in the `lib/ext` subdirectory of the SDK installation, for example, `/usr/lpp/java/J5.0/lib/ext/ibmjzos.jar`.

3. Next, create a new Java class as shown in Example 6-1. Again, this class just serves as a wrapper to hide the ZFile operations that are not relevant to (or not even usable for) VSAM file access.

Example 6-1 Wrapper class for VSAM access

```
package com.ibm.itso.sg247669.vsam;

import java.io.IOException;

import com.ibm.jzos.ZFile;
import com.ibm.jzos.ZFileException;

public class VsamFile {

   private ZFile vsam;                                                        1

   private byte[] buf;

   public VsamFile(String name) throws IOException {
      String mvsName = ZFile.getSlashSlashQuotedDSN(name, true);              2
      vsam = new ZFile(mvsName, "rb+,type=record");                           3
      if (vsam.getVsamType() != ZFile.VSAM_TYPE_KSDS                          4
            && vsam.getVsamType() != ZFile.VSAM_TYPE_KSDS_PATH) {
```

```
      vsam.close();
      throw new IOException("Not a KSDS dataset: " + name);
   }
   buf = new byte[getRecordLength()];                                      5
}

public int getRecordLength() throws IOException {
   try {
      return vsam.getLrecl();
   } catch (ZFileException e) {
      throw new IOException("Error obtaining record length: "
            + e.getMessage());
   }
}

public int getKeyLength() throws ZFileException {
   return vsam.getVsamKeyLength();
}

public int read(byte[] buf) throws ZFileException {                        6
   return vsam.read(buf);
}

public byte[] read() throws ZFileException {                               7
   if (read(this.buf) > 0) {
      return this.buf;
   } else {
      return null;
   }
}

public void close() throws ZFileException {
   vsam.close();
   vsam = null;
}

public void write(byte[] record) throws ZFileException {
   vsam.write(record);
}

public boolean locate(byte[] record, int keyOffset, int keyLength)
      throws ZFileException {
   return vsam.locate(record, keyOffset, keyLength, ZFile.LOCATE_KEY_GE);   8
}
```

```
   public boolean locate(byte[] key) throws ZFileException {
      return locate(key, 0, key.length);
   }

   public int update(byte[] record) throws ZFileException {
      return vsam.update(record);
   }

   public void deleteRecord() throws ZFileException {
      vsam.delrec();
   }

   public boolean delete(byte[] record, int keyOffset, int keyLength)
         throws ZFileException {
      if (locate(record, keyOffset, keyLength)) {
         read();
         deleteRecord();
         return true;
      } else {
         return false;
      }
   }

   public boolean delete(byte[] key) throws ZFileException {
      return delete(key, 0, key.length);
   }
}
```

Notes on Example 6-1 on page 131 (these numbers correspond to the numbers on the right):

1 The underlying JZOS ZFile object used to access the data set is shown.

2 Convert the data set name to the naming conventions of the C/C++ standard I/O library. The Boolean argument instructs the ZFile class to not automatically prepend the TSO prefix if the name is not enclosed in single quotation marks, that is, the constructor expects a fully qualified dataset name.

3 Open the file in read/write mode. Refer to *C/C++ Run-Time Library Reference,* SA22-7821, and *C/C++ Programming Guide,* SC09-4765, for a full description of the possible modes.

4 Verify that the file is a VSAM KSDS.

5 Allocate a buffer for records.

6 Read the current record into a user-supplied buffer.

7 Read the current record into the pre-allocated buffer. Note that client code will have to make a copy of the buffer contents, because it will change when the next record is read.

8 Search for a record whose key is greater than or equal to the key that is passed as a parameter.

6.4 Creating the Web service implementation

In this step, we use the wrapper class that we developed in 6.3, “Creating the generic VSAM access bean” on page 131 to create a Web service. The service interface will offer the methods to create, read, update, and delete records.

Unlike the wrapper class just created, there will be no externally exposed methods to open or close a VSAM file, however. The reason is simple: Web services are stateless by nature. There is no way to pass a “handle” to an open file to the service consumer and let the service consumer then invoke additional operations that can pass that handle as a parameter.

Therefore, all operations follow a similar sequence of steps:

1. Open the VSAM file.
2. Perform the operation (such as insert, update, list, or delete).
3. Close the VSAM file.
4. Return the result (if applicable).

Example 6-2 The VsamAccess service implementation

```
package com.ibm.itso.sg247669.vsam;

import java.io.IOException;
import java.util.ArrayList;
import java.util.List;

public class VsamAccess {

   public void insert(String fileName, byte[] record) throws IOException {
      VsamFile file = new VsamFile(fileName);
      try {
         file.write(record);
      } finally {
         file.close();                                                         1
      }
   }
   public void update(String fileName, byte[] record) throws IOException {
      VsamFile file = new VsamFile(fileName);
      try {
         file.locate(record);
         file.read();
         file.update(record);
      } finally {
         file.close();
      }
   }

   public boolean delete(String fileName, byte[] key) throws IOException {
      VsamFile file = new VsamFile(fileName);
      try {
         return file.delete(key);
      } finally {
         file.close();
      }
   }

   public byte[][] list(String fileName, byte[] key, int maxRecords)
         throws IOException {
      VsamFile file = new VsamFile(fileName);
      try {
         List<byte[]> result = new ArrayList<byte[]>();
         if (file.locate(key)) {
            for (int count = 0; count < maxRecords || maxRecords == 0; count++) {   2
               byte[] record = file.read();
               if (record == null) {
                  break;                                                            3
               }
               result.add(record.clone());                                          4
            }
         }
         return result.toArray(new byte[result.size()][]);
      } finally {
         file.close();
      }
   }
}
```

Notes on Example 6-2 on page 134 (These numbers correspond to the numbers on the right):

1 We have to make sure that the file is closed when the method ends, no matter what; otherwise, the file remains open to the operating system, and the next attempt to open it will fail. Therefore, the call to **`file.close()`** is in an end block to ensure that it gets called even when **`file.write()`** caused an exception.

2 Loop until the maximum number of records has been read, unless maxRecords is set to zero in which case all records are returned.

3 Exit the loop when the end-of-file has been reached.

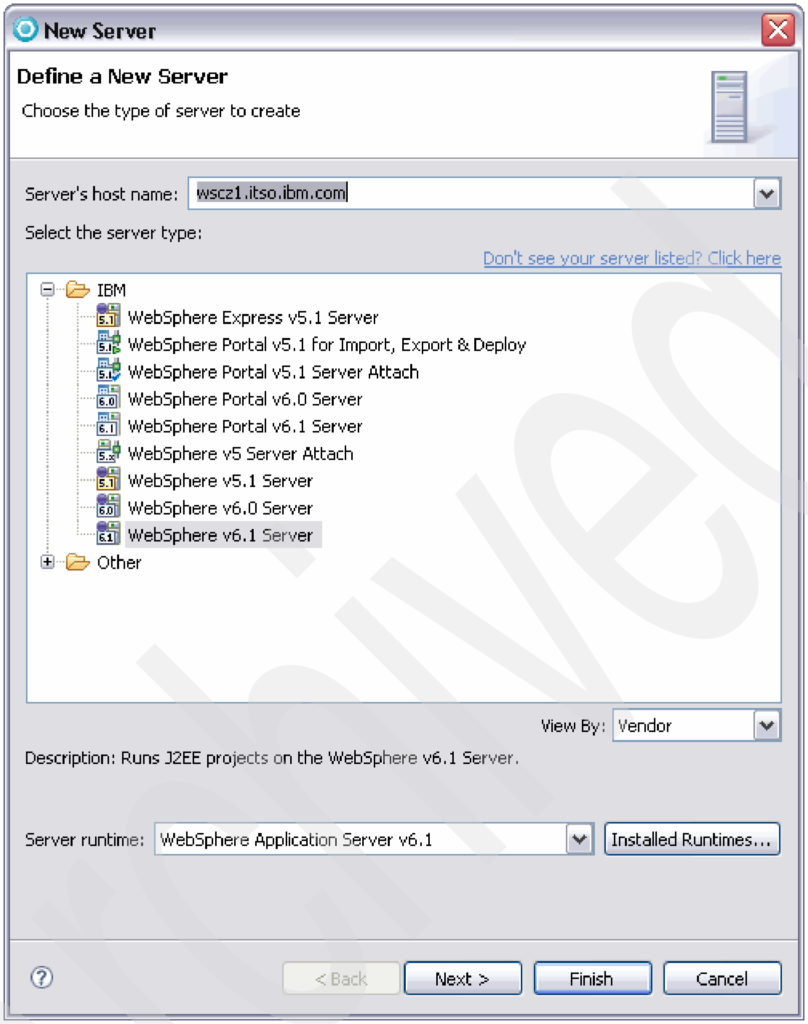
4 We have to clone the byte array that was returned from **`file.read()`**, because it will be reused in the next **`read()`** call. Otherwise, we end up with all identical records in the list (namely, the last record read).

6.5 Creating and deploying the Web service

In this step, we turn the service implementation class into a Web service and deploy it to WebSphere Application Server on z/OS.

As a prerequisite for deployment, we have to make the WebSphere Application Server instance on z/OS known to RDz so that we can deploy to it:

1. Show the Servers view (select **Window** → **Show View** → **Server** → **Servers**). Right-click and select **New** → **Server**.
2. In the Server's host name field, type your WebSphere Application Server server's host name. Select **IBM** → **WebSphere v6.1 Server** as the server type, and click **Next** (Figure 6-1 on page 137).



New Server

Define a New Server

Choose the type of server to create

Server's host name: wscz1.itso.ibm.com

Select the server type:

Don't see your server listed? Click here

- IBM
  - WebSphere Express v5.1 Server
  - WebSphere Portal v5.1 for Import, Export & Deploy
  - WebSphere Portal v5.1 Server Attach
  - WebSphere Portal v6.0 Server
  - WebSphere Portal v6.1 Server
  - WebSphere v5 Server Attach
  - WebSphere v5.1 Server
  - WebSphere v6.0 Server
  - WebSphere v6.1 Server
- Other

View By: Vendor

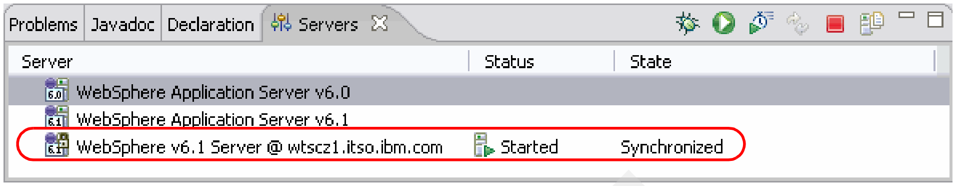
Description: Runs J2EE projects on the WebSphere v6.1 Server.

Server runtime: WebSphere Application Server v6.1

Figure 6-1 Define WebSphere Application Server in RDz

3. On the next window, enter either your server's Object Request Broker (ORB) bootstrap port or SOAP connector port. If security is enabled on the server, you must fill in the respective fields as well. Click **Finish**.

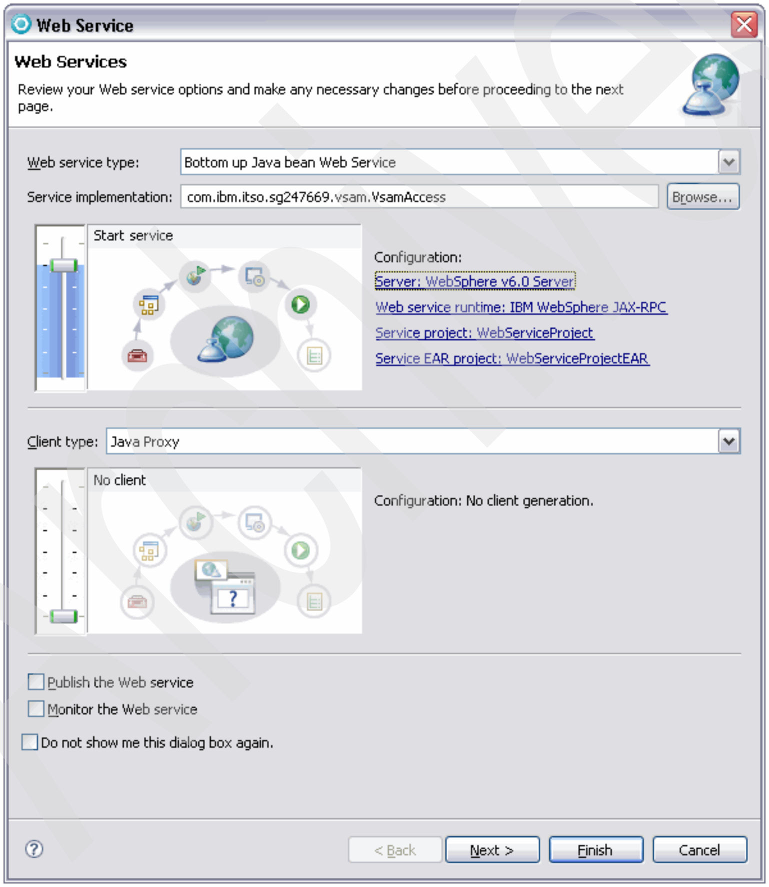
   The server is now listed in the Servers view (Figure 6-2 on page 138).



Server	Status	State
WebSphere Application Server v6.0		
WebSphere Application Server v6.1		
WebSphere v6.1 Server @ wtscz1.itso.ibm.com	Started	Synchronized

Figure 6-2 Servers view showing WebSphere Application Server on z/OS

4. Now, we are ready to create our VsamAccess Web service and deploy it to the application server. Select the VsamAccess class, right-click and click **Web Services** → **Create Web service**. The Web service wizard opens (Figure 6-3).



Web Services

Review your Web service options and make any necessary changes before proceeding to the next page.

Web service type: Bottom up Java bean Web Service

Service implementation: com.ibm.itso.sg247669.vsam.VsamAccess

Start service

Configuration:
Server: WebSphere v6.0 Server
Web service runtime: IBM WebSphere JAX-RPC
Service project: WebServiceProject
Service EAR project: WebServiceProjectEAR

Client type: Java Proxy

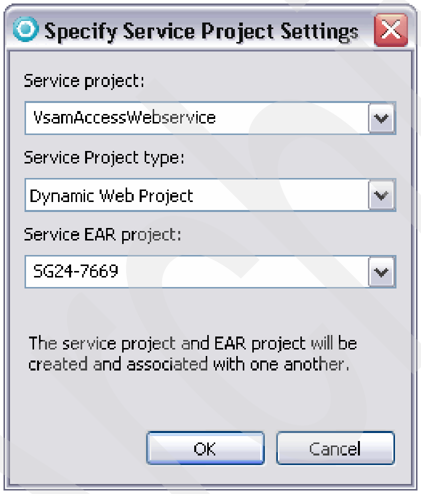
No client

Configuration: No client generation.

□ Publish the Web service
□ Monitor the Web service
□ Do not show me this dialog box again.

Figure 6-3 The Web Service wizard

5. We are going to create a **Bottom-up Java bean Web service** from our service implementation class, `com.ibm.itso.sg247669.vsam.VsamAccess`, so leave the first two entry fields as is. Move the top slider to **Start Service**.
6. Next, we have to adjust the four settings under the Configuration heading, by clicking the respective links. First, change the target server type by clicking **Server: WebSphere v6.0 server**. From the dialog box that opens, select **Choose server** first, **Existing servers**, and select the WebSphere on z/OS server that we made known to the workbench in the previous step.
7. Leave the Web Service Runtime configuration item unchanged.
8. The Web Service wizard is going to create a Web project and an Enterprise project for us. We want more descriptive names than the default names (`WebServiceProject` and `WebServiceProjectEAR`). So, click either the Service Project or the Service EAR project link, and enter `VsamAccessWebservice` as the service project name. Because we are going to reuse the EAR project later, we chose a more generic name for the EAR project, `SG24-7669` (Figure 6-4). Click **OK** to return to the Web service wizard.



Specify Service Project Settings

Service project: VsamAccessWebservice

Service Project type: Dynamic Web Project

Service EAR project: SG24-7669

The service project and EAR project will be created and associated with one another.

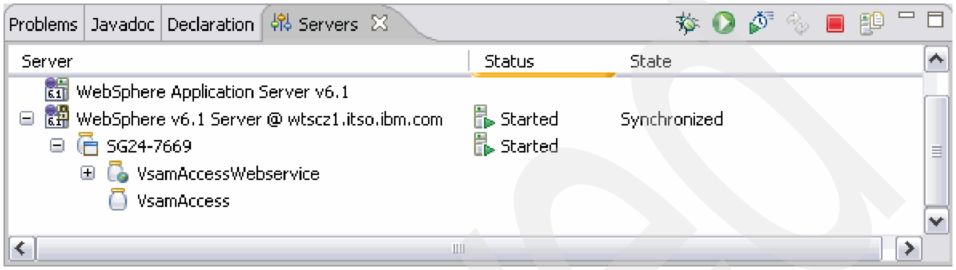
Figure 6-4 Service project settings

9. Move the Client generation slider to **No client** and click **Next**. The Web service wizard now creates a Web project with all the necessary artifacts, such as the Web module deployment descriptor.
10. On the next window, Service Endpoint Interface Selection, leave the defaults as is and click **Next**. The next window, Web Service Java Bean Identity, allows you to change the generated Web Services Description Language (WSDL) port and file names and to select the methods that you want to expose. Again, leave the settings as is and click **Next**.

11. The wizard now generates the WSDL file to match the Java method signature. It also creates an EAR project and installs the EAR on the application server, which might take a while.

12. In the next and final panel, leave the defaults and click **Finish**.

If everything went well, the Servers view now indicates that the application has been installed and is running on the application server (Figure 6-5).



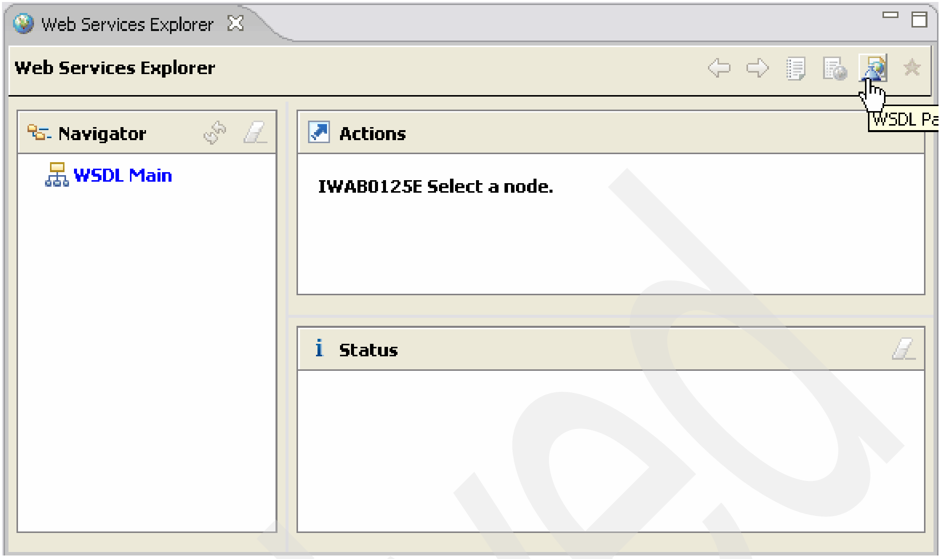
Server	Status	State
WebSphere Application Server v6.1		
WebSphere v6.1 Server @ wtscz1.itso.ibm.com	Started	Synchronized
SG24-7669	Started	
VsamAccessWebservice		
VsamAccess		

Figure 6-5 VSAM Web service successfully created and deployed

6.6 Testing the service

Now, we are ready to test the Web service. RDz and RAD come with a great tool for that purpose: The Web Services Explorer. To test the service:

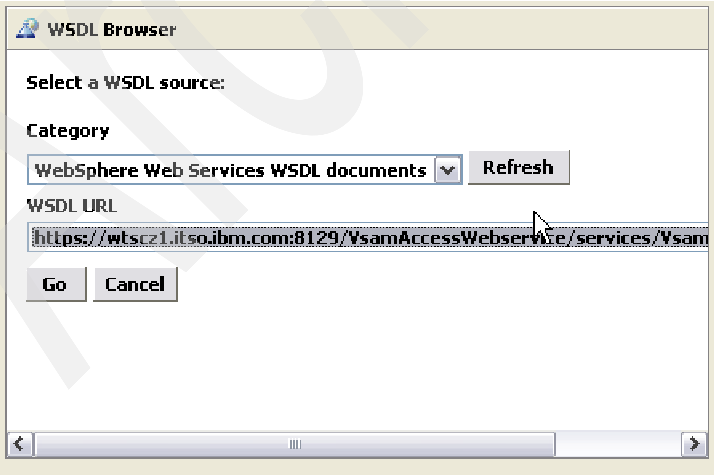
1. Select **Run** → **Launch the Web Services Explorer** (or click the icon). From the icon bar in the top row of the view, click the **WSDL Page** icon (Figure 6-6 on page 141).



IWAB0125E Select a node.

Figure 6-6 The Web services explorer

2. Next, we need to find the WSDL document for the VSAM Web service. Click the WSDL Main node in the Navigator pane. Next, click the **Browse** link in the Actions bar. The WSDL Browser dialog opens. Select **WebSphere Web Services WSDL documents** as the WSDL source category and **VsamAccessWebservice** as Workspace project (Figure 6-7). Alternatively, you can choose **Workspace WSDL documents**, because the WSDL file actually sits in our workspace.



Select a WSDL source:

Category

WebSphere Web Services WSDL documents

WSDL URL

https://wtscz1.itso.ibm.com:8129/VsamAccessWebservice/services/Vsam

Figure 6-7 WSDL browser

3. Click **Go** to close the WSDL browser, and then, click **Go** again in the Actions pane. The Web Services Explorer now retrieves the WSDL document from the server, parses it, and displays a tree in the Navigator pane showing the services declared in that WSDL, their respective bindings, and the operations (Figure 6-8).

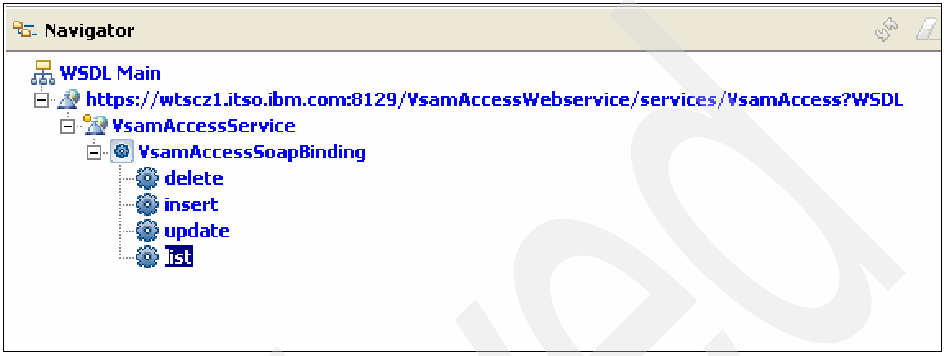

Navigator
WSDL Main
https://wtscz1.itso.ibm.com:8129/VsamAccessWebservice/services/VsamAccess?WSDL
VsamAccessService
VsamAccessSoapBinding
delete
insert
update
list

Figure 6-8 Navigator pane showing the VsamAccess Web service

4. The list operation is probably the obvious one to test first, because it does not change any data. So, select **list** from the operations as shown in Figure 6-8. The Actions pane changes to reflect the currently selected operation, so you see three text entry fields corresponding to the three parameters on the list operation.

5. The first parameter is easy: Enter the name of an existing VSAM KSDS data set on your z/OS system. Be sure to enter a fully qualified data set name; the double slashes can be omitted (the `ZFile.getSlashSlashQuotedDSN` method takes care of that; refer to the comments about Example 6-1 on page 131).

   Note: The VSAM file that we used in this example is the one that comes with the CICS Catalog sample application. Refer to “JCL for creating and loading the catalog VSAM file” on page 482 for instructions about how to create a copy of that sample file.

6. The second parameter, however, is a bit tricky. As you can see, the Java byte array type has been mapped to a Base64-encoded string (“base64Binary”) in the WSDL. So, to search for the key 0180 we have to find the Base64 representation of the bytes making up the string “0180”. No, wait a minute, we have to find the Base64 representation of those bytes *in EBCDIC encoding*.

   An easy way is to use class `sun.misc.BASE64Encoder` (which is not an official part of the SDK, but for our purpose, that does not matter). Open a new Java Scrapbook page (**File** → **New** → **Other** → **Java Scrapbook Page**) and type the following expression (we are using EBCDIC code page 1047, but any other EBCDIC variant will produce the same result):

```
new sun.misc.BASE64Encoder().encode("0180".getBytes("Cp1047"))
```

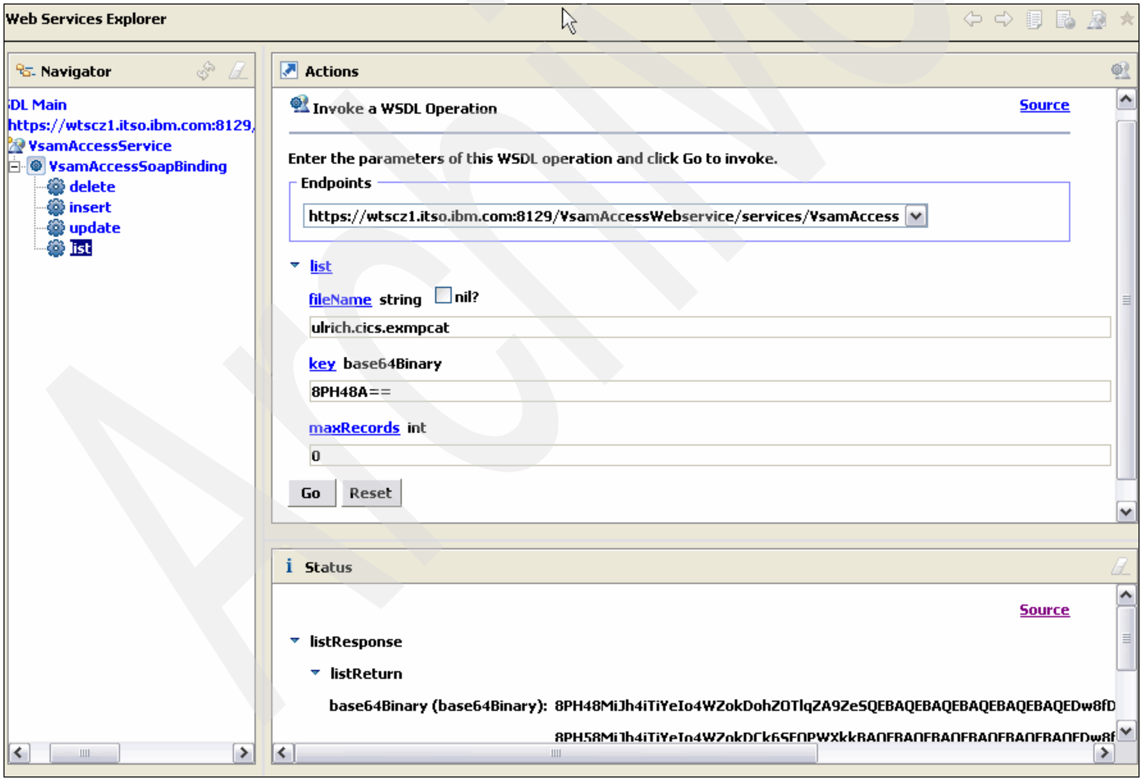
Then, select the entire expression, right-click, and select **Display**. You get the following output in the scrapbook window:

```
(java.lang.String) 8PH48A==
```

Copy the expression result (`8PH48A==`), go back to the Web Service Explorer and paste it into the key entry field. Finally, enter any positive value or 0 for no limit as the third parameter, `maxRecords`.

7. Click **Go**.
8. If the output looks like Figure 6-9, you did it.

   Just like the key, the return values are Base64-encoded strings in EBCDIC encoding. To convert these values into human-readable format, select and copy one of them and go back to the Java Scrapbook page.



Enter the parameters of this WSDL operation and click Go to invoke.

Endpoints: https://wtscz1.itso.ibm.com:8129/VsamAccessWebservice/services/VsamAccess

list

fileName string □ nil?

ulrich.cics.exmpcat

key base64Binary

8PH48A==

maxRecords int

0

listResponse

listReturn

base64Binary (base64Binary): 8PH48MiJh4iTiYeIo4WZokDohZOTlqZA9ZeSQEBAQEBAQEBAQEBAQEDw8fD

8PH58MiJh4iTiYeIo4WZokDCk6SFOPWXkkBAQEBAQEBAQEBAQEDw8f

Figure 6-9 Output from invoking VsamAccessService.list

9. In the scrapbook page, enter the following expression:

   ```
   new String(new sun.misc.BASE64Decoder().decodeBuffer(""), "Cp1047")
   ```

   Paste the output string into the argument of `decodeBuffer`, highlight the entire expression again and display the result as you did before. If you selected the first row of the output, you get:

   ```
   0180Highlighters Yellow 5pk               010003.490088010
   ```

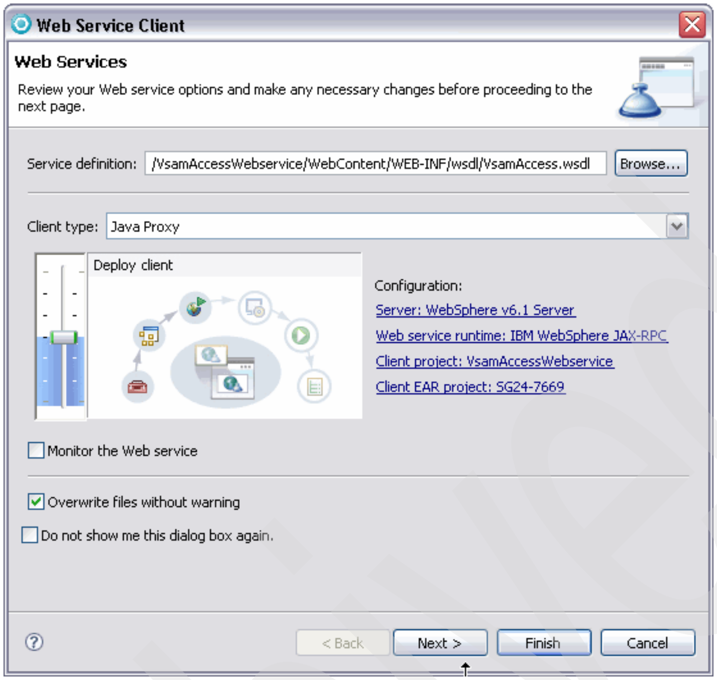
At this point, feel free to experiment a bit with the Web Services Explorer. Maybe, try the insert and delete operations. You have to use the Scrapbook page again to get the encoded values to paste into the record argument.

Now, admittedly, all of that Base64 encoding and decoding is rather clumsy, so in the next step, we create a simple Java client.

6.7 Creating a Java client for the VsamAccess service

To create a stand-alone Java client that can invoke our VsamAccess Web service, we use the Web service wizard again:

1. The first step is to create a new Java project for the Web service client. Select **Project** → **New** → **Java Project**. Enter `VsamAccessThinClient` as the project name, and click **Finish**.
2. Now, in the VsamAccessWebservice project, expand the **WebContent/WEB-INF/wsdl folder** and select the WSDL file, **VsamAccess.wsdl**. Right-click and select **Web Services** → **Generate Client**. The Web service wizard opens (Figure 6-10 on page 145). Move the slider to **Deploy client**.


Web Service Client

Web Services

Review your Web service options and make any necessary changes before proceeding to the next page.

Service definition: /VsamAccessWebservice/WebContent/WEB-INF/wsdl/VsamAccess.wsdl

Client type: Java Proxy

Configuration:
Server: WebSphere v6.1 Server
Web service runtime: IBM WebSphere JAX-RPC
Client project: VsamAccessWebservice
Client EAR project: SG24-7669

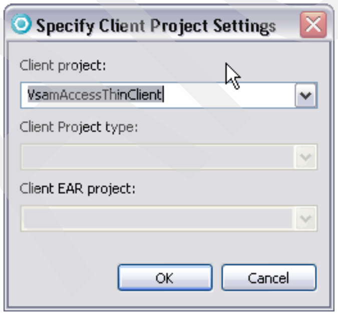
□ Monitor the Web service

☑ Overwrite files without warning

□ Do not show me this dialog box again.

Figure 6-10 Generating a client using the Web service wizard

3. Next, we have to tell the wizard that we want to generate the client code into the Java project that we just created. So, click the **Client project** link. In the dialog that opens, select the project name (**VsamAccessThinClient**) from the **Client project** list box (Figure 6-11). Because this project is a plain Java project (as opposed to a Dynamic Web project, for example), the Client project type and Client EAR project entry fields are disabled automatically.


Specify Client Project Settings

Client project: VsamAccessThinClient

Client Project type:

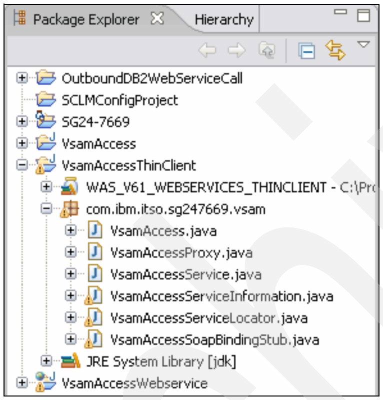
Client EAR project:

Figure 6-11 Specify client project settings for the Web service client project

Note: There seems to be no other way to create a standalone Java Web service client application using the Web services wizard. All Client project-type selections in the Client Project Settings dialog lead to the creation of a Web module project or Web utility project, which is not what we want here.

When the target project exists however and is a simple Java project, the wizard happily creates a stand-alone client, as described in this section.

4. Click **OK** to get back to the Web services client, and click **Finish**. The wizard now generates Java client code and adds a library containing the Web services client run time to the project's classpath (Figure 6-12).



```
OutboundDB2WebServiceCall
SCLMConfigProject
SG24-7669
VsamAccess
VsamAccessThinClient
    WAS_V61_WEBSERVICES_THINCLIENT - C:\Pro
    com.ibm.itso.sg247669.vsam
        VsamAccess.java
        VsamAccessProxy.java
        VsamAccessService.java
        VsamAccessServiceInformation.java
        VsamAccessServiceLocator.java
        VsamAccessSoapBindingStub.java
    JRE System Library [jdk]
VsamAccessWebservice
```

Figure 6-12 Generated client code

5. Now, we are ready to create a Java program that looks up the service and invokes it. Select the project (**VsamAccessThinClient**) and create a new Java class by selecting **File** → **New** → **Class**. Enter the package name (`com.ibm.itso.sg247669.vsam`) and the class name (`ClientTestMain`). Paste the client program as shown in Example 6-3 on page 147.

Example 6-3 Simple Java client program to invoke the VSAM Web service

```
package com.ibm.itso.sg247669.vsam;

public class ClientTestMain {

   public static void main(String[] args) {
      try {
         VsamAccess vsam = new VsamAccessServiceLocator().getVsamAccess();            1
         byte[][] result = vsam.list("ulrich.cics.exmpcat",                           2
                                     "0010".getBytes("Cp1047"),                       3
                                     0);                                              4
         for (int i = 0; i < result.length; i++) {
            System.out.println(new String(result[i], "Cp1047"));                      5
         }
      } catch (Exception e) {
         e.printStackTrace();
      }
   }
}
```

Notes on Example 6-3 (these numbers correspond to the numbers on the right):

1 The generated VsamAccessServiceLocator class “knows” about the service endpoints. We ask it for the default endpoint (the one that is specified in the WSDL).

2 We invoke the list operation.

3 We use the EBCDIC representation of 0010 as key.

4 We use 0 to indicate that we want to retrieve all records having the same or greater key.

5 We print each record by converting the bytes to a string, using EBCDIC encoding.

6. Now, try to run the client program (select the class, and then select **Run** → **Run As** → **Java Application**. We got the output as shown in Example 6-4.

Example 6-4 Error from invoking the Java client: No Secure Sockets Layer (SSL) configuration available

```
Sep 4, 2008 10:48:57 AM com.ibm.ws.ssl.config.SSLConfigManager
INFO: ssl.disable.url.hostname.verification.CWPKI0027I
Sep 4, 2008 10:48:58 AM com.ibm.ws.webservices.engine.PivotHandlerWrapper invoke
WARNING: WSWS3734W: Warning: Exception caught from invocation to
com.ibm.ws.webservices.engine.transport.http.HTTPSender:
WebServicesFault
 faultCode: {http://schemas.xmlsoap.org/soap/envelope/}Server.generalException
 faultString: WSWS3740E: Error: No SSL configuration is available for
endpoint—https://wtscz1.itso.ibm.com:8129/VsamAccessWebservice/services/VsamAccess
 faultActor: null
 faultDetail:

WSWS3740E: Error: No SSL configuration is available for endpoint -
https://wtscz1.itso.ibm.com:8129/VsamAccessWebservice/services/VsamAccess
   at
com.ibm.ws.webservices.engine.transport.security.ConfigSSLProvider.getConfig(ConfigSS
LProvider.java:257)
   at
com.ibm.ws.webservices.engine.transport.http.HTTPSender$2.run(HTTPSender.java:973)
[... stack trace omitted ...]
```

An easy way to get around this problem is to use the HTTP endpoint instead of the HTTPS endpoint. Modify the client program by changing the line:

```
VsamAccess vsam = new VsamAccessServiceLocator().getVsamAccess();
```

to:

```
URL httpEndpoint = new URL("http://wtscz1.itso.ibm.com:8128/" +
                        "VsamAccessWebservice/services/VsamAccess");
VsamAccess vsam = new VsamAccessServiceLocator()
                        .getVsamAccess(httpEndpoint);
```

Obviously, you need to change the URL to match your host name and HTTP port.

7. Run the program again. This time, it successfully connects to the HTTP endpoint and produces the expected output, as shown in Example 6-5.

Example 6-5 Output from running the VSAM client against the HTTP endpoint

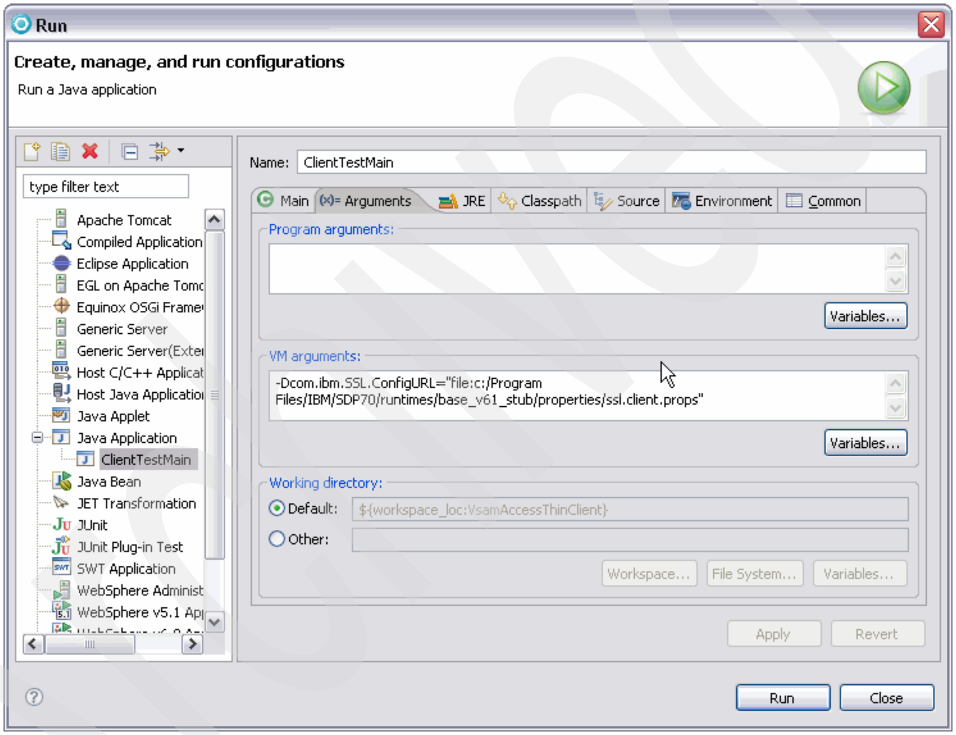
```
Sep 4, 2008 11:06:24 AM com.ibm.ws.ssl.config.SSLConfigManager
INFO: ssl.disable.url.hostname.verification.CWPKI0027I
0010Ball Pens Black 24pk                    010002.900135000
0020Ball Pens Blue 24pk                     010002.900006050
0030Ball Pens Red 24pk                      010002.900106000
0040Ball Pens Green 24pk                    010002.900080000
[ ... rest of output omitted ...]
```

8. Alternatively, you can configure SSL for the client, using the SSL configuration that comes with the RDz installation. Modify the launch configuration to invoke the program:

   a. Select **Run** → **Run** to open the Launch Configuration editor. Select the **Arguments** tab. In VM arguments (Figure 6-13), enter:

      ```
      -Dcom.ibm.SSL.ConfigURL="file:c:/Program
      Files/IBM/SDP70/runtimes/base_v61_stub/properties/ssl.client.props"
      ```

      Be sure to enclose the URL in double quotation marks if the path name contains blanks.



Create, manage, and run configurations

Run a Java application

Name: ClientTestMain

VM arguments:

```
-Dcom.ibm.SSL.ConfigURL="file:c:/Program
Files/IBM/SDP70/runtimes/base_v61_stub/properties/ssl.client.props"
```

Working directory:

● Default: ${workspace_loc:VsamAccessThinClient}

○ Other:

Figure 6-13 Modifying the client launch configuration for SSL support

   b. Now, change the program back to use the default endpoint and run again. This time, it successfully connects to the HTTPS endpoint.

> **Note:** For more information about SSL configuration, refer to the WebSphere Application Server product documentation (look for the ssl.client.props client configuration file section).

6.8 Creating a wrapper service

At this point, we have a complete Web service that can read and update any VSAM KSDS file on the system, and we have a Java client to invoke that service from anywhere. However, the service is still not easy to use. The client has to know about the exact layout of the records in the file, including the record data types and lengths. It becomes complicated when the data in the file is not encoded as strings but uses native COBOL types, such as packed decimal fields. If the layout of the records ever changes, all clients accessing the file using this service have to be changed accordingly. Therefore, the service is too generic. It exposes not the business view of the data, but a purely technical view.

Therefore, in this section, we add a new layer on top of the existing service implementation that hides the record layout from the clients and exposes the business meaning of the individual fields instead (Example 6-6).

Example 6-6 COBOL level 01 definition of the sample VSAM file

```
01  WS-CAT-ITEM.
    05 WS-ITEM-REF          PIC 9(4).
    05 WS-DESCRIPTION       PIC X(40).
    05 WS-DEPARTMENT        PIC 9(3).
    05 WS-COST              PIC ZZZ.99.
    05 WS-IN-STOCK          PIC 9(4).
    05 WS-ON-ORDER          PIC 9(3).
    05 FILLER               PIC X(20).
```

One of the numerous useful features in the JZOS toolkit is a complete set of field converter classes in the package `com.ibm.jzos.fields`. These field types operate on a byte array and can be used to convert from COBOL or Assembler structures to Java types, and from Java types to COBOL or Assembler structures.

> **Note:** Of course, there is always more than one way to do it. In this example, we show you how to use the JZOS record framework and generator. An equally valid alternative is to use the CICS/IMS Java Binding tooling available in RDz.

Now, the field converter classes deal with converting from COBOL (or Assembler) types to Java types, for example, from packed decimal to integer, on an elementary field level. But this is only part of the job, because you still have to manually calculate field offsets and lengths within the COBOL data structures.

Given that COBOL structures can be quite complex, it is a tedious and error-prone job to do that.

The JZOS record generator does precisely that. It uses IBM Enterprise COBOL to compile the copybook and uses a special data set ("SYSADATA") produced by Enterprise COBOL to learn about the types, offsets, and lengths of the data items described by that copybook. It then generates Java classes that use the record converter utility classes of the JZOS run time (Example 6-7 on page 152). We illustrate this process in Figure 6-14.

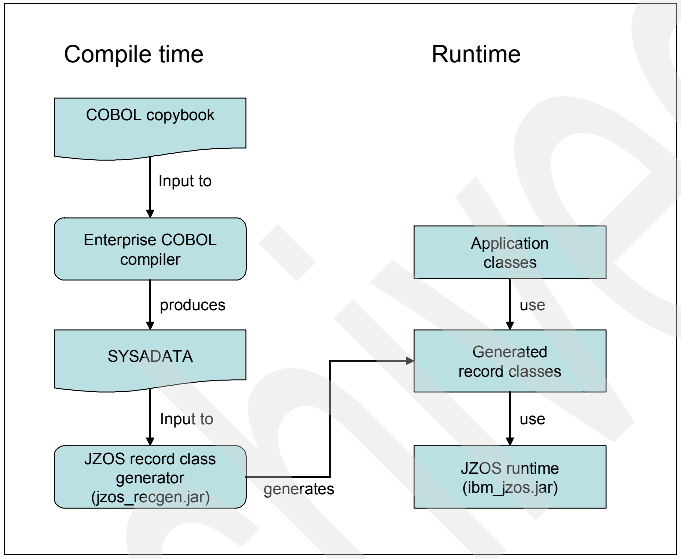


Figure 6-14 Generating record classes with the JZOS record generator

As of the time of writing this book, the Record Class Generator is not an official part of the SDK for z/OS. The JZOS version in the SDK is at level 2.1.0, while the Record Class Generator is available in level 2.2.1 and higher. We therefore downloaded the latest AlphaWorks version of JZOS and copied the Jar file containing the Generator to a directory on the z/OS Unix file system.

Note: You will find the jar file, `jzos_recgen.jar`, in the additional materials for this book. Refer to Appendix B, "Additional material" on page 485.

Note: It is not necessary (and not recommended) to replace the JZOS version in the SDK with the AlphaWorks version. All we need for the purposes of this section is the `jzos_recgen.jar` file. The generated code will work fine with the older JZOS level that is part of the SDK.

Example 6-7 JCL to invoke the JZOS record class generator

```
//RECGEN JOB ,NOTIFY=&SYSUID,MSGLEVEL=(1,1)
//*
//COBADATA PROC CPYBKLIB=,CPYBOOK=                                       1
//COBOL    EXEC IGYWC,PARM='LIB,ADATA'                                   2
//SYSIN    DD DISP=SHR,DSN=ULRICH.JZOS.RECGEN(COBPREFX)
//         DD DISP=SHR,DSN=&CPYBKLIB(&CPYBOOK)                           3
//         DD DISP=SHR,DSN=ULRICH.JZOS.RECGEN(COBSUFIX)
//SYSADATA DD DSN=&&ADATA,DISP=(,PASS)                                   4
//         PEND
//*
//CATITEM EXEC COBADATA,                                                 5
//       CPYBKLIB=ULRICH.CICSCAT.COPYLIB,
//       CPYBOOK=CATITEM
//JAVAGEN EXEC JVMPRC50,                                                 6
//*      LOGLVL='+T',
//       JAVACLS='com.ibm.jzos.recordgen.cobol.RecordClassGenerator'
//MAINARGS DD *                                                          7
bufoffset=false                                                          8
package=com.ibm.itso.sg247669.vsam.catalog                               9
outputDir=/u/ulrich/cobgen                                               10
//SYSADATA DD DSN=&&ADATA,DISP=(OLD,DELETE)                              11
//STDENV   DD *                                                          12
JAVA_HOME=/usr/lpp/java/J5.0
PATH="/bin:$JAVA_HOME"/bin:
LIBPATH=/lib:/usr/lib:"$JAVA_HOME"/bin:"$JAVA_HOME"/bin/j9vm
export JZOS_JVM_OPTIONS=""
# Add the JZOS alphaWorks jars to the classpath
CLASSPATH="$CLASSPATH":"/u/ulrich/jzos_recgen.jar"
export JAVA_HOME PATH LIBPATH CLASSPATH
```

Notes on Example 6-7:

1 An inline JCL procedure invokes the COBOL compiler. The caller must pass the library and member name for the copybook. Of course, you are free to put this procedure into your own PROCLIB instead of using an inline procedure.

2 Invoke the COBOL compiler with the ADATA option.

3 The input to the compiler is our copybook, wrapped into a dummy prefix and suffix to make it a valid COBOL program. So, the prefix contains dummy IDENTIFICATION and DATA DIVISIONs, and the suffix contains a dummy PROCEDURE DIVISION.

4 The SYSADATA output will be generated into a temporary dataset and passed to the subsequent steps.

5 Call the COBADATA cataloged procedure to invoke the COBOL compiler. You can process more than one copybook by simply duplicating this step and modifying it accordingly. The record generator will produce classes for each structure that it finds in SYSADATA.

6 This step invokes the Record Generator tool, using the JZOS batch launcher. The Record Generator will create one Java class for each copybook.
Note: If your installation does not have the JZOS batch launcher procedure (JVMPRC50) in the standard PROCLIB, you will have to add a JCLLIB statement after the jobcard.

7 The MAINARGS DD statement can be used to supply command-line arguments to a Java application, in this case, to the Record Generator.

8 This line is an option to the Record Generator to suppress generation of buffer offsets. For the full set of options supported by the Record Generator, refer to the documentation.

9 This line tells the Record Generator into which package to generate the record classes.

10 This line is the output directory for the generated classes.

11 This line references the SYSADATA data set produced by the COBOL compiler.

12 Set up the environment for the Java Virtual Machine (refer to the JZOS documentation for detailed information). You probably want to externalize this information into a partitioned data set (PDS) member; we used an instream dataset here just to be self-contained.

Now, import the generated Java file into the VsamAccessWebservice project. You can use FTP, or if you have RDz, you can use the “Import from remote file system” feature (select **File** → **Import** → **Other** → **Existing USS File Filter** or **File** → **Import** → **Other** → **Remote File System**. You need to have a definition for the remote system in advance.)

Next, we create the implementation for the CatalogAccess Web service (Example 6-8 on page 154). As you can see, the code is almost identical to the original generic VsamAccess service, except that instead of byte arrays, it deals with CatalogItems.

Also, as a slight variation, the VSAM file name is no longer passed as a parameter to each method call, but it will be configured when the Web service is deployed.

Example 6-8 The CatalogAccess Web service implementation

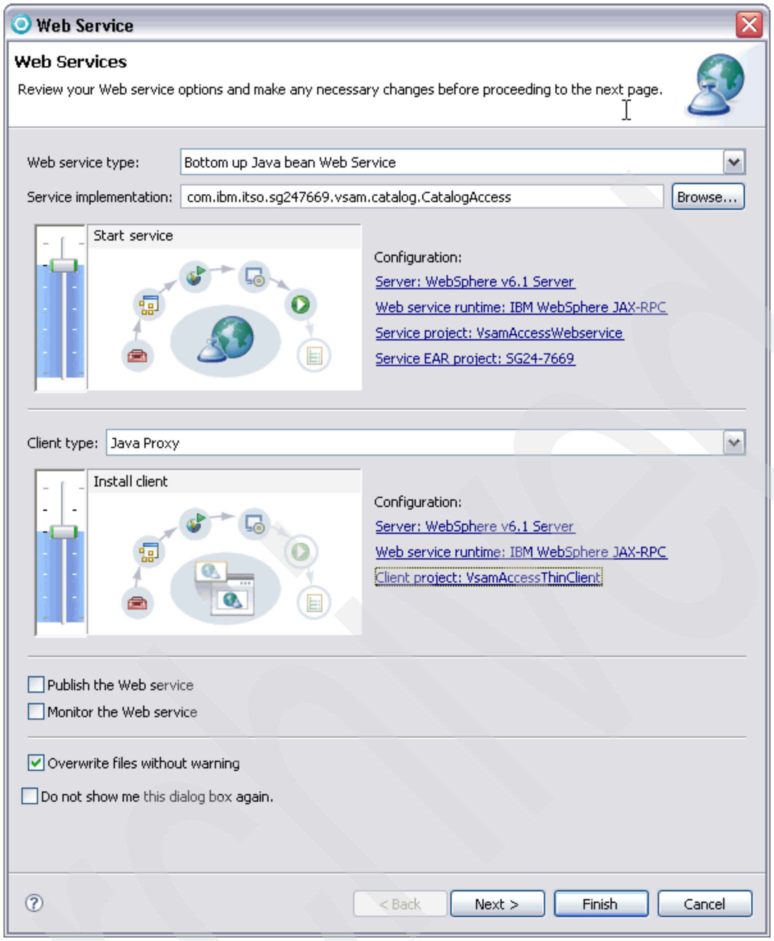
```
package com.ibm.itso.sg247669.vsam.catalog;

import java.io.IOException;
import java.util.ArrayList;
import java.util.List;

import javax.naming.Context;
import javax.naming.InitialContext;
import javax.naming.NamingException;

import com.ibm.itso.sg247669.vsam.VsamFile;

public class CatalogAccess {

   private String getFileName() throws NamingException {                1
      Context ctx = new InitialContext();
      return (String) ctx.lookup("java:comp/env/fileName");
   }

   public void insert(CatalogItem item) throws IOException, NamingException {
      VsamFile file = new VsamFile(getFileName());
      try {
         file.write(item.getByteBuffer());                                  2
      } finally {
         file.close();
      }
   }

   public void update(CatalogItem item) throws IOException, NamingException {
      [ ... implementation omitted ... ]
   }

   public boolean delete(int itemRef) throws IOException, NamingException {  3
      VsamFile file = new VsamFile(getFileName());
      try {
         CatalogItem item = new CatalogItem();                              4
         item.setWsItemRef(itemRef);
         return file.delete(item.getByteBuffer(),                           5
                       CatalogItem.WS_ITEM_REF.getOffset(),
                       CatalogItem.WS_ITEM_REF.getByteLength());
      } finally {
         file.close();
      }
   }

   public CatalogItem[] list(int itemRef, int maxRecords)
         throws IOException, NamingException {
      [ ... implementation omitted ... ]
   }
}
```

Notes on Example 6-8 on page 154:

1. We no longer expect the VSAM file name as a parameter on the service call. But rather than hard-coding it in the service implementation, we look it up in Java Naming and Directory Interface. We describe this step in more detail later.
2. To perform the actual insert operation, we have to convert the CatalogItem instance that was passed in as a parameter to a byte array. The generated code in the CatalogItem class handles all the conversion details for us.
3. The parameter to the `delete` method is just the item number (as opposed to a complete CatalogItem object).
4. We need to create a "dummy" CatalogItem object and set the item number on that object.
5. Now, we call the `VsamFile.delete()` method, using the dummy CatalogObject converted to a byte array. We use the three-argument version of `VsamFile.delete`, passing the offset and the length of the key field (`WS_ITEM_REF`). Each field in the original COBOL record has a corresponding static member field in the generated Java class that describes the field, including its offset from the beginning of the buffer, and its length.

Next, we use the Web service wizard again to create a Web service for the CatalogAccess implementation. This time, we tell the Web service wizard to also create a Java client for invoking the service from a stand-alone application.

The procedure is familiar by now: Select the service implementation (the CatalogAccess class), and select **Web services** → **Create Web Service**. Set the options as shown in Figure 6-15 on page 156. Note that we decided to also create the client proxy at this point into the VsamAccessThinClient project.


Web Service

Web Services

Review your Web service options and make any necessary changes before proceeding to the next page.

Web service type: Bottom up Java bean Web Service

Service implementation: com.ibm.itso.sg247669.vsam.catalog.CatalogAccess

Start service

Configuration:
Server: WebSphere v6.1 Server
Web service runtime: IBM WebSphere JAX-RPC
Service project: VsamAccessWebservice
Service EAR project: SG24-7669

Client type: Java Proxy

Install client

Configuration:
Server: WebSphere v6.1 Server
Web service runtime: IBM WebSphere JAX-RPC
Client project: VsamAccessThinClient

□ Publish the Web service
□ Monitor the Web service

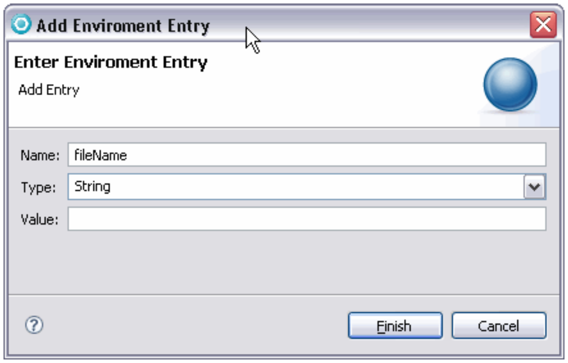
☑ Overwrite files without warning

□ Do not show me this dialog box again.

Figure 6-15 Creating the CatalogAccess Web service and client

After the wizard has finished, we need to modify the deployment descriptor of the Web module to create an *environment entry* that will hold the VSAM file name.

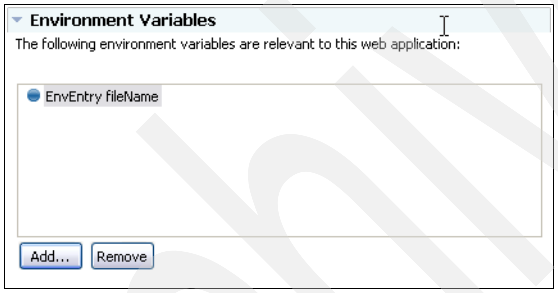
Open the deployment descriptor of **VsamAccessWebservice** (the `web.xml` file in the `WebContent/WEB-INF` folder). Switch to the **Environment** tab, find the Environment variables section and click **Add**. The Add Environment Entry dialog opens (Figure 6-16 on page 157). Enter the name of the environment entry, and select **String** as the variable type. We can add a default value in the Value entry field; in this example, we left it empty so we will have to specify a value after deployment. Click **Finish**.



Name: fileName
Type: String
Value:

Figure 6-16 Add an environment entry to the Web deployment descriptor

The new environment entry now shows up in the deployment descriptor, as shown in Figure 6-17.



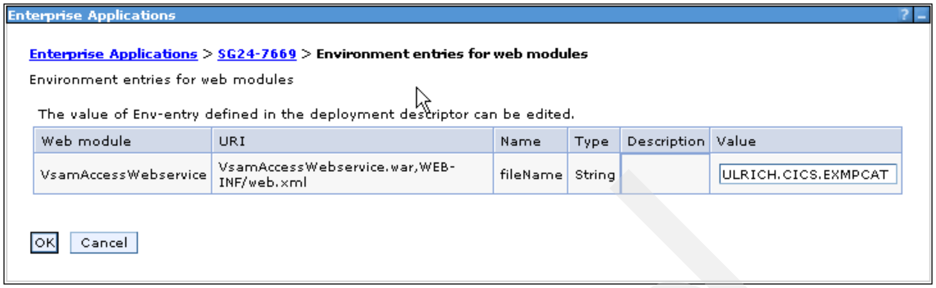
The following environment variables are relevant to this web application:

EnvEntry fileName

Figure 6-17 New environment entry

Save the deployment descriptor and wait until the application has successfully been published to WebSphere.

Now, we have to specify a value for the newly created environment entry. Open the WebSphere Application Server Integrated Console (select the server entry in the Servers view, right-click and select **Run administrative console**). Select **Applications** → **Enterprise Applications** and click **SG24-7669**. In the Web Module Properties section, click **Environment entries for web modules**. In the panel that appears, enter the file name of the VSAM file to be accessed by the CatalogAccess service (Figure 6-18 on page 158). Click **OK** and then click **Save** to apply the changes.



Enterprise Applications

Enterprise Applications > SG24-7669 > Environment entries for web modules

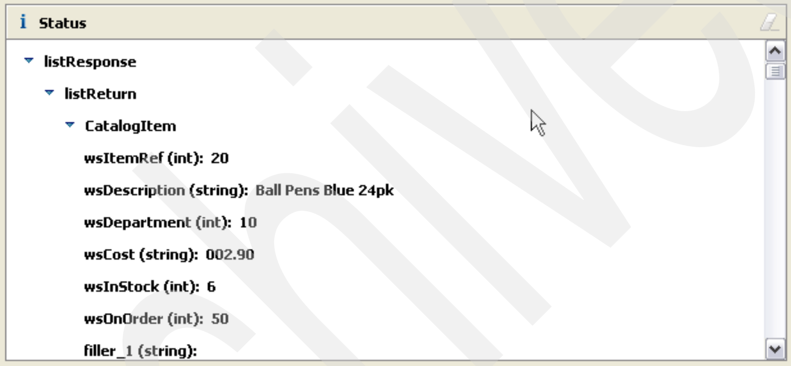
Environment entries for web modules

The value of Env-entry defined in the deployment descriptor can be edited.

Web module	URI	Name	Type	Description	Value
VsamAccessWebservice	VsamAccessWebservice.war,WEB-INF/web.xml	fileName	String		ULRICH.CICS.EXMPCAT

Figure 6-18 Specifying a value for the fileName environment variable

Now, you can test the new Web service using the Web Services Explorer, or you can create a stand-alone Java client as we just did. Figure 6-19 shows a partial response from invoking the list operation via the Web Services Explorer.



Status

- listResponse
  - listReturn
    - CatalogItem
      - wsItemRef (int): 20
      - wsDescription (string): Ball Pens Blue 24pk
      - wsDepartment (int): 10
      - wsCost (string): 002.90
      - wsInStock (int): 6
      - wsOnOrder (int): 50
      - filler_1 (string):

Figure 6-19 Response from CatalogAccess.list in Web Services Explorer

7

Exposing DB2 data as a service

In this chapter, we describe the steps that are involved in exposing DB2 data as a service.

7.1 Overview

While DB2 can act as a Web service requester (as we explain in Chapter 14, “Using DB2 as a Web service requester” on page 455), DB2 made a conscious decision to reuse the Web Services infrastructure that works well that is provided with products, such as WebSphere Application Server, WebSphere Message Broker, WebSphere DataPower, and so on, and focused on the Web Services to DB2 mapping instead of reimplementing everything from scratch.

DB2 development made a conscious decision to not start over, but to leverage the existing Web services infrastructure provided by application servers.

There are several alternatives for how that Web service actually accesses the database. They differ in the amount of coding necessary and in the tooling required:

- Using plain Java DataBase Connectivity (JDBC) or SQLJ
- Using *pureQuery*
- Using Entity EJBs (with either Container-Managed (CMP) or Bean-Managed persistence (BMP))
- Using *Data Web Services (DWS)*

> **Note:** In this section, we focus on exposing DB2 data (in the form of queries) as a service, as opposed to DB2 business logic (in the form of stored procedures). As mentioned elsewhere in this book, this section might be a good starting point, but it is somewhat questionable from an architectural point of view.
>
> In an ideal world (at least from a DB2 point of view), your business logic is already neatly encapsulated behind stored procedures; in fact, the main design point of DWS is to expose stored procedures.

7.2 Using Data Web Services (DWS)

Probably the easiest way to expose DB2 data and business logic as a Web service is using the *Data Web Services (DWS)* feature of IBM Data Studio Developer.

In this section, we use the following tools:

- IBM Data Studio Developer, Version 1.2 for development
- WebSphere Application Server as the Web service hosting environment

Note: We installed Data Studio Developer by extending the existing Rational Developer for System z installation in order to avoid having to switch between tools.

We wrote this book using Version 1.2 of Data Studio Developer. Meanwhile, Version 2.1 has been made generally available. Version 2.1 can be combined with Rational Developer for System z Version 7.5.0.1. For information about the latest release of Data Studio, refer to:

`http://www.ibm.com/software/data/studio/`

7.2.1 Data Web Services

Data Web Services (DWS) is a new solution to significantly ease the development, deployment, and management of Web services-based access to DB2. DWS lets you take Data Manipulation Language (DML) statements (such as SELECT, INSERT, UDATE, DELETE, XQuery, and, last but not least, stored procedure calls) and generate Web services from these statements without writing a single line of code. The generated Web services are packaged as a ready-to-deploy Web application (as a .war file), which can easily be deployed to supported application servers.

Highlights of DWS include:

- Creating Web services using DWS requires no programming.

  DWS lets you create Web services using a drag-and-drop interface.

- DWS supports SOAP over HTTP and Web Services Description Language (WSDL) generation.

  DWS automatically generates a WSDL file that contains a description of the Web service.

- No code generation.

  DWS consists of a common metadata-driven run time, and there is no “black box” code that gets generated “under the covers,” which results in a reliable and lightweight application.

7.2.2 Introduction to the example

In this example, we show how to create a simple service that allows clients to query and update one of the sample tables that are part of the DB2 installation.

If the DB2 sample tables are not installed on your system, or if you are not authorized to access them, refer to “DDL to create the DEPT sample table” on page 483.

Note: In this example, we show how you can use Data Studio by building a simple query on a DB2 table and generating a Web service from that query. Technically, this approach is good, but from an architectural point of view, it is more likely that you will choose to Web service-enable stored procedures.

7.2.3 Setting up the connection to DB2

If you have not already configured your connection to DB2:

1. Open the Data Perspective (**Window** → **Open Perspective** → **Data**).
2. In the Database Explorer view, right-click **Connections** and select **New Connection**.
3. Depending on the DB2 version that you want to use for this sample, expand either DB2 for Linux, Unix, or Windows or DB2 for z/OS. Select **All Versions**.
4. Enter the details for the connection, depending on the type of database. For DB2 for z/OS, you need to enter the location name, the host name of the DB2 server, and the distributed data facility (DDF) port number.

   Tip: An easy way to find out the values for your installation of DB2 for z/OS is to search for messages DSNL519I and DSNL004I in the DB2 MSTR address space or to issue the -DIS DDF DB2 command.

   Additionally, you have to configure the location of the two Jar files that contain the JCC driver and the driver license file. If the Jar files are not already on your workstation, you can download them (via FTP, for example) from the DB2 installation directory on the host (typically, `/usr/lpp/db2/db2/db2910/jdbc/classes`).

   Because we are going to access the DB2 sample tables, we need to remove the check from “Retrieve objects created by this user only.”
5. In the bottom left part of the dialog, enter the user name and password. Click **Test Connection** to verify. If the connection test was successful, click **Next**.
6. Because a DB2 for z/OS subsystem typically contains a large number of objects, we want to restrict the list to only those objects in which we are interested. So, on the next panel, we can specify a filter to only show objects in the DSN8910 schema. Click **Selection**, and in the list of available schema names, check **DSN8910**. Click **Finish**.

The new connection now shows up in the Database Explorer view. Expand the tree up to the Schemas level; you will see the DSN8910 schema.

> **Important:** IBM Data Studio relies on the use of a set of DB2 stored procedures to extract information from the DB2 catalog. If these procedures are not installed, you will get an SQLException when trying to establish the connection. For details and instructions, refer to:
>
> `http://www.redbooks.ibm.com/abstracts/redp4510.html?Open`

7.2.4 Creating the SQL statement

Now, we are ready to build an SQL statement. First, we need to create a new Data Development project. In the Data Project Explorer Tab, right-click and select **New** → **Data Development Project**. Enter `Employee` as the project name. Leave the other settings as is, and click **Next**. On the next window, select **Use an existing connection** and select the connection that you created in the previous step.

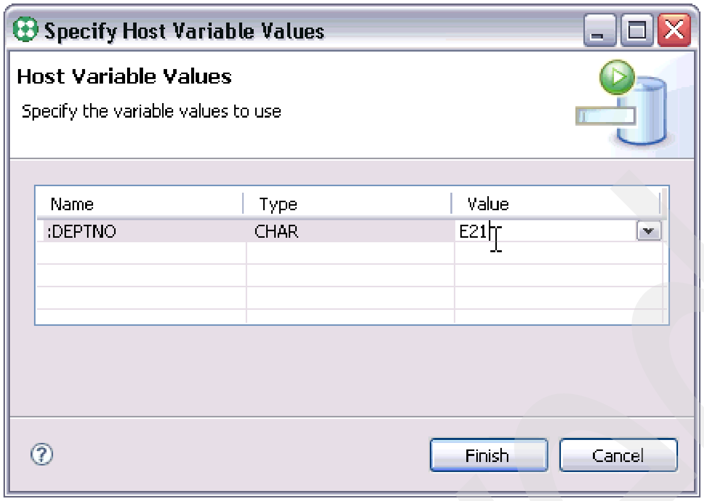
Next, we are going to build the SQL statement. In the Data Project Explorer, expand the newly created project and select **SQL Scripts**. Right-click and select **New** → **SQL Statement**. Enter `getDepartment` in the Statement name field. Depending on your preferences, you can choose to write the SQL statement manually (select **Edit using SQL editor**) or interactively (select **Edit using SQL builder**). The SQL builder is straightforward to use, and although the SQL that we are going to write is quite trivial, we encourage you at this point to try to use it.

Either way, the SQL eventually looks like Example 7-1.

Example 7-1 SQL for department lookup by department number

```
SELECT DEPTNAME, MGRNO
  FROM DSN8910.DEPT
 WHERE DEPTNO = :DEPTNO
```

Now is a good time to test the statement. In the SQL editor pane, right-click and select **Run SQL**. Because the SQL contains a host variable, the tool now prompts you to specify a value for that host variable (Figure 7-1 on page 164). Enter `E21` or any other value that appears in the DEPTNO column of the table, and click **Finish**. You see the result of running the query in the Data Output view.



Specify Host Variable Values
Host Variable Values
Specify the variable values to use

Name	Type	Value
:DEPTNO	CHAR	E21

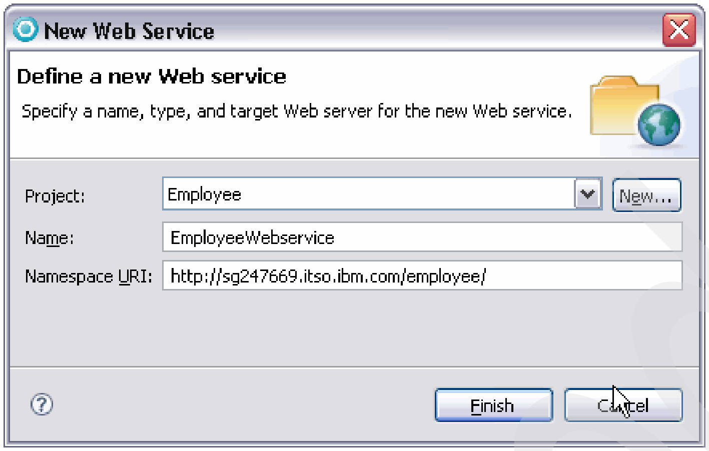
Figure 7-1 Specify host variable values

7.2.5 Creating a Web service from the query

At this point, we are ready to create a new Web service for the query. The new Web service will have one operation, which is the query that we just created, with one parameter, which is the variable part of the statement (the :DEPTNO host variable).The steps are:

1. Right-click the **Web Services folder** in the Data Project Explorer, and select **New Web Service**. In the dialog that opens, enter `EmployeeWebservice` as the Web service name and `http://sg247669.itso.ibm.com/employee/` as the Namespace URI (Figure 7-2 on page 165). Click **Next**.

   Note: The namespace URI serves to avoid name clashes between XML element names. Although it looks like something that can be accessed via HTTP, it is not (necessarily) the case; it is just meant to be a string that is unique.



New Web Service

Define a new Web service

Specify a name, type, and target Web server for the new Web service.

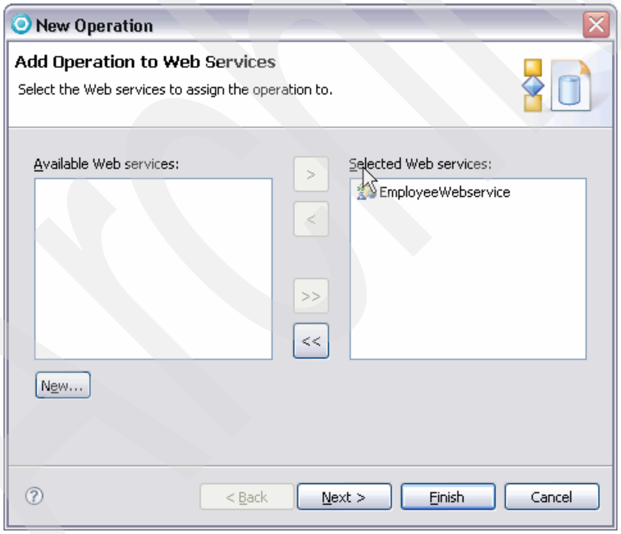
Project: Employee

Name: EmployeeWebservice

Namespace URI: http://sg247669.itso.ibm.com/employee/

Figure 7-2 Define new Web service

2. Now, right-click the SQL statement, **getDepartment.sql**, and select **Add to Web Service**. Select the Web service and click the top button (**>**) to move it from the **Available Web services** to the **Selected Web services list box** (Figure 7-3). Click **Next**.



New Operation

Add Operation to Web Services

Select the Web services to assign the operation to.

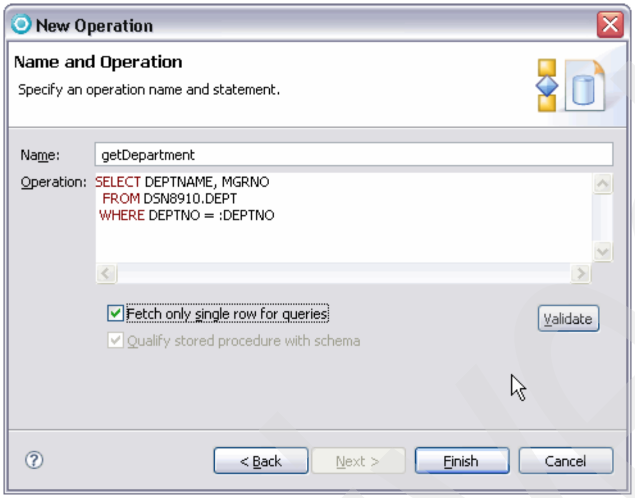
Available Web services:

Selected Web services:
EmployeeWebservice

Figure 7-3 Add SQL script to existing Web service

3. Because the query will return at most one result, we check **Fetch only single row for queries** on the next window (Figure 7-4 on page 166). This setting has an impact on the generated WSDL: It will be much simpler because in the response element, we will have just a complex type consisting of two simple

types rather than an unbounded sequence of that complex type. The simpler WSDL in turn affects language binding generation (refer to 12.4, “Generating the CICS artifacts” on page 395).



Specify an operation name and statement.

Name: getDepartment

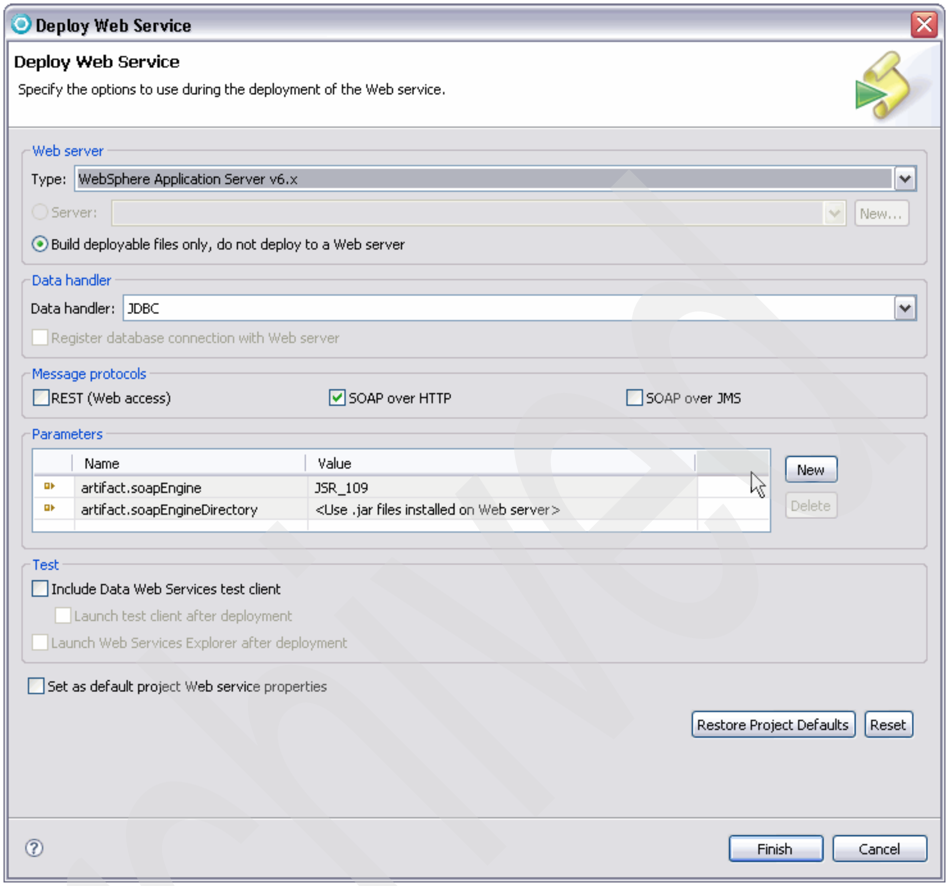
Operation:
```
SELECT DEPTNAME, MGRNO
 FROM DSN8910.DEPT
WHERE DEPTNO = :DEPTNO
```

☑ Fetch only single row for queries

☑ Qualify stored procedure with schema

Figure 7-4   Fetch only single row for queries

4. The next step is to build the Web service. Right-click **EmployeeWebservice*** (the asterisk indicates that the Web service was modified since the last deployment operation) and select **Build and Deploy**. In the following dialog, specify the options to use as shown in Figure 7-5 on page 167. Be sure to select **WebSphere Application Server v6.x** as the Web Server type. Click **Finish**.



Deploy Web Service

Deploy Web Service

Specify the options to use during the deployment of the Web service.

Web server

Type: WebSphere Application Server v6.x

○ Server:

● Build deployable files only, do not deploy to a Web server

Data handler

Data handler: JDBC

□ Register database connection with Web server

Message protocols

□ REST (Web access) ☑ SOAP over HTTP □ SOAP over JMS

Parameters

Name	Value
artifact.soapEngine	JSR_109
artifact.soapEngineDirectory	<Use .jar files installed on Web server>

Test

□ Include Data Web Services test client

□ Launch test client after deployment

□ Launch Web Services Explorer after deployment

□ Set as default project Web service properties

Figure 7-5 Prepare Web service for deployment

5. In the Data Project Explorer view, expand the XML folder and its WSDL subfolder. You now see that a WSDL file for our new Web service has been created.

> **Note:** We did not generate bindings for the REST binding, because that does not really add any useful functionality for this scenario (it adds support for HTTP GET invocation, thus allowing browser-based access).
>
> We do not explain the SOAP over JMS method in this book, but if you want to experiment with it, be aware of a minor bug in the DWS tooling (you will see compilation errors in the generated code due to missing libraries on the compiler classpath). Refer to 7.4, “Troubleshooting” on page 175 for the work-around.

7.2.6 Installing the Web service in WebSphere Application Server

Go back to either the Java 2 Platform, Enterprise Edition (J2EE) or the Java perspective. You will see that our new Web service was automatically made available as a dynamic Web project named `EmployeeEmployeeWebserviceWeb`.

To install the Web service in WebSphere Application Server, simply drag the Web project onto the deployment descriptor of the EAR project (Figure 7-6).

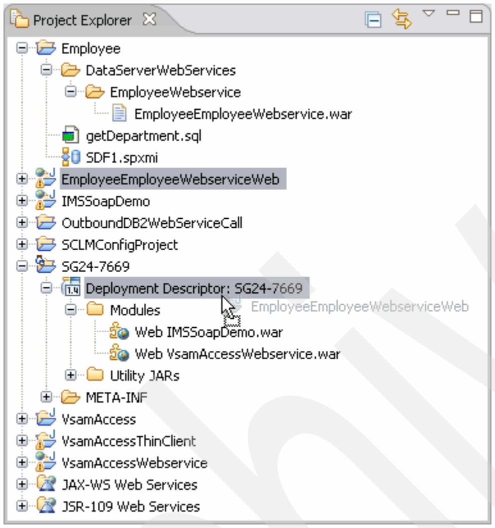


Figure 7-6 Adding the Employee Web service project to the EAR project

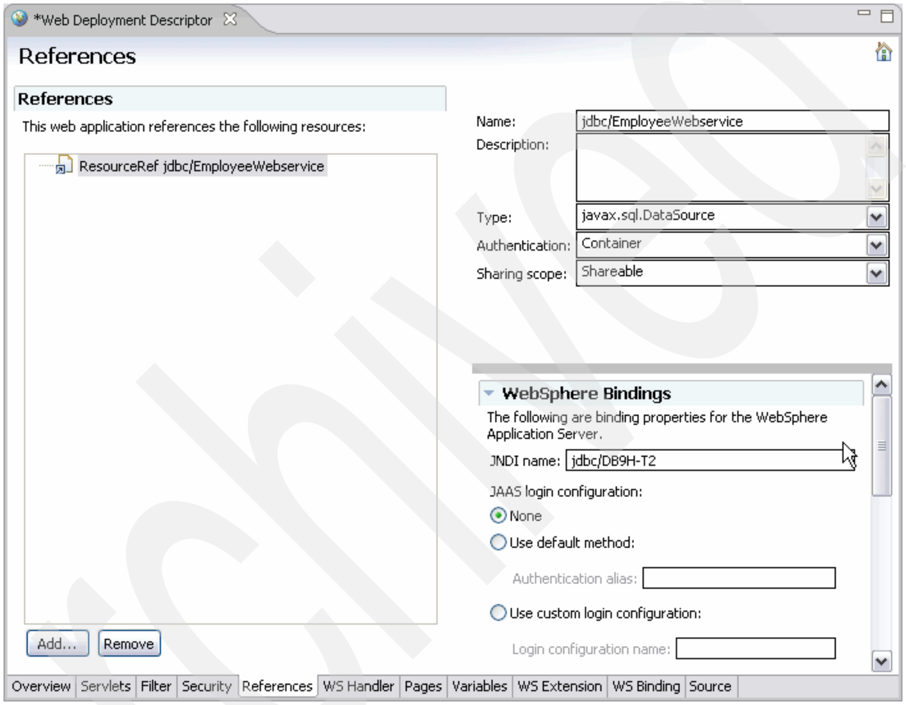
There is one final thing to do before the application can successfully run on WebSphere. Maybe you noticed the yellow warning sign next to the `EmployeeEmployeeWebserviceWeb` project. Looking at the Problems view, we see the message:

```
CHKJ2877W: Missing JNDI name for reference jdbc/EmployeeWebservice
```

This message indicates that DWS is going to access the database using a datasource with the JDBC name `jdbc/EmployeeWebservice`. We have to map that resource reference to an existing datasource configured in WebSphere either after deployment (via the WebSphere Application Server Integrated Console), or you can specify a default binding in the IBM WebSphere extension deployment descriptor. To do the latter, we have to enable that functionality first. Right-click the Web project and select **Properties**. Highlight **Project Facets** and click **Add/Remove Project Facets**. Check **WebSphere Web (Co-existence)** and make sure that **6.1** is selected in the list box. Click **Finish**, and then click **OK** to close the properties dialog.

Now, open the deployment descriptor of the Web project and change to the References pane. Highlight the resource reference, and enter the Java Naming and Directory Interface (JNDI) name of an existing datasource in the WebSphere Bindings section (Figure 7-7).

> **Note:** Without adding the WebSphere project facet, the WebSphere Bindings section is missing from the References pane.



*Web Deployment Descriptor

References

References

This web application references the following resources:

ResourceRef jdbc/EmployeeWebservice

Name: jdbc/EmployeeWebservice

Description:

Type: javax.sql.DataSource

Authentication: Container

Sharing scope: Shareable

WebSphere Bindings

The following are binding properties for the WebSphere Application Server.

JNDI name: jdbc/DB9H-T2

JAAS login configuration:

● None

○ Use default method:

Authentication alias:

○ Use custom login configuration:

Login configuration name:

Figure 7-7 Configuring a default WebSphere binding for the datasource reference

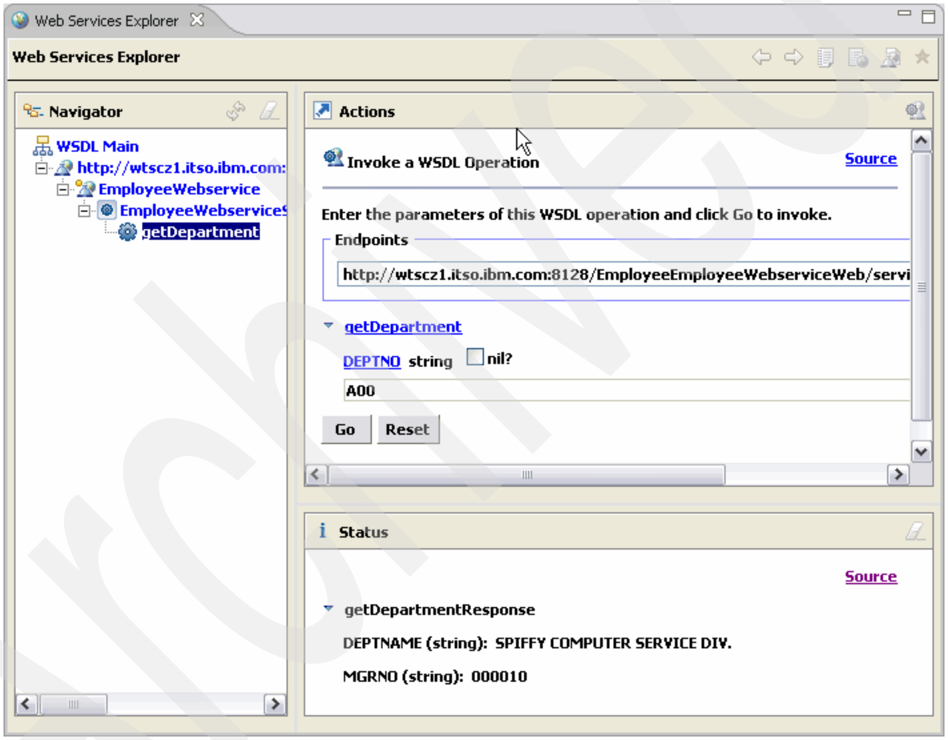
The application is now ready for installation on WebSphere. Right-click the application in the Servers view, and click **Publish**.

7.2.7 Testing the Web service

To test the Web service, go back to the Workbench. From the menu bar, select **Run** → **Launch the Web Services Explorer**. The Web Service Explorer window will now open with an icon bar and three panes: Navigator, Actions, and Status. In the icon bar, click the **WSDL page** icon. In the WSDL URI field, enter the following URI:

```
http://host.name:port/EmployeeEmployeeWebserviceWeb/services/EmployeeWe
bservice?WSDL
```

The *host.name* is the host name of your WebSphere Application Server server, and *port* is the HTTP Transport port for the default_host virtual host. Click **Go**. The Web Services Explorer now retrieves the WSDL document from WebSphere Application Server, parses it, and updates the Navigator pane to show the services that are declared in that WSDL, and their binding and operation details. Expand the tree in the Navigator pane and click the **getDepartment** operation. The Action pane now allows you to specify the parameters for the getDepartment operation. Enter `A00` and click **Go**. You see output similar to Figure 7-8.



Enter the parameters of this WSDL operation and click Go to invoke.

http://wtscz1.itso.ibm.com:8128/EmployeeEmployeeWebserviceWeb/servi

DEPTNO string □ nil?

A00

```
getDepartmentResponse
DEPTNAME (string): SPIFFY COMPUTER SERVICE DIV.
MGRNO (string): 000010
```

Figure 7-8 Invoking the Web service via the Web Services Explorer

To see the actual SOAP response XML document, click **Source** in the Status pane. You will see both the SOAP request and SOAP response documents (Examples Example 7-2 on page 171 and Example 7-3 on page 171).

> **Note:** For better readability, the example documents have been slightly reformatted.

Example 7-2 SOAP request document

```
<?xml version="1.0" encoding="UTF-8" ?>
<soapenv:Envelope xmlns:q0="http://sg247669.itso.ibm.com/employee/"              1
                  xmlns:soapenv="http://schemas.xmlsoap.org/soap/envelope/"
                  xmlns:xsd="http://www.w3.org/2001/XMLSchema"
                  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
  <soapenv:Body>                                                                  2
    <q0:getDepartment>
      <DEPTNO>A00</DEPTNO>
    </q0:getDepartment>
  </soapenv:Body>
</soapenv:Envelope>
```

Notes on Example 7-2:

1 The XML namespace declaration is for the application-specific parts of the SOAP response. The namespace URI, `http://sg247669.itso.ibm.com/employee/`, is the one that we assigned earlier when we created the Web service. Note that the Web service explorer uses a randomly generated prefix, `q0` in this case, to refer to that namespace.

2 This name is the SOAP body element. This next part is the application-specific part of the request. Note that unprefixed elements (`DEPTNO`) inherit the namespace from their immediate parent, in this case, from `getDepartment`.

Example 7-3 SOAP response document

```
<soapenv:Envelope xmlns:soapenc="http://schemas.xmlsoap.org/soap/encoding/"
                  xmlns:soapenv="http://schemas.xmlsoap.org/soap/envelope/"
                  xmlns:xsd="http://www.w3.org/2001/XMLSchema"
                  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
  <soapenv:Header />
  <soapenv:Body>
    <ns1:getDepartmentResponse xmlns:ns1="http://sg247669.itso.ibm.com/employee/"     1
                               xmlns=""
                               xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
      <DEPTNAME>SPIFFY COMPUTER SERVICE DIV.</DEPTNAME>                                2
      <MGRNO>000010</MGRNO>
    </ns1:getDepartmentResponse>
  </soapenv:Body>
</soapenv:Envelope>
```

Notes on Example 7-3 on page 171:

1 Just as in the SOAP request, we have namespace declaration for the application-specific part of the response. The SOAP engine generated a random namespace prefix to refer to our application namespace, in this case, `ns1`.

2 This part is the application-specific part of the response.

Note: We occasionally received the following SQL error when trying to invoke the service after a few minutes of idle time:

```
SQL State = null SQL Code = -4499 SQL Message =
[ibm][db2][jcc][t4][2030][11211] A communication error has been
detected. Communication protocol being used: TCP/IP.

Communication API being used: SOCKETS.  Location where the error
was detected: T4Agent.sendRequest().

Communication function detecting the error: OutputStream.flush().
Protocol specific error codes Software caused connection abort:
socket write error, *, 0.  Message: Software caused connection
abort: socket write error Exception message =
com.ibm.db2.jcc.c.DisconnectException:
[ibm][db2][jcc][t4][2030][11211] A communication error has been
detected. Communication protocol being used: TCP/IP.
```

The next attempt after this error was then successful again.

We found that the reason for this problem was an unrecommended ZPARM setting in our DB2 installation: the CMTSTAT parameter was set to ACTIVE. Refer to 7.4, “Troubleshooting” on page 175 for details.

7.2.8 Additional activities

At this point, feel free to explore the DWS tooling by creating additional operations. For example, you can create an SQL statement to update department or employee data, and add that SQL statement to the existing Web service as a new operation.

7.3 Exposing a DB2 stored procedure as a service

In this section, we show how to expose a DB2 stored procedure as a Web service. Again, we use DWS and Data Studio. As you will see, this task is just as easy as exposing SQL statements; in fact, the steps are very much the same.

7.3.1 Creating the stored procedure

The stored procedure that we use in this example calculates an employee's bonus, subject to a base bonus, a rating (1 = excellent to 4 = poor), and the number of years that the employee has been with the company.

In our Employee project in RDz/Data Studio, right-click **Stored Procedures** and select **New** → **Stored Procedure**. Because we are not going to build the procedure interactively but will simply paste the SQL, you can type any value in the Name field. From the Language drop-down list, select **SQL-Native**. Click **Finish**. In the editor window that opens, replace the text with the code in Example 7-4, and then, save the file.

Example 7-4 Sample stored procedure for bonus calculation

```
CREATE PROCEDURE CALCULATE_BONUS
  (  IN EMP_NO     CHAR(6)
  ,  IN BASE_BONUS DECIMAL(9, 2)
  ,  IN RATING     SMALLINT
  , OUT EMP_BONUS  DECIMAL(9, 2)
  )
  LANGUAGE SQL
  MODIFIES SQL DATA
  QUALIFIER DSN8910
  WLM ENVIRONMENT FOR DEBUG MODE DB9HWLM5
BEGIN
  DECLARE YEARS_WITH_COMPANY SMALLINT;

  -- Calculate bonus depending on rating
  CASE RATING
    WHEN 1 THEN                          -- High performer
      SET EMP_BONUS = BASE_BONUS * 1.30;
    WHEN 2 THEN                          -- Average
      SET EMP_BONUS = BASE_BONUS;
    WHEN 3 THEN                          -- Below Average
      SET EMP_BONUS = BASE_BONUS * 0.80;
    WHEN 4 THEN                          -- Loser
      SET EMP_BONUS = 0;
    ELSE
      SIGNAL SQLSTATE 'EMP99'
         SET MESSAGE_TEXT = 'Invalid rating';
  END CASE;

  -- Extra bonus for every 10 years with the company
  SELECT YEAR(CURRENT DATE) - YEAR(HIREDATE)
```

```
    INTO YEARS_WITH_COMPANY
    FROM EMP
   WHERE EMPNO = EMP_NO;
  IF MOD(YEARS_WITH_COMPANY, 10) = 0 THEN
    SET EMP_BONUS = EMP_BONUS + 1000;
  END IF;

  -- Record bonus in database
  UPDATE EMP SET BONUS = EMP_BONUS
   WHERE EMP.EMPNO = EMP_NO;
END
```

The new procedure shows up in the Stored Procedures folder. Select it, right-click and select **Deploy** (Figure 7-9). Data Studio will install the procedure in DB2, and we are ready for the next step.

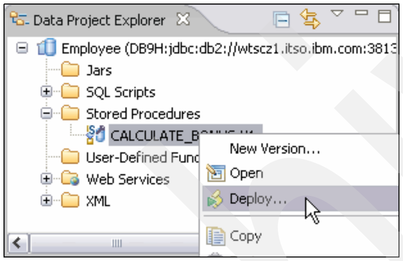


Figure 7-9 Deploying the stored procedure to DB2

7.3.2 Creating a Web service for the stored procedure

Now, creating a Web service that exposes the stored procedure is extremely easy. Highlight the procedure in the Stored Procedures folder, select **Add to Web Service** and go through the wizard that opens. Or simply expand the existing Web Services folder, and drag and drop the procedure to our EmployeeWebservice as we show in Figure 7-10 on page 175.

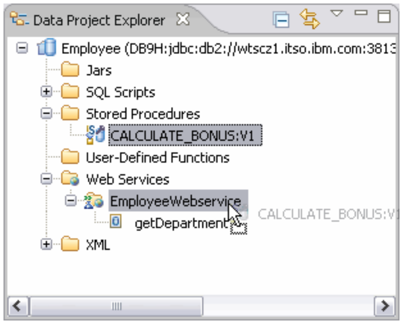


Figure 7-10 Drag and drop stored procedure to add it to the Web service

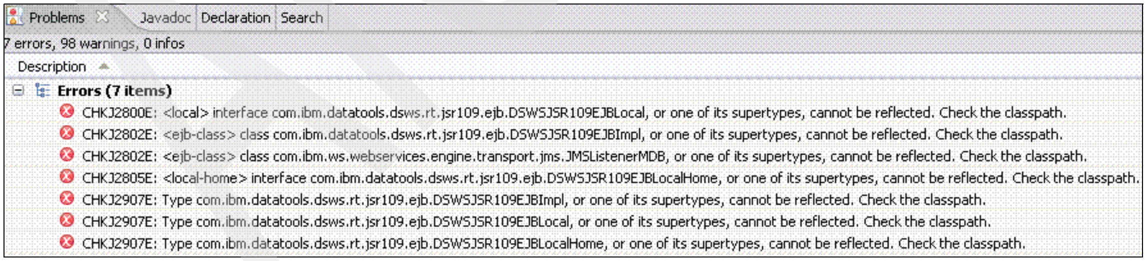
For consistency, rename the operation to `calculateBonus` by highlighting it and selecting **Rename**. Finally, to install the updated service, follow the steps described in 7.2.6, “Installing the Web service in WebSphere Application Server” on page 168.

7.4 Troubleshooting

This section describes work-arounds for problems that we ran into when developing the samples in this chapter.

7.4.1 Errors in generated code for SOAP over JMS binding

If you tried to generate code for SOAP over JMS binding in 7.2.5, “Creating a Web service from the query” on page 164, you might have received compilation errors in the generated code (Figure 7-11).

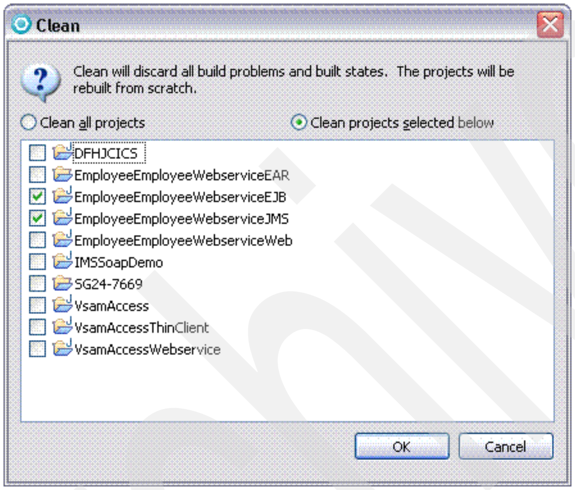


```
CHKJ2800E: <local> interface com.ibm.datatools.dsws.rt.jsr109.ejb.DSWSJSR109EJBLocal, or one of its supertypes, cannot be reflected. Check the classpath.
CHKJ2802E: <ejb-class> class com.ibm.datatools.dsws.rt.jsr109.ejb.DSWSJSR109EJBImpl, or one of its supertypes, cannot be reflected. Check the classpath.
CHKJ2802E: <ejb-class> class com.ibm.ws.webservices.engine.transport.jms.JMSListenerMDB, or one of its supertypes, cannot be reflected. Check the classpath.
CHKJ2805E: <local-home> interface com.ibm.datatools.dsws.rt.jsr109.ejb.DSWSJSR109EJBLocalHome, or one of its supertypes, cannot be reflected. Check the classpath.
CHKJ2907E: Type com.ibm.datatools.dsws.rt.jsr109.ejb.DSWSJSR109EJBImpl, or one of its supertypes, cannot be reflected. Check the classpath.
CHKJ2907E: Type com.ibm.datatools.dsws.rt.jsr109.ejb.DSWSJSR109EJBLocal, or one of its supertypes, cannot be reflected. Check the classpath.
CHKJ2907E: Type com.ibm.datatools.dsws.rt.jsr109.ejb.DSWSJSR109EJBLocalHome, or one of its supertypes, cannot be reflected. Check the classpath.
```

Figure 7-11 Compilation errors when generating the SOAP over JMS binding

This issue is due to a minor bug in the DWS tooling, which can easily be handled. We need to manually add the WebSphere libraries to the compile classpath of both the Enterprise Java Bean (EJB™) and the JMS project:

1. Open the property settings for the EJB project, select **Java Build Path** and click **Add Library**. In the dialog that opens, select **Server Runtime** and click **Next**. Select **WebSphere Application Server v6.1** and click **Finish**. Finally, click **OK** to close the properties dialog.
2. Perform the same steps for the generated JMS project.
3. Finally, rebuild the two projects. **Select Project** → **Clean**, check both projects, and click **OK** (Figure 7-12). The compilation errors are now gone.



Clean will discard all build problems and built states. The projects will be rebuilt from scratch.

○ Clean all projects ● Clean projects selected below

□ DFHJCICS
□ EmployeeEmployeeWebserviceEAR
☑ EmployeeEmployeeWebserviceEJB
☑ EmployeeEmployeeWebserviceJMS
□ EmployeeEmployeeWebserviceWeb
□ IMSSoapDemo
□ SG24-7669
□ VsamAccess
□ VsamAccessThinClient
□ VsamAccessWebservice

Figure 7-12 Rebuilding the projects after correcting the classpath.

7.4.2 Stale connection when DWS uses a Type 4 connection

As mentioned in 7.2.6, “Installing the Web service in WebSphere Application Server” on page 168, we saw SQL errors indicating a stale connection when trying to invoke a DWS-generated Web service after idle time and when the application was bound to a data source using a Type 4 JDBC connection.

We found that the reason for this kind of error was an unrecommended ZPARM setting: The CMTSTAT parameter was set to ACTIVE in our DB2 system, which disables thread pooling in the DDF address space. With this setting, DDF will cancel each thread that has been idle for at least IDTHTOIN (“Idle Thread Timeout”) seconds, unless IDTHOIN is set to zero which, you guessed it, is also not recommended.

Refer to *Distributed Functions of DB2 for z/OS and OS/390*, SG24-6952 for an in-depth discussion of these parameters.

7.5 Sample material

Refer to Appendix B, “Additional material” on page 485 for instructions on obtaining the workspace with the sample code.

You may also have to refer to Appendix A, “Defining data used in samples” on page 481 for information on defining the DB2 DEPT table.

8

Exposing IMS data as a service

In this chapter, we describe the steps that are involved in exposing IMS data as a service.

8.1 Introduction

In this example, we show how IMS databases can be accessed directly from a Java 2 Platform, Enterprise Edition (J2EE) environment in WebSphere Application Server for z/OS, hence, giving you the option to create a Web service. IMS Transaction Manager and IMS Connect are not used in this scenario.

You can write Java applications that run in WebSphere Application Server for z/OS and access IMS databases directly when WebSphere Application Server for z/OS and IMS are on the same logical partition (LPAR).

To deploy an application to WebSphere Application Server for z/OS, you must install the IMS DB Resource Adapter (the Java class libraries for IMS) in WebSphere Application Server for z/OS and configure both *IMS Open Database Access (ODBA)* and the *Database Resource Adapter (DRA)*.

Java Database Connectivity (JDBC) or the IMS hierarchical database interface for Java calls is passed to the IMS DB Resource Adapter, which converts the calls to DL/I calls. The IMS DB Resource Adapter passes these calls to *Open DataBase Access (ODBA)*, which uses the database resource adapter (DRA) to access the DL/I region in IMS.

8.2 Steps

To use the IMS DB Resource Adapter with WebSphere Application Server for z/OS, you will follow these steps (which we will describe in detail):

1. IMS setup

   To use the IMS DB Resource Adapter to access IMS DB from WebSphere Application Server for z/OS, you first must configure WebSphere Application Server for z/OS to access IMS databases using ODBA. ODBA uses the Database Resource Adapter (DRA) to access IMS databases.

2. WebSphere Application Server for z/OS setup

   This section assumes that you are familiar with WebSphere Application Server Version 6 for z/OS and its WebSphere Application Server Integrated Console:

   - WebSphere Application Server for z/OS Servant Region STEPLIB
   - Installing the IMS DB Resource Adapter
   - Installing the custom service

3. Running the IMS Installing Verification Program (IVP) for the WebSphere Application Server for z/OS Java environment

   This topic provides the high-level tasks required to run the IMS IVP applications for the WebSphere Application Server for z/OS Java environment:

   – Installing the data source for the IMS IVP application

   – Installing the IMS IVP application

   – Testing the IMS IVP application

4. Generating IMS database metadata by using the IMS DLIModel utility

   In order for a Java application to access an IMS database, it needs information about that database. The DLIModel utility allows you to transform your IMS database information (program specification blocks, database descriptions, and COBOL copybooks) into application independent metadata:

   – Creating a DLIModel Project

   – Importing a COBOL copybook

5. Running your application on WebSphere Application Server for z/OS:

   – Installing the data source for your application

   – Deploying your application to WebSphere Application Server for z/OS

8.3 IMS Setup

To use the IMS DB Resource Adapter to access the IMS DB from WebSphere Application Server for z/OS, you must first configure WebSphere Application Server for z/OS to access IMS databases using ODBA. ODBA uses the *Database Resource Adapter (DRA)* to access IMS databases.

To configure WebSphere Application Server for z/OS to access IMS databases, perform the following tasks:

1. If not already done, create a DRA startup table. The DRA startup table module name must have the following naming convention:

   – Bytes 1-3: “DFS”

   – Bytes 4-7: 1-byte to 4-byte ID

     Recommendation: The 1-byte to 4-byte ID must be the IMS system ID.

   – Byte 8: “0”

   Example 8-1 on page 182 shows an example of the DRA startup table.

Example 8-1 The DRA startup table (example)

```
DFSIMSA0 CSECT
*
         DFSPRP DSECT=NO,                                              X
               CNBA=20,                :total FP NBA buffers           X
               DBCTLID=IMSA,           :name of DB or DB/DC region     X
               DDNAME=ODBADD,          :ddname with dynalloc IMS DB libX
               DSNAME=IMS10A.SDFSRESL, :dataset name of IMS DB lib     X
               FPBOF=3,                :the number of FP OBA per threadX
               FPBUF=5,                :the number of FP NBA per threadX
               FUNCLV=1,               :the DRA level                  X
               IDRETRY=0,              :the number of retry IDENTIFY   X
               MAXTHRD=10,             :the maximam number of DRA thrd X
               MINTHRD=10,             :the minimum number of DRA thrd X
               SOD=T,                  :SNAP DUMP sysout class         X
               TIMER=60                :the time btw attempts of DRA
*
         END
```

2. If not already done, link the DRA startup table into a load library. The skeleton JCL that you need to perform this task is shown in Example 8-2.

Example 8-2 The DRA startup table assemble JCL (sample)

```
//ITSOAM1A JOB (999,POK),'ITSOAM1',NOTIFY=&SYSUID,
//    CLASS=A,MSGCLASS=H,TIME=1439,
//    REGION=5000K,MSGLEVEL=(1,1)
//ASMLK  PROC  MBR=TEMPNAME,SOUT=H,RGN=512K,SYS2=
//C   EXEC  PGM=ASMA90,REGION=&RGN,PARM='OBJECT,NODECK'
//SYSLIB   DD  DSN=IMS10A.&SYS2.SDFSMAC,DISP=SHR
//         DD  DSN=SYS1.MACLIB,DISP=SHR
//SYSLIN   DD  UNIT=SYSDA,DISP=(,PASS),
//             SPACE=(80,(100,100),RLSE),
//             DCB=(BLKSIZE=80,RECFM=F,LRECL=80)
//SYSPRINT DD  SYSOUT=&SOUT,DCB=BLKSIZE=1089,
//             SPACE=(121,(300,300),RLSE,,ROUND)
//SYSUT1   DD  UNIT=SYSDA,DISP=(,DELETE),
//             SPACE=(CYL,(10,5))
//L      EXEC  PGM=IEWL,PARM='XREF,LIST',COND=(0,LT,C),REGION=512K
//SYSLIN   DD  DSN=*.C.SYSLIN,DISP=(OLD,DELETE)
//SYSPRINT DD  SYSOUT=&SOUT,DCB=BLKSIZE=1089,
//             SPACE=(121,(90,90),RLSE)
//SYSLMOD  DD  DSN=IMS10A.&SYS2.SDFSRESL(&MBR),DISP=SHR
//SYSUT1   DD  UNIT=(SYSDA,SEP=(SYSLMOD,SYSLIN)),
//           SPACE=(1024,(100,10),RLSE),DISP=(,DELETE)
//  PEND
//  EXEC ASMLK,MBR=DFSIMSA0,SOUT=H
//C.SYSIN  DD  DISP=SHR,DSN=ITSOAM.IMSDBRA.ASM(DFSIMSA0)
```

For more information about configuring ODBA and DRA, refer to:

- The topic “The database resource adapter (DRA)” in *IMS Version 10 System Programming API Reference*, SC18-9967-00.
- The topic “Accessing IMS databases through the ODBA interface” in *IMS Version 10 Communications and Connections Guide*, SC18-9703-00.

8.4 WebSphere Application Server for z/OS setup

This section assumes that you are familiar with WebSphere Application Server Version 6 for z/OS and its WebSphere Application Server Integrated Console.

A prerequisite step before continuing is installing the Java class libraries for IMS. Refer to the *IMS Version 10 Installation Guide*, GC18-9710-00, for more information.

8.4.1 Updating WebSphere Application Server for z/OS Servant Region STEPLIB

Update the JCL for WebSphere Application Server for z/OS by adding the following data sets to the STEPLIB:

- The load library that contains the DRA startup table.
- The SDFSRESL data set. This data set contains the ODBA runtime code.
- The SDFSJLIB data set. This data set contains the DFSCLIB member.

8.4.2 Installing the IMS DB Resource Adapter

After you configure WebSphere Application Server for z/OS to have access to IMS databases, you must install the IMS DB resource adapter in WebSphere Application Server for z/OS.

To install the IMS DB Resource Adapter, perform the following tasks:

1. Install the Resource Archive (RAR):
   a. From the WebSphere Application Server for z/OS WebSphere Application Server Integrated Console, click **Resources**, expand **Resource**

Adapters, and then click **Resource Adapters**. A list of resource adapters is displayed.

   b. Click **Install RAR**. A dialog for installing the resource adapter is displayed.

   c. Select **Server path** and type the path to the imsDBJCA.rar file:

      pathprefix/usr/lpp/ims/imsjava10/imsDBJCA.rar

   d. Click **Next**. A configuration dialog is displayed.

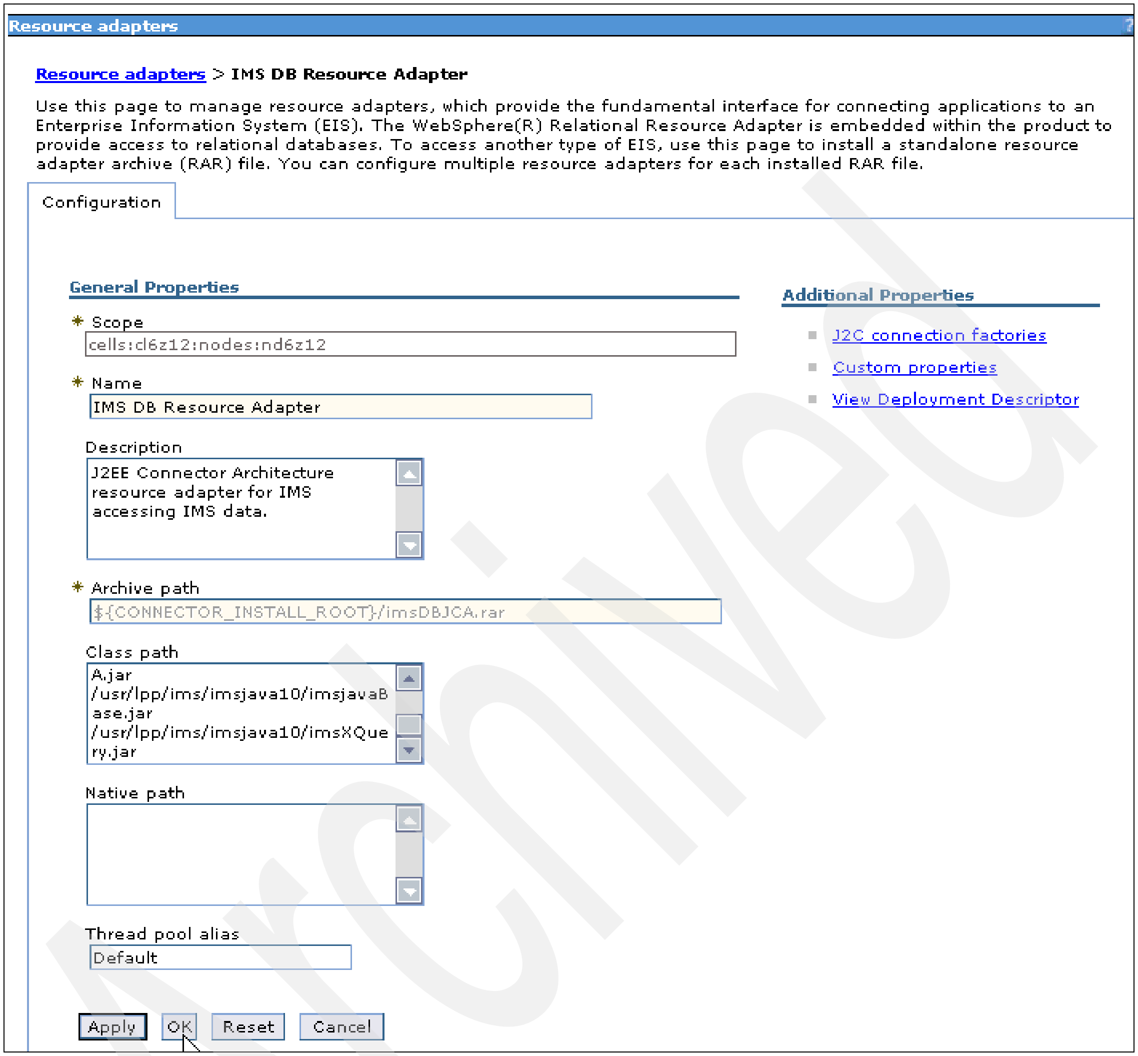
2. Configure the resource adapter by typing the following information:

   – **Name**: A name for the resource adapter

   – **Classpath**: The Java library for IMS consists of the following JAR files. The path and file names are:

      - *pathprefix*/usr/lpp/ims/imsjava10/imsJDBC.jar
      - *pathprefix*/usr/lpp/ims/imsjava10/imsDBJCA.jar
      - *pathprefix*/usr/lpp/ims/imsjava10/imsjavaBase.jar
      - *pathprefix*/usr/lpp/ims/imsjava10/imsXQuery.jar

Refer to Figure 8-1 on page 185 for a snapshot of the WebSphere Application Server Integrated Console panel used for configuring the IMS DB Resource Adapter.



Resource adapters > IMS DB Resource Adapter

Use this page to manage resource adapters, which provide the fundamental interface for connecting applications to an Enterprise Information System (EIS). The WebSphere(R) Relational Resource Adapter is embedded within the product to provide access to relational databases. To access another type of EIS, use this page to install a standalone resource adapter archive (RAR) file. You can configure multiple resource adapters for each installed RAR file.

General Properties

* Scope
cells:cl6z12:nodes:nd6z12

* Name
IMS DB Resource Adapter

Description
J2EE Connector Architecture resource adapter for IMS accessing IMS data.

* Archive path
${CONNECTOR_INSTALL_ROOT}/imsDBJCA.rar

Class path
A.jar
/usr/lpp/ims/imsjava10/imsjavaBase.jar
/usr/lpp/ims/imsjava10/imsXQuery.jar

Native path

Thread pool alias
Default

Additional Properties

- J2C connection factories
- Custom properties
- View Deployment Descriptor

Figure 8-1 Configuring the IMS DB Resource Adapter

Important:

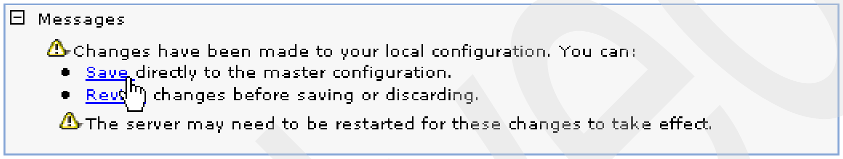
- The path and file names use both upper case and lower case characters.
- The `imsXQuery.jar` file is required only if you intend to use XQuery.

Important: In Chapter 8 on Page 120 of the *IMS Version 10 Communications and Connections Guide*, SC18-9703, the name of one of the jar files is spelled incorrectly:

- Correct: `pathprefix/usr/lpp/ims/imsjava10/imsjavaBase.jar`
- Incorrect: `pathprefix/usr/lpp/ims/imsjava10/imsjavabase.jar`

In Figure 8-1 on page 185, click **OK**. The IMS DB resource adapter is listed.

In the messages box, click **Save** to update the master repository with your changes, as shown in Figure 8-2.



⊟ Messages

⚠ Changes have been made to your local configuration. You can:
- Save directly to the master configuration.
- Revi changes before saving or discarding.

⚠ The server may need to be restarted for these changes to take effect.

Figure 8-2 Save to the master configuration

8.4.3 Installing the custom service

When WebSphere Application Server for z/OS is started, the custom service initializes the ODBA environment. When the server is stopped, the custom service terminates the ODBA environment. After a server is started, every application that is running in the server uses the initialized ODBA environment.

To install the custom service, perform the following steps:

1. Modify the WebSphere Application Server for z/OS server.policy file. The WebSphere Application Server for z/OS server.policy file is in the properties directory (for example, `installdir/profiles/default/properties`). Add the code as shown in Example 8-3.

Example 8-3 Adding code to server.policy file

```
grant codeBase "file:/pathprefix/usr/lpp/ims/imsjava10/-" {
//Allows the IMS DB resource adapter and the custom service to read and
//write environment properties .
permission java.util.PropertyPermission "*", "read, write";
//Allows the IMS DB resource adapter and the custom service to use
//the JavTDLI load library during runtime. permission
java.lang.RuntimePermission "loadLibrary.JavTDLI";
};
```

The WebSphere Application Server for z/OS server.policy file is stored in the ASCII ISO8859 character set. To edit the server.policy file under OMVS:

a. Change the directory to properties directory:

```
cd installdir/profiles/default/properties
```

b. Convert from ASCII to EBCDIC:

```
iconv -f ISO8859-1 -t IBM-1047 server.policy > servernew.policy
```

c. Use the Uniform Symbol Specification **oedit** command to add code to the end of file (refer to Example 8-3 on page 186).

d. Rename the existing server.policy file:

```
mv server.policy file to server.policy.bu
```

e. Convert from EBCDIC to ASCII:

```
iconv -f IBM-1047 -t ISO8859-1 servernew.policy >server.policy
```

f. Set the permissions of the new server.policy file:

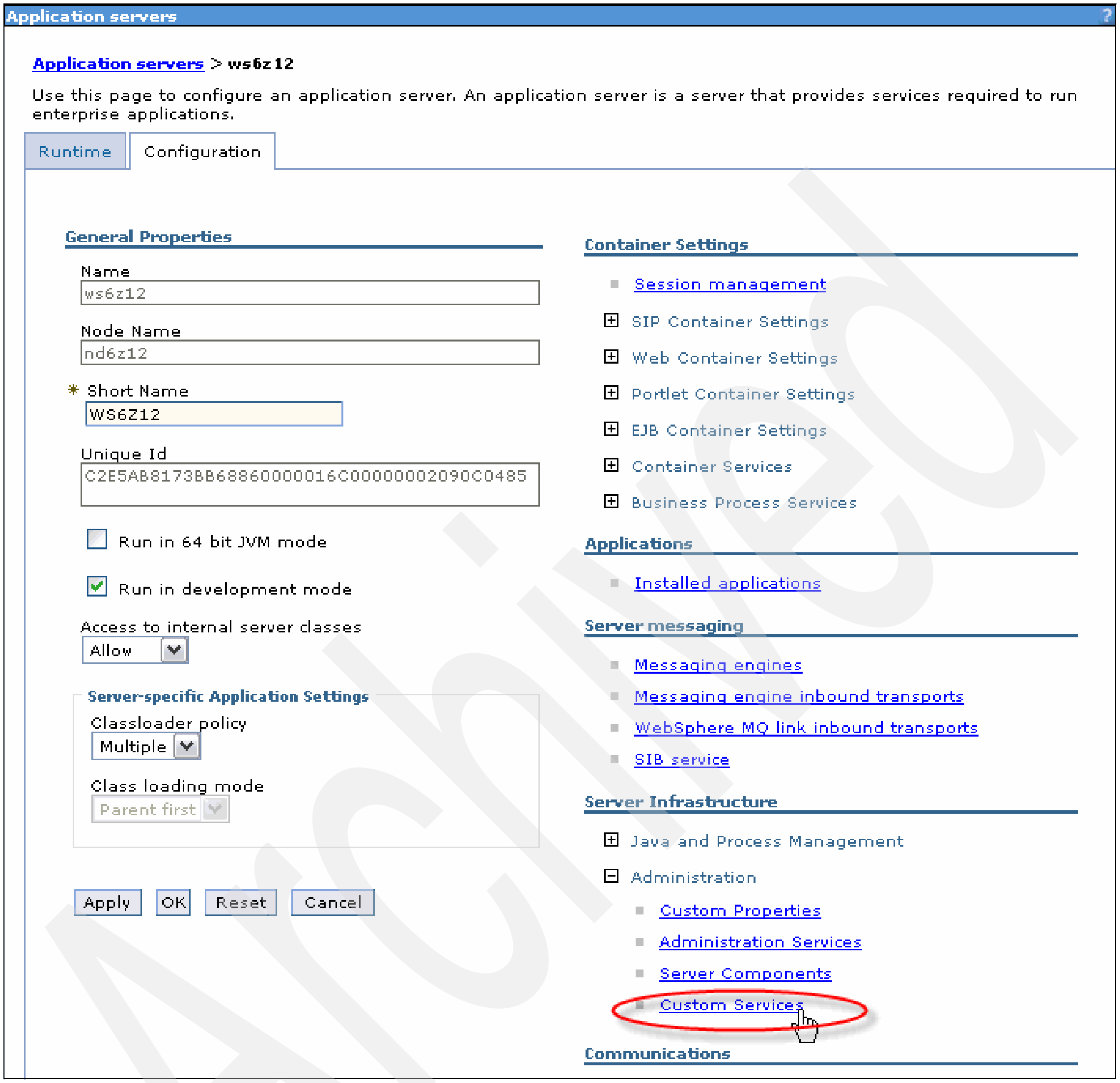
```
chmod 775 server.policy
```

2. Install the custom service:

   a. In the left frame of the WebSphere Application Server for z/OS Integrated Console, click **Servers**, and then click **Application servers**. A list of application servers is displayed.

   b. Click the name of the server on which you want to deploy your custom service.

   c. Under **Server Infrastructure**, click **Administration**, and then click **Custom Services**, as shown in Figure 8-3 on page 188. A list of custom services is displayed.



Application servers

Application servers > ws6z12

Use this page to configure an application server. An application server is a server that provides services required to run enterprise applications.

General Properties

Name: ws6z12

Node Name: nd6z12

* Short Name: WS6Z12

Unique Id: C2E5AB8173BB68860000016C00000002090C0485

☐ Run in 64 bit JVM mode

☑ Run in development mode

Access to internal server classes: Allow

Server-specific Application Settings

Classloader policy: Multiple

Class loading mode: Parent first

Figure 8-3 Open Custom Services

d. Click **New**. A configuration dialog is displayed.

e. Select the **Enable service at server startup** check box. If you do not select this check box, the custom service is not invoked when you start the server.

f. Type the following information:

- Classname: `com.ibm.connector2.ims.db.IMSJdbcCustomService`

- Display Name: A name for the custom service
- Classpath: The directory name containing the jar with the IMS JDBC classes, `imsjava.jar`, and the symbolic link `libJavTDLI.so`, which points to the data set, `IMS.SDFSJLIB`, in the WebSphere Application Server for z/OS Servant region STEPLIB. For example:

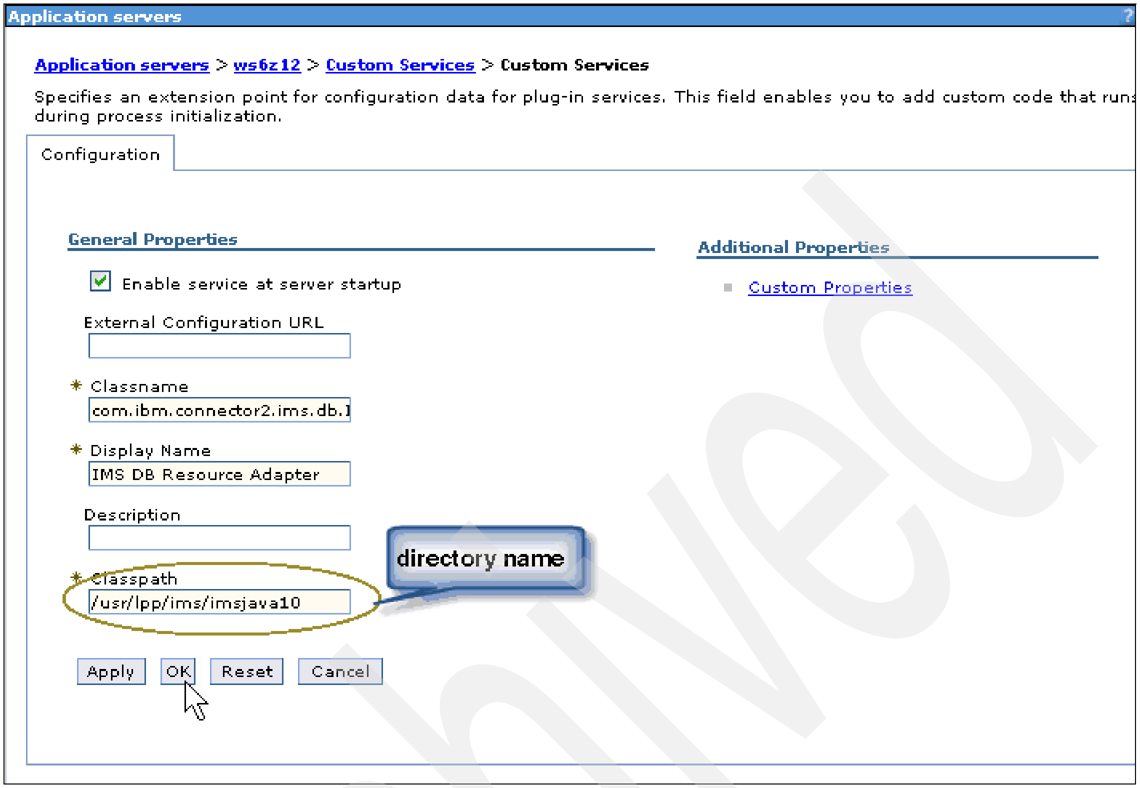
  pathprefix`/usr/lpp/ims/imsjava10`

g. Click **OK**. The custom service is listed (Figure 8-4 on page 190).

h. In the messages box, click **Save** to update the master repository with your changes.

i. Restart the server in order for the custom service to take effect.

> **Important:** In the *OMS Version 10 IMS Communications and Connections Guide,* SC18-9703, there is an error in chapter 8 on page 121. The directory name is correct, but the path and file name are incorrect.



Application servers

Application servers > ws6z12 > Custom Services > Custom Services

Specifies an extension point for configuration data for plug-in services. This field enables you to add custom code that run during process initialization.

Configuration

General Properties

☑ Enable service at server startup

External Configuration URL

* Classname
com.ibm.connector2.ims.db.I

* Display Name
IMS DB Resource Adapter

Description

* Classpath
/usr/lpp/ims/imsjava10

Additional Properties

- Custom Properties

Figure 8-4 Configuration of custom services

8.5 Running the IMS IVP for the WebSphere Application Server for z/OS Java environment

Run the IMS IVP applications for the WebSphere Application Server for z/OS Java environment in WebSphere Application Server for z/OS to ensure that you have configured IMS and WebSphere Application Server for z/OS properly. This topic provides the high-level tasks that are required to run the IMS IVP applications for the WebSphere Application Server for z/OS Java environment.

Prerequisites: Ensure that the base IMS IVPs have been run. The IMS IVPs prepare the DBD for the IVP database, named `IVPDB2`, and load the IVP database. They also prepare the Java application program specification block (PSB) (named DFSIVP37), build application control blocks (ACBs), and prepare other IMS control blocks that are required by the IMS IVP applications for the WebSphere Application Server for z/OS Java environment. For details about how to run the base IMS IVPs, refer to the *IMS V10 Installation Guide,* GC18-9710.

8.5.1 Installing the data source for the IMS IVP application

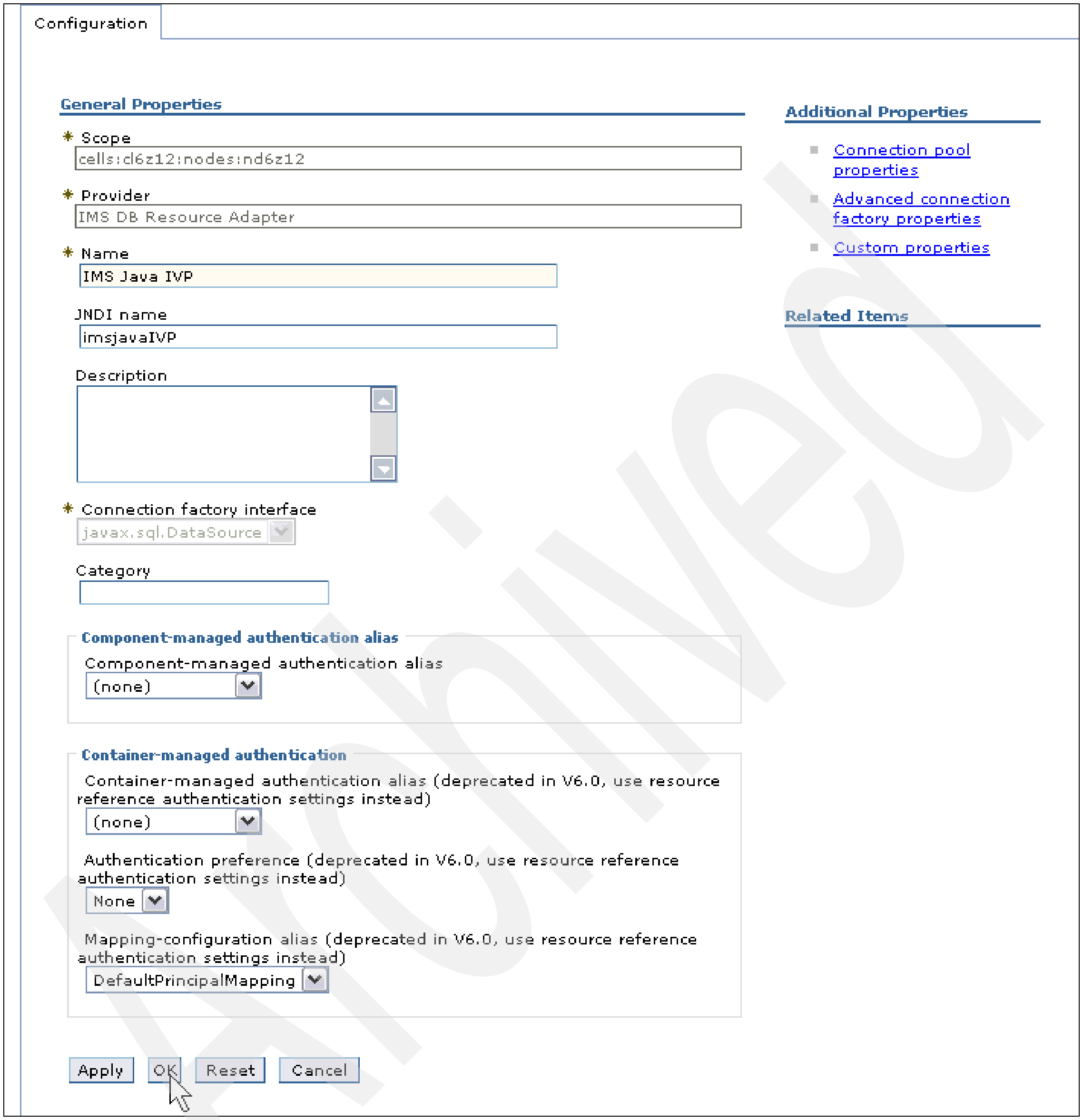
The *DataSource* facility is a factory for connections to a physical data source, or database. A data source is registered with a naming service based on the Java Naming and Directory (JNDI) application programming interface (API). DataSource objects have properties that pertain to the actual data source that an application needs to access.

Note: You must use the DataSource facility, which replaces the DriverManager facility, because the DriverManager facility is not supported by the J2EE Connection Architecture Specification.

To install the data source for the IMS IVP application, perform the following tasks:

1. In the left frame of the WebSphere Application Server for z/OS Integrated Console, click **Resources**, expand **Resource Adapters**, and then click **Resource Adapters**. A list of resource adapters is displayed.
2. Click the name of IMS DB resource adapter that you chose when you installed the adapter. A configuration dialog is displayed.
3. Under Additional Properties, click **J2C connection factories**.
4. Click **New**. A configuration dialog is displayed.
5. Type the following information:
   - **Name**: Name for the data source
   - **JNDI Name**: `imsjavaIVP`
6. Click **OK**.

   Refer to Figure 8-5 on page 192. The data source is listed in the J2C Connection Factories.


Configuration

General Properties

* Scope
cells:cl6z12:nodes:nd6z12

* Provider
IMS DB Resource Adapter

* Name
IMS Java IVP

JNDI name
imsjavaIVP

Description

* Connection factory interface
javax.sql.DataSource

Category

Component-managed authentication alias
Component-managed authentication alias
(none)

Container-managed authentication
Container-managed authentication alias (deprecated in V6.0, use resource reference authentication settings instead)
(none)

Authentication preference (deprecated in V6.0, use resource reference authentication settings instead)
None

Mapping-configuration alias (deprecated in V6.0, use resource reference authentication settings instead)
DefaultPrincipalMapping

Additional Properties
- Connection pool properties
- Advanced connection factory properties
- Custom properties

Related Items

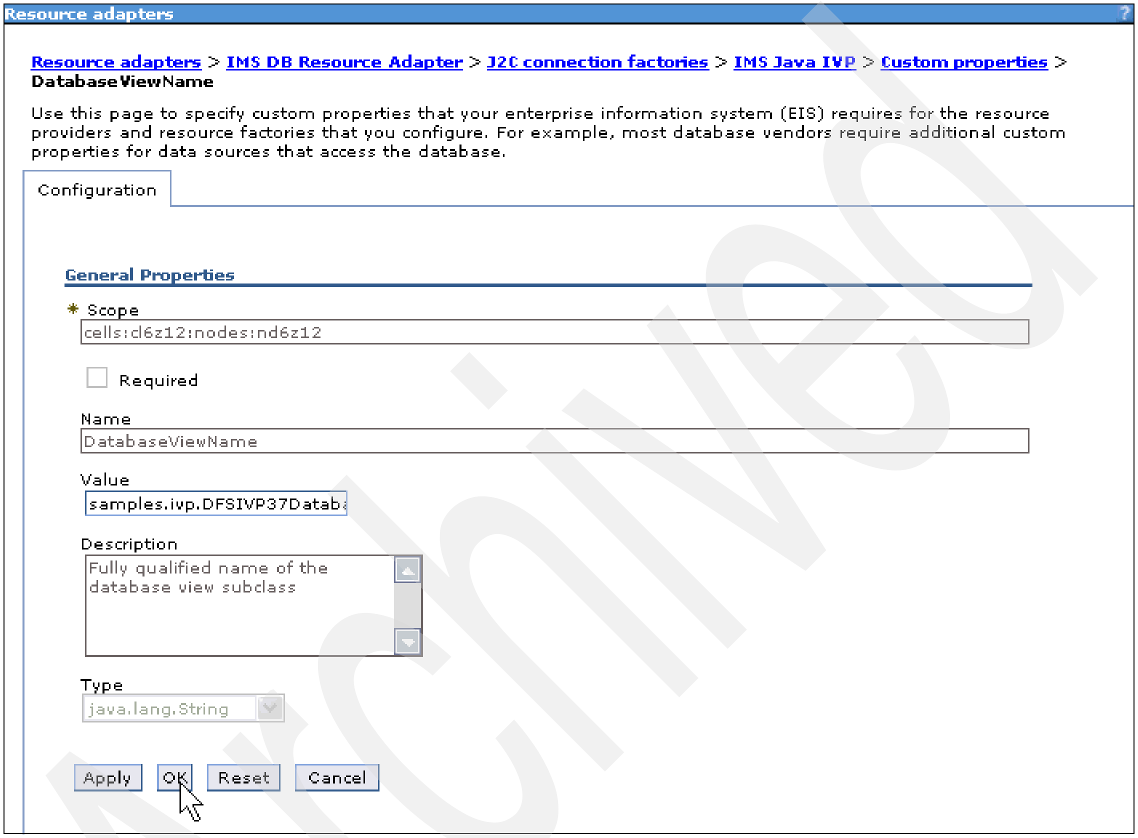
Figure 8-5 Configure J2C connection factories

7. Click the name of the data source that you installed.
8. Under **Additional Properties**, click **Custom properties**. Three properties are listed in a table.
9. Click **DatabaseViewName**. A configuration dialog is displayed.

10. In the Value field, type: `samples.ivp.DFSIVP37DatabaseView`

11. Click **OK**.

    Refer to Figure 8-6. The properties table displays the DatabaseViewName value that you just entered.



Resource adapters

Resource adapters > IMS DB Resource Adapter > J2C connection factories > IMS Java IVP > Custom properties > DatabaseViewName

Use this page to specify custom properties that your enterprise information system (EIS) requires for the resource providers and resource factories that you configure. For example, most database vendors require additional custom properties for data sources that access the database.

Configuration

General Properties

* Scope
cells:cl6z12:nodes:nd6z12

□ Required

Name
DatabaseViewName

Value
samples.ivp.DFSIVP37Datab

Description
Fully qualified name of the database view subclass

Type
java.lang.String

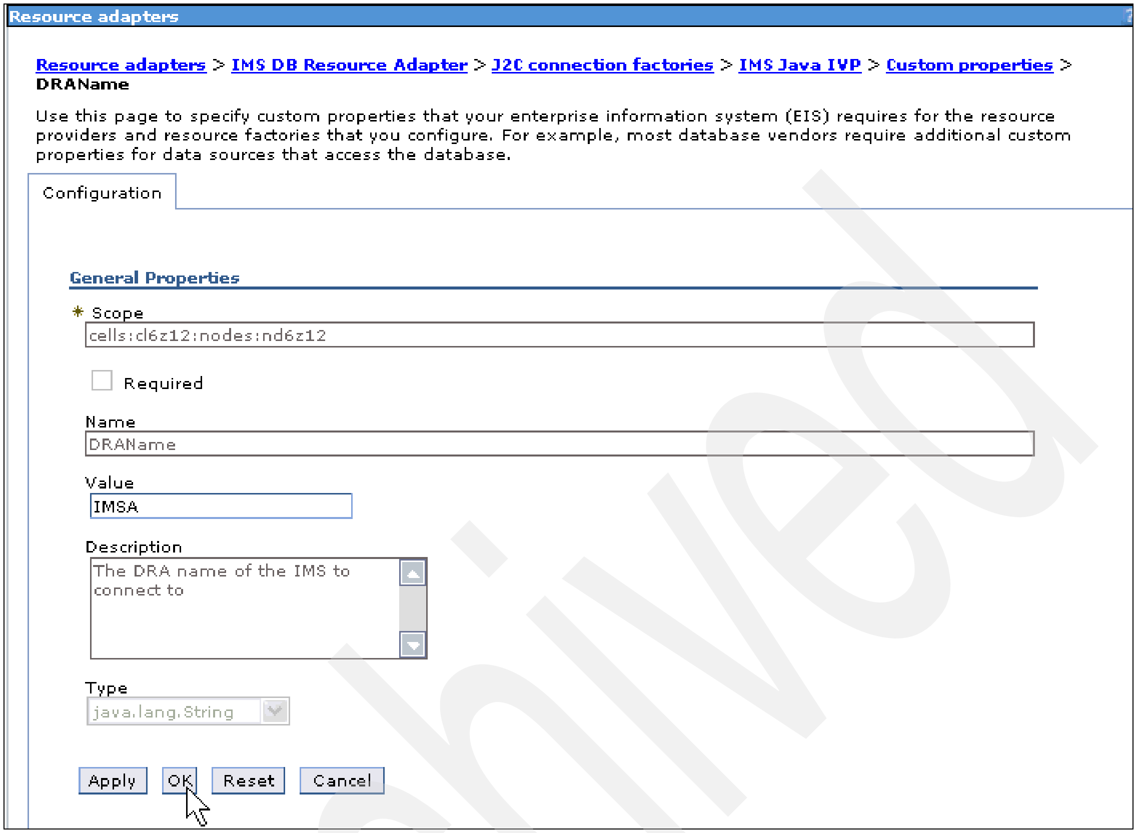
Figure 8-6 Configure database view name

12. Click **DRAName**. A configuration dialog is displayed.

13. In the Value field, type bytes 4 - 7 of the DRA startup table module name (usually the IMS system ID). For more information about the DRA startup table, refer to “IMS Setup” on page 181.

14. Click **OK**.

    Refer to Figure 8-7 on page 194. The properties table displays the DRA name that you just entered.



Resource adapters

Resource adapters > IMS DB Resource Adapter > J2C connection factories > IMS Java IVP > Custom properties > DRAName

Use this page to specify custom properties that your enterprise information system (EIS) requires for the resource providers and resource factories that you configure. For example, most database vendors require additional custom properties for data sources that access the database.

General Properties

* Scope: cells:cl6z12:nodes:nd6z12

□ Required

Name: DRAName

Value: IMSA

Description: The DRA name of the IMS to connect to

Type: java.lang.String

Figure 8-7 Configure DRAName

15. In the messages box, click **Save** to update the master repository with your changes.

16. Restart the server in order for the custom service to take effect.

8.5.2 Installing the IMS IVP application

This section describes how to deploy the IMS IVP application to WebSphere Application Server for z/OS.

To install the IMS IVP application, perform the following tasks from the WebSphere Application Server for z/OS Integrated Console:

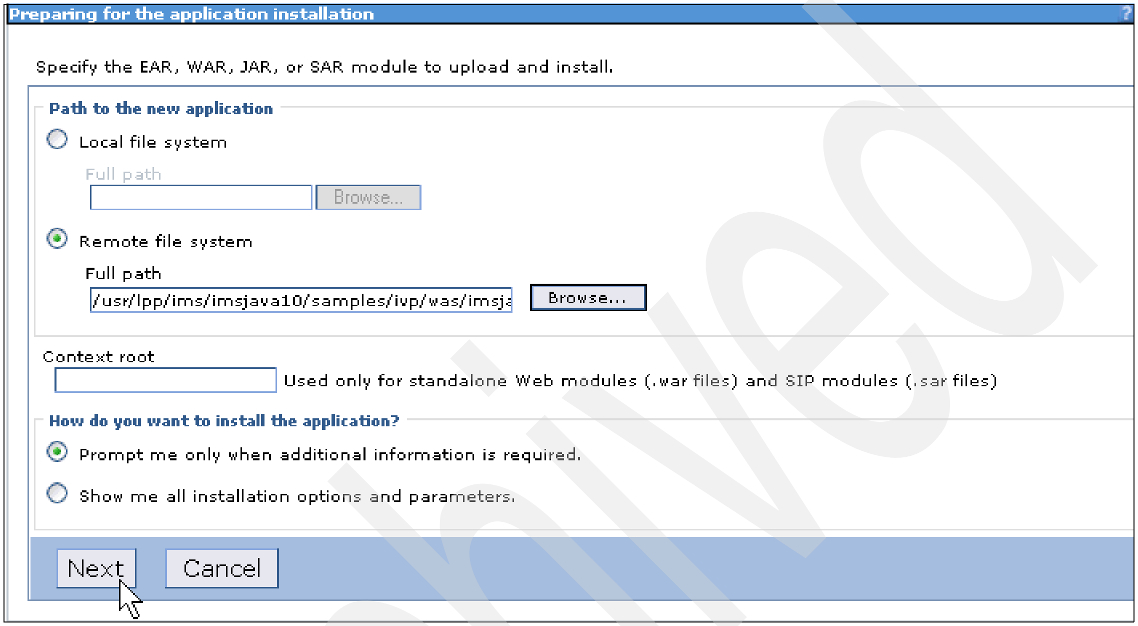
1. Click **Applications**, and then click **Install New Application**. A dialog for installing the application is displayed.

2. Select **Remote file system** and type the path to `IMSJavaIVP.ear`:

   `pathprefix``/usr/lpp/ims/imsjava10/samples/ivp/was/imsjavaIVP.ear`

3. Click **Next**.

   Refer to Figure 8-8.



Preparing for the application installation

Specify the EAR, WAR, JAR, or SAR module to upload and install.

Path to the new application

○ Local file system

Full path [ ] Browse...

● Remote file system

Full path /usr/lpp/ims/imsjava10/samples/ivp/was/imsj Browse...

Context root [ ] Used only for standalone Web modules (.war files) and SIP modules (.sar files)

How do you want to install the application?

● Prompt me only when additional information is required.

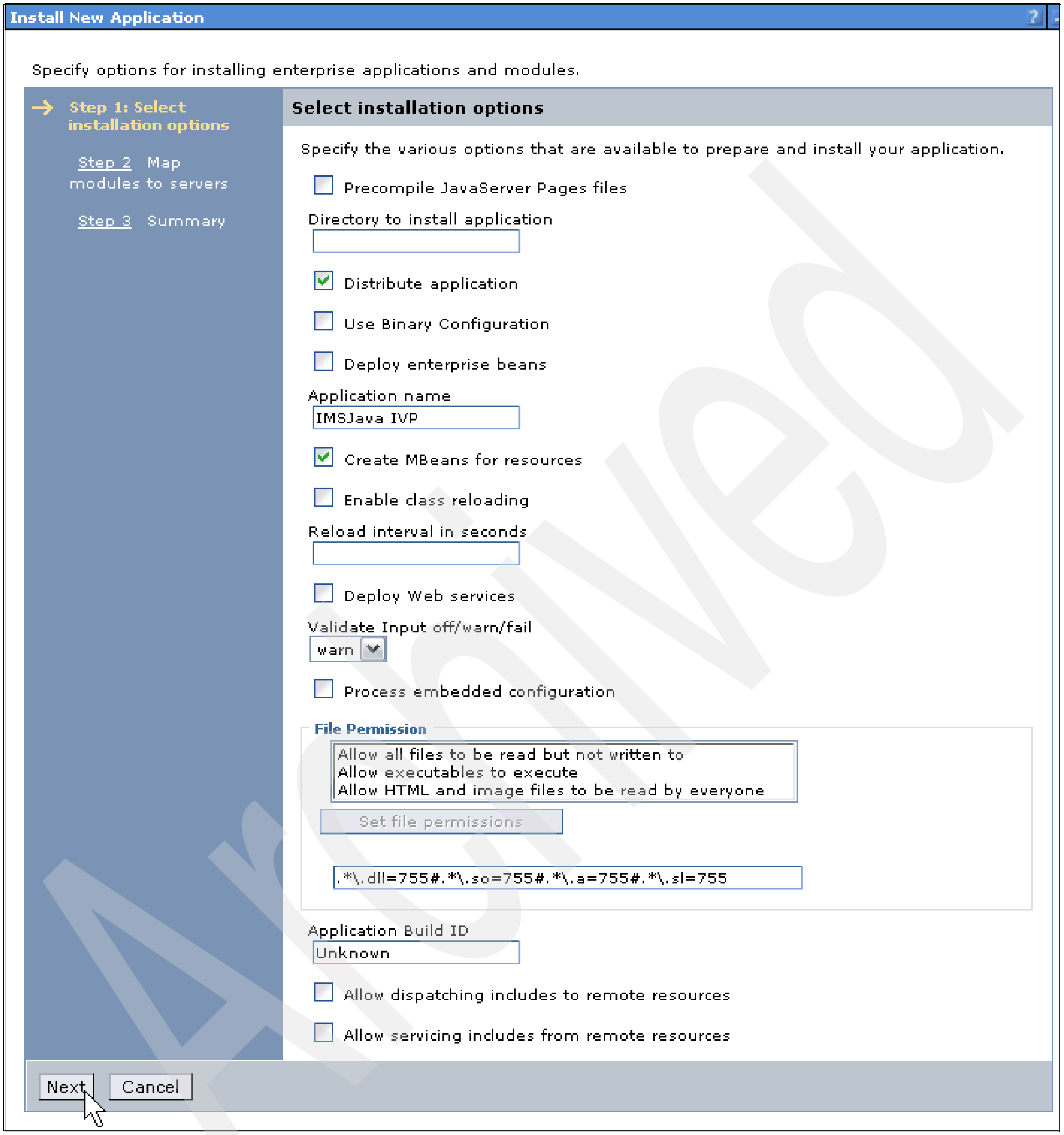
○ Show me all installation options and parameters.

Next Cancel

Figure 8-8 Installing the IMS IVP application (panel one of five)

4. In the next window, accept the defaults and click **Next**. The **Install New Application wizard** is started. Refer to Figure 8-9 on page 196 for the first panel. Click **Next**.

> **Note:** Depending on your specific server configuration, you might have to use the wizard to change certain default values.



Specify options for installing enterprise applications and modules.

→ Step 1: Select installation options
Step 2 Map modules to servers
Step 3 Summary

Select installation options

Specify the various options that are available to prepare and install your application.

□ Precompile JavaServer Pages files

Directory to install application:

☑ Distribute application

□ Use Binary Configuration

□ Deploy enterprise beans

Application name: IMSJava IVP

☑ Create MBeans for resources

□ Enable class reloading

Reload interval in seconds:

□ Deploy Web services

Validate Input off/warn/fail: warn

□ Process embedded configuration

File Permission

Allow all files to be read but not written to
Allow executables to execute
Allow HTML and image files to be read by everyone

.*\.dll=755#.*\.so=755#.*\.a=755#.*\.sl=755

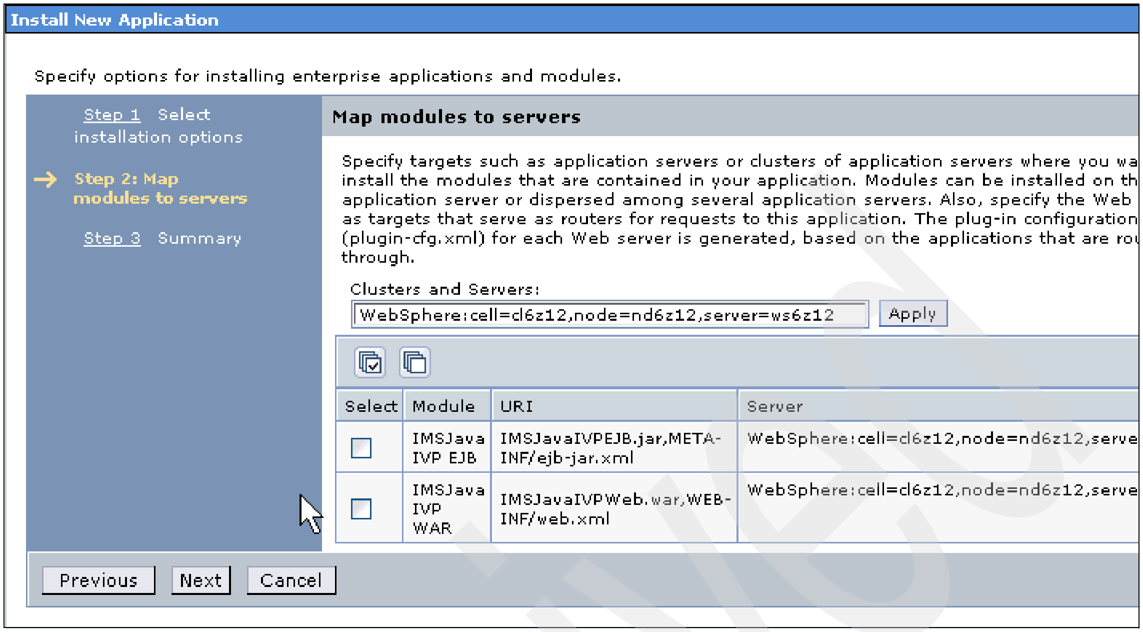
Application Build ID: Unknown

□ Allow dispatching includes to remote resources

□ Allow servicing includes from remote resources

Figure 8-9 Installing the IMS IVP application (panel two of five)

5. In the panel titled “Step 2: Map modules to servers,” as shown in Figure 8-10 on page 197, accept the defaults, and click **Next**.



Install New Application

Specify options for installing enterprise applications and modules.

Step 1 Select installation options
→ Step 2: Map modules to servers
Step 3 Summary

Map modules to servers

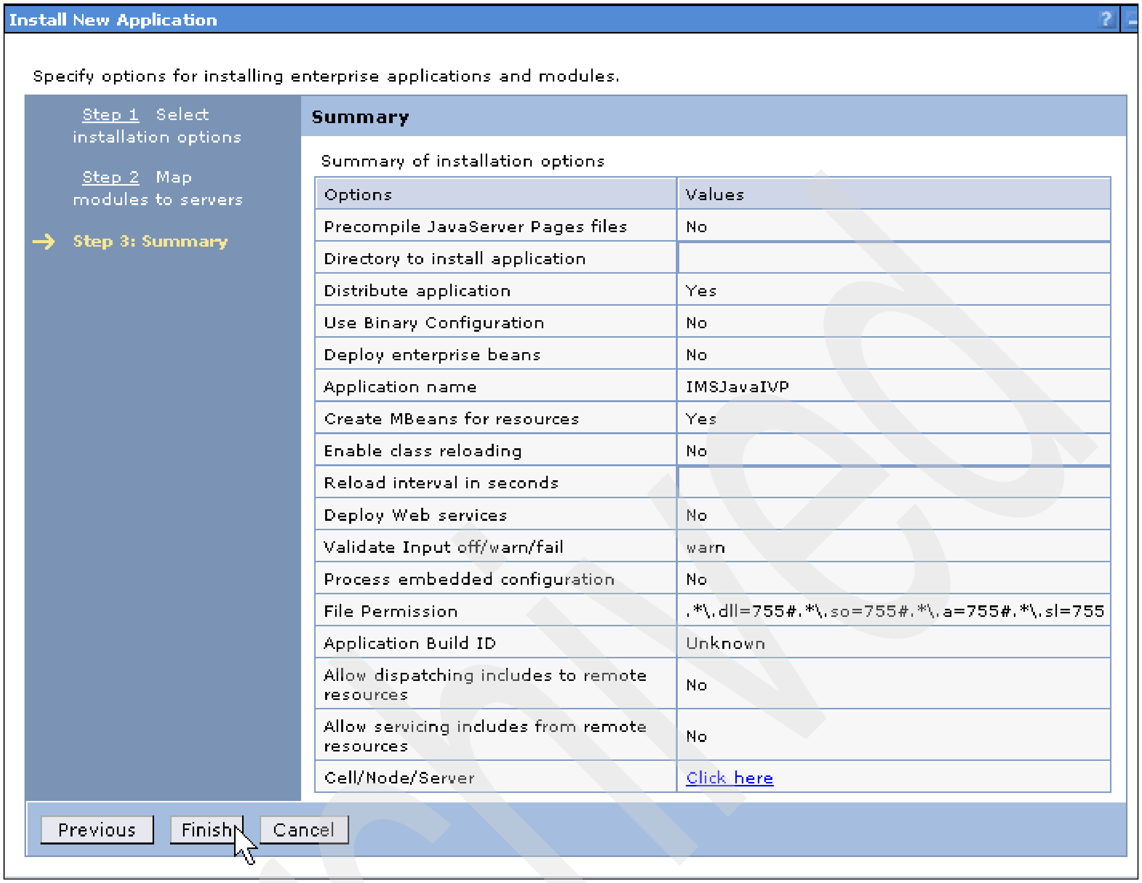
Specify targets such as application servers or clusters of application servers where you wa install the modules that are contained in your application. Modules can be installed on th application server or dispersed among several application servers. Also, specify the Web as targets that serve as routers for requests to this application. The plug-in configuration (plugin-cfg.xml) for each Web server is generated, based on the applications that are rou through.

Clusters and Servers: WebSphere:cell=cl6z12,node=nd6z12,server=ws6z12

Select	Module	URI	Server
□	IMSJava IVP EJB	IMSJavaIVPEJB.jar,META-INF/ejb-jar.xml	WebSphere:cell=cl6z12,node=nd6z12,serve
□	IMSJava IVP WAR	IMSJavaIVPWeb.war,WEB-INF/web.xml	WebSphere:cell=cl6z12,node=nd6z12,serve

Figure 8-10 Installing the IMS IVP application (panel three of five)

6. In the “Step 3: Summary panel,” as shown in Figure 8-11 on page 198, click **Finish**. A message is displayed that indicates first that the application is being installed, and then, that the installation was successful.



Specify options for installing enterprise applications and modules.

Step 1 Select installation options
Step 2 Map modules to servers
→ Step 3: Summary

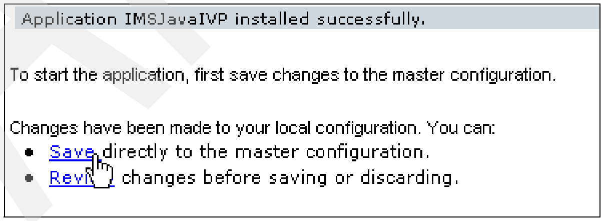
Summary

Summary of installation options

Options	Values
Precompile JavaServer Pages files	No
Directory to install application	
Distribute application	Yes
Use Binary Configuration	No
Deploy enterprise beans	No
Application name	IMSJavaIVP
Create MBeans for resources	Yes
Enable class reloading	No
Reload interval in seconds	
Deploy Web services	No
Validate Input off/warn/fail	warn
Process embedded configuration	No
File Permission	.*\.dll=755#.*\.so=755#.*\.a=755#.*\.sl=755
Application Build ID	Unknown
Allow dispatching includes to remote resources	No
Allow servicing includes from remote resources	No
Cell/Node/Server	Click here

Figure 8-11 Installing the IMS IVP application (panel four of five)

7. Click **Save** to save to the Master Configuration to update the master repository with your changes, as shown in Figure 8-12.



Application IMSJavaIVP installed successfully.

To start the application, first save changes to the master configuration.

Changes have been made to your local configuration. You can:

- Save directly to the master configuration.
- Review changes before saving or discarding.

Figure 8-12 Installing the IMS IVP application (panel five of five)

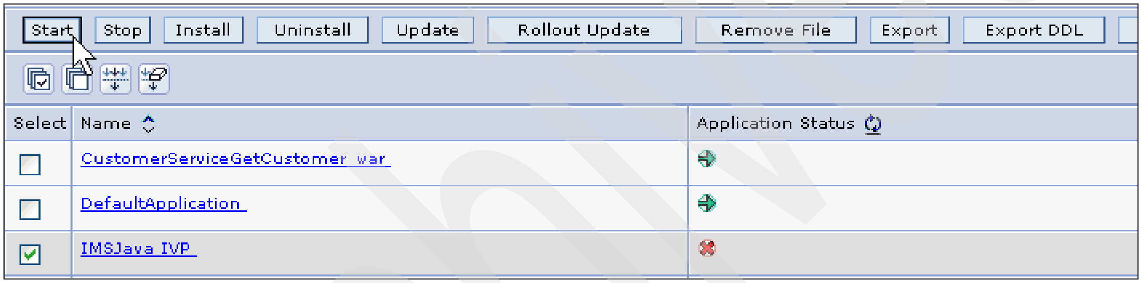
8.5.3 Testing the IMS IVP application

This topic describes how to test the IMS IVP application in WebSphere Application Server z/OS.

To test the IMS IVP application, perform the following steps using the WebSphere Application Server for z/OS Integrated Console:

1. Click **Applications**, and then, click **Enterprise Applications**. The application IMSJava IVP is listed with a red X, which indicates that the application is stopped.
2. Select **IMSJava IVP**.
3. Click **Start**.

   Refer to Figure 8-13. The Application Status of application IMSJava IVP will turn into a **green arrow**, which indicates that the application is started.



Select	Name	Application Status
□	CustomerServiceGetCustomer_war	➔
□	DefaultApplication	➔
☑	IMSJava IVP	✗

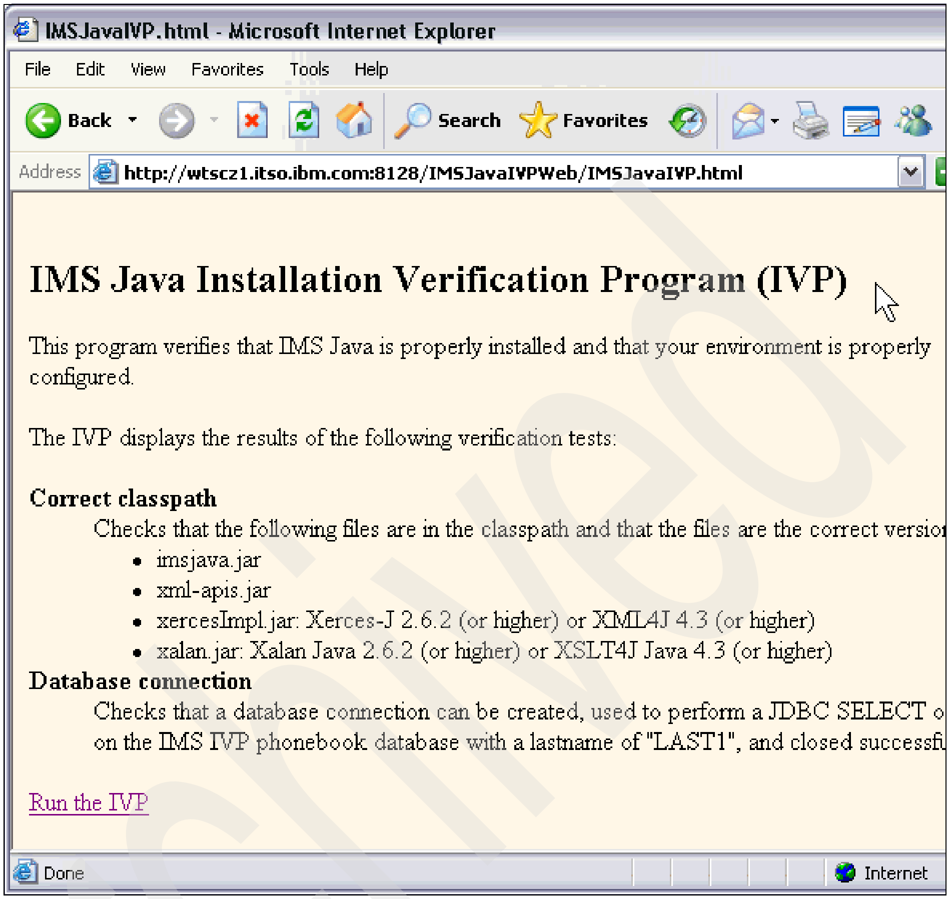
Figure 8-13 Start the IMS IVP application

4. Open a Web browser.
5. Type the Web address:

   `http://host_IP_address:port/IMSJavaIVPWeb/IMSJavaIVP.html`

   An input Web page opens.
6. Click **Run the IVP**.

   Refer to Figure 8-14 on page 200.


IMSJavaIVP.html - Microsoft Internet Explorer
File
Edit
View
Favorites
Tools
Help
Back
Search
Favorites
Address
http://wtsc z1.itso.ibm.com:8128/IMSJavaIVPWeb/IMSJavaIVP.html
Done
Internet

IMS Java Installation Verification Program (IVP)

This program verifies that IMS Java is properly installed and that your environment is properly configured.

The IVP displays the results of the following verification tests:

Correct classpath

Checks that the following files are in the classpath and that the files are the correct versio

- imsjava.jar
- xml-apis.jar
- xercesImpl.jar: Xerces-J 2.6.2 (or higher) or XML4J 4.3 (or higher)
- xalan.jar: Xalan Java 2.6.2 (or higher) or XSLT4J Java 4.3 (or higher)

Database connection

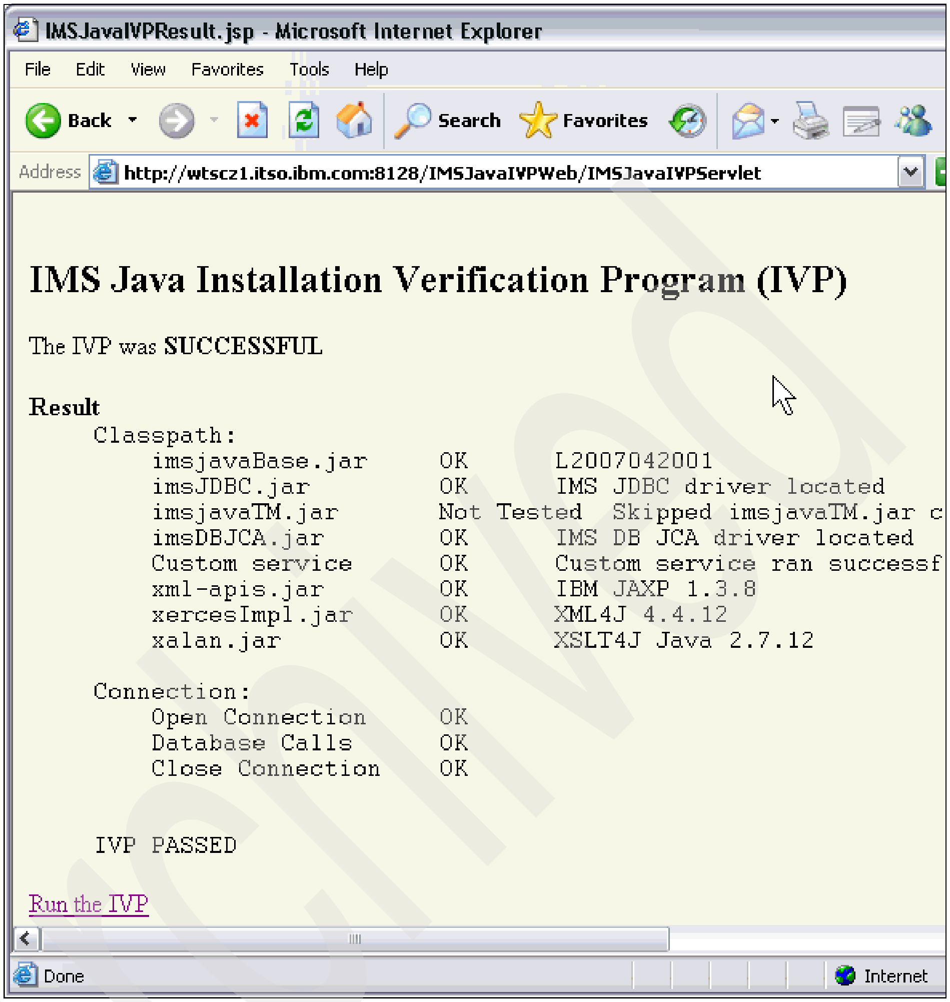
Checks that a database connection can be created, used to perform a JDBC SELECT o on the IMS IVP phonebook database with a lastname of "LAST1", and closed successfi

Run the IVP

Figure 8-14 IMS Java Installation Verification Program (IVP)

If WebSphere Application Server for z/OS is configured properly, the IVP shows "`The IVP was SUCCESSFUL`" and displays the results of checks performed by the IVP. Figure 8-15 on page 201 shows the output in a case where the IVP is successful.

If WebSphere Application Server for z/OS is not configured properly, the IVP shows "`The IVP was NOT SUCCESSFUL`" and displays the results of checks performed by the IVP.



http://wtsc21.itso.ibm.com:8128/IMSJavaIVPWeb/IMSJavaIVPServlet

IMS Java Installation Verification Program (IVP)

The IVP was SUCCESSFUL

Result

```
    Classpath:
        imsjavaBase.jar      OK        L2007042001
        imsJDBC.jar          OK        IMS JDBC driver located
        imsjavaTM.jar        Not Tested  Skipped imsjavaTM.jar c
        imsDBJCA.jar         OK        IMS DB JCA driver located
        Custom service       OK        Custom service ran successf
        xml-apis.jar         OK        IBM JAXP 1.3.8
        xercesImpl.jar       OK        XML4J 4.4.12
        xalan.jar            OK        XSLT4J Java 2.7.12

    Connection:
        Open Connection      OK
        Database Calls       OK
        Close Connection     OK


    IVP PASSED
```

Run the IVP

Figure 8-15 The IVP was successful

8.6 Generating IMS database metadata using DLIModel utility

In order for a Java application to access an IMS database, it needs information about that database. The *DLIModel utility* allows you to transform your IMS database information (program specification blocks, database descriptions, and COBOL copybooks) into application independent metadata.

Two versions of the IMS DLIModel utility are available:

- An IMS-shipped version that runs in the UNIX System Services and can also be run using the z/OS BPXBATCH utility.
- A Web-download version that runs as a plug-in to Eclipse, WebSphere Developer for zSeries, Rational Application Developer (RAD), or Rational Developer for System z (RDz).

> **Recommendation**: IMS Version 10 is the last release of IMS to support the IMS-shipped version of the DLIModel utility. Clients using this version need to migrate to using the DLIModel utility plug-in (Eclipse plug-in).

The plug-in version of the DLIModel utility allows you to generate and modify metadata in an Eclipse application development environment. We recommend this version of the utility for Java application developers using WebSphere Developer for zSeries, Rational Application Developer, and Rational Developer for System z. You can run this utility using your IMS source files as input, eliminating the need for a hand-coded control statement. The plug-in version of the utility also produces a graphical Uniform Modeling Language (UML) model file that makes viewing and modifying metadata easier.

For more information and to download the DL/I Model Utility, go to the following Web site:

http://www-01.ibm.com/software/data/ims/toolkit/dlimodelutility/

8.6.1 Creating a DLIModel Project

You can create a new DLIModel project using the DLIModel wizard.

Before you begin, review the requirements and restrictions for using the DLIModel utility.

To create a new DLIModel project:

1. Launch Eclipse or Rational Developer for System z.
2. Click **File** → **New** → **Project** , select **DLIModel Utility Project** from the list.
3. Click **Next** to launch the DLIModel wizard.

   Alternately, you can right-click the Package Explorer view, and then, click **New** → **Project**. If you are unable to locate the Package Explorer view, make sure that you are using the IMS perspective. The Package Explorer view defaults to the left side of the IMS perspective.

4. On the DLIModel Utility Project page, type a project name, type a Java package name, and specify a location in which to save your project:

   – Your project name is strictly an internal name used by Eclipse to reference your specific project; this name will not be reflected in the generated metadata or in your application.

   – The Java package name indicates into which Java package the generated metadata will be built.

   – The Java package name field is optional and can be left blank; however, we recommend that you follow a logical naming scheme based on the company and application type for which the metadata will be used (for example, `com.mycompany.ims.payroll`).

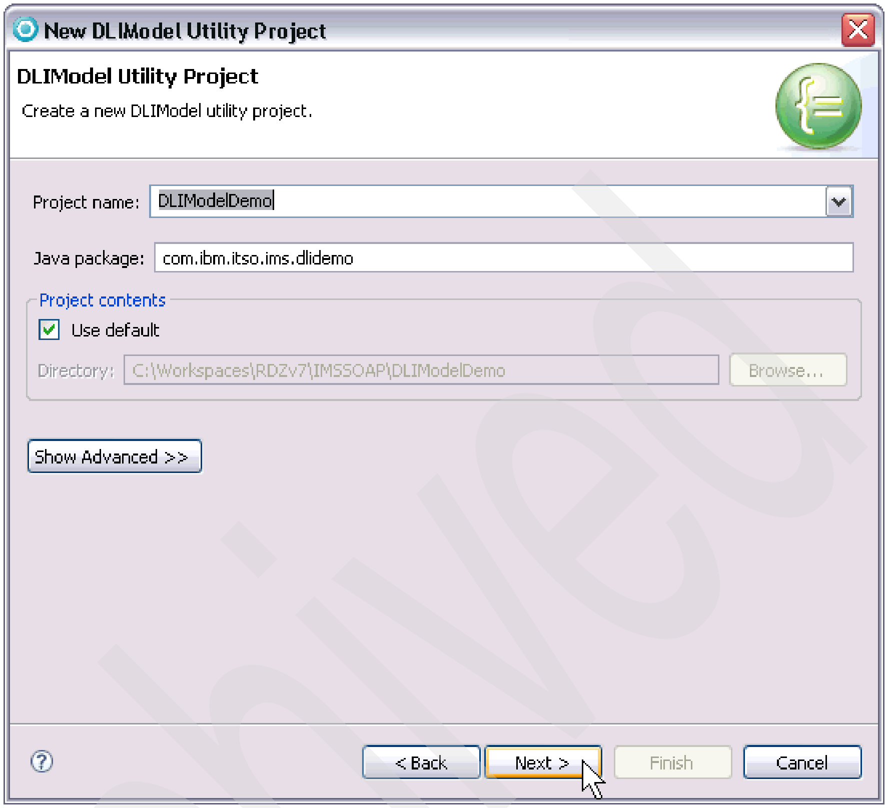
   – The project location is the location on your local hard drive to which your generated files will be saved. By default, the DLIModel wizard saves your project to your Eclipse workspace.

5. **Optional**: To customize the output options that will be generated into your project, click Show Advanced and check the box associated with the output type that you want to generate. Output options include:

   – An XML schema
   – A DLIModel database report
   – A trace log

6. **Optional**: If you have an existing IMS control statement that you want to reuse as input to the utility, select Run utility from an IMS control statement. For example, you can reuse the control statements that you wrote to run the version of the DLIModel utility that is shipped with IMS.

   Refer to Figure 8-16 on page 204.


New DLIModel Utility Project

DLIModel Utility Project

Create a new DLIModel utility project.

Project name: DLIModelDemo

Java package: com.ibm.itso.ims.dlidemo

Project contents

☑ Use default

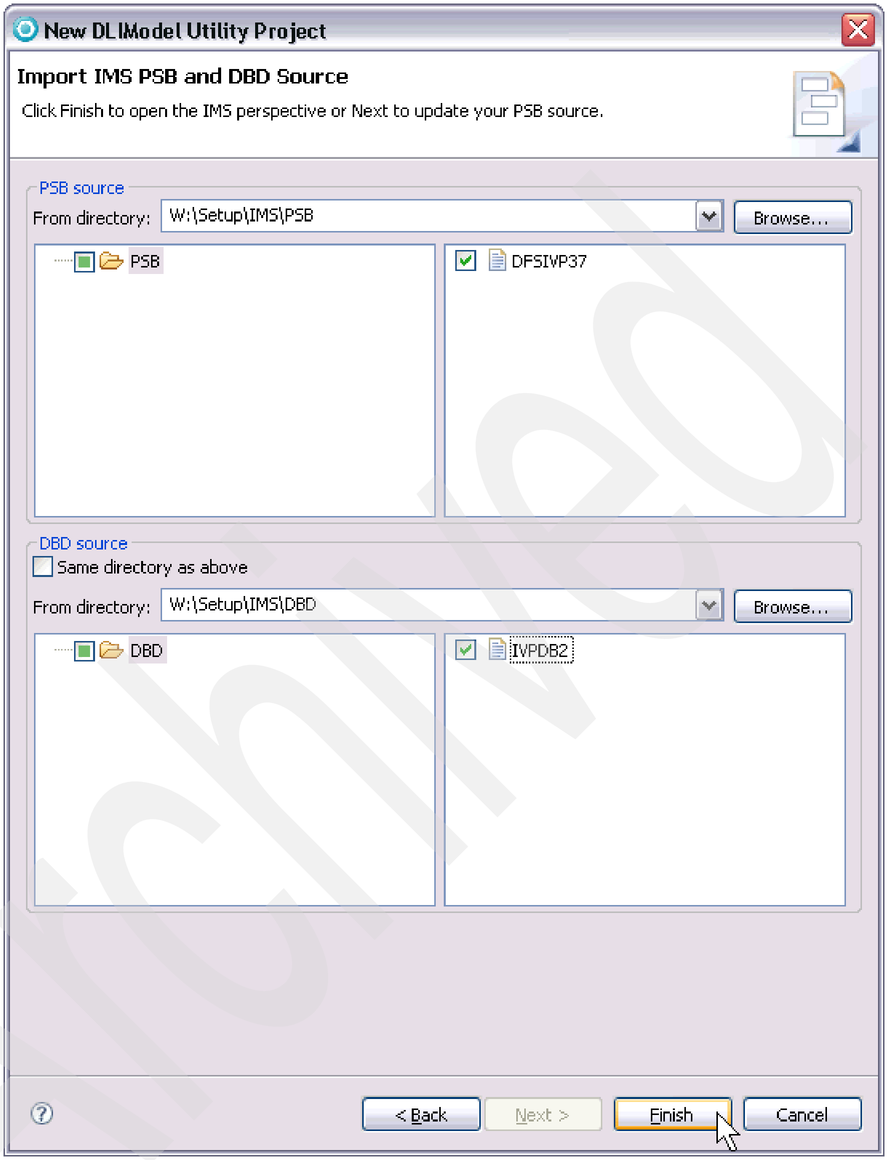
Directory: C:\Workspaces\RDZv7\IMSSOAP\DLIModelDemo

Figure 8-16 New DLIModel Utility Project

7. On the Import IMS PSB and DBD Source page, browse existing projects or your local file system for the folder containing your PSB and DBD source files, then select a PSB and all of the DBD source files referred to by the selected PSB. Refer to Figure 8-17 on page 205.

Important:

- It is necessary to download the IMS PSB and DBD source to your local file system. You cannot use the remote file system on z/OS.
- The DBD file name in your local file system must be the same name as the DBD name.
- The Database PSB file names in your local file system must be the same name as the Database PSB names.



Import IMS PSB and DBD Source

Click Finish to open the IMS perspective or Next to update your PSB source.

From directory: W:\Setup\IMS\PSB

☑ DFSIVP37

□ Same directory as above

From directory: W:\Setup\IMS\DBD

☑ IVPDB2

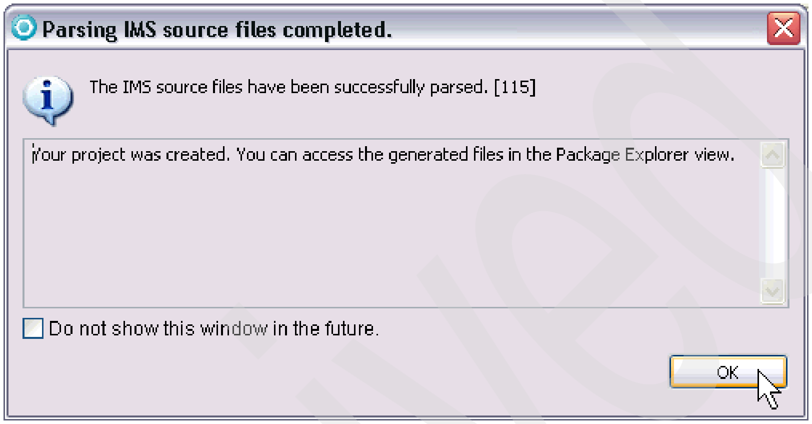
Figure 8-17 Import IMS PSB and DBD source

8. Generate the DLIModel project files by clicking **Finish**. The following files are created:

   – Metadata file (.java)
   – Graphical model file (.mdl)
   – XML Metadata Interchange™ file (.xmi)

- XML schema file (.xsd) - optional
- DLIModel database report (.txt) - optional
- Trace log (.txt) - optional

9. After the output files are generated, a Parsing IMS source files completed window opens to confirm that your DLIModel project was created. Click **OK** to close this window.



Parsing IMS source files completed.

The IMS source files have been successfully parsed. [115]

Your project was created. You can access the generated files in the Package Explorer view.

□ Do not show this window in the future.

Figure 8-18 Parsing IMS source files completed window

The IMS perspective launches automatically and the generated .java and .mdl files open in the DLIModel editor. You can either exit the DLIModel editor and use the metadata for Java application development, or you can use the DLIModel editor to modify field, segment, or program communication block (PCB) information.

8.6.2 Importing a COBOL copybook

You can enhance metadata with additional information about field layouts by importing one or more COBOL copybooks into your DLIModel project.

You can only import a COBOL copybook if you have RAD, RDz, or WebSphere Developer for zSeries.

To import a COBOL copybook, perform the following steps:

1. Right-click the model background or the segment to which you want to add the COBOL field definitions.
2. Select **Import COBOL Fields**, as shown in Figure 8-19 on page 207.

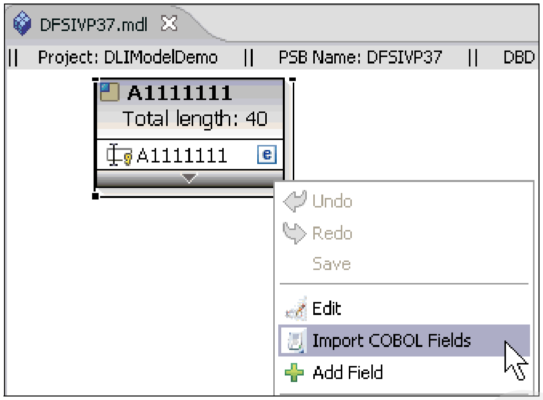


Figure 8-19 Importing a COBOL copybook

3. Browse your local file system for your COBOL copybook files.

   A COBOL copybook can use any of the following file extensions: .cbl, .ccp, .cpy, or .cob.

4. Click **Select** to select a segment into which to import the COBOL copybook (Figure 8-20 on page 208).

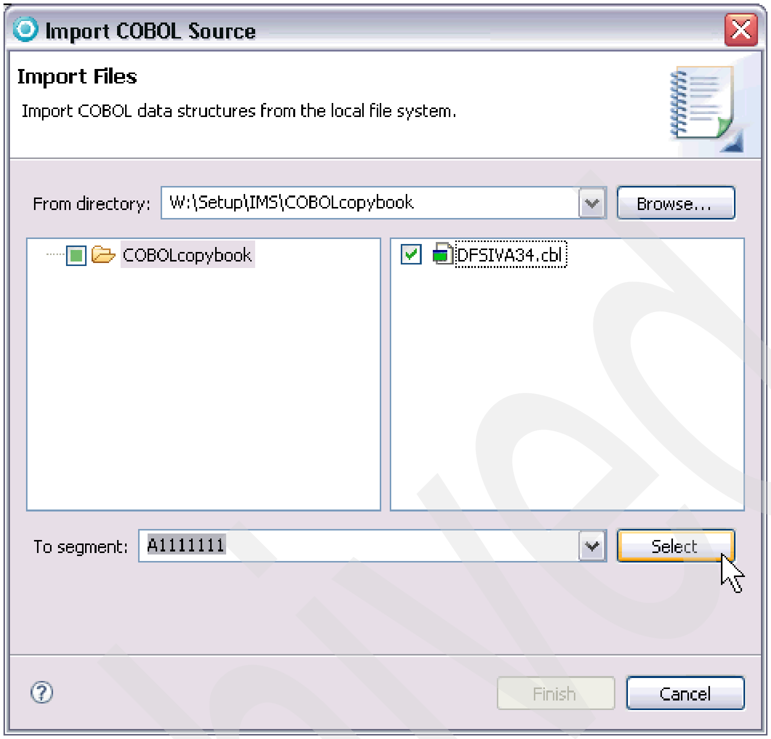
5. Click **Finish** to integrate the COBOL fields into the selected segment or browse the local file system to import additional COBOL copybook files into a different segment.

   Optional: If you get an error after clicking **Finish**, verify that your COBOL preferences are set to support data structures only:

   a. Click **Window** → **Preferences**, and then select **COBOL** from the list on the left of the window.

   b. Select the **More COBOL options** tab and change the file extension support to **Data structures only**.

   c. Click **Apply** to update the changes, and then, reimport your COBOL copybook.



Import COBOL Source

Import Files

Import COBOL data structures from the local file system.

From directory: W:\Setup\IMS\COBOLcopybook

☐ COBOLcopybook

☑ DFSIVA34.cbl

To segment: A1111111

Figure 8-20 Import COBOL Copybook files

Example 8-4 shows a Java representation of an imported COBOL Copybook.

Example 8-4 DLIDatabaseView subclass (sample)

```
package com.ibm.itso.dlidemo;

import com.ibm.ims.db.*;
import com.ibm.ims.base.*;

public class DFSIVP37DatabaseView extends DLIDatabaseView {

    // This class describes the data view of PSB: DFSIVP37
    // PSB DFSIVP37 has database PCBs with 8-char PCBNAME or label:
    //      PHONEAP

    // The following describes Segment: A1111111 ("A1111111") in PCB:
    // PHONEAP ("PHONEAP")
    static DLITypeInfo[] PHONEAPA1111111Array= {
        new DLITypeInfo("A1111111", DLITypeInfo.CHAR, 1, 10,
                        "A1111111", DLITypeInfo.UNIQUE_KEY),
        new DLITypeInfo("IOLINE", DLITypeInfo.CHAR, 1, 37),
        new DLITypeInfo("IODATA", DLITypeInfo.CHAR, 1, 37),
        new DLITypeInfo("IOLASTNAME", DLITypeInfo.CHAR, 1, 10),
        new DLITypeInfo("IOFIRSTNAME", DLITypeInfo.CHAR, 11, 10),
        new DLITypeInfo("IOEXTENSION", DLITypeInfo.CHAR, 21, 10),
        new DLITypeInfo("IOZIPCODE", DLITypeInfo.CHAR, 31, 7),
        new DLITypeInfo("IOFILLER", DLITypeInfo.CHAR, 38, 3)
    };
    static DLISegment PHONEAPA1111111Segment= new DLISegment
        ("A1111111","A1111111",PHONEAPA1111111Array,40);

    // An array of DLISegmentInfo objects follows to describe the view
    // for PCB: PHONEAP ("PHONEAP")
    static DLISegmentInfo[] PHONEAParray = {
        new DLISegmentInfo(PHONEAPA1111111Segment,DLIDatabaseView.ROOT)
    };

    // Constructor
    public DFSIVP37DatabaseView() {
        super("2.0","DFSIVP37", "PHONEAP", "PHONEAP", PHONEAParray);
    } // end DFSIVP37DatabaseView constructor

} // end DFSIVP37DatabaseView class definition
```

Note: We had a problem with the original field names in the COBOL Copybook, because they contained minus signs. The SQL parser did not accept these names (and does not seem to support quotation marks). So, we manually changed the field names in the generated class, removing the minus signs.

8.7 Running an application in WebSphere Application Server for z/OS

This topic provides the high-level steps that are required to run an application that accesses IMS DB from WebSphere Application Server for z/OS.

8.7.1 Installing the data source for your application

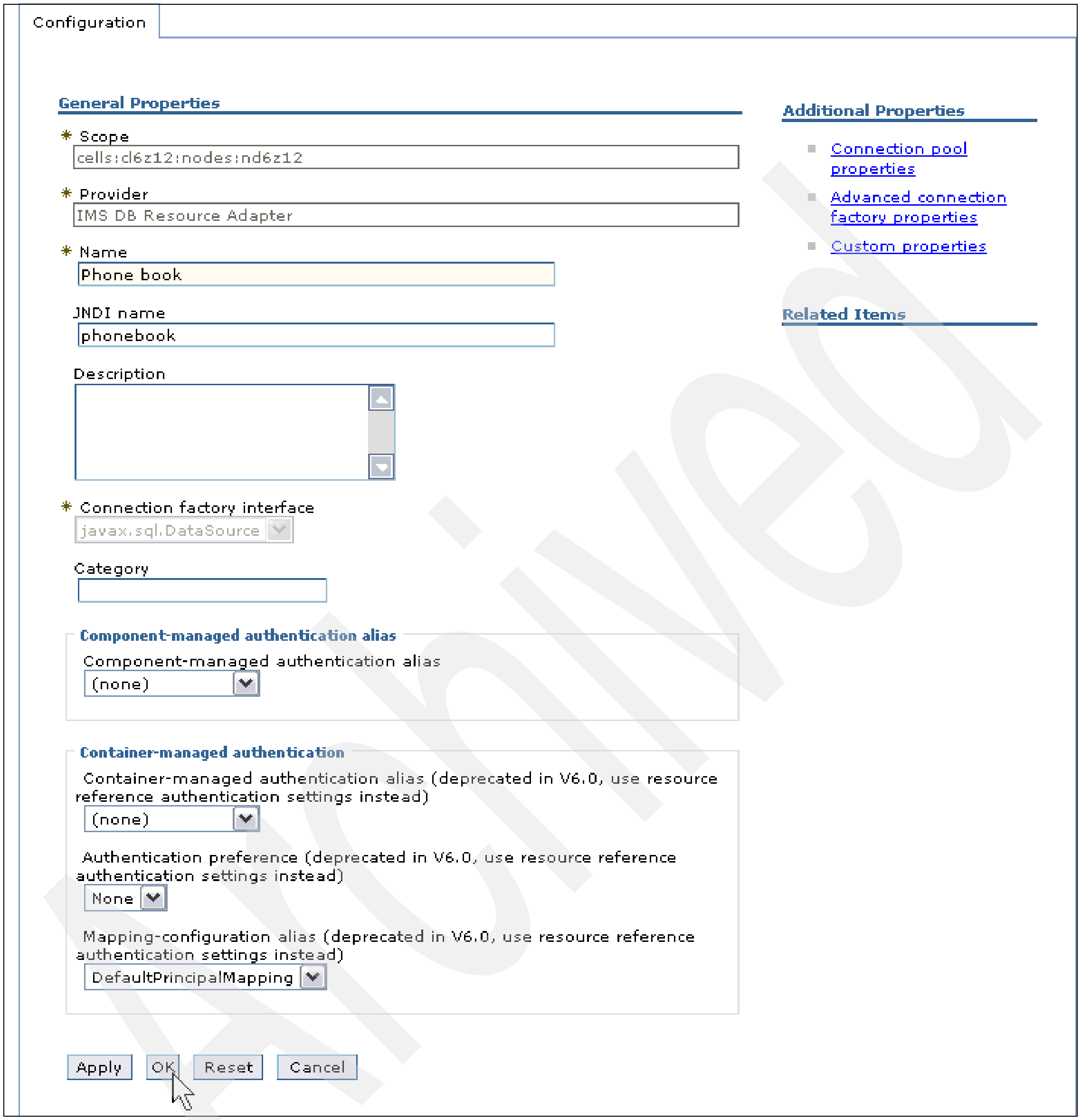
The DataSource facility is a factory for connections to a physical data source, or database. A data source is registered with a naming service based on the Java Naming and Directory (JNDI) API. DataSource objects have properties that pertain to the actual data source that an application needs to access.

> **Requirement:** You must use the DataSource facility, which replaces the DriverManager facility, because the DriverManager facility is not supported by the J2EE Connection Architecture Specification.

To install the data source for your application:

1. In the left frame of the WebSphere Application Server for z/OS Integrated Console, click **Resources**, expand **Resource Adapters**, and then, click **Resource Adapters**. A list of resource adapters is displayed.
2. Click the name of the IMS DB resource adapter that you chose when you installed the adapter. A configuration dialog is displayed.
3. Under Additional Properties, click **J2C connection factories**.
4. Click **New**. A configuration dialog is displayed.
5. Type the following information:
   - Name: The name for the data source
   - JNDI Name: The JNDI name for the data source
6. Click **OK**.

   Refer to Figure 8-21 on page 211. The data source is now listed in the J2C connection factories.


Configuration

General Properties

* Scope
cells:cl6z12:nodes:nd6z12

* Provider
IMS DB Resource Adapter

* Name
Phone book

JNDI name
phonebook

Description

* Connection factory interface
javax.sql.DataSource

Category

Component-managed authentication alias
Component-managed authentication alias
(none)

Container-managed authentication
Container-managed authentication alias (deprecated in V6.0, use resource reference authentication settings instead)
(none)

Authentication preference (deprecated in V6.0, use resource reference authentication settings instead)
None

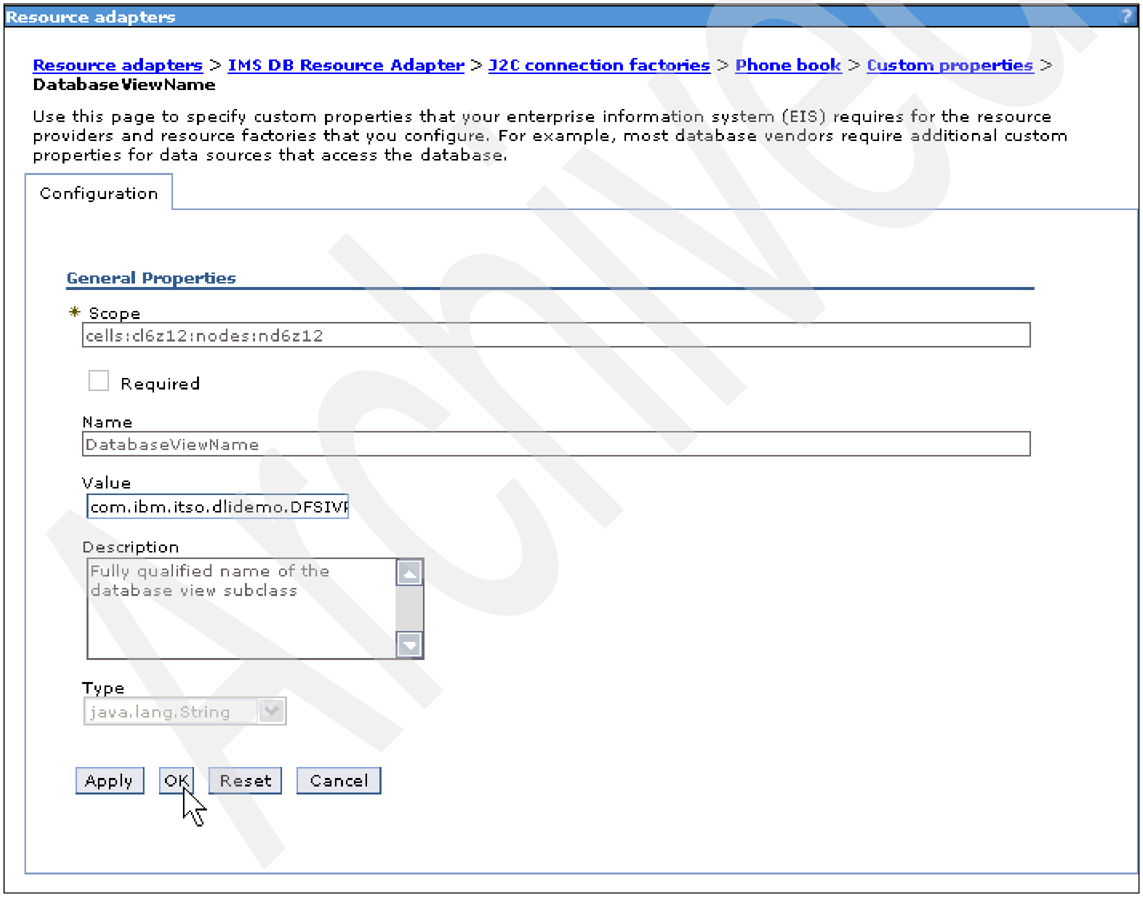
Mapping-configuration alias (deprecated in V6.0, use resource reference authentication settings instead)
DefaultPrincipalMapping

Figure 8-21 Configure J2C connection factories

7. Click the name of the data source that you installed.
8. Under **Additional Properties**, click **Custom properties**. Three properties are listed in a table.
9. Click **DatabaseViewName**. A configuration dialog is displayed.

10. **Optional**: In the Value field, type the fully qualified DLIDatabaseView subclass name. If you set the subclass name, you must either create a data source for every PSB that an application accesses, or you must override the DLIDatabaseView subclass name in the DataSource object that is within the application by calling the `setDatabaseView` method and providing the fully qualified name of the subclass. If you do not set the subclass name, you need to create a data source only for each IMS. In the application, define the DLIDatabaseView subclass name in the DataSource object by calling the `setDatabaseView` method and providing the fully qualified name of the subclass.

11. Click **OK**. The properties table displays the DatabaseViewName value that you just entered (Figure 8-22).



Resource adapters

Resource adapters > IMS DB Resource Adapter > J2C connection factories > Phone book > Custom properties > DatabaseViewName

Use this page to specify custom properties that your enterprise information system (EIS) requires for the resource providers and resource factories that you configure. For example, most database vendors require additional custom properties for data sources that access the database.

Configuration

General Properties

* Scope: cells:d6z12:nodes:nd6z12

□ Required

Name: DatabaseViewName

Value: com.ibm.itso.dlidemo.DFSIVI

Description: Fully qualified name of the database view subclass

Type: java.lang.String

Figure 8-22 Configure Database View name

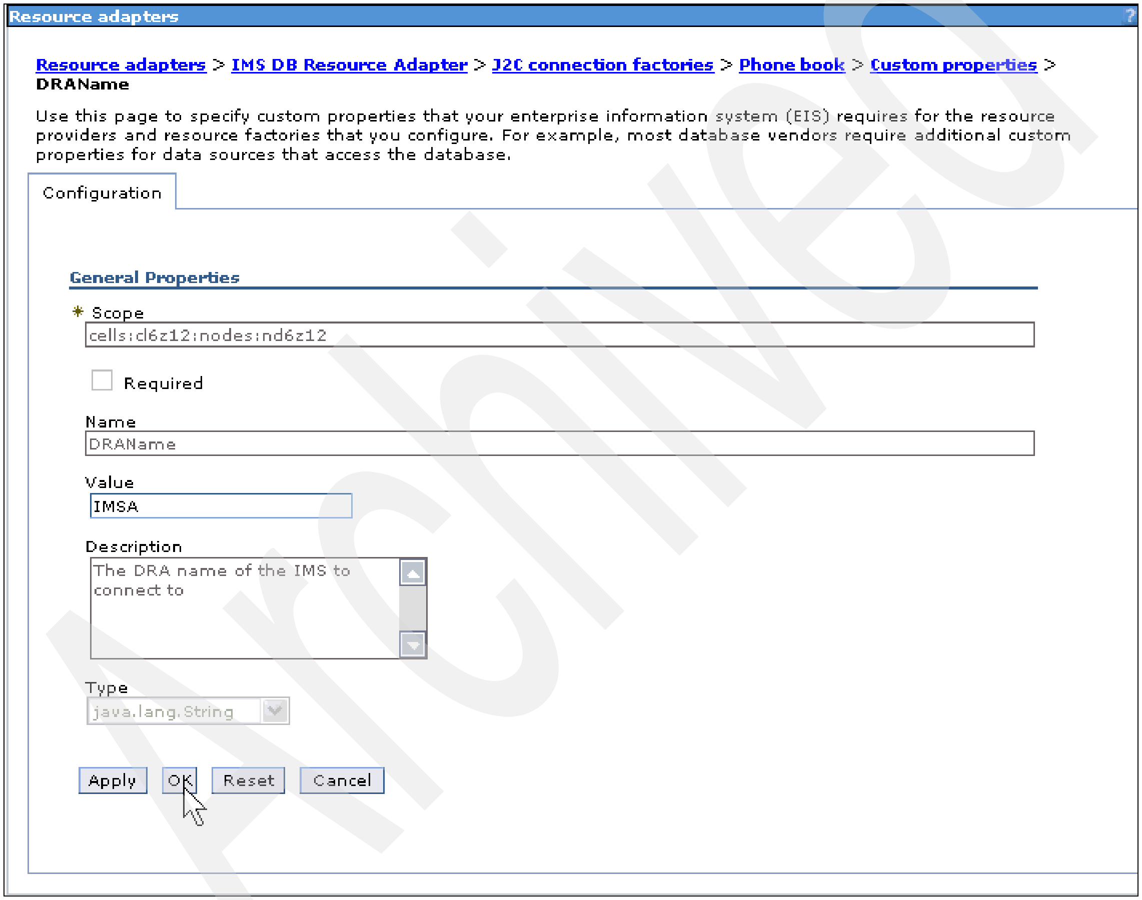
12. Click **DRAName**. A configuration dialog is displayed.

13. In the Value field, type bytes 4 - 7 of the DRA startup table module name (usually the IMS system ID). For more information about the DRA startup table, refer to 8.3, “IMS Setup” on page 181.

14. Click **OK** (Figure 8-23). The properties table displays the DRA name that you just entered.

15. In the messages box, click **Save** to update the master repository with your changes.

16. Restart the server in order for the custom service to take effect.



Resource adapters

Resource adapters > IMS DB Resource Adapter > J2C connection factories > Phone book > Custom properties > **DRAName**

Use this page to specify custom properties that your enterprise information system (EIS) requires for the resource providers and resource factories that you configure. For example, most database vendors require additional custom properties for data sources that access the database.

Configuration

General Properties

* Scope
cells:cl6z12:nodes:nd6z12

□ Required

Name
DRAName

Value
IMSA

Description
The DRA name of the IMS to connect to

Type
java.lang.String

Figure 8-23 Configure Database DRAName

8.7.2 Developing an application for WebSphere Application Server

You can develop an application program using a development tool, such as Rational Developer for System z (RDz).

The code in Example 8-5 and Example 8-6 is a sample that accesses the IMS Phone book database via the IMS DB Resource Adapter.

> **Important:** The database name is the database PCB name, not the IMS database descriptor (DBD) name using SQL.

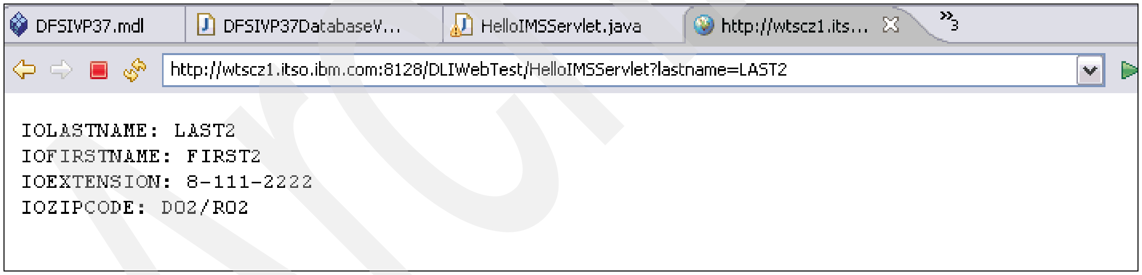
Example 8-5 SQL sample

```
PreparedStatement stmt = conn.prepareStatement(
     "SELECT IOLASTNAME"
   + "     , IOFIRSTNAME"
   + "     , IOEXTENSION"
   + "     , IOZIPCODE"
   + "  FROM PHONEAP.A1111111"
   + " WHERE A1111111 = ?");
```

Example 8-6 Program code sample

```
package com.ibm.itso.sg247669.ims.web;

import java.io.IOException;
import java.io.PrintWriter;
import java.sql.Connection;
import java.sql.PreparedStatement;
import java.sql.ResultSet;
import java.sql.ResultSetMetaData;
import java.sql.SQLException;

import javax.naming.Context;
import javax.naming.InitialContext;
import javax.naming.NamingException;
import javax.servlet.ServletException;
import javax.servlet.http.HttpServletRequest;
import javax.servlet.http.HttpServletResponse;
import javax.sql.DataSource;
import javax.transaction.HeuristicMixedException;
import javax.transaction.HeuristicRollbackException;
import javax.transaction.NotSupportedException;
import javax.transaction.RollbackException;
import javax.transaction.SystemException;
import javax.transaction.UserTransaction;

/**
 * Servlet implementation class for Servlet: HelloIMSServlet
 *
 */
public class HelloIMSServlet extends javax.servlet.http.HttpServlet
implements
      javax.servlet.Servlet {
   /*
    * (non-Java-doc)
    *
    * @see javax.servlet.http.HttpServlet#HttpServlet()
    */
   public HelloIMSServlet() {
      super();
   }

   /*
    * (non-Java-doc)
    *
    * @see javax.servlet.http.HttpServlet#doGet(HttpServletRequest
request,
    *      HttpServletResponse response)
    */
   protected void doGet(HttpServletRequest request,
         HttpServletResponse response) throws ServletException,
IOException {
      PrintWriter pw = response.getWriter();
      try {
         Context ctx = new InitialContext();
         UserTransaction trn = (UserTransaction) ctx
               .lookup("java:comp/UserTransaction");
         trn.begin();
         DataSource dataSource = (DataSource) ctx
               .lookup("java:comp/env/jdbc/IMS");
         Connection conn = dataSource.getConnection();
         PreparedStatement stmt = conn.prepareStatement(//
               "SELECT " //
               + "  IOLASTNAME"
               + ", IOFIRSTNAME"
               + ", IOEXTENSION"
               + ", IOZIPCODE"
               + "  FROM PHONEAP.A1111111" + " WHERE A1111111 = ?");
         String lastname = request.getParameter("lastname");
         stmt.setString(1, lastname);
         ResultSet rs = stmt.executeQuery();
         ResultSetMetaData metaData = rs.getMetaData();
         response.setContentType("text/plain");
         if (rs.next()) {
            for (int idx = 1; idx <= 4; idx++) {
               pw.println(metaData.getColumnName(idx) + ": " +
rs.getString(idx));
            }
         } else {
            pw.println("No matching segment found");
         }
         trn.rollback();
         conn.close();
      } catch (Exception e) {
         e.printStackTrace(pw);
      }
   }
}
```

You can test the Java application after it has been deployed to WebSphere Application Server. Figure 8-24 shows the test output.



http://wtscz1.itso.ibm.com:8128/DLIWebTest/HelloIMSServlet?lastname=LAST2

```
IOLASTNAME: LAST2
IOFIRSTNAME: FIRST2
IOEXTENSION: 8-111-2222
IOZIPCODE: D02/R02
```

Figure 8-24 Testing the sample program

9

Exposing data as a service by using IBM WebSphere Message Broker

In this chapter, we show an example to access VSAM and DB2 data directly from *WebSphere Message Broker*. The service request is sent from the consumer to WebSphere Message Broker. In our example, we retrieve customer information based on a customer number. If the customer number does not exist, an error is produced and passed back to the consumer.

This example is based on the scenario that is described in 3.1, “Accessing VSAM data as a service” on page 28 and “Accessing DB2 on z/OS using WebSphere Message Broker” on page 45.

9.1 Introduction

This example demonstrates how a WebSphere Message Broker message flow can support two consumers. One consumer is an XML over MQ format/protocol, and the second consumer is SOAP over HTTP. WebSphere Message Broker performs the protocol conversion, data transformation, and content-based routing.

You must have a COBOL copybook that describes the format of the input and output messages for the VSAM file.

We developed this example using WebSphere Message Broker Toolkit Version 6.1.0.3 and WebSphere Message Broker Version 6.1 with Fix Pack 3 running on z/OS.

9.2 Steps

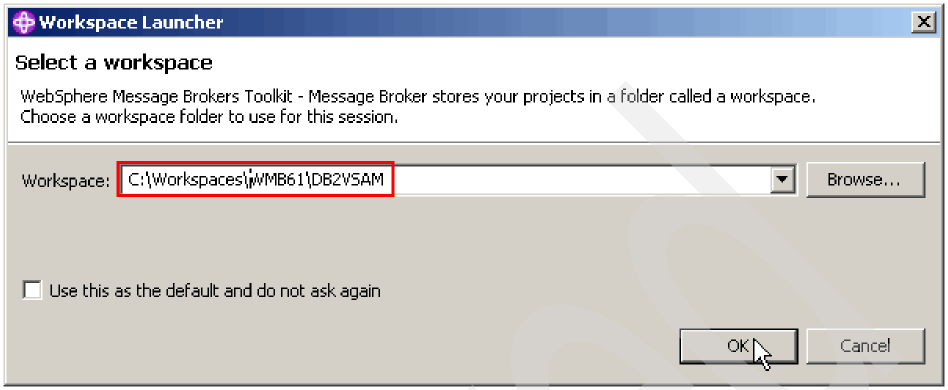
We guide you through these steps to access data in VSAM and DB2 using WebSphere Message Broker:

1. Invoke the WebSphere Message Broker Toolkit and create a project.
2. Build a WebSphere Message Broker *Message Set* for the VSAM record definition. A WebSphere Message Broker Message Set is needed to define the structure of the VSAM file.
3. Build a WebSphere Message Broker message set for the request/reply.
4. Build the *Message Flow*. The message flow defines the protocol conversion, data transformation, VSAM access, DB2 access, and content-based routing.
5. Describe and modify the node properties. Most nodes need one or several properties defined. The compute nodes need customized extended SQL (ESQL).
6. Deploy the flow to z/OS.
7. Test the flow on z/OS.

9.2.1 Invoking WebSphere Message Broker Toolkit to create a project

The WebSphere Message Broker Toolkit is the graphical “buildtime” environment that is used to develop Broker *Message Flows,* as well as the artifacts that are needed by flows, for example, the Broker *Message Sets*. The Toolkit runs in the Linux or Windows environment. After building the flow, it must be deployed to a runtime environment for execution, which we describe later in this chapter.

Start the WebSphere Message Broker Toolkit from the Windows Start menu and enter the workspace name that you want to use, as shown in Figure 9-1.



Workspace Launcher

Select a workspace

WebSphere Message Brokers Toolkit - Message Broker stores your projects in a folder called a workspace.
Choose a workspace folder to use for this session.

Workspace: C:\Workspaces\WMB61\DB2VSAM

□ Use this as the default and do not ask again

Figure 9-1 Select a workspace in WebSphere Message Broker Toolkit

The Broker Toolkit includes several perspectives. A *perspective* is a pre-customized set of window panes, organized in a particular way to facilitate the development. For this part of the sample, you must use the *Broker Application Development* perspective. The current perspective is displayed in the title bar of the Toolkit window. If this perspective is not the correct one, switch to the correct perspective by selecting **Window** → **Open Perspective** → **Other** → **Broker Application Development (default).** Refer to Figure 9-2.

Alternatively, you can also select the recently used perspectives from the Toolkit tab buttons displayed in the upper right part of the Toolkit window.

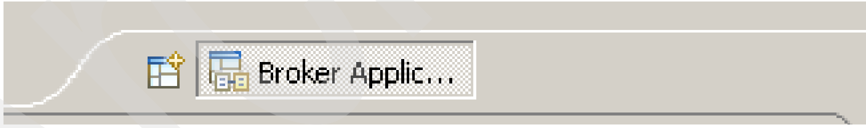


Figure 9-2 Select Broker Application Development perspective

The finished flow that is developed in this exercise appears as shown in Figure 9-3 on page 220.

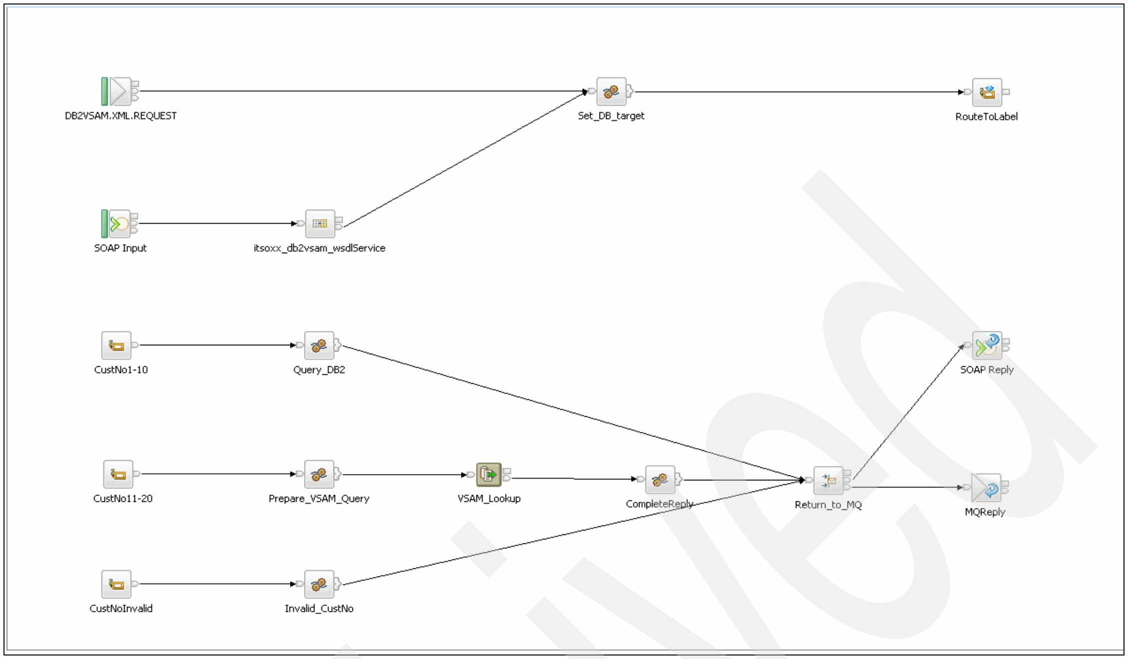


Figure 9-3 Flow

9.2.2 Building a Message Set for the VSAM record definition

In the following steps, we show how to create the Message Set for the VSAM file:

1. Select **File** → **New** → **Message Set**, as shown in Figure 9-4 on page 221.

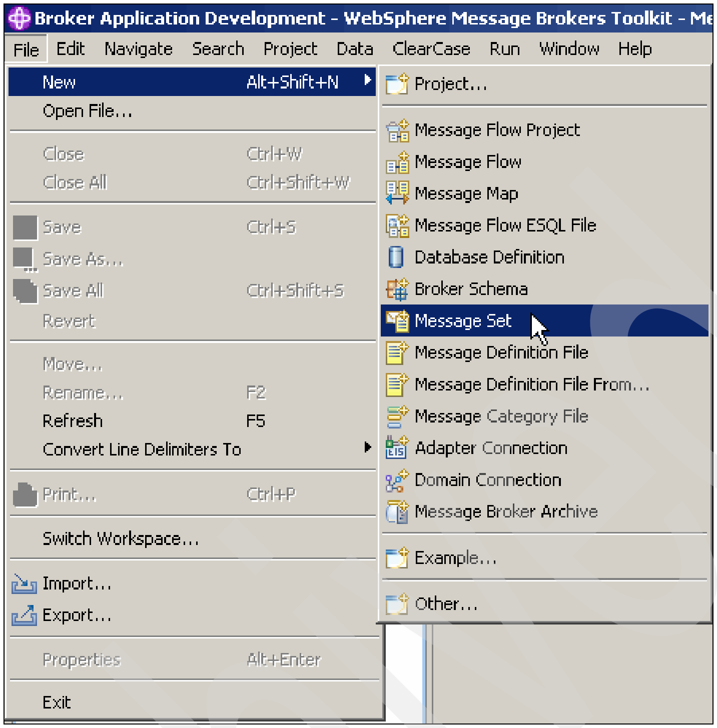
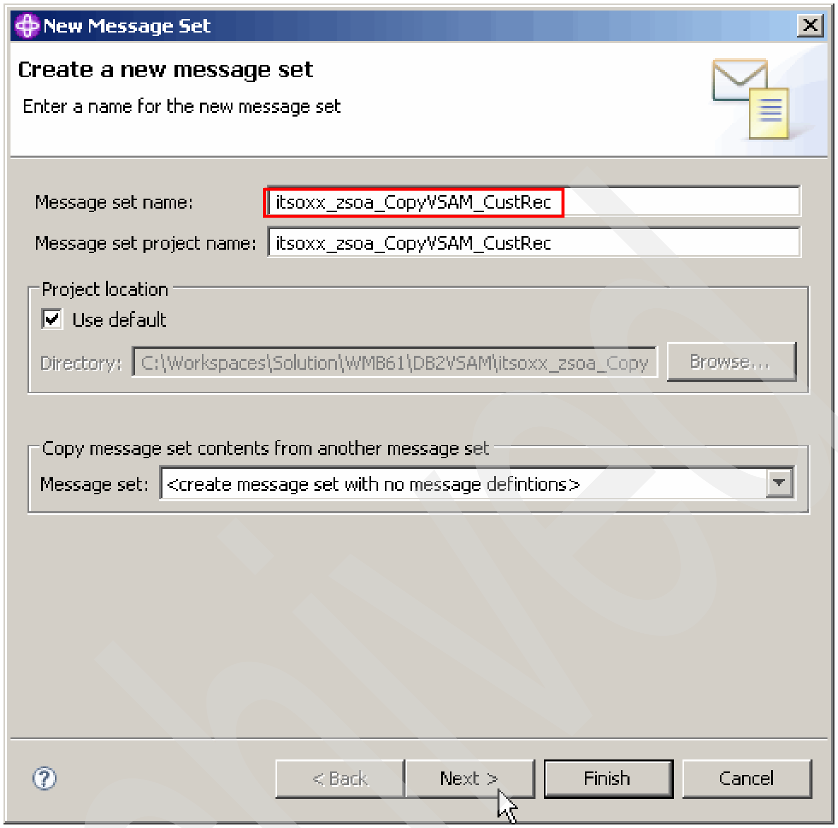


Figure 9-4 Create a new Message Set

The “Create a new message set” wizard appears now.

2. Fill in the fields as shown in Figure 9-5 on page 222. You have to enter a name for the Message set. The wizard automatically uses the same name for the Message set project, which can generally be accepted. Note that the message set name must be unique in a Broker. For this example, we use the name `itsoxx_zsoa_CopyVSAM_CustRec`. Click **Next**.



New Message Set

Create a new message set

Enter a name for the new message set

Message set name: itsoxx_zsoa_CopyVSAM_CustRec

Message set project name: itsoxx_zsoa_CopyVSAM_CustRec

Project location

☑ Use default

Directory: C:\Workspaces\Solution\WMB61\DB2VSAM\itsoxx_zsoa_Copy

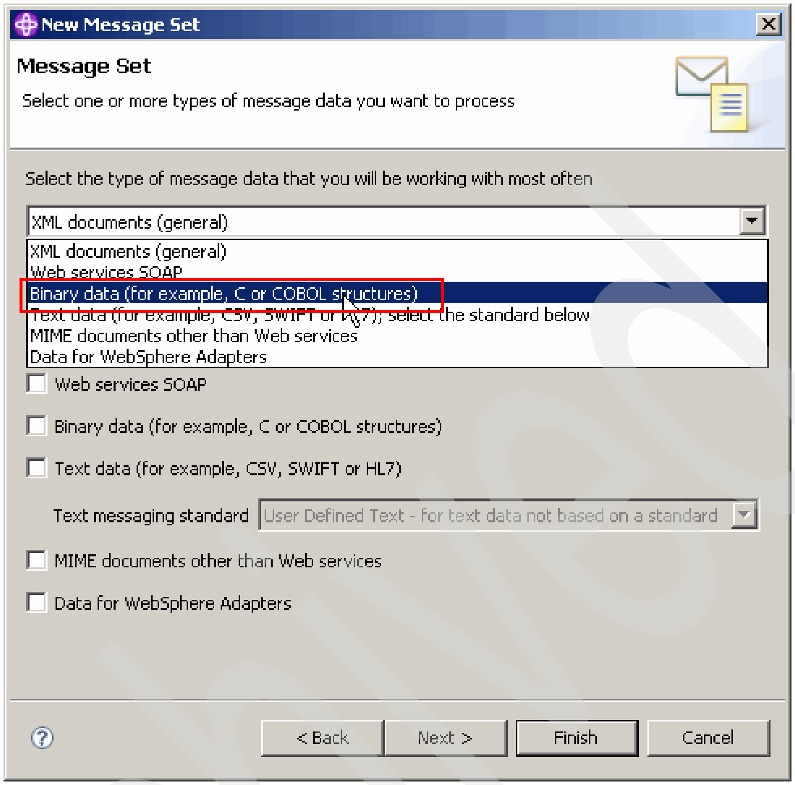
Copy message set contents from another message set

Message set: <create message set with no message defintions>

Figure 9-5 Specify Message Set name

The Message set window is presented next. This message set definition is used to parse data read from a VSAM file. The data is retrieved in a simple structure-like format as used in C or COBOL.

3. Select the message set data type by dropping down the list of data types and selecting **Binary data**. Clear the check marks in any other boxes and click **Next**. Refer to Figure 9-6 on page 223.



New Message Set

Message Set

Select one or more types of message data you want to process

Select the type of message data that you will be working with most often

XML documents (general)

XML documents (general)
Web services SOAP
Binary data (for example, C or COBOL structures)
Text data (for example, CSV, SWIFT or HL7); select the standard below
MIME documents other than Web services
Data for WebSphere Adapters

☐ Web services SOAP

☐ Binary data (for example, C or COBOL structures)

☐ Text data (for example, CSV, SWIFT or HL7)

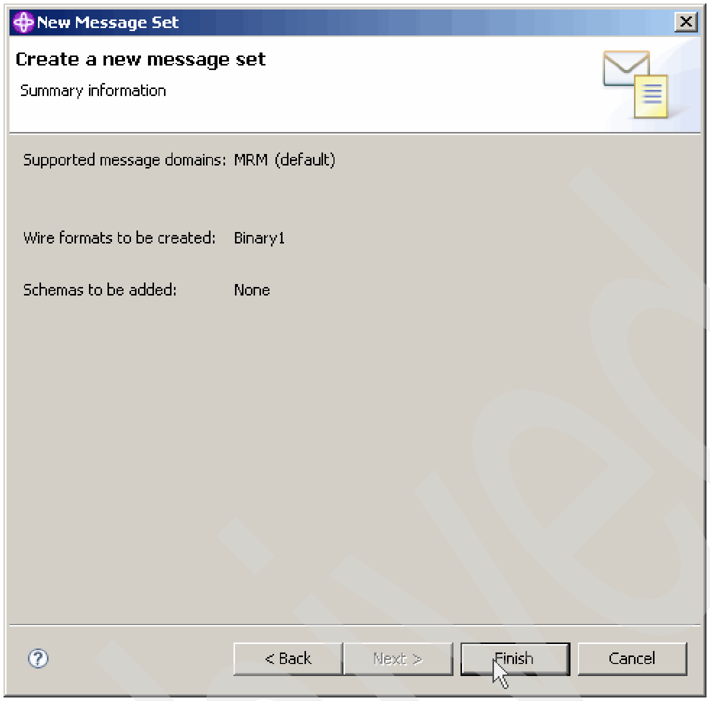
Text messaging standard: User Defined Text - for text data not based on a standard

☐ MIME documents other than Web services

☐ Data for WebSphere Adapters

Figure 9-6 Select physical message format

The “Create a new message set” window is shown next. Click **Finish**. Refer to Figure 9-7 on page 224.



New Message Set

Create a new message set

Summary information

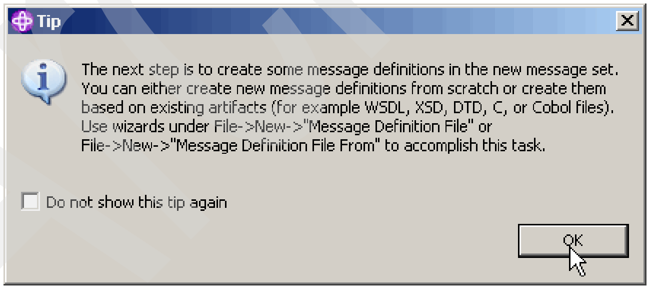
Supported message domains: MRM (default)

Wire formats to be created: Binary1

Schemas to be added: None

Figure 9-7 Message set confirmation window

The Message set is now generated, and a pop-up Tip window appears as shown in Figure 9-8. Click **OK**.



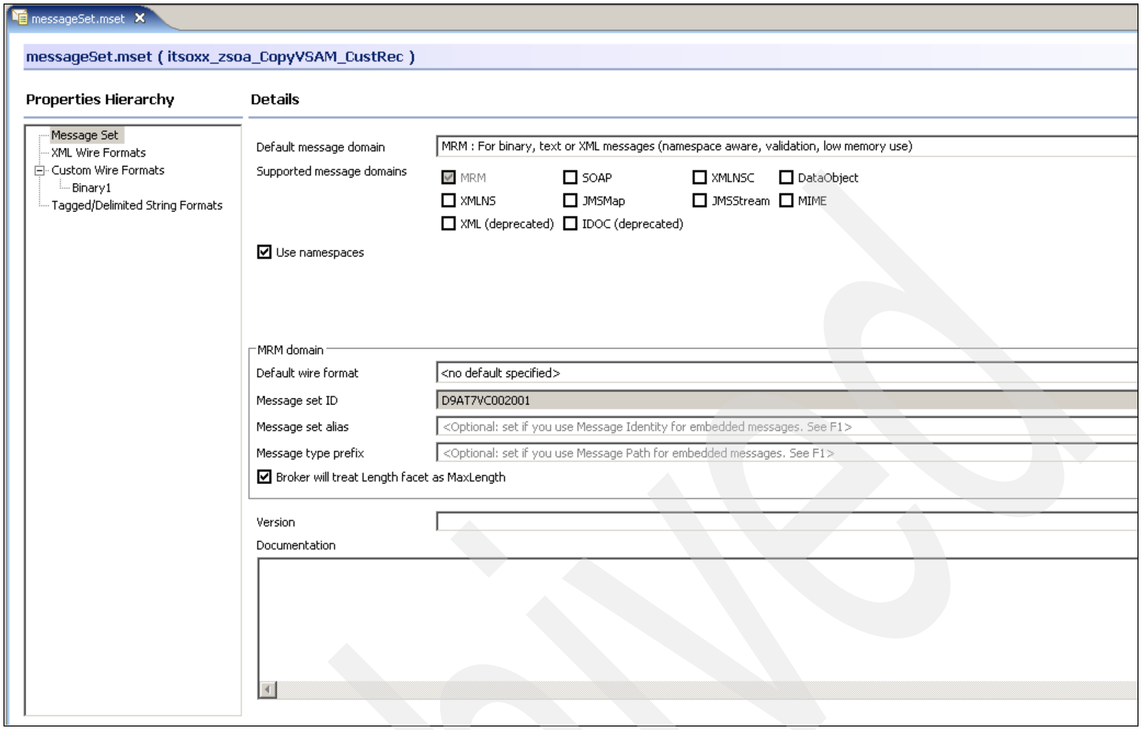
Tip

The next step is to create some message definitions in the new message set. You can either create new message definitions from scratch or create them based on existing artifacts (for example WSDL, XSD, DTD, C, or Cobol files). Use wizards under File->New->"Message Definition File" or File->New->"Message Definition File From" to accomplish this task.

□ Do not show this tip again

Figure 9-8 Tip window

You now have a window open in your workspace with the just defined message set, as shown in Figure 9-9 on page 225.



messageSet.mset

messageSet.mset (itsoxx_zsoa_CopyVSAM_CustRec)

Properties Hierarchy

- Message Set
- XML Wire Formats
- Custom Wire Formats
  - Binary1
- Tagged/Delimited String Formats

Details

Default message domain: MRM : For binary, text or XML messages (namespace aware, validation, low memory use)

Supported message domains: ☑ MRM ☐ SOAP ☐ XMLNSC ☐ DataObject ☐ XMLNS ☐ JMSMap ☐ JMSStream ☐ MIME ☐ XML (deprecated) ☐ IDOC (deprecated)

☑ Use namespaces

MRM domain

Default wire format: <no default specified>

Message set ID: D9AT7VC002001

Message set alias: <Optional: set if you use Message Identity for embedded messages. See F1>

Message type prefix: <Optional: set if you use Message Path for embedded messages. See F1>

☑ Broker will treat Length facet as MaxLength

Version

Documentation

Figure 9-9 Message set definition

Note: Notice the automatically generated message set ID. You might need it later in the definition of the nodes.

Tip: Be careful when noting a message set ID. Zeros (0) and the character “O” in particular can be confused. Better yet, you can later copy the Message Set ID to the clipboard and then paste it into the required field.

In the next step, the message set is defined from a COBOL copybook.

4. Highlight **messageSet.set** and right-click it. Select **New** → **Message Definition File From** → **COBOL File**, as shown in Figure 9-10 on page 226.

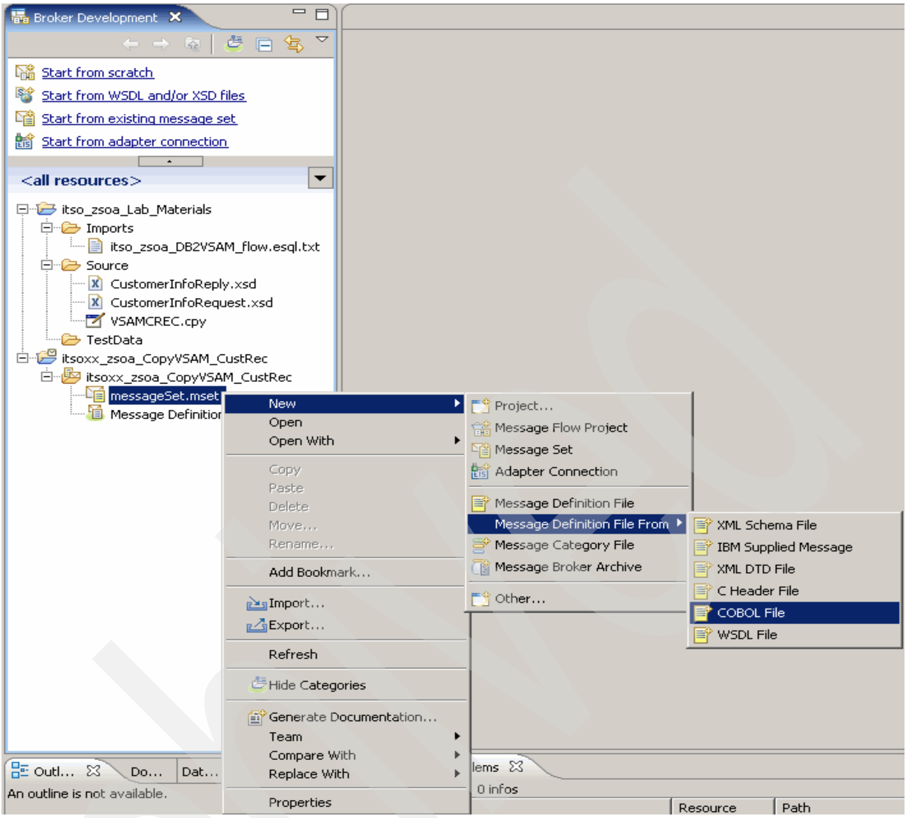


Figure 9-10 Creating a new Message Definition File from COBOL

The COBOL copybook to import is shown in Example 9-1.

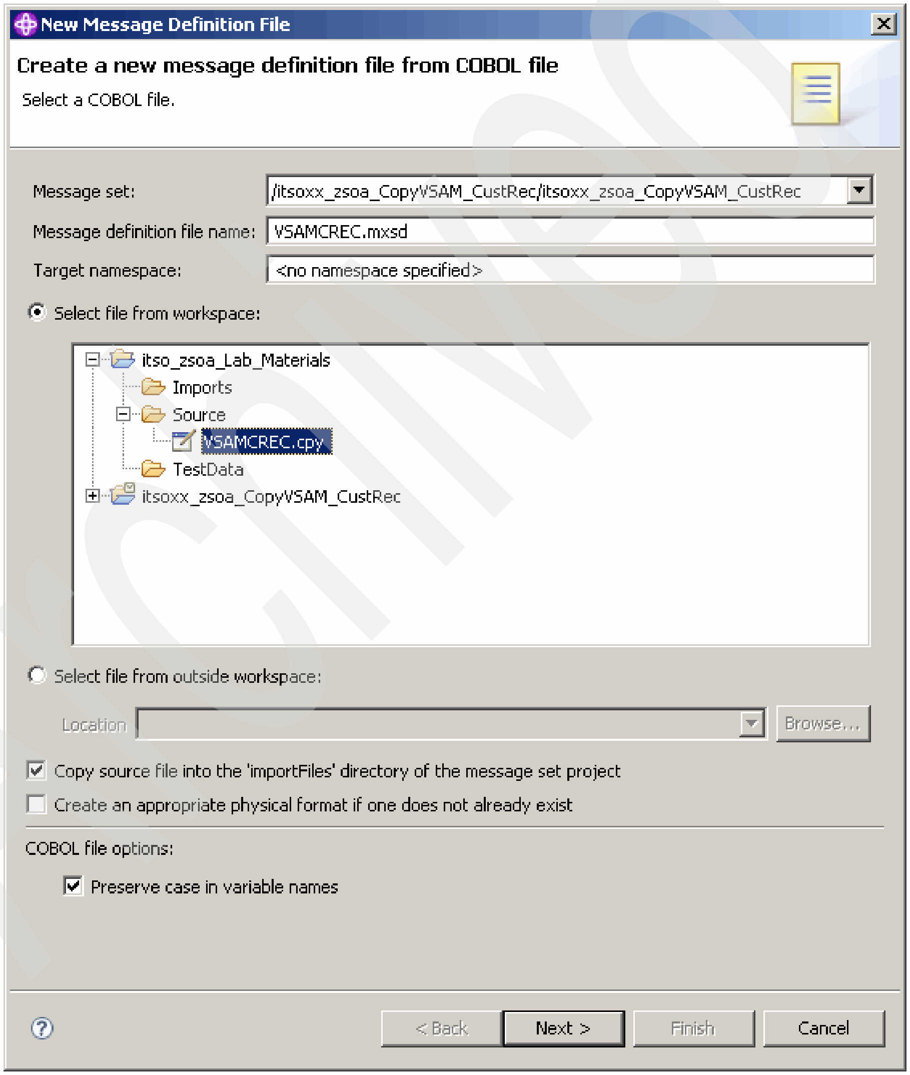
Example 9-1 VSAMCREC COBOL copybook

```
01  CUSTREC.
        02  CustNo        PIC 9(3).
        02  LastName      PIC X(25).
        02  FirstName     PIC X(15).
        02  Address1      PIC X(20).
        02  City          PIC X(20).
        02  State         PIC X(5).
        02  Country       PIC X(15).
```

5. In the next window, select the COBOL copybook file that represents the VSAM record. In our example, the name of this copybook file is `VSAMCREC.cpy`.

   If the COBOL copybook file has previously been imported into the workspace, select **Select file from workspace**, as shown in Figure 9-11. If not, select Select file from outside workspace. The VSAM copybook is already part of the workspace included with the additional material.

   Leave all the other field defaults in this window, and click **Next**.



New Message Definition File

Create a new message definition file from COBOL file

Select a COBOL file.

Message set: /itsoxx_zsoa_CopyVSAM_CustRec/itsoxx_zsoa_CopyVSAM_CustRec

Message definition file name: VSAMCREC.mxsd

Target namespace: <no namespace specified>

● Select file from workspace:

```
⊟ itso_zsoa_Lab_Materials
    Imports
  ⊟ Source
      VSAMCREC.cpy
    TestData
⊞ itsoxx_zsoa_CopyVSAM_CustRec
```

○ Select file from outside workspace:

Location

☑ Copy source file into the 'importFiles' directory of the message set project

□ Create an appropriate physical format if one does not already exist

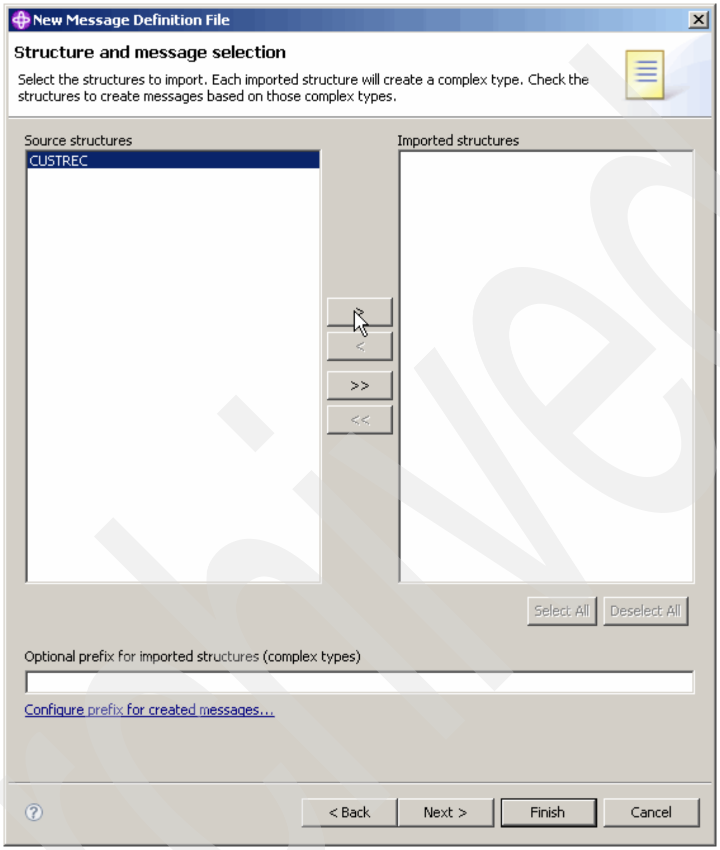
COBOL file options:

☑ Preserve case in variable names

Figure 9-11 Selecting the COBOL copybook file from the workspace

The next window is the Structure and message selection window.

6. Highlight **CUSTREC** and click **>** to move the structure to the Imported structures column. Refer to Figure 9-12.



New Message Definition File

Structure and message selection

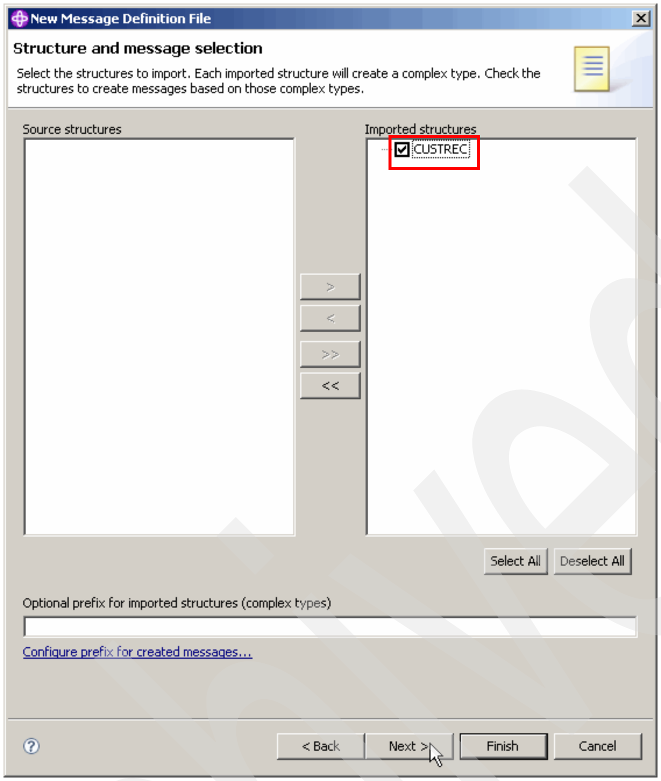
Select the structures to import. Each imported structure will create a complex type. Check the structures to create messages based on those complex types.

Source structures: CUSTREC

Imported structures
>
<
>>
<<
Select All
Deselect All
Optional prefix for imported structures (complex types)
Configure prefix for created messages...
< Back
Next >
Finish
Cancel

Figure 9-12 Selecting a structure from a COBOL copybook

7. Next, check the **CUSTREC** in Imported structures, and click **Next**, as shown in Figure 9-13 on page 229.


New Message Definition File

Structure and message selection

Select the structures to import. Each imported structure will create a complex type. Check the structures to create messages based on those complex types.

Source structures

Imported structures

☑ CUSTREC

Optional prefix for imported structures (complex types)

Configure prefix for created messages...

Figure 9-13 Selecting CUSTREC

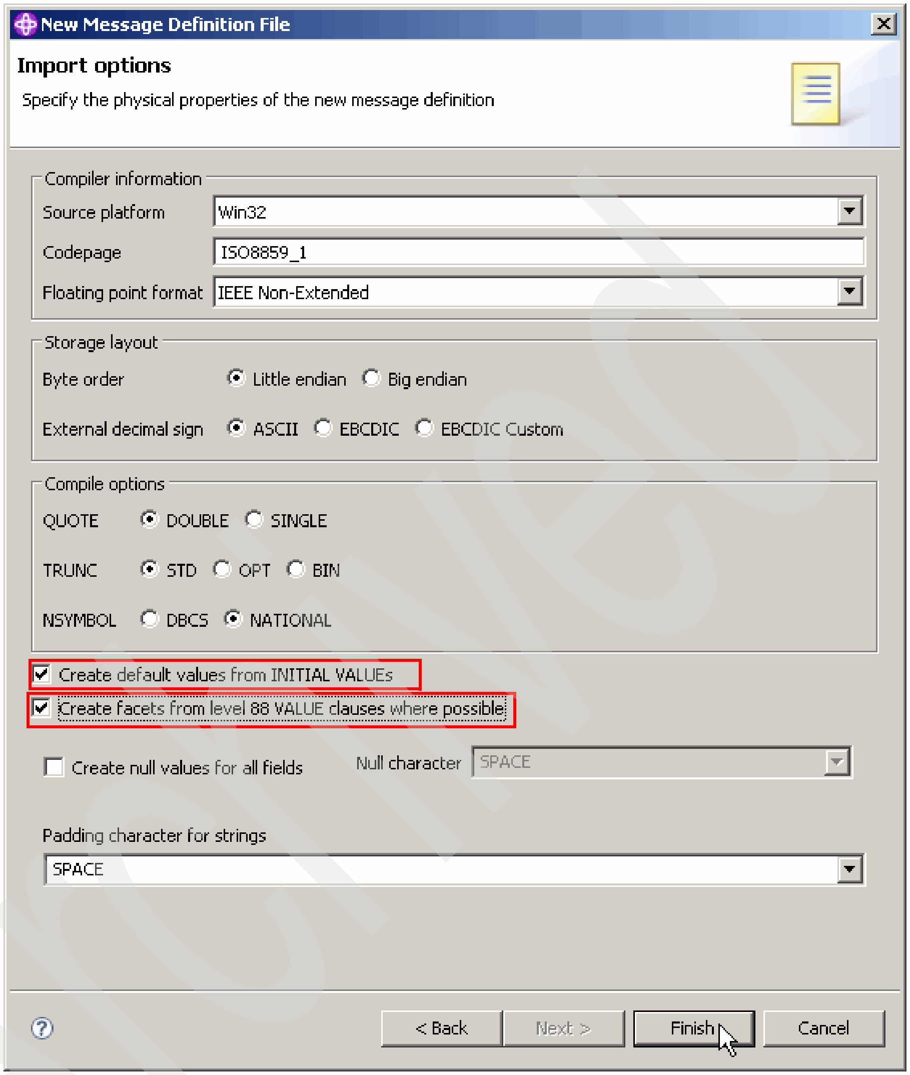
8. The next window is Import options (Figure 9-14 on page 230). In this window, you specify the physical properties of the message definition.

   Check the following two boxes:

   – Create default values from INITIAL VALUEs

   – Create facets from level 88 VALUE clauses where possible

   Leave the other fields as shown in Figure 9-14 on page 230 (defaults), and click **Finish**.



New Message Definition File

Import options

Specify the physical properties of the new message definition

Compiler information

Source platform: Win32

Codepage: ISO8859_1

Floating point format: IEEE Non-Extended

Storage layout

Byte order: ● Little endian ○ Big endian

External decimal sign: ● ASCII ○ EBCDIC ○ EBCDIC Custom

Compile options

QUOTE: ● DOUBLE ○ SINGLE

TRUNC: ● STD ○ OPT ○ BIN

NSYMBOL: ○ DBCS ● NATIONAL

☑ Create default values from INITIAL VALUEs

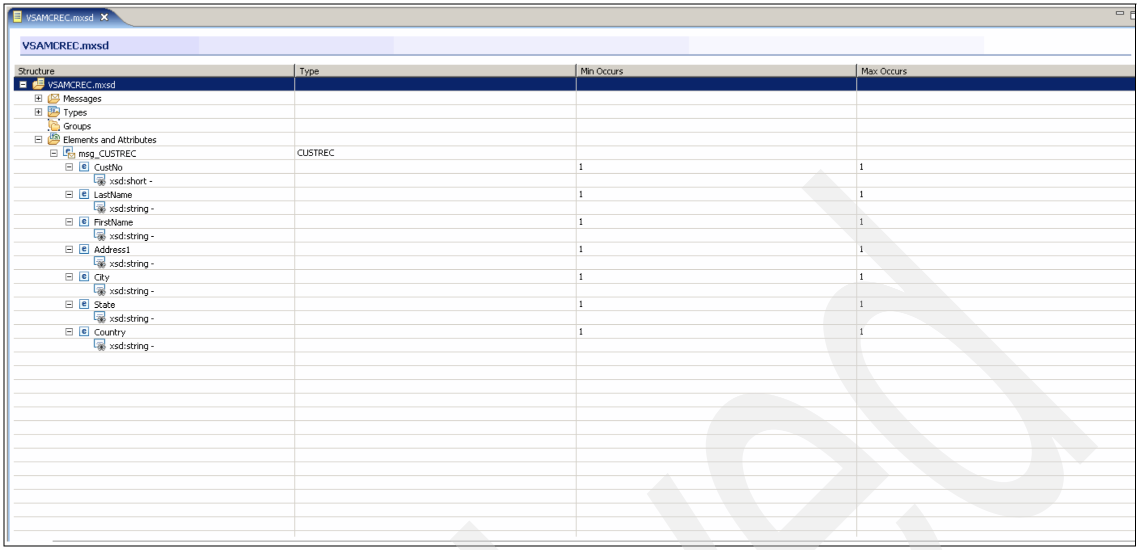
☑ Create facets from level 88 VALUE clauses where possible

□ Create null values for all fields   Null character: SPACE

Padding character for strings: SPACE

Figure 9-14   Import options

If you expand the message definition, it looks like the window that is shown in Figure 9-15 on page 231.



VSAMCREC.mxsd

Structure	Type	Min Occurs	Max Occurs
VSAMCREC.mxsd			
Messages			
Types			
Groups			
Elements and Attributes			
msg_CUSTREC	CUSTREC		
CustNo		1	1
xsd:short -			
LastName		1	1
xsd:string -			
FirstName		1	1
xsd:string -			
Address1		1	1
xsd:string -			
City		1	1
xsd:string -			
State		1	1
xsd:string -			
Country		1	1
xsd:string -			

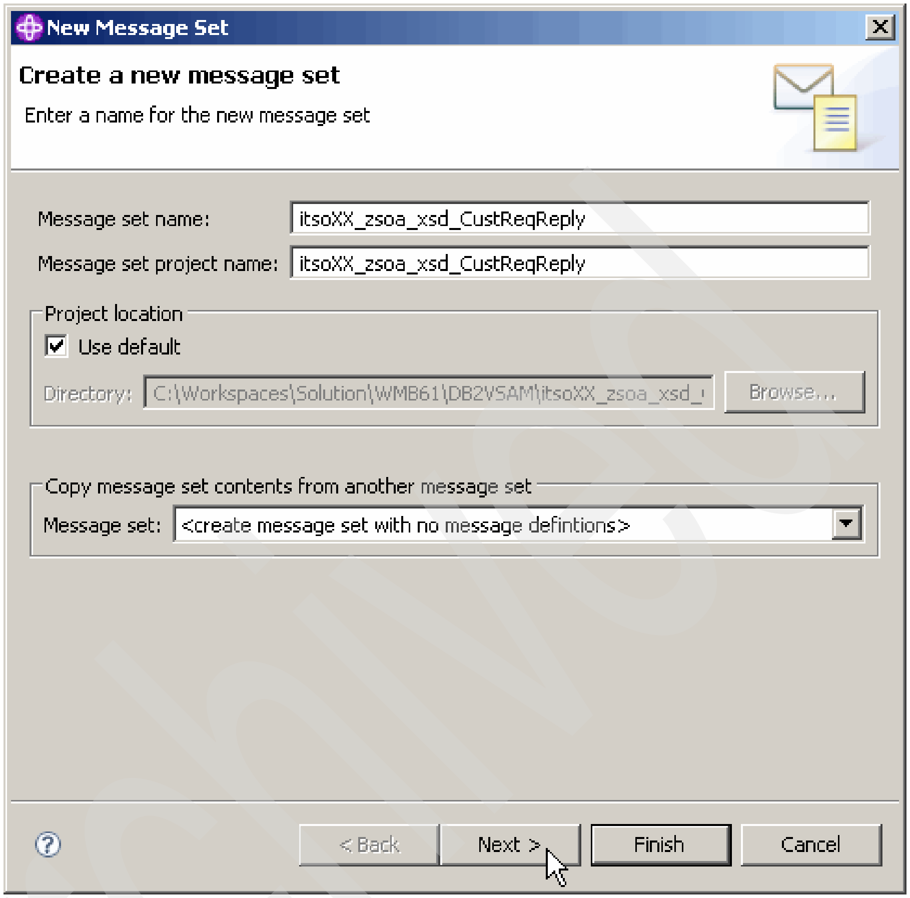
Figure 9-15 Message definition expanded

9. This is a good time to save the message set by holding down Ctrl+s.

9.2.3 Building a message set for the request/reply

In the following steps, we show how to build a message set for the request/reply. The process is similar to the process that is explained in 9.2.2, “Building a Message Set for the VSAM record definition” on page 220. This time, however, we work with SOAP, and we build our message set from an XML schema. The steps are:

1. Select **File** → **New** → **Message Set**.
2. In the “Create a new message set” window, type a name for the message set. We used `itsoXX_zsoa_xsd_CustReqReply` in our example. The message set project name is filled by the wizard. Click **Next**. Refer to Figure 9-16 on page 232.


New Message Set

Create a new message set

Enter a name for the new message set

Message set name: itsoXX_zsoa_xsd_CustReqReply

Message set project name: itsoXX_zsoa_xsd_CustReqReply

Project location

☑ Use default

Directory: C:\Workspaces\Solution\WMB61\DB2VSAM\itsoXX_zsoa_xsd_

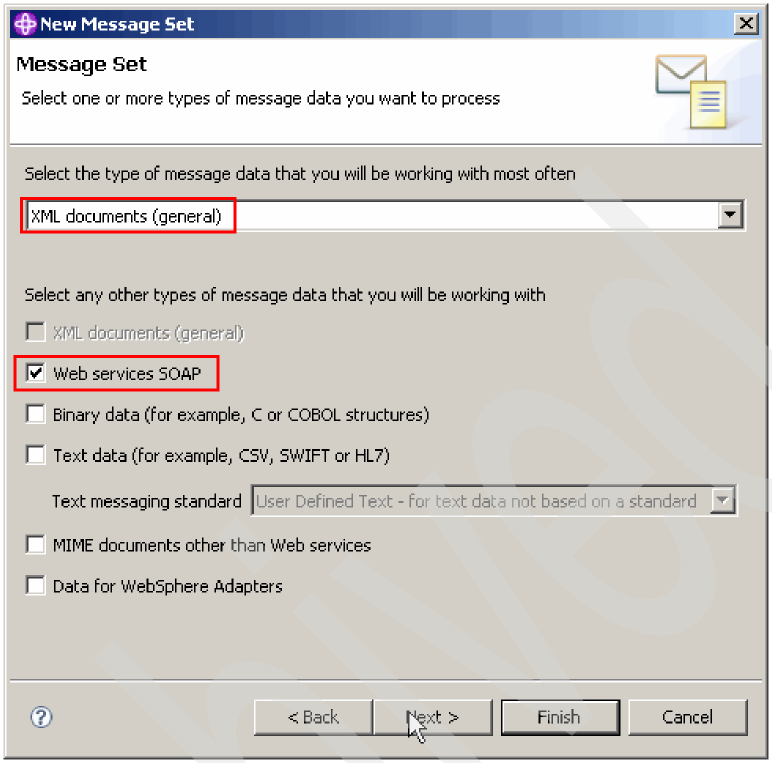
Copy message set contents from another message set

Message set: <create message set with no message defintions>

Figure 9-16 Creating another message set

The next window is the Message Set window.

3. Select the message set data type by dropping down the list of data types and selecting **XML documents**. Check **Web services SOAP**, and clear the check marks from all other boxes. Click **Next**. Refer to Figure 9-17 on page 233.



New Message Set

Message Set

Select one or more types of message data you want to process

Select the type of message data that you will be working with most often

XML documents (general)

Select any other types of message data that you will be working with

□ XML documents (general)

☑ Web services SOAP

□ Binary data (for example, C or COBOL structures)

□ Text data (for example, CSV, SWIFT or HL7)

Text messaging standard: User Defined Text - for text data not based on a standard

□ MIME documents other than Web services

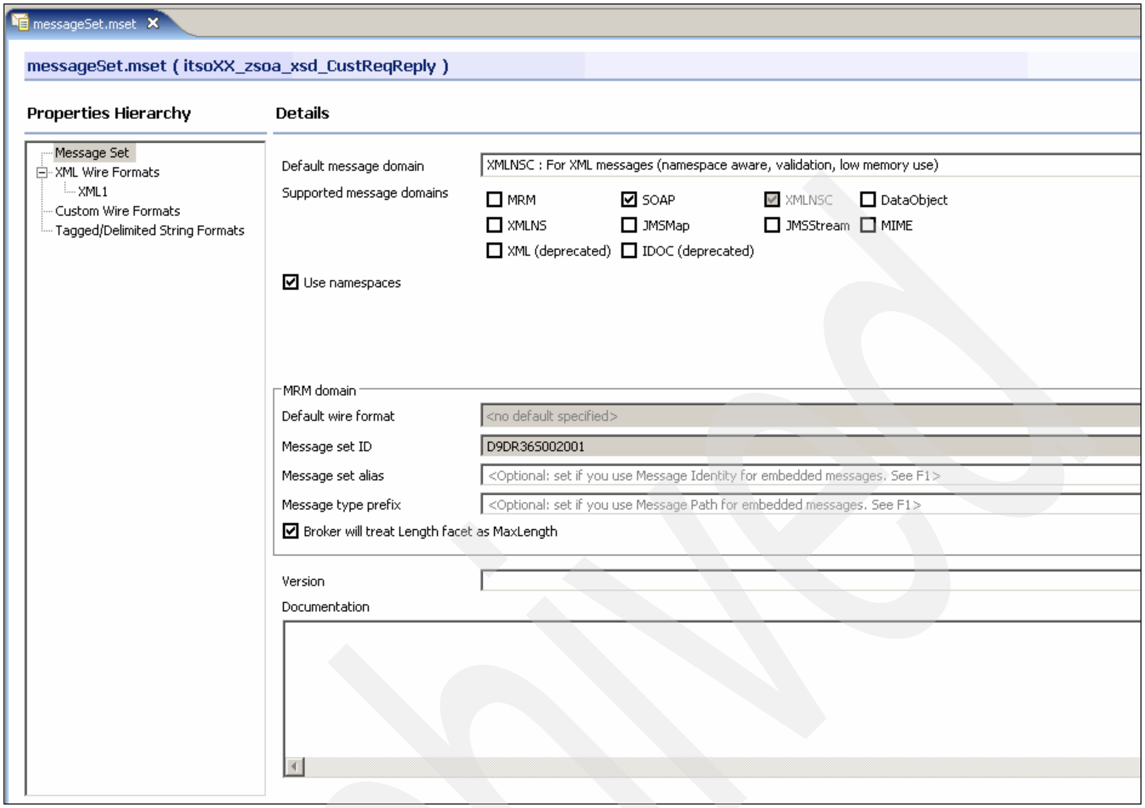
□ Data for WebSphere Adapters

Figure 9-17 Select physical message format for the request/reply message

4. In the Summary information window, click **Finish**. If the Tip pop-up window appears, click **OK**.

   At this point, you have two message sets defined: one for the VSAM record and one for the SOAP request/reply message.

   The message set will look like the window that is shown in Figure 9-18 on page 234.


messageSet.mset (itsoXX_zsoa_xsd_CustReqReply)

Properties Hierarchy

Details

Default message domain: XMLNSC : For XML messages (namespace aware, validation, low memory use)

Supported message domains: □ MRM ☑ SOAP ☑ XMLNSC □ DataObject □ XMLNS □ JMSMap □ JMSStream □ MIME □ XML (deprecated) □ IDOC (deprecated)

☑ Use namespaces

MRM domain

Default wire format: <no default specified>

Message set ID: D9DR365002001

Message set alias: <Optional: set if you use Message Identity for embedded messages. See F1>

Message type prefix: <Optional: set if you use Message Path for embedded messages. See F1>

☑ Broker will treat Length facet as MaxLength

Version

Documentation

Figure 9-18 Message Set for the request/reply message

Tip: Be careful when noting a message set ID. Zeros (0) and the character “O” in particular can be confused. Better yet, you can later copy the Message Set ID to the clipboard and then paste it into the required field.

The next step is to create a message definition file from the supplied XML schemas, one for the request message and one for the reply message.

5. Highlight **itsoXX_zsoa_xsd_CustReqReply** and right-click it. Select **New** → **Message Definition File From** → **XML Schema File**, as shown in Figure 9-19 on page 235.

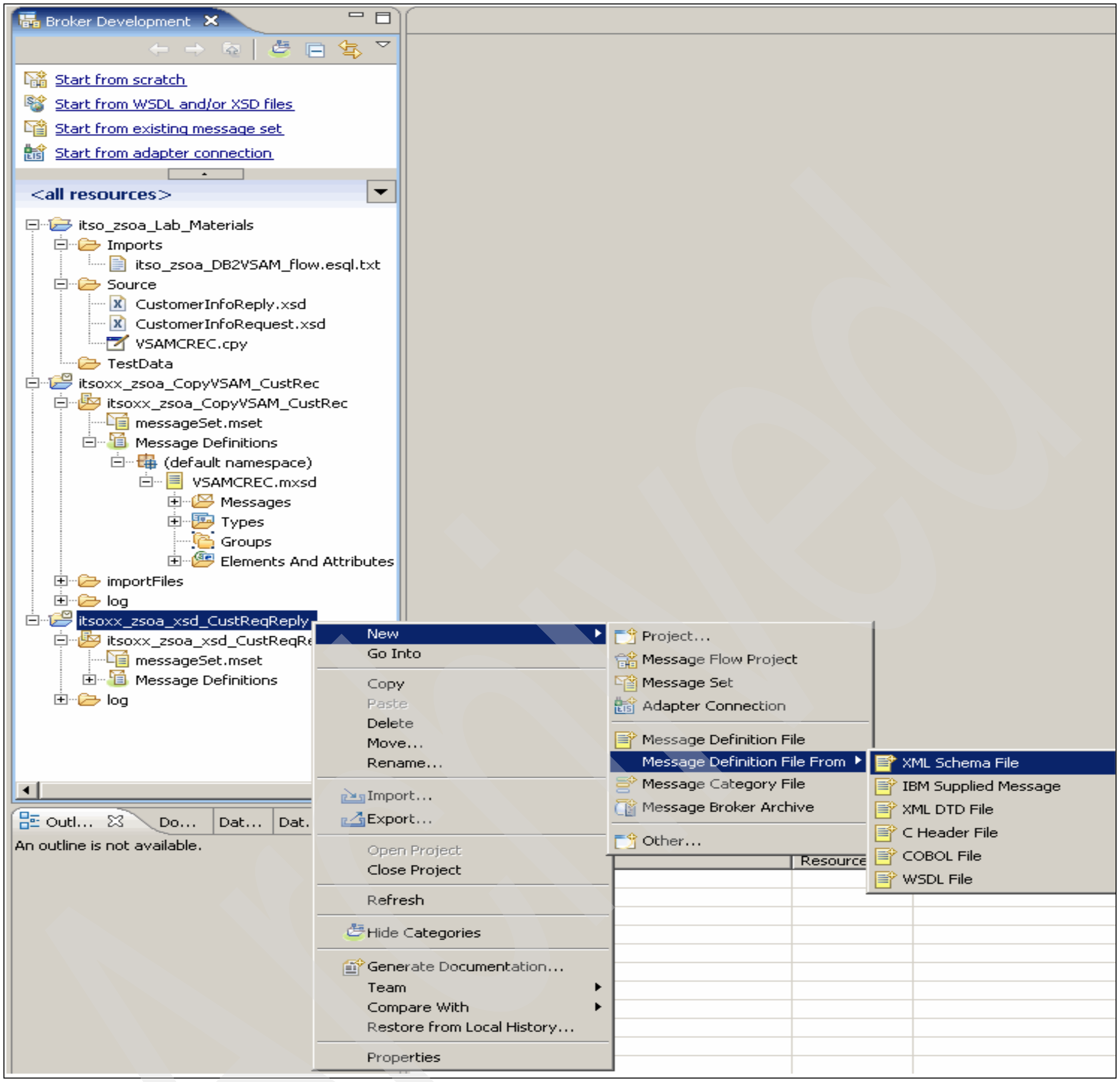


Figure 9-19 Create a new Message Definition File from an XML Schema file

The XML schema file to import is shown in Example 9-2 on page 236. It is the one for the request message.

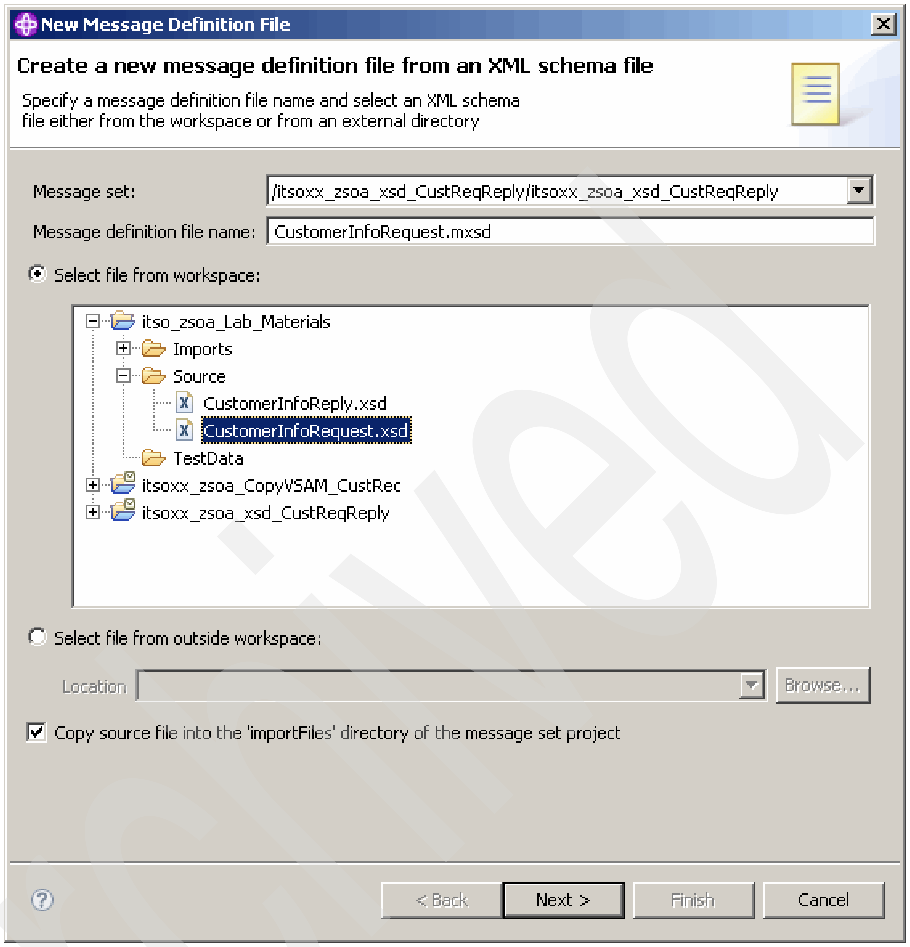
Example 9-2 CustomerInfoRequest XML Schema file

```
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<xs:schema version="1.0" xmlns:xs="http://www.w3.org/2001/XMLSchema"
targetNamespace="www.ibm.com" xmlns:q0="www.ibm.com">
<xs:element name="CustomerReq">
  <xs:complexType>
    <xs:sequence>
      <xs:element name="CustNo" type="xs:int"/>
    </xs:sequence>
  </xs:complexType>
  </xs:element>
</xs:schema>
```

6. In the next window, select the XML schema file. If the XML file has previously been imported into the workspace, select **Select file from workspace**, as shown in Figure 9-20 on page 237. If not, select Select file from outside workspace.

   The XML schema file for the request message is already part of the workspace that is packaged in the additional material for this book. Refer to Appendix B, “Additional material” on page 485.

7. Navigate to the XML file to import, select **CustomerInfoRequest.xsd**, and click **Next**.



New Message Definition File

Create a new message definition file from an XML schema file

Specify a message definition file name and select an XML schema file either from the workspace or from an external directory

Message set: /itsoxx_zsoa_xsd_CustReqReply/itsoxx_zsoa_xsd_CustReqReply

Message definition file name: CustomerInfoRequest.mxsd

● Select file from workspace:

- itso_zsoa_Lab_Materials
  - Imports
  - Source
    - CustomerInfoReply.xsd
    - CustomerInfoRequest.xsd
  - TestData
- itsoxx_zsoa_CopyVSAM_CustRec
- itsoxx_zsoa_xsd_CustReqReply

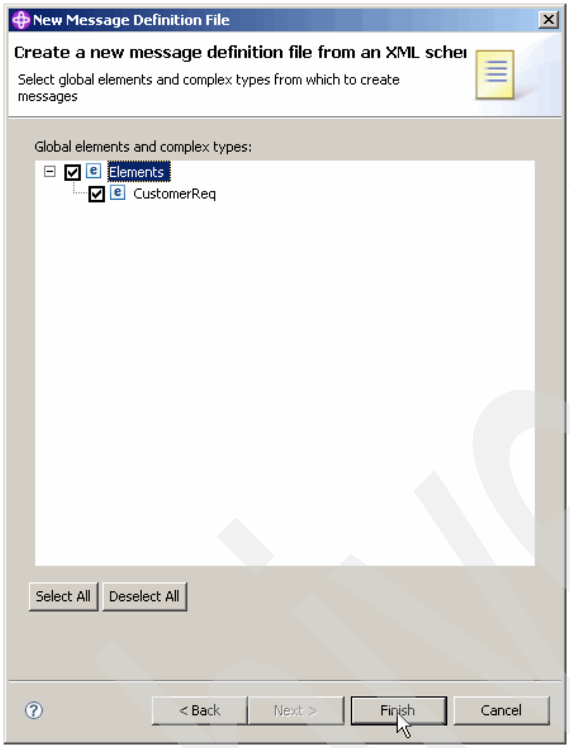
○ Select file from outside workspace:

Location

☑ Copy source file into the 'importFiles' directory of the message set project

Figure 9-20 Selecting the XML file to import

8. In the next window, check **Elements** → **CustomerReq**, as shown in Figure 9-21 on page 238, and click **Finish**.



New Message Definition File

Create a new message definition file from an XML schei

Select global elements and complex types from which to create messages

Global elements and complex types:

- ☑ Elements
  - ☑ CustomerReq

Figure 9-21 Selecting the elements in the XML Schema file

We now follow the same process for the reply message.

9. Highlight **itsoXX_zsoa_xsd_CustReqReply** and follow steps 5 on page 234 through 8 on page 237. However, instead of the CustomerInfoRequest XML Schema file, select the **CustomerInfoReply** XML Schema file.

   The CustomerInfoReply XML Schema file is shown in Example 9-3 on page 239.

Example 9-3   CustomerInfoReply XML Schema file

```
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<xs:schema version="1.0" xmlns:xs="http://www.w3.org/2001/XMLSchema"
targetNamespace="www.ibm.com">
<xs:element name = "CustomerReply">
  <xs:complexType>
    <xs:sequence>
      <xs:element name="CustNo" type="xs:int"/>
      <xs:element name="LastName" type="xs:string" minOccurs="0"/>
      <xs:element name="FirstName" type="xs:string" minOccurs="0"/>
      <xs:element name="Address1" type="xs:string" minOccurs="0"/>
      <xs:element name="City" type="xs:string" minOccurs="0"/>
      <xs:element name="State" type="xs:string" minOccurs="0"/>
      <xs:element name="Country" type="xs:string" minOccurs="0"/>
      <xs:element name="RetCode" type="xs:int"/>
    </xs:sequence>
  </xs:complexType>
  </xs:element>
</xs:schema>
```

At this point, you have created one new message set and two new message definition files based on XML Schema files: one message definition file for the request message and one message definition file for the reply message.

10. Save everything by pressing Ctrl+s.

    In the next steps, we generate the Web Services Description Language (WSDL).

11. Highlight **itsoXX_zsoa_xsd_CustReqReply**, right-click it, and select **Generate** → **WSDL Definition**, as shown in Figure 9-22 on page 240.

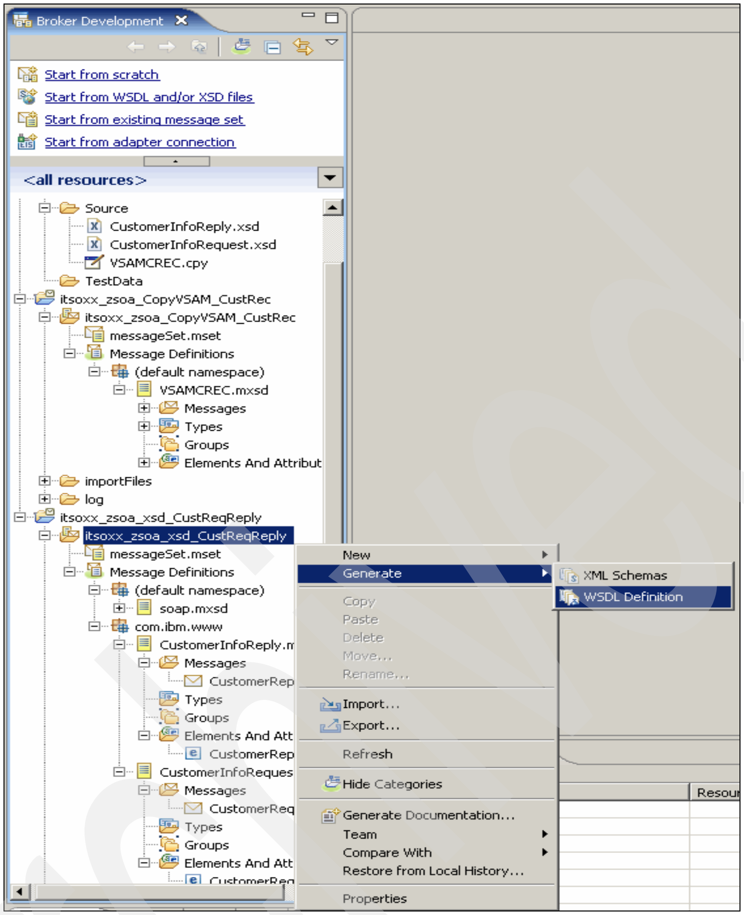
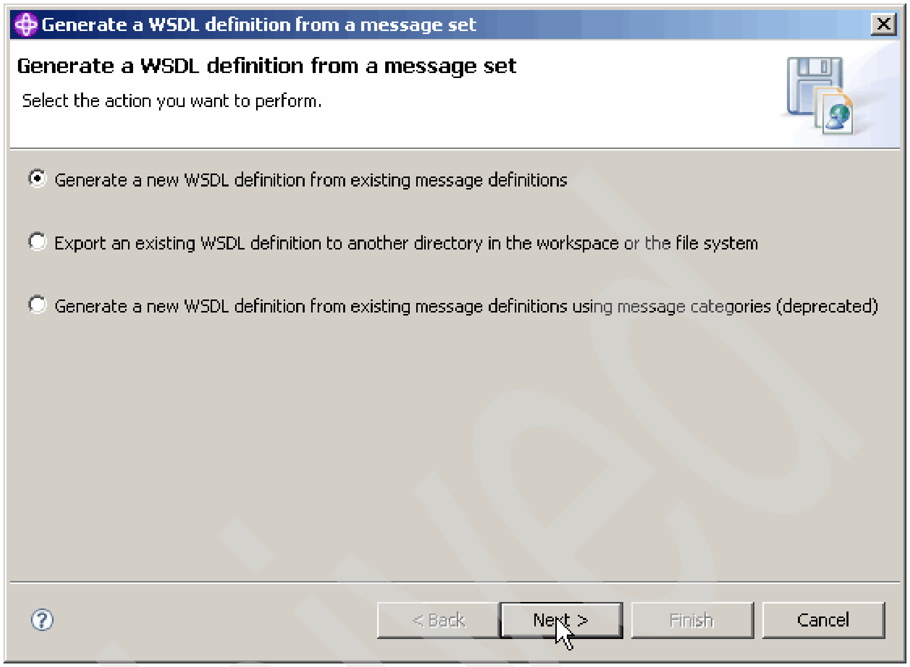


Figure 9-22 Generating WSDL

12. In the next window, because we already have existing message definitions in the workspace, select **Generate a new WSDL definition from existing message definitions** and click **Next**, as shown in Figure 9-23 on page 241.



Generate a WSDL definition from a message set

Select the action you want to perform.

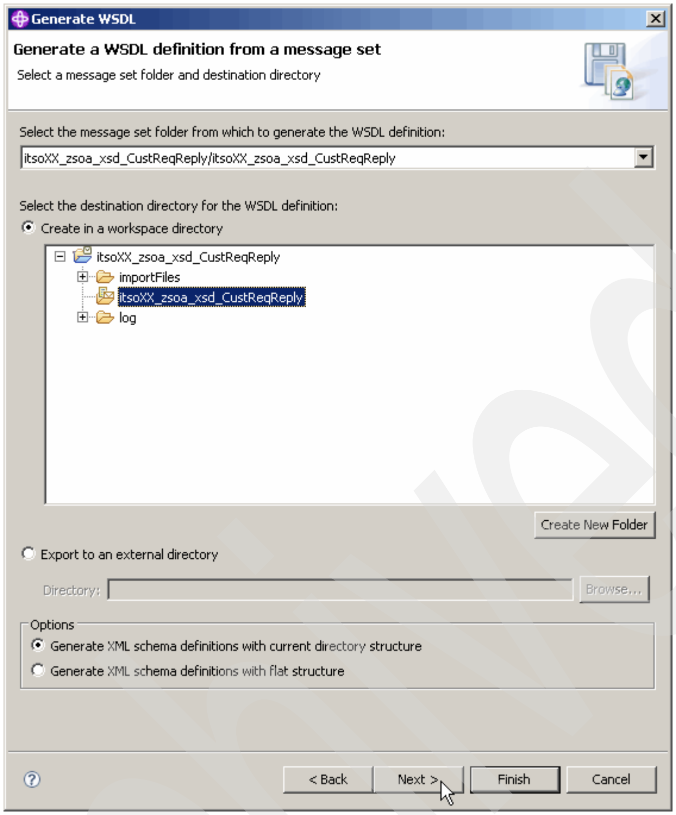
● Generate a new WSDL definition from existing message definitions

○ Export an existing WSDL definition to another directory in the workspace or the file system

○ Generate a new WSDL definition from existing message definitions using message categories (deprecated)

Figure 9-23 Generating WSDL

13. In the next window, select the workspace directory, **itsoXX_zsoa_xsd_CustReqReply**, as shown in Figure 9-24 on page 242, and click **Next**.



Generate a WSDL definition from a message set

Select a message set folder and destination directory

Select the message set folder from which to generate the WSDL definition:

itsoXX_zsoa_xsd_CustReqReply/itsoXX_zsoa_xsd_CustReqReply

Select the destination directory for the WSDL definition:

● Create in a workspace directory

```
⊟ itsoXX_zsoa_xsd_CustReqReply
    ⊞ importFiles
      itsoXX_zsoa_xsd_CustReqReply
    ⊞ log
```

○ Export to an external directory

Directory:

Options

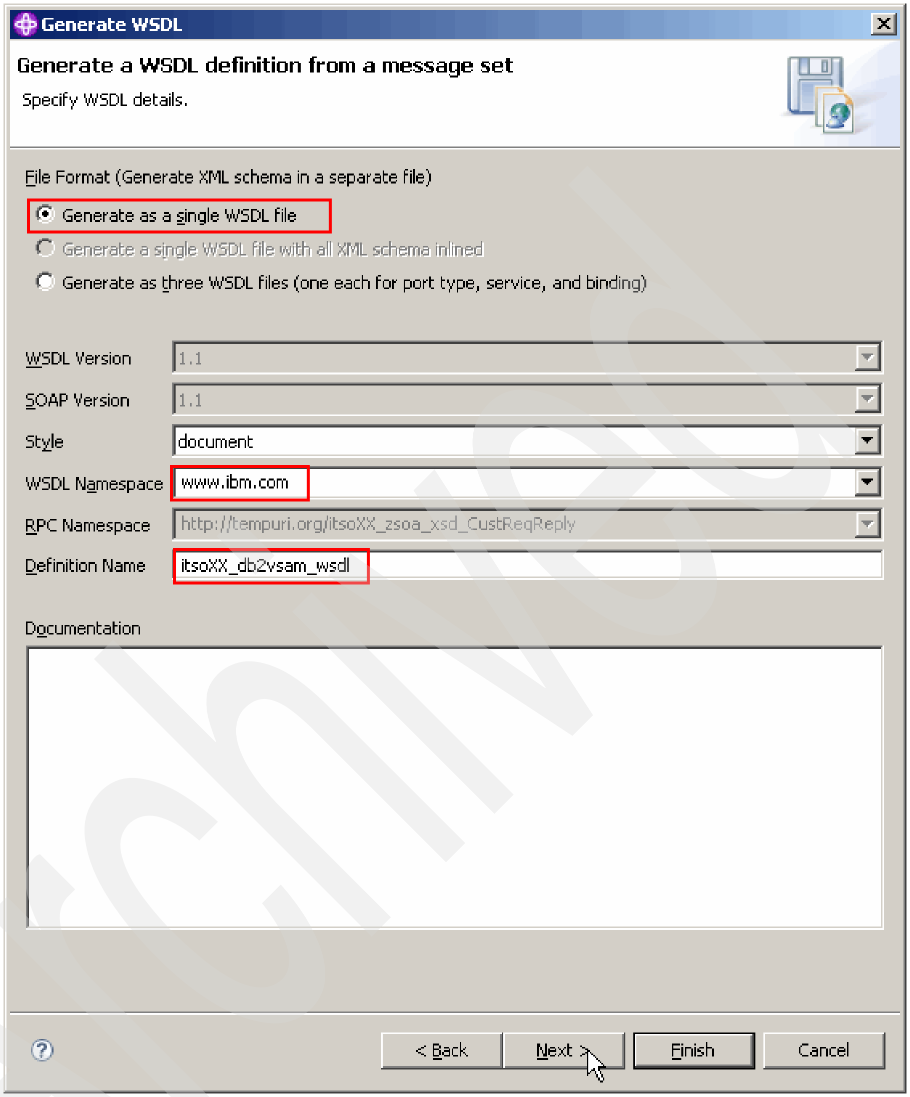
● Generate XML schema definitions with current directory structure

○ Generate XML schema definitions with flat structure

Figure 9-24 Selecting the message set for the WSDL generation

14. In the next window, specify the WSDL details:
   - Select **Generate as a single WSDL file**
   - Type `www.ibm.com` in the WSDL Namespace
   - Type a name for the Definition Name; we used `itsoXX_db2vsam_wsdl`

   Refer to Figure 9-25 on page 243. Click **Next**.



Generate WSDL

Generate a WSDL definition from a message set

Specify WSDL details.

File Format (Generate XML schema in a separate file)

● Generate as a single WSDL file

○ Generate a single WSDL file with all XML schema inlined

○ Generate as three WSDL files (one each for port type, service, and binding)

WSDL Version: 1.1

SOAP Version: 1.1

Style: document

WSDL Namespace: www.ibm.com

RPC Namespace: http://tempuri.org/itsoXX_zsoa_xsd_CustReqReply

Definition Name: itsoXX_db2vsam_wsdl

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Figure 9-25 WSDL details

15. In the next window, the “Add Operations to the WSDL Definition” window, add the following operations to the WSDL:

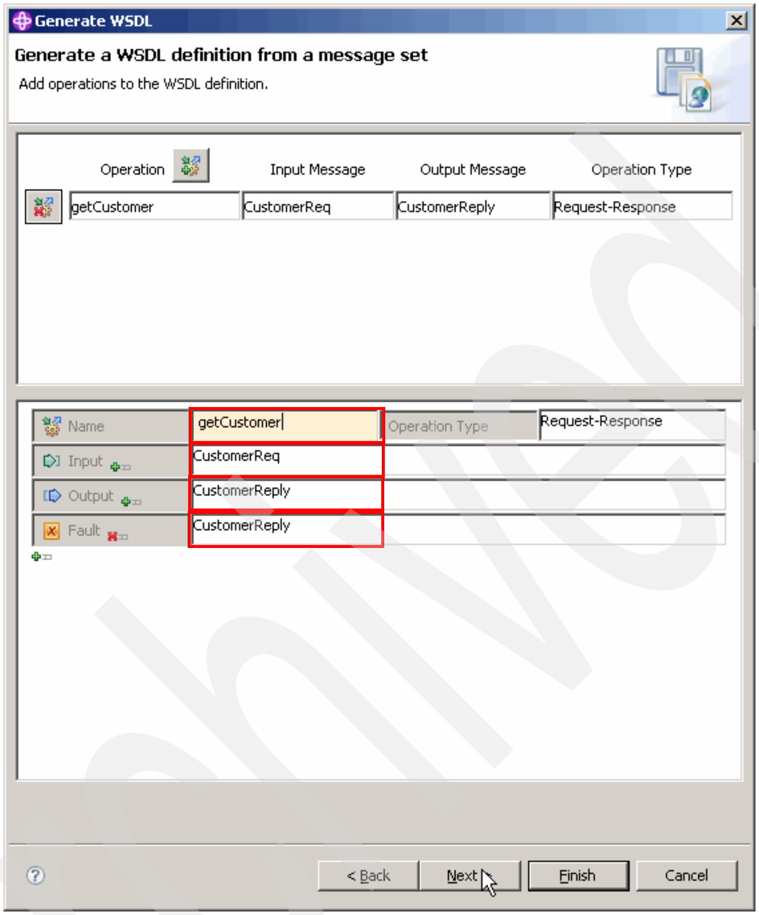
   – Type `getCustomer` in the Name.

   – In Input, select **CustomerReq**.

   – In Output, select **CustomerReply**.

   – In Fault, select **CustomerReply**.

Click **Next**. Refer to Figure 9-26.



Generate a WSDL definition from a message set

Add operations to the WSDL definition.

Operation	Input Message	Output Message	Operation Type
getCustomer	CustomerReq	CustomerReply	Request-Response

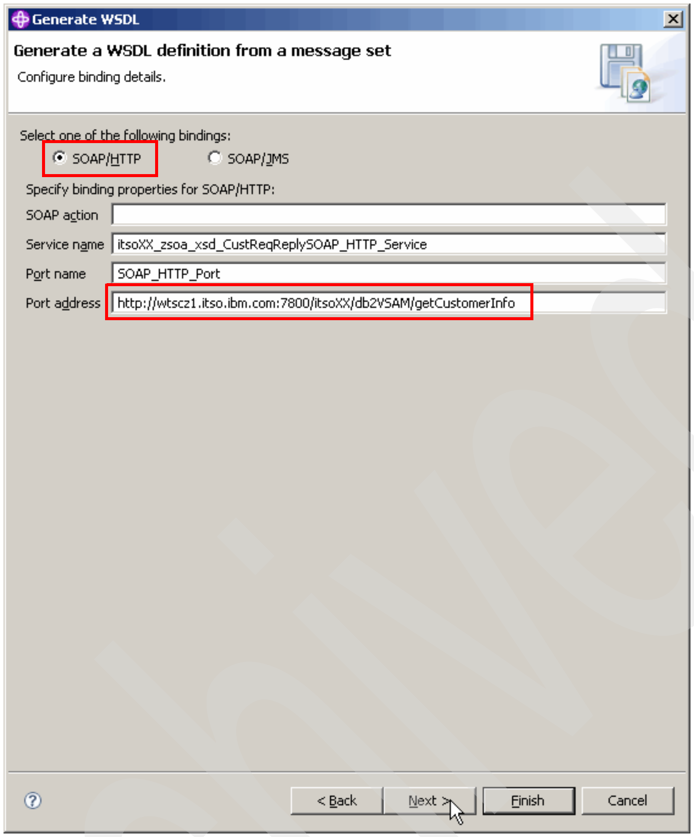
Name	getCustomer	Operation Type	Request-Response
Input	CustomerReq		
Output	CustomerReply		
Fault	CustomerReply		

Figure 9-26 Adding operations to the WSDL definition

16. In the next window, the Configure binding details window:
   - Select **SOAP/HTTP** as the bindings.
   - In the Port address, type the endpoint of the service. In our sample, we used:

     `http://wtsczl.itso.ibm.com:7800/itsoXX/db2VSAM/getCustomerInfo`

   Click **Next**. Refer to Figure 9-27 on page 245.


Generate WSDL
Generate a WSDL definition from a message set
Configure binding details.

Select one of the following bindings:
● SOAP/HTTP ○ SOAP/JMS

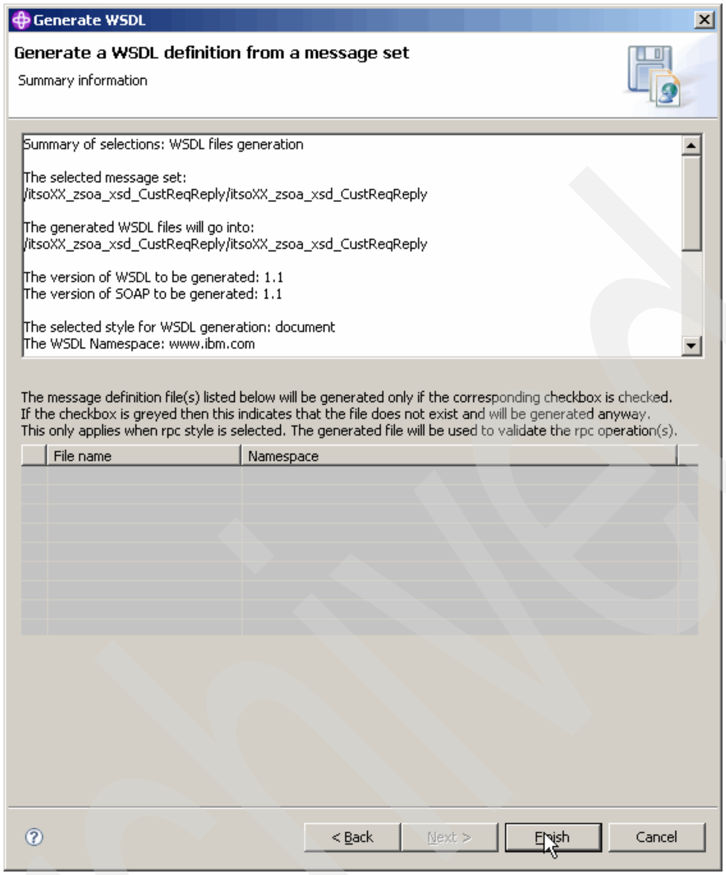
Specify binding properties for SOAP/HTTP:

SOAP action:
Service name: itsoXX_zsoa_xsd_CustReqReplySOAP_HTTP_Service
Port name: SOAP_HTTP_Port
Port address: http://wtscz1.itso.ibm.com:7800/itsoXX/db2VSAM/getCustomerInfo

< Back
Next >
Finish
Cancel

Figure 9-27 Specifying bindings

A summary of the WSDL that was generated by the wizard is shown now (Figure 9-28 on page 246). Click **Finish**. Click **File** → **Save**.



Summary of selections: WSDL files generation

The selected message set:
/itsoXX_zsoa_xsd_CustReqReply/itsoXX_zsoa_xsd_CustReqReply

The generated WSDL files will go into:
/itsoXX_zsoa_xsd_CustReqReply/itsoXX_zsoa_xsd_CustReqReply

The version of WSDL to be generated: 1.1
The version of SOAP to be generated: 1.1

The selected style for WSDL generation: document
The WSDL Namespace: www.ibm.com

The message definition file(s) listed below will be generated only if the corresponding checkbox is checked.
If the checkbox is greyed then this indicates that the file does not exist and will be generated anyway.
This only applies when rpc style is selected. The generated file will be used to validate the rpc operation(s).

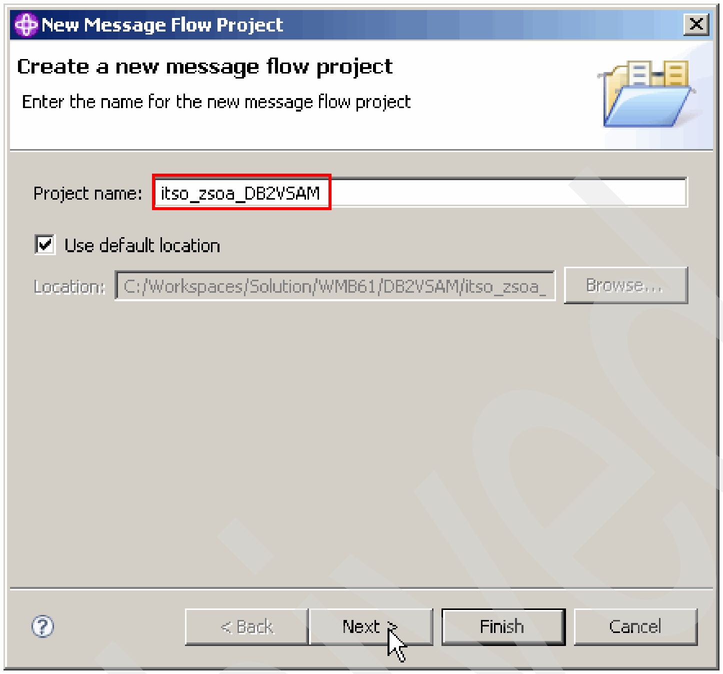
	File name	Namespace

Figure 9-28 Summary of WSDL generated

9.2.4 Building the message flow

In the following steps, we build the message flow for what we want to achieve.

1. Create a new message flow project. From the menu bar, select **File** → **New** → **Message Flow Project**.
2. In the following window, give a name to the project. We used `itso_zsoa_DB2VSAM` in our sample. Click **Next**. Refer to Figure 9-29 on page 247.



New Message Flow Project

Create a new message flow project

Enter the name for the new message flow project

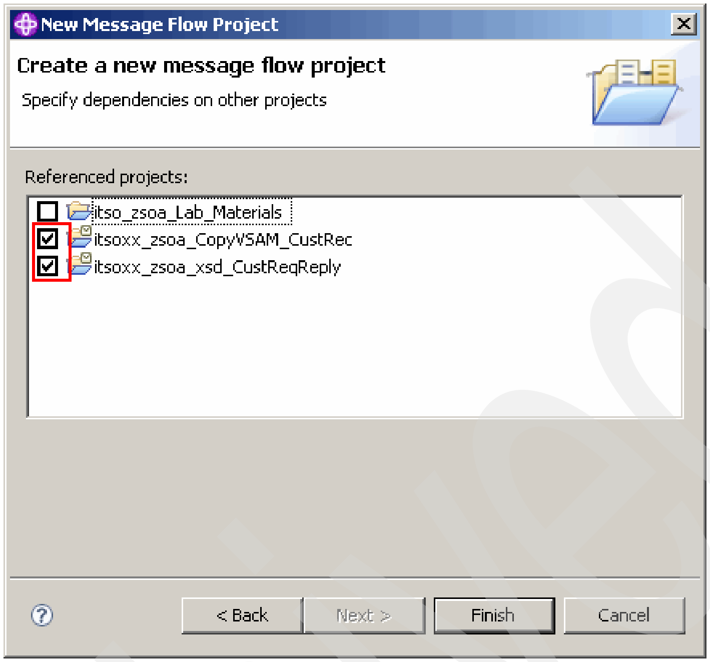
Project name: itso_zsoa_DB2VSAM

☑ Use default location

Location: C:/Workspaces/Solution/WMB61/DB2VSAM/itso_zsoa_

Figure 9-29 Specifying a name for the message flow project

3. In the next window, specify dependencies of the message flow project. Check the boxes for both **itsoXX_zsoa_CopyVSAM_CustRec** and **itsoXX_zsoa_xsd_CustReqReply**. Click **Finish**. Refer to Figure 9-30 on page 248.



New Message Flow Project

Create a new message flow project

Specify dependencies on other projects

Referenced projects:

- ☐ itso_zsoa_Lab_Materials
- ☑ itsoxx_zsoa_CopyVSAM_CustRec
- ☑ itsoxx_zsoa_xsd_CustReqReply

Figure 9-30 Selecting dependencies for Message Flow project

We now create the Message Flow within the project that we have just created.

4. Highlight **itso_zsoa_DB2VSAM** → **Flows**. Right-click and select **New** → **Message Flow**. Refer to Figure 9-31 on page 249.

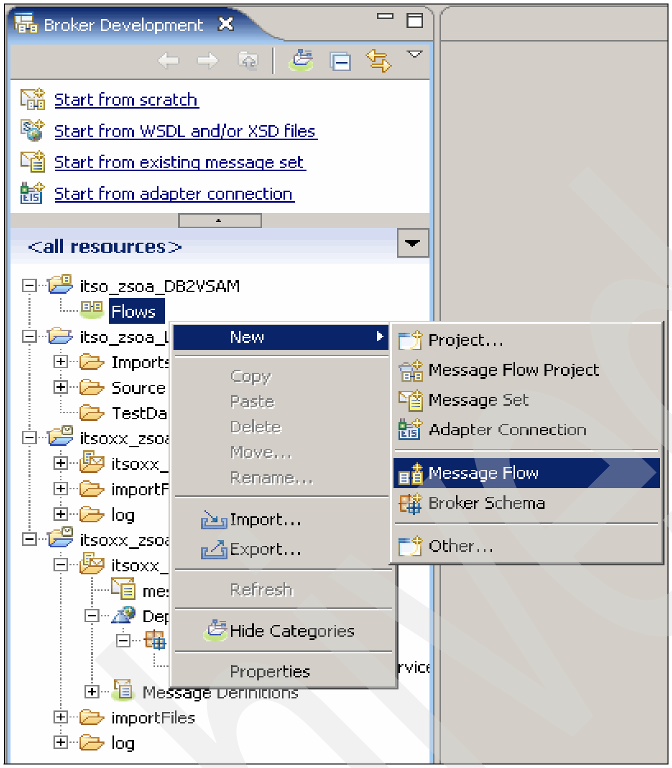


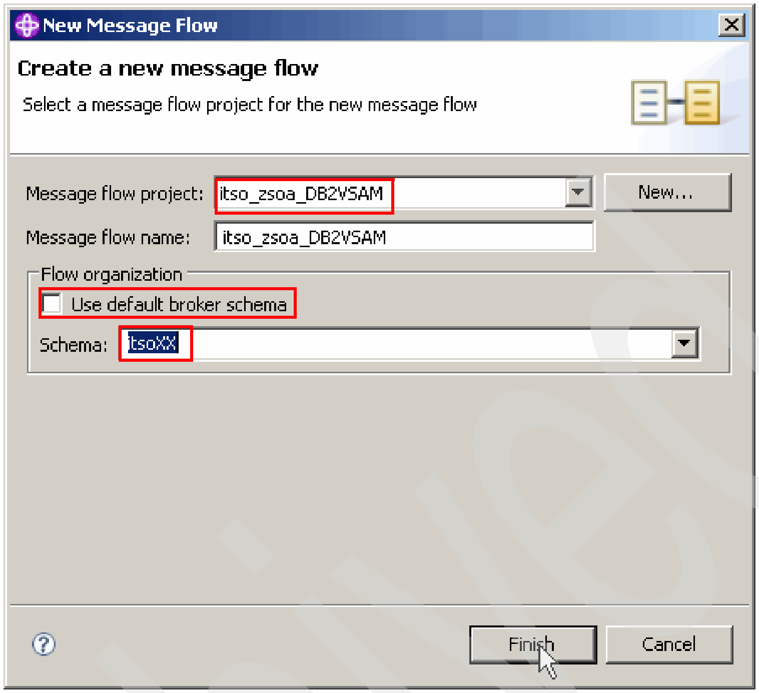
Figure 9-31 Creating a new message flow

5. In the next window:

   – Type a name for the Message Flow name. We used `itso_zsoa_DB2VSAM`.

   – Clear the check mark from **Use default broker schema** and type `itsoXX` in schema.

   Click **Finish**. Refer to Figure 9-32 on page 250.



Create a new message flow

Select a message flow project for the new message flow

Message flow project: itso_zsoa_DB2VSAM

Message flow name: itso_zsoa_DB2VSAM

Flow organization

□ Use default broker schema

Schema: itsoXX

Figure 9-32 Specifying more details for the message flow

The canvas opens now with an empty flow, as shown in Figure 9-33 on page 251.

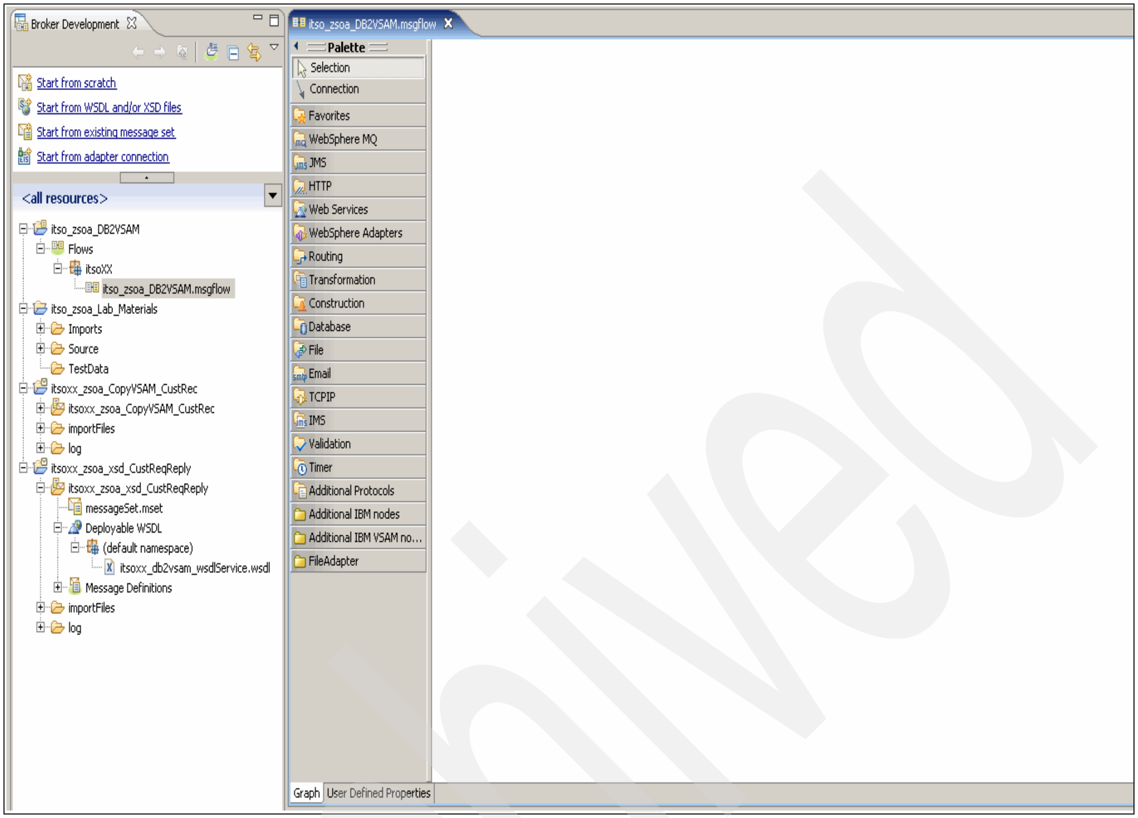
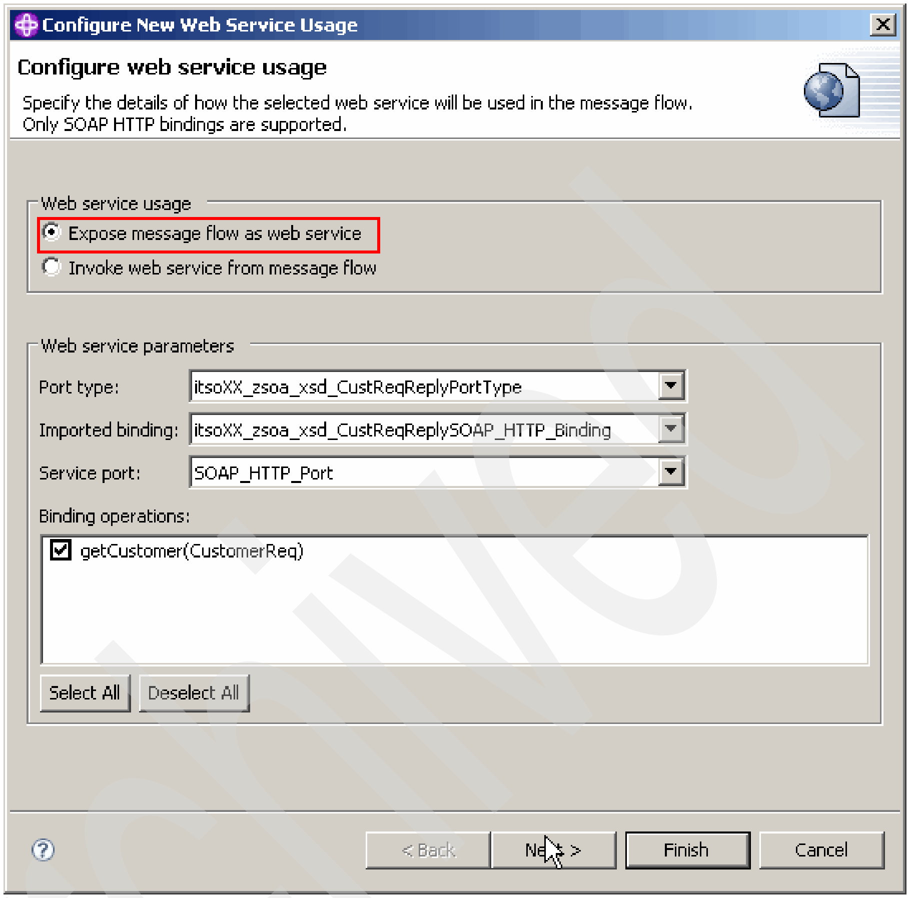


Figure 9-33 Canvas with empty message flow

We will now start the process of building the flow, which consists of placing *nodes* on the canvas, naming them, eventually specifying attributes, and connecting them.

First, we will import the generated WSDL to the canvas, which describes a Web service interface into our message flow. Our purpose is that Web service consumers can invoke this message flow from any place as a Web service.

6. Expand the message set **itsoXX_zsoa_xsd_CustReqReply** and navigate to **itsoXX_db2vsam_wsdlService.wsdl** within Deployable WSDL.
7. Drag the **itsoXX_db2vsam_wsdlService.wsdl** to the canvas by selecting it with the left mouse button and moving it to the canvas while holding down the left mouse button. A wizard opens as soon as you release the mouse button. This wizard is called “Configure Web service usage.”
8. Select **Expose message flow as web service** in the wizard, and click **Next**. Refer to Figure 9-34 on page 252. Leave the rest of the fields to the default.



Configure New Web Service Usage

Configure web service usage

Specify the details of how the selected web service will be used in the message flow.
Only SOAP HTTP bindings are supported.

Web service usage

● Expose message flow as web service

○ Invoke web service from message flow

Web service parameters

Port type: itsoXX_zsoa_xsd_CustReqReplyPortType

Imported binding: itsoXX_zsoa_xsd_CustReqReplySOAP_HTTP_Binding

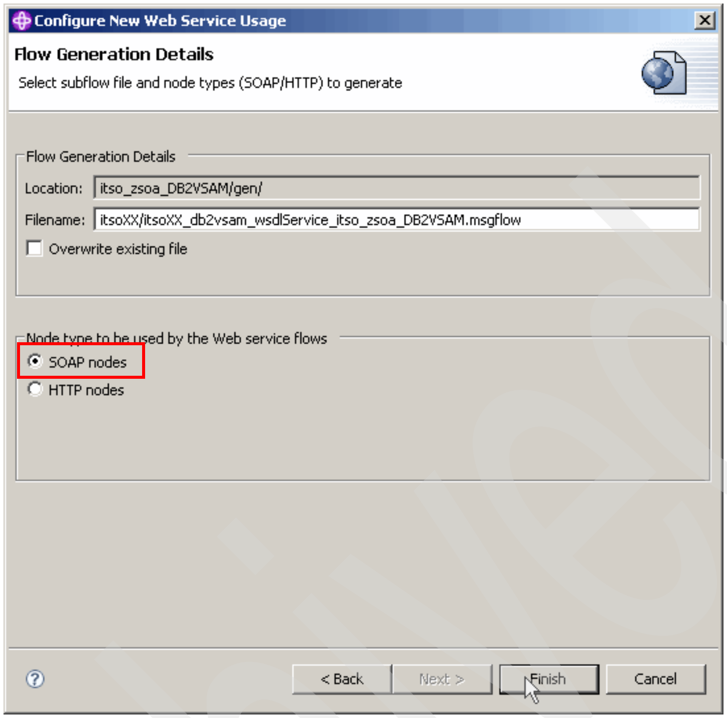
Service port: SOAP_HTTP_Port

Binding operations:

☑ getCustomer(CustomerReq)

Figure 9-34 Configure Web service usage window

9. In the next window, Flow Generation Details, select **SOAP nodes**, and click **Finish**. Refer to Figure 9-35 on page 253.



Select subflow file and node types (SOAP/HTTP) to generate

Flow Generation Details

Location: itso_zsoa_DB2VSAM/gen/

Filename: itsoXX/itsoXX_db2vsam_wsdlService_itso_zsoa_DB2VSAM.msgflow

□ Overwrite existing file

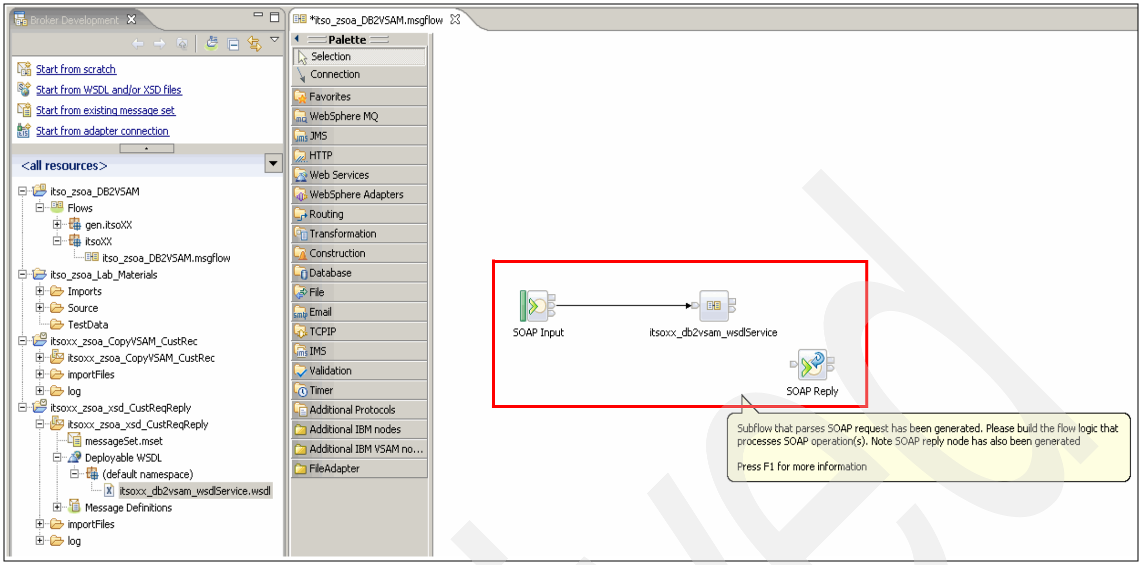
Node type to be used by the Web service flows

● SOAP nodes

○ HTTP nodes

Figure 9-35 Flow Generation Details window

A few nodes have been added to the canvas, as shown in Figure 9-36 on page 254. The nodes added represent a SOAP request, a Web service, and a SOAP reply. This canvas is the base for expanding the flow.



Subflow that parses SOAP request has been generated. Please build the flow logic that processes SOAP operation(s). Note SOAP reply node has also been generated

Press F1 for more information

Figure 9-36 Canvas with SOAP Input and SOAP reply nodes

We can now begin to draw the flow. In order to draw the flow, you must use the Palette on the left side of the flow editor pane. As with most Eclipse-based flow drawing interfaces, you proceed as follows for each node:

a. Click a folder, for example, WebSphere MQ or Routing, to display the possible nodes within that folder.

b. Click a node within the folder, for example, the MQInput node in the WebSphere MQ folder, to select the node.

c. Move the cursor to an empty area in the canvas, and click once with the left mouse button to place the chosen node on the canvas.

The name of the node is now highlighted. You can retype the name of the node.

Continue with this procedure to place all of the nodes required for this flow onto the canvas. The node names can be found in Figure 9-37 on page 255 and in Table 9-1 on page 256.

We explain the customization and function of the major nodes in this flow next. We advise you not to save the flow until you have finished configuring all of the nodes within this section. If you perform a save before you finish, several error messages will display, because the Toolkit detects that several nodes have not (yet) been set up correctly. Figure 9-37 on page 255 provides the details of the nodes and their names. Note that there is no specific order necessary for creating the nodes.

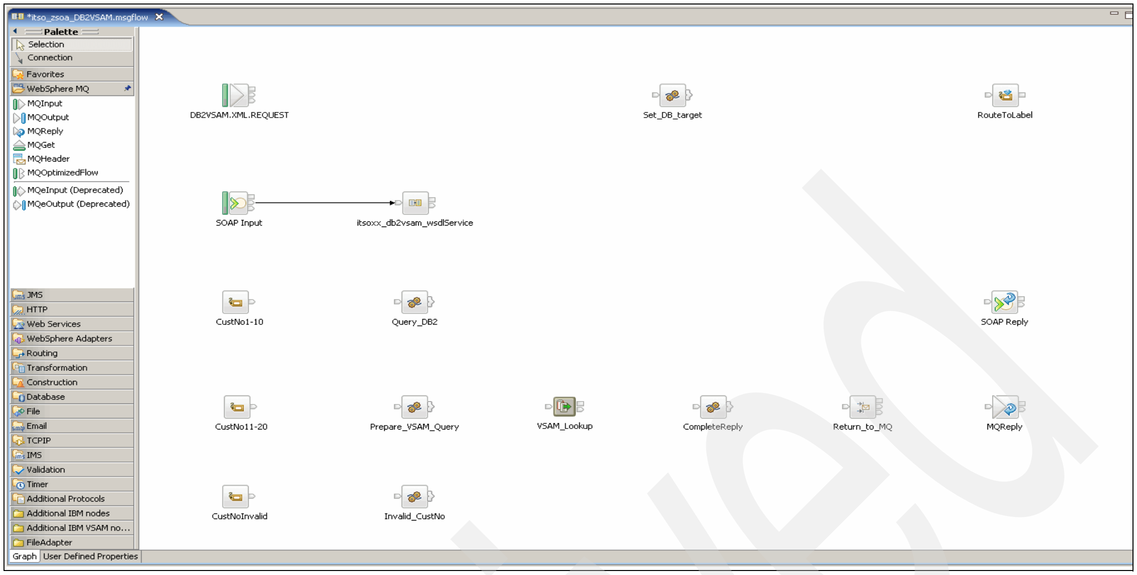


Figure 9-37 All nodes required for the message flow without wiring

Table 9-1 DB2VSAM flow nodes

Node	In folder	Node type	Rename to	Outgoing terminal
A	WebSphere MQ	MQInput	DB2VSAM.XML.REQUEST	Out
B	Transformation	Compute	Set_DB_target	Out
C	Routing	RouteToLabel	No rename	None
D	Routing	Label	CustNo1-10	Out
E	Routing	Label	CustNo11-20	Out
F	Routing	Label	CustNoInvalid	Out
G	Transformation	Compute	Query_DB2	Out
H	Transformation	Compute	Prepare_VSAM_Query	Out
I	Transformation	Compute	Invalid_CustNo	Out
J	Additional IBM VSAM nodes	VSAMRead	VSAM_Lookup	Out
K	Transformation	Compute	CompleteReply	Out
L	Routing	Route	Return_to_MQ	Match to MQReply Default to SOAP Reply
M	WebSphere MQ	MQReply	No rename	None

Important: Be sure to specify the *node names exactly as shown in Table 9-1 on page 256*, especially for the compute nodes. In general, these node names do not matter, but in order to complete this sample, you must use the exact names, because we will refer to imported ESQL code blocks with those exact names later.

10. After you have placed all the nodes on the canvas, wire them as illustrated in Figure 9-38.

In order to “wire” the nodes together:

- Pass the mouse arrow over the outgoing terminal on the right of a node. When the mouse hovers over a terminal, the terminal name is displayed. Be sure that you have the correct terminal (refer to Table 9-1 on page 256).
- Click with the left mouse button to “take” or grab the terminal. Hold the mouse button down.
- Drag the line that now appears until you get to the incoming terminal of the node to which you want to connect the wire. You can now click again with the left mouse button to set the wire destination.

> **Note**: For *compute nodes*, the procedure differs slightly. On the second step we just discussed, when you click the large outgoing terminal of a compute node, a window appears and you need to select the appropriate outgoing terminal. For this sample, always select the **Out** terminal, and click **OK**. You can then proceed by dragging the line.

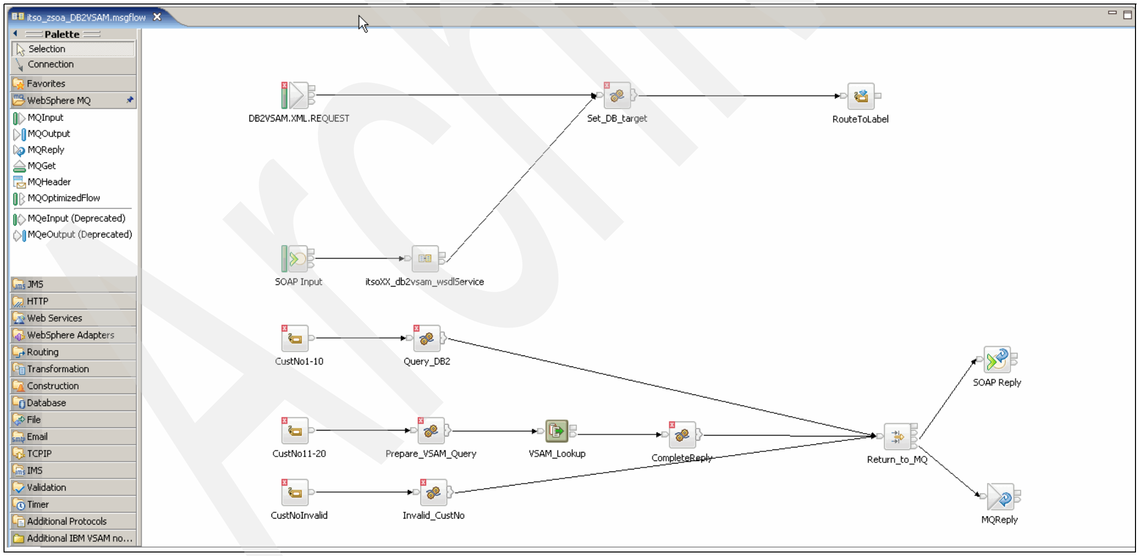


Figure 9-38 All nodes required for the message flow, wired

9.2.5 Customizing the nodes

In the following steps, we customize the nodes. In specific cases, we only need to specify attributes, in certain cases, we need to customize ESQL code, and in other cases, we need to *both* specify attributes and customize ESQL code.

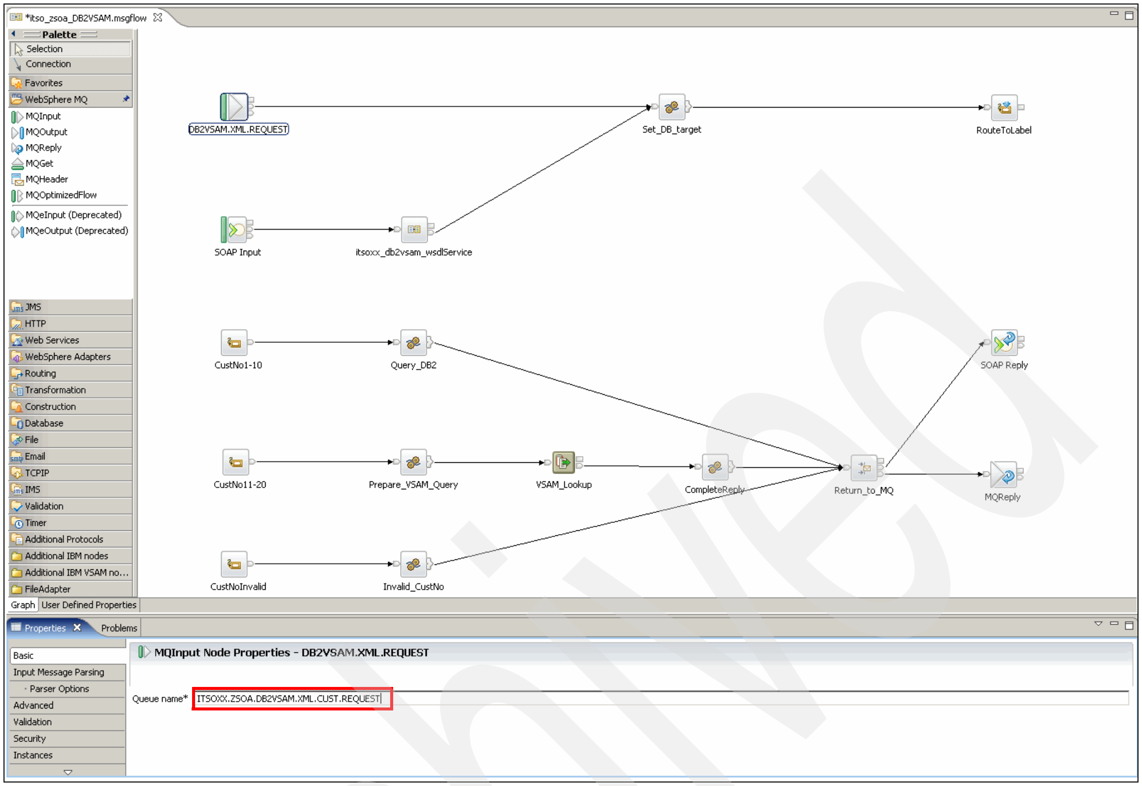
Customizing ESQL

ESQL is a descriptive language used in a message flow. Each compute node has default ESQL associated to it when the node is created. In all cases, this default ESQL needs to be customized to suit your needs. If you double-click a compute node, it opens the default ESQL portion associated to that node. All ESQL for the compute nodes in a message flow are kept in one file, and the file name is the message flow name and the .esql file extension.

DB2VSAM.XML.REQUEST node

This node receives a message from an WebSphere MQ queue. We need to describe from which queue this node gets the message:

1. Select the **DB2VSAM.XML.REQUEST** node, and click it. Beneath the flow editor window, you see the Properties tab. Select the **Basic** tab. Fill in the Queue name field with a queue name as defined in your WebSphere MQ environment. We used `ITSOXX.ZSOA.DB2VSAM.XML.CUST.REQUEST`. Refer to Figure 9-39 on page 259.



MQInput Node Properties - DB2VSAM.XML.REQUEST

Queue name* ITSOXX.ZSOA.DB2VSAM.XML.CUST.REQUEST

Figure 9-39 Specifying the queue name for the DB2VSAM.XML.REQUEST node

2. Next, click the side tab marked **Input Message Parsing**. In the Message domain drop-down list box, select **XMLNSC**, as shown in Figure 9-40 on page 260.

   This action tells the Broker that, by default, it needs to parse the incoming message with an XML parser that supports namespaces. Note that WebSphere Message Broker also includes other XML parsers, for instance, the machine readable material (MRM) XML parser that requires that the message is predefined with a schema.

   For simplicity, we have chosen to use the simpler XMLNS parser for this sample.

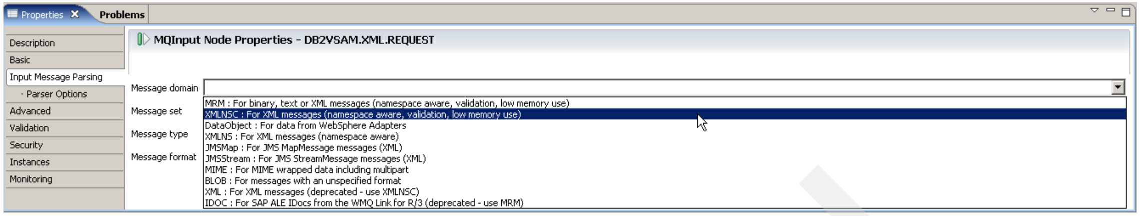

Properties
Problems
Description
Basic
Input Message Parsing
Parser Options
Advanced
Validation
Security
Instances
Monitoring
MQInput Node Properties - DB2VSAM.XML.REQUEST
Message domain
Message set
Message type
Message format
MRM : For binary, text or XML messages (namespace aware, validation, low memory use)
XMLNSC : For XML messages (namespace aware, validation, low memory use)
DataObject : For data from WebSphere Adapters
XMLNS : For XML messages (namespace aware)
JMSMap : For JMS MapMessage messages (XML)
JMSStream : For JMS StreamMessage messages (XML)
MIME : For MIME wrapped data including multipart
BLOB : For messages with an unspecified format
XML : For XML messages (deprecated - use XMLNSC)
IDOC : For SAP ALE IDocs from the WMQ Link for R/3 (deprecated - use MRM)

Figure 9-40 Input Message Parsing option

Set_DB_Target compute node

To create the ESQL for the Set_DB_Target compute node:

1. Return to the message flow editor by clicking the tab marked **itso_zsoa_DB2VSAM.msgflow** in the upper right editor pane. Now, double-click the first compute node labeled **Set_DB_target** (alternatively, you can right-click and select Open ESQL), which brings up the ESQL editor in the upper right panel.

   > **Important:** Note that this action brings up the entire file with all the default ESQL code for the entire flow. We now replace each portion for each node one by one. Also, note that each ESQL module gets the name of the label of the node, which is prefixed with the name of the message flow.

2. Replace the default ESQL with the customized ESQL, as shown in Example 9-4.

   > **Note:** We have included this code block as part of `itso_zsoa_DB2VSAM_flow.esql.txt` file in the itso_zsoa_Lab_Materials → Imports folder, which is inside the workspace packaged in the additional material. For the additional material information, refer to Appendix B, “Additional material” on page 485.

Example 9-4 ESQL for Set_DB_target compute node

```
CREATE COMPUTE MODULE itso_zsoa_DB2VSAM_Set_DB_target
   CREATE FUNCTION Main() RETURNS BOOLEAN
   BEGIN
      /* Determine which database to access for customer information, DB2 or VSAM */
      CALL CopyEntireMessage();
      SET OutputLocalEnvironment.Destination.RouterList.DestinationData[1].labelname
=
      CASE
         WHEN InputRoot.XMLNSC.*:CustomerReq.*:CustNo < 11 THEN 'do_db2'
         WHEN InputRoot.XMLNSC.*:CustomerReq.*:CustNo < 20 THEN 'do_vsam'
         ELSE 'do_invalid'
      END;
      RETURN TRUE;
   END;

   CREATE PROCEDURE CopyEntireMessage() BEGIN
      SET OutputRoot = InputRoot;
   END;
END MODULE;
```

3. Save the ESQL code into the flow by pressing Ctrl+s.

   The only code developed is shown in Example 9-5.

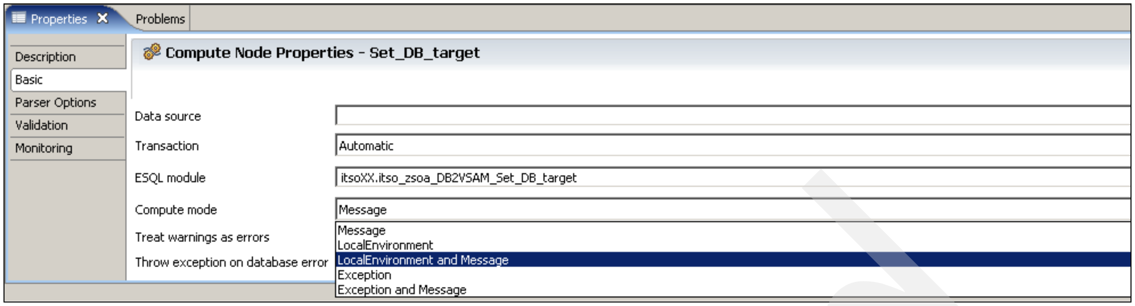
Example 9-5 ESQL code developed

```
SET OutputLocalEnvironment.Destination.RouterList.DestinationData[1].labelname =
      CASE
         WHEN InputRoot.XMLNSC.*:CustomerReq.*:CustNo < 11 THEN 'do_db2'
         WHEN InputRoot.XMLNSC.*:CustomerReq.*:CustNo < 20 THEN 'do_vsam'
         ELSE 'do_invalid'
      END;
```

The code associated with this node performs the heart of the “routing” function of this mediation. It inspects the incoming data (the CustNo field) and based upon its value, it sets up the label to where the flow will branch in the subsequent RouteToLabel node. This sequence of nodes performs the classic “select” logic that is found in most second generation programming languages.

In addition to this ESQL code, there is a small configuration change that is necessary for the Set_DB_target node.

4. Return to the message flow editor window tab by clicking the tab marked **itso_zsoa_DB2VSAM.msgflow**, and click the **Set_DB_target** node one time. In the Properties page shown in Figure 9-41 on page 262, make sure that the **Basic** tab is selected as the left tab.
5. You must select **LocalEnvironment and Message** as the compute mode, as shown in Figure 9-41 on page 262. This selection is necessary to ensure that this node passes the local environment data to the following node. The local environment data is additional data that is carried in the flow along with the message. This local environment data is set in the ESQL code displayed in Example 9-5.



Compute Node Properties - Set_DB_target

Data source:
Transaction: Automatic
ESQL module: itsoXX.itso_zsoa_DB2VSAM_Set_DB_target
Compute mode: Message
Treat warnings as errors
Throw exception on database error

Figure 9-41 Passing local environment data

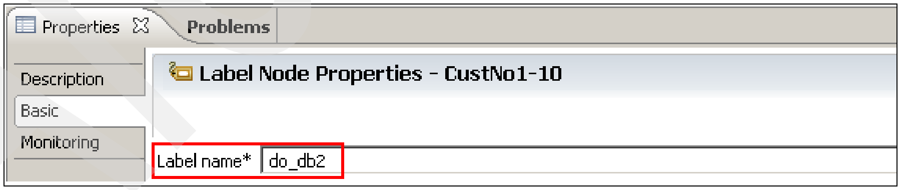
RouteToLabel node

The final node in the upper section of this flow is the RouteToLabel node. This node simply performs a “branch” to the label set in the prior Set_DB_target node. No configuration is needed here.

CustNo1-10, CustNo11-20, and CustNoInvalid Label nodes

The lower part of this flow begins with three label nodes . Each label node needs to be configured with the appropriate branch point label. The names that are used here must match with the names that are used in the ESQL in “Set_DB_Target compute node” on page 260:

1. Select the node marked **CustNo1-10** and make sure that you have the **Properties** tab selected, as well as the **Basic** tab on the left. This node is the branch point when the incoming request is for customer number 1 - 10, in which case, the flow queries DB2.
2. Type the value `do_db2` in the branch Label name field as shown in Figure 9-42.



Label Node Properties - CustNo1-10

Label name*: do_db2

Figure 9-42 Specifying the Label for the CustNo1-10 node

3. Perform the same customization on the other two label nodes:
   - The **CustNo11-20** node has the branch Label name of `do_vsam`.
   - The **CustNoInvalid** node has the branch Label name of `do_invalid`.

Query_DB2 node

To create the ESQL code for the Query_DB2 node:

1. As in “Set_DB_Target compute node” on page 260, open the ESQL code for the compute node named Query_DB2.

   Replace the default ESQL code of this module with the customized ESQL code that is shown in Example 9-6.

> **Note:** We have included this code block as part of `itso_zsoa_DB2VSAM_flow.esql.txt` file in the itso_zsoa_Lab_Materials → Imports folder, which is inside the workspace packaged in the additional material. For the additional material information, refer to Appendix B, “Additional material” on page 485.

Example 9-6 ESQL for Query_DB2 node

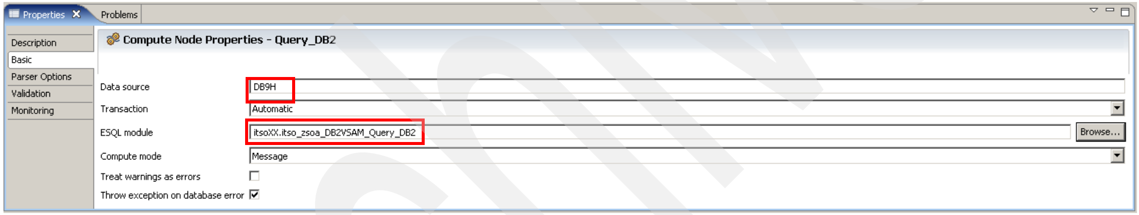
```
CREATE COMPUTE MODULE itso_zsoa_DB2VSAM_Query_DB2
   CREATE FUNCTION Main() RETURNS BOOLEAN
   BEGIN
      /* Retrieve customer data from DB2 */
      CALL CopyMessageHeaders();
      SET OutputRoot.XMLNSC.CustomerReply[] = (SELECT
         A.CUST_NO AS CustNo, A.CUST_LN AS LastName, A.CUST_FN AS FirstName,
         A.CUST_ADDR1 AS Address1, A.CUST_CITY AS City, A.CUST_ST AS State,
         A.CUST_CTRY AS Country FROM Database.ITSOOC.EOTCUST AS A
         WHERE A.CUST_NO = InputRoot.XMLNSC.*:CustomerReq.*:CustNo);
      /* Verify if DB2 inquiry found the customer record */
      IF (Cardinality(OutputRoot.XMLNSC.CustomerReply[]) = 1 ) THEN
         SET OutputRoot.XMLNSC.CustomerReply.RetCode = 0;
      ELSE
         SET OutputRoot.XMLNSC.CustomerReply.RetCode = 8;
      END IF;
      RETURN TRUE;
   END;

   CREATE PROCEDURE CopyMessageHeaders() BEGIN
      DECLARE I INTEGER 1;
      DECLARE J INTEGER;
      SET J = CARDINALITY(InputRoot.*[]);
      WHILE I < J DO
         SET OutputRoot.*[I] = InputRoot.*[I];
         SET I = I + 1;
      END WHILE;
   END;
END MODULE;
```

The first line of customized code (SET) performs the actual database lookup with a SELECT statement that is virtually identical to standard SQL, which, of course, explains why the native broker language is called ESQL (Extended SQL). The second line of customized code (IF) simply validates if reasonable data was returned from the DB2 SELECT and assigns an appropriate return code.

In addition to supplying the ESQL code in Example 9-6 on page 263, it is necessary to perform a minor configuration change for this compute node.

2. Return to the Message Flow canvas, and click the **DB2_Query** node.
3. In the **Properties** tab, select the **Basic** side tab. Type the location name of the z/OS DB2 database in the Data Source field. In our sample, we use `DB9H`.
4. Browse and select **itsoXX.itso_zsoa_DB2VSAM_Query_DB2** as the ESQL module.

   Refer to Figure 9-43.



Properties | Problems

Description
Basic
Parser Options
Validation
Monitoring

Compute Node Properties - Query_DB2

Data source: DB9H
Transaction: Automatic
ESQL module: itsoXX.itso_zsoa_DB2VSAM_Query_DB2 (Browse...)
Compute mode: Message
Treat warnings as errors: □
Throw exception on database error: ☑

Figure 9-43 Query_DB2 properties

Prepare_VSAM_Query node

To create the ESQL for the Prepare_VSAM_Query node:

1. Move to the Message Flow editor window and select the **Prepare_VSAM_Query** node. Double-click this node, which opens the ESQL code associated with this node.

   This node gets executed when the incoming client request specified a CustNo between 11 to 20 and the flow branches to the second label node CustNo11-20. In this case, the compute node labeled Prepare_VSAM_Query is invoked. The entire ESQL code associated to this node is shown in Example 9-7 on page 265.

   The code printed in bold has been added to the default code (the code between `BEGIN` and `RETURN TRUE`).

> **Note:** We have included this code block as part of the `itso_zsoa_DB2VSAM_flow.esql.txt` file in the itso_zsoa_Lab_Materials → Imports folder, which is inside the workspace packaged in the additional material. For the additional material information, refer to Appendix B, “Additional material” on page 485.

Example 9-7 ESQL code for the Prepare_VSAM_Query node

```
CREATE COMPUTE MODULE itso_zsoa_DB2VSAM_Prepare_VSAM_Query
   CREATE FUNCTION Main() RETURNS BOOLEAN
   BEGIN
      /* Position and format the VSAM search key where the VSAM node expects to 
retrieve it */
      CALL CopyMessageHeaders();
      DECLARE Pattern CHARACTER '000';
      SET OutputRoot.XMLNSC.VSAM.Request.Position.Key =
         CAST( CAST(InputRoot.XMLNSC.*:CustomerReq.*:CustNo AS INTEGER) AS CHARACTER 
FORMAT Pattern);
      RETURN TRUE;
   END;

   CREATE PROCEDURE CopyMessageHeaders() BEGIN
      DECLARE I INTEGER 1;
      DECLARE J INTEGER;
      SET J = CARDINALITY(InputRoot.*[]);
      WHILE I < J DO
         SET OutputRoot.*[I] = InputRoot.*[I];
         SET I = I + 1;
      END WHILE;
   END;
END
MODULE;
```

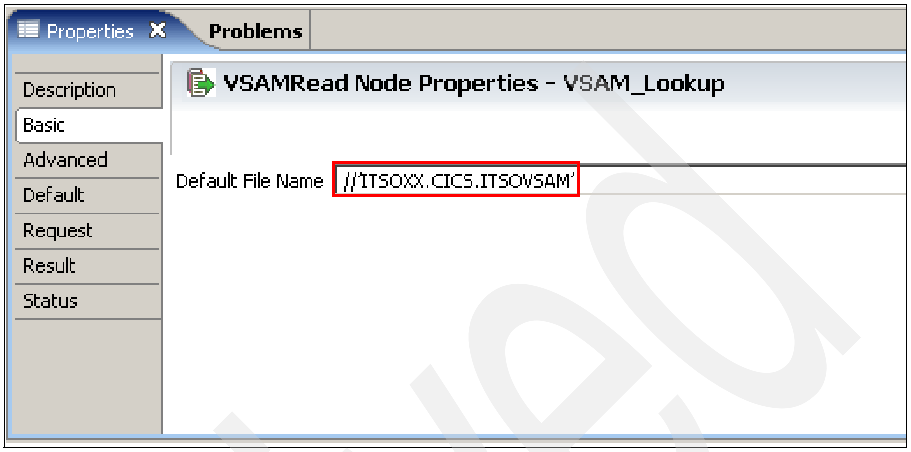
This code picks out the incoming CustNo field, formats it with leading zeros, and places it in the field expected by the following VSAMRead node.

VSAM_Lookup node

To configure this node:

1. Move to the Message Flow editor window and select the VSAMRead node labeled **VSAM_Lookup**, which must be configured.
2. In the lower **Properties** page, make sure that the **Basic** tab is selected.

3. Set the Default File name to the VSAM data set that you plan to use. In our sample, we used `//'ITSOXX.CICS.ITSOVSAM'` (single quotation marks included). Refer to Figure 9-44.



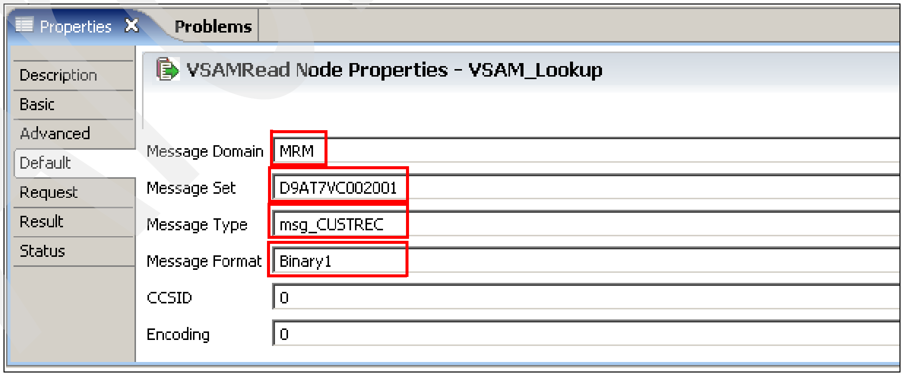
VSAMRead Node Properties - VSAM_Lookup

Default File Name: //'ITSOXX.CICS.ITSOVSAM'

Figure 9-44 Default tab of the VSAMRead node

4. Select the **Default** tab and:
   – Set the Message Domain to `MRM`.
   – Specify the message set ID that you noted earlier in the sample.
   – Type `msg_CUSTREC` for the Message Type.
   – Type `Binary1` for the Message Format.

   Refer to Figure 9-45.



VSAMRead Node Properties - VSAM_Lookup

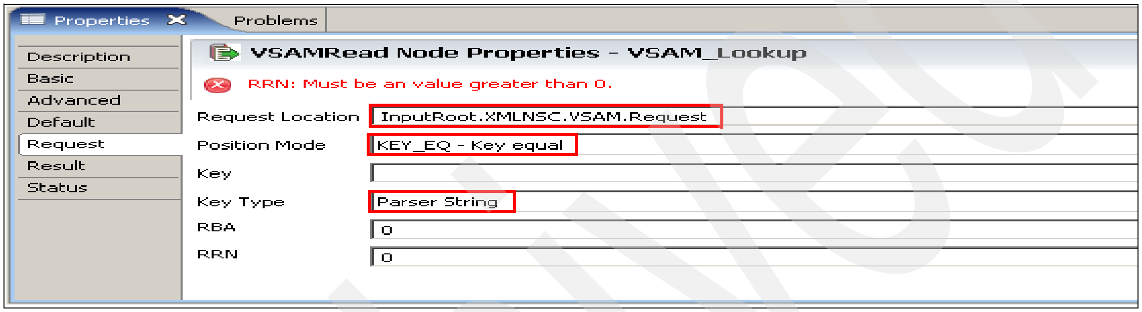
Message Domain: MRM
Message Set: D9AT7VC002001
Message Type: msg_CUSTREC
Message Format: Binary1
CCSID: 0
Encoding: 0

Figure 9-45 Default tab in VSAMRead node

5. Select the **Request** tab and:
   - Type `InputRoot.XMLNSC.VSAM.Request` as the Request Location.
   - Select **KEY_EQ - Key equal** as the Position Mode.
   - Select **Parser String** as the Key Type.

> **Note:** An error message appears on this menu “`X RRN: Must be a value greater than 0.`” Ignore this message.

Refer to Figure 9-46.



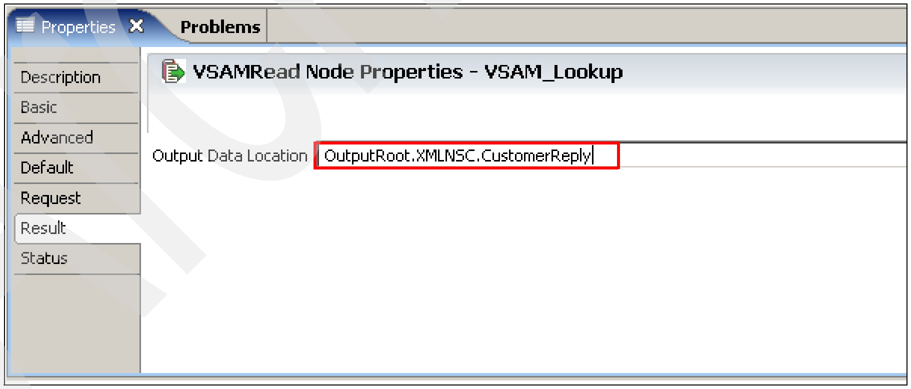
VSAMRead Node Properties - VSAM_Lookup

RRN: Must be an value greater than 0.

Request Location: InputRoot.XMLNSC.VSAM.Request
Position Mode: KEY_EQ - Key equal
Key:
Key Type: Parser String
RBA: 0
RRN: 0

Figure 9-46 Request tab for the VSAMRead node

6. Select the **Result** tab. Type `OutputRoot.XMLNSC.CustomerReply` as the Output Data Location. Refer to Figure 9-47.



VSAMRead Node Properties - VSAM_Lookup

Output Data Location: OutputRoot.XMLNSC.CustomerReply

Figure 9-47 Result tab for the VSAMRead node

CompleteReply node

Move to the Message Flow editor window and select the compute node labeled **CompleteReply**. Double-click the node to show its ESQL code. This node uses the following ESQL that is shown in Example 9-8. The customized (added) code is in bold.

Example 9-8 CompleteReply ESQL code

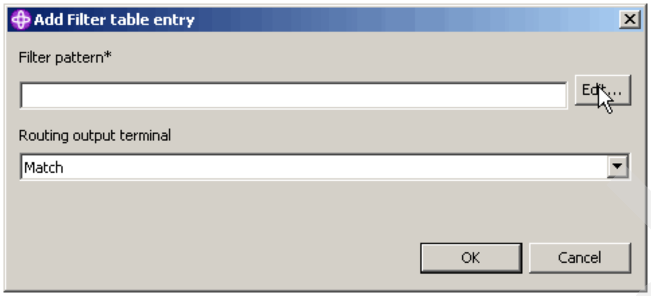
```
CREATE COMPUTE MODULE itso_zsoa_DB2VSAM_CompleteReply
   CREATE FUNCTION Main() RETURNS BOOLEAN
   BEGIN
      /* For VSAM returned data, check if inquiry found a customer record */
      CALL CopyEntireMessage();
      IF (InputLocalEnvironment.VSAM.Report.Length > 0 ) THEN
         SET OutputRoot.XMLNSC.CustomerReply.RetCode = 0;
      ELSE
         SET OutputRoot.XMLNSC.CustomerReply.RetCode = 8;
      END IF;
      RETURN TRUE;
   END;

   CREATE PROCEDURE CopyEntireMessage() BEGIN
      SET OutputRoot = InputRoot;
   END;
END
MODULE;
```

This code performs a simple verification if the VSAM search returned valid data and sets a return code appropriately.

Return_to_MQ node

The routing logic for this node uses the ReplyProtocol field in the Properties folder. Based on the protocol that is used for the request message, the reply message is routed appropriately. The routing expression used in this node is built with the XPath Expression® Builder wizard. Follow these steps to build the expression for the routing logic for this node:

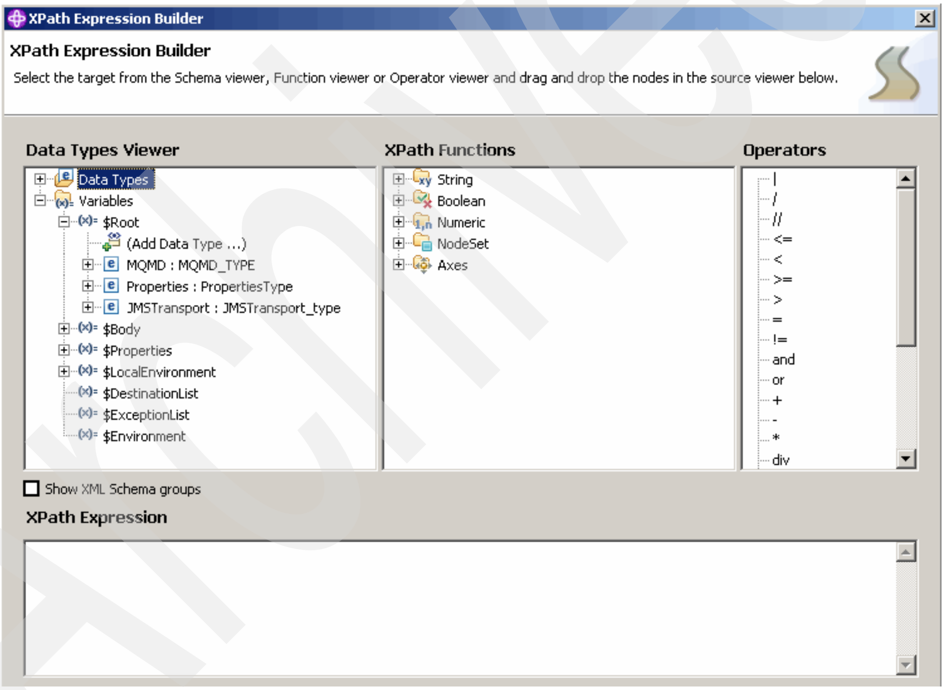
1. Left-click the **Return_to_MQ** node.
2. In the Properties window, select the **Basic** tab, and click **Add**.
3. In the Add filter table entry window, as shown in Figure 9-48 on page 269, click **Edit**.



Routing output terminal: Match

Figure 9-48 Add Filter table entry

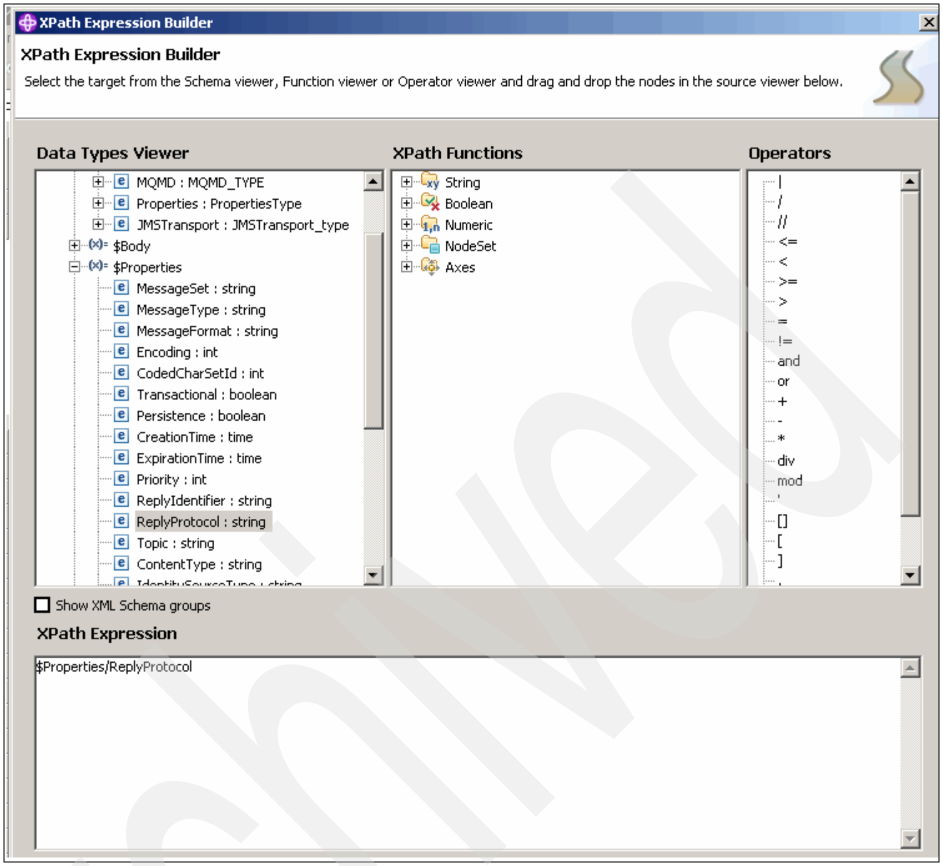
4. In the XPath Expression Builder window, expand **Variables** → **$Root**, as shown in Figure 9-49.



Select the target from the Schema viewer, Function viewer or Operator viewer and drag and drop the nodes in the source viewer below.

Figure 9-49 Expanding Variables → $Root

5. Expand **Properties**.
6. Double-click **ReplyProtocol**. The XPath expression is built now, as shown in Figure 9-50 on page 270.



XPath Expression Builder

Select the target from the Schema viewer, Function viewer or Operator viewer and drag and drop the nodes in the source viewer below.

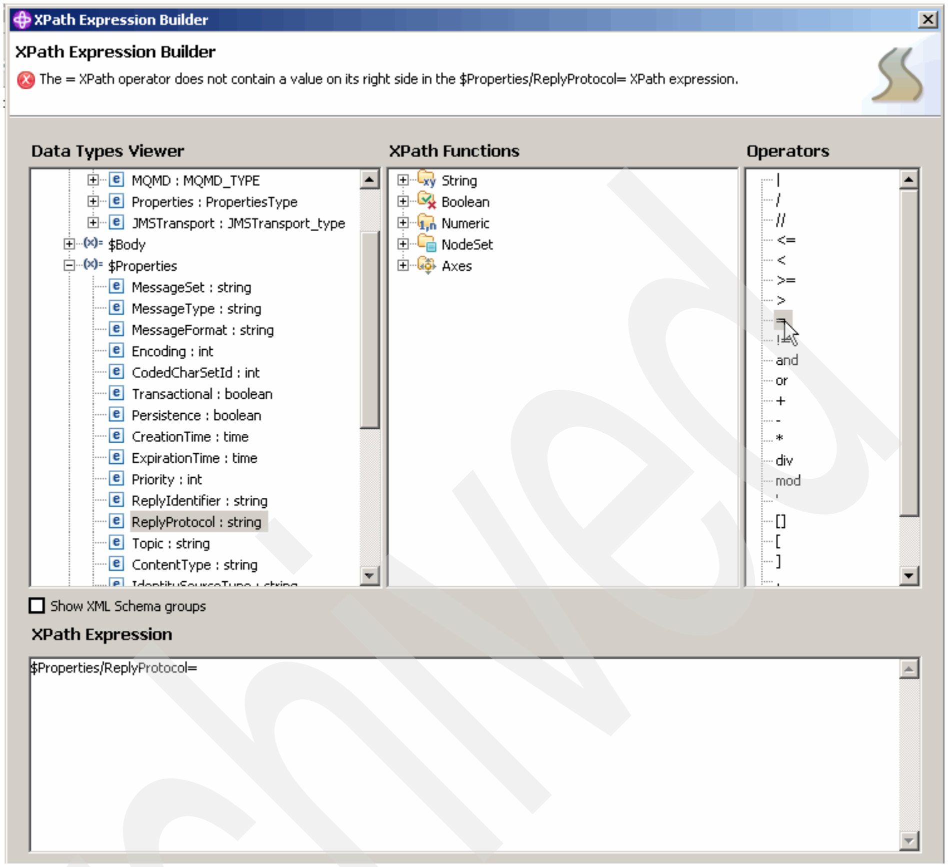
□ Show XML Schema groups

XPath Expression

$Properties/ReplyProtocol

Figure 9-50 Selecting ReplyProtocol

7. In the Operators pane, click **=** (equal symbol), as shown in Figure 9-51 on page 271.



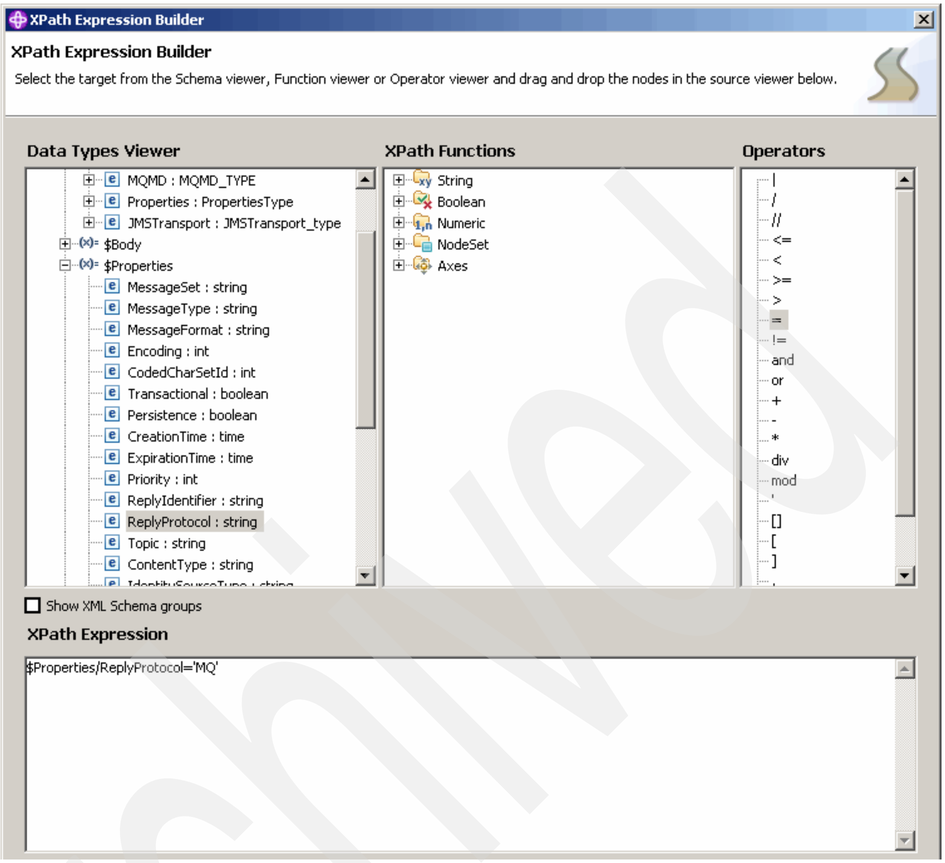
XPath Expression Builder

The = XPath operator does not contain a value on its right side in the $Properties/ReplyProtocol= XPath expression.

```
$Properties/ReplyProtocol=
```

Figure 9-51 Selecting the operator

8. In the XPath Expression field, type `'MQ'` (including single quotation marks) after the = (equal symbol) just inserted. The expression now looks as shown in Figure 9-52 on page 272.



```
$Properties/ReplyProtocol='MQ'
```

Figure 9-52 Specifying the criteria to match

9. Click **Finish**.

10. The table entry is built now. Click **OK** in the Add Filter entry table window.

The expression created is the “match” expression. If the condition in this expression is met, the branch that is connected to the output terminal named `match` will get executed.

Invalid_CustNo

Now, we look at the second branch option. Move to the Message Flow editor window and select the compute node labeled **Invalid_CustNo**, which has the ESQL code that is shown in Example 9-9 on page 273. The added customized code is in bold. In this code, we set a return code of 12, because there is no record found.

Example 9-9 ESQL code of the Invalid_CustNo node

```
CREATE COMPUTE MODULE itso_zsoa_DB2VSAM_Invalid_CustNo
   CREATE FUNCTION Main() RETURNS BOOLEAN
   BEGIN
      /* Provide return code for a request out of range */
      CALL CopyMessageHeaders();
      SET OutputRoot.XMLNSC.CustomerReply.RetCode = 12;
      RETURN TRUE;
   END;

   CREATE PROCEDURE CopyMessageHeaders() BEGIN
      DECLARE I INTEGER 1;
      DECLARE J INTEGER;
      SET J = CARDINALITY(InputRoot.*[]);
      WHILE I < J DO
         SET OutputRoot.*[I] = InputRoot.*[I];
         SET I = I + 1;
      END WHILE;
   END;
END
MODULE;
```

9.2.6 Deploying and testing the flow

Now that the message and flow definitions are complete, you can create a Broker Archive (.bar) file with the artifacts, deploy it to the Broker run time, and test it. A WebSphere Message Broker uses the .bar file in the same way that WebSphere Application Server uses .war or .ear files; the .bar file is a simple file that contains all the necessary components in a compressed, unified format for easy deploying to a runtime environment. To deploy and test the flow:

1. Select the **Broker Administration** perspective in the Toolkit in the upper right part of the Toolkit, as shown in Figure 9-53.

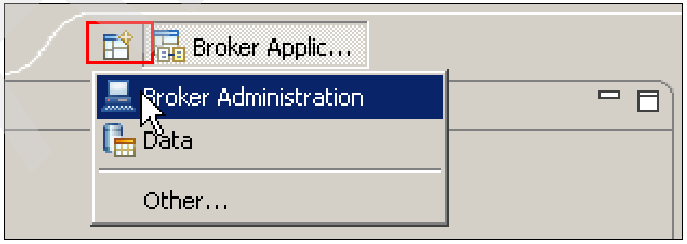


Figure 9-53 Select Broker Administration perspective

2. In the Broker Administration pane found in the upper left, right-click the **Broker Archives** folder. Select **New** → **Message Broker Archive**, as shown in Figure 9-54.

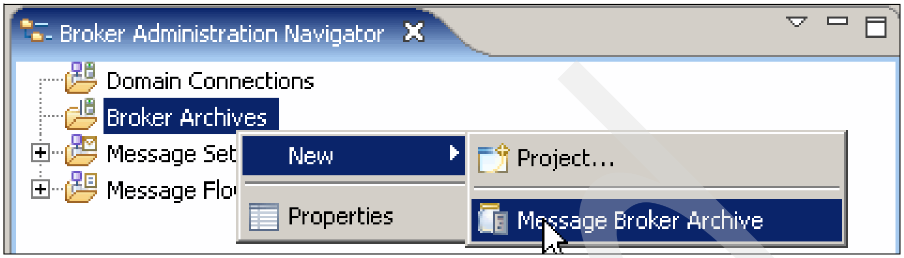
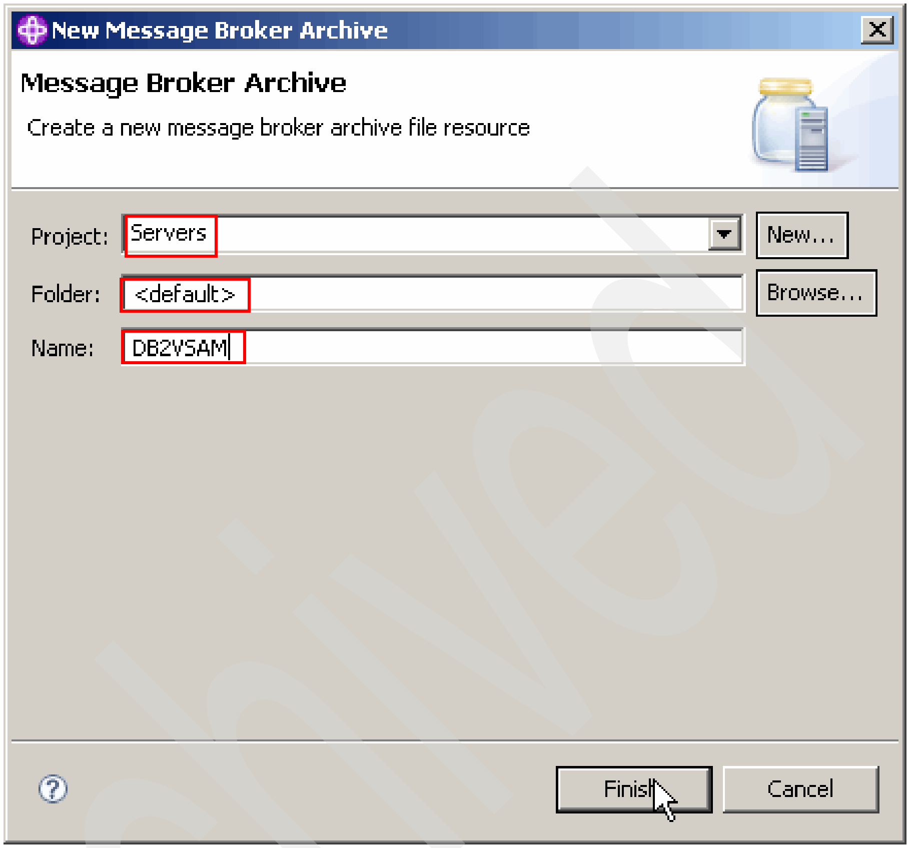


Figure 9-54 Create New Message Broker Archive

3. This action brings up the Message Broker Archive creation window. You can use any name when filling in the name of a .bar file to create. The .bar file typically has a name that indicates the project. Type `Servers` in the Project field and `DB2VSAM` in the Name field. Click **Finish**. Refer to Figure 9-55 on page 275.


New Message Broker Archive
Message Broker Archive
Create a new message broker archive file resource
New...
Browse...
Finish
Cancel

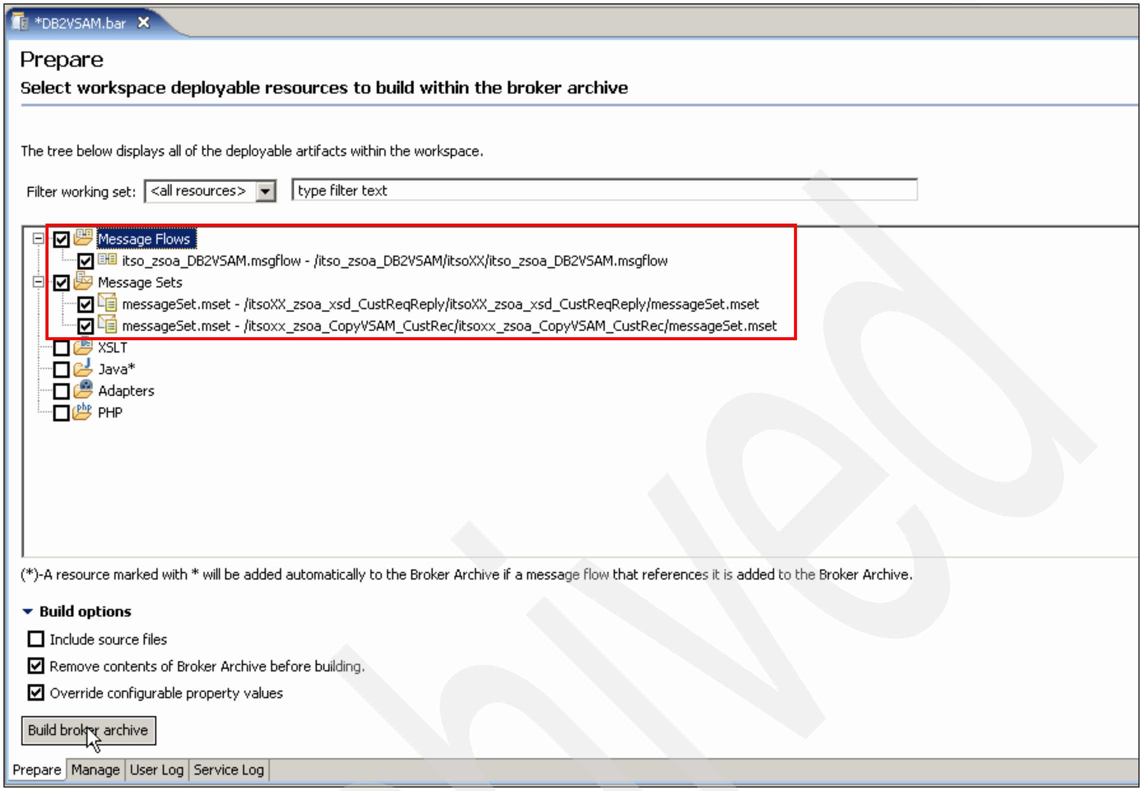
Project: Servers

Folder: <default>

Name: DB2VSAM

Figure 9-55 Message Broker Archive file name

4. A window opens now in which you can describe the contents of the bar file. Select the following check boxes:
   - **itso_zsoa_DB2VSAM.msgflow** in the Message Flows folder
   - messageSet.set **-/itsoXX_zsoa_CopyVSAM_CustRec/itsoXX_zsoa_CopyVSAM_CustRec/messageSet.set** in the Message Sets folder
   - messageSet.set **-/itsoXX_zsoa_xsd_CustRecqReply/itsoXX_zsoa_xsd_CustReqReply/messageSet.set** in the Message Sets folder
5. Click **Build message broker archive**. Refer to Figure 9-56 on page 276.



Prepare

Select workspace deployable resources to build within the broker archive

The tree below displays all of the deployable artifacts within the workspace.

Filter working set: <all resources> type filter text

- ☑ Message Flows
  - ☑ itso_zsoa_DB2VSAM.msgflow - /itso_zsoa_DB2VSAM/itsoXX/itso_zsoa_DB2VSAM.msgflow
- ☑ Message Sets
  - ☑ messageSet.mset - /itsoXX_zsoa_xsd_CustReqReply/itsoXX_zsoa_xsd_CustReqReply/messageSet.mset
  - ☑ messageSet.mset - /itsoxx_zsoa_CopyVSAM_CustRec/itsoxx_zsoa_CopyVSAM_CustRec/messageSet.mset
- □ XSLT
- □ Java*
- □ Adapters
- □ PHP

(*)-A resource marked with * will be added automatically to the Broker Archive if a message flow that references it is added to the Broker Archive.

Build options

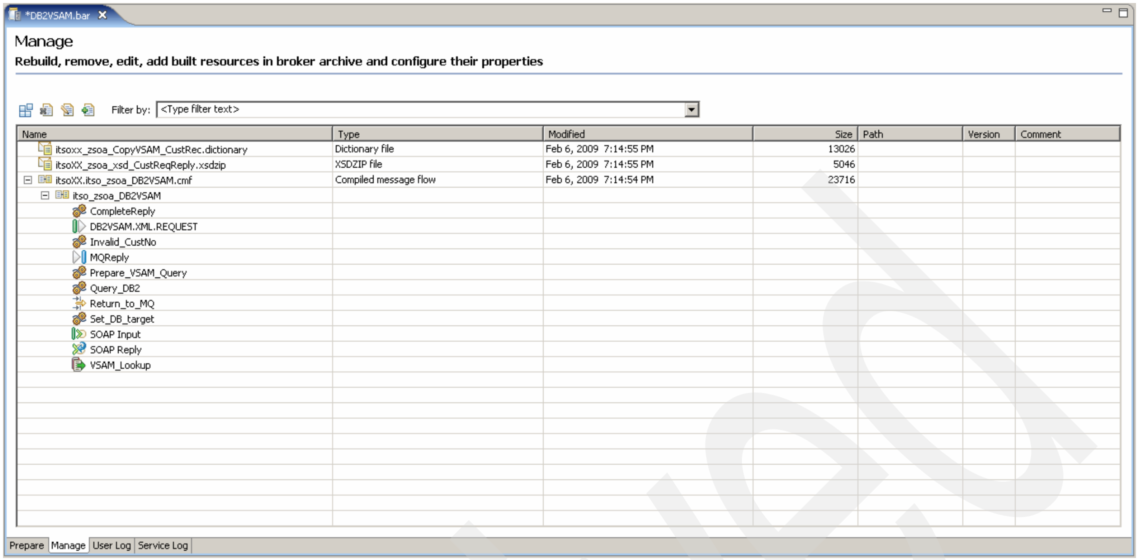
□ Include source files

☑ Remove contents of Broker Archive before building.

☑ Override configurable property values

Figure 9-56 Selecting the contents of a bar file

6. A confirmation window is displayed; click **OK** to dismiss the window, and the .bar editor displays the artifact names, as shown in Figure 9-57 on page 277.
7. Click the **Manage** tab to see the contents of the bar file. Refer to Figure 9-57 on page 277.



Manage

Rebuild, remove, edit, add built resources in broker archive and configure their properties

Filter by: <Type filter text>

Name	Type	Modified	Size	Path	Version	Comment
itsoxx_zsoa_CopyVSAM_CustRec.dictionary	Dictionary file	Feb 6, 2009 7:14:55 PM	13026			
itsoXX_zsoa_xsd_CustReqReply.xsdzip	XSDZIP file	Feb 6, 2009 7:14:55 PM	5046			
⊟ itsoXX.itso_zsoa_DB2VSAM.cmf	Compiled message flow	Feb 6, 2009 7:14:54 PM	23716			
⊟ itso_zsoa_DB2VSAM						
CompleteReply						
DB2VSAM.XML.REQUEST						
Invalid_CustNo						
MQReply						
Prepare_VSAM_Query						
Query_DB2						
Return_to_MQ						
Set_DB_target						
SOAP Input						
SOAP Reply						
VSAM_Lookup						

Figure 9-57 Overview of the .bar file contents

8. Press Ctrl+s to save the .bar file.

   You can now deploy the .bar to the Broker executing on z/OS. First, however, you need to connect the Toolkit to the Configuration Manager. This connection only needs to be done once each time that you start the Toolkit.

   The Configuration Manager controls and filters access to the Broker. All artifacts are first verified by the Configuration Manager.

9. In the lower left Domain window, right-click the Configuration Manager domain and select **Connect**. Refer to Figure 9-58.

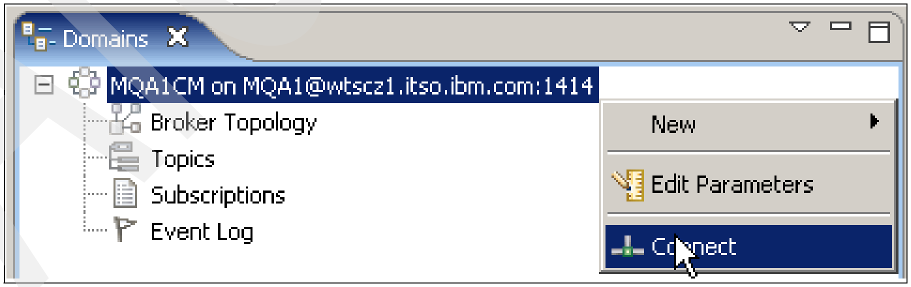


Figure 9-58 Connecting the Toolkit to the Configuration Manager

After a few seconds, you see the Broker name, MQA1BRK, appear under the Broker Topology heading. You also see several Broker Execution Groups appear under the Broker name.

Now, right-click the .bar file in the Navigator pane, and select the option **Deploy File** from the pop-up menu, as shown in Figure 9-59.

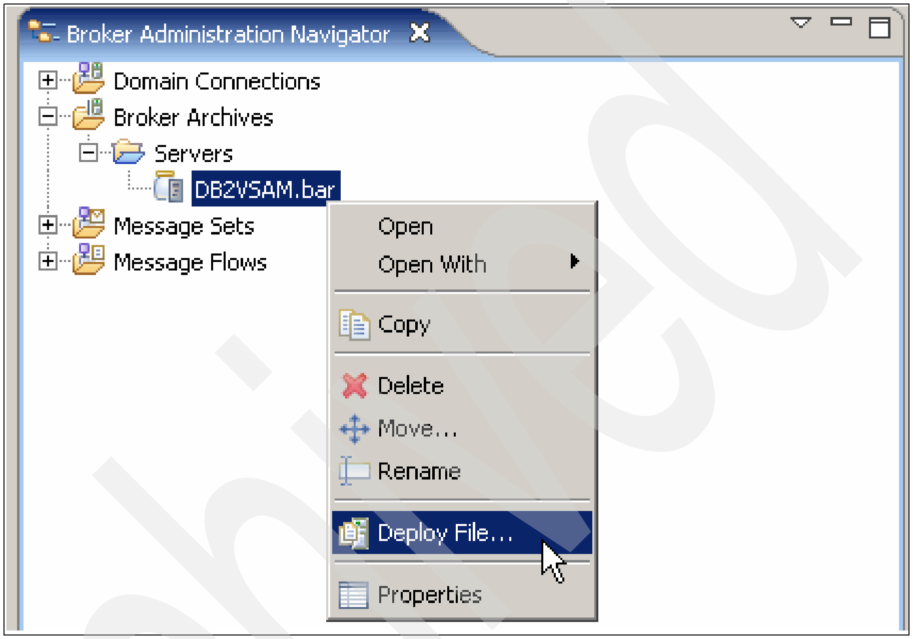
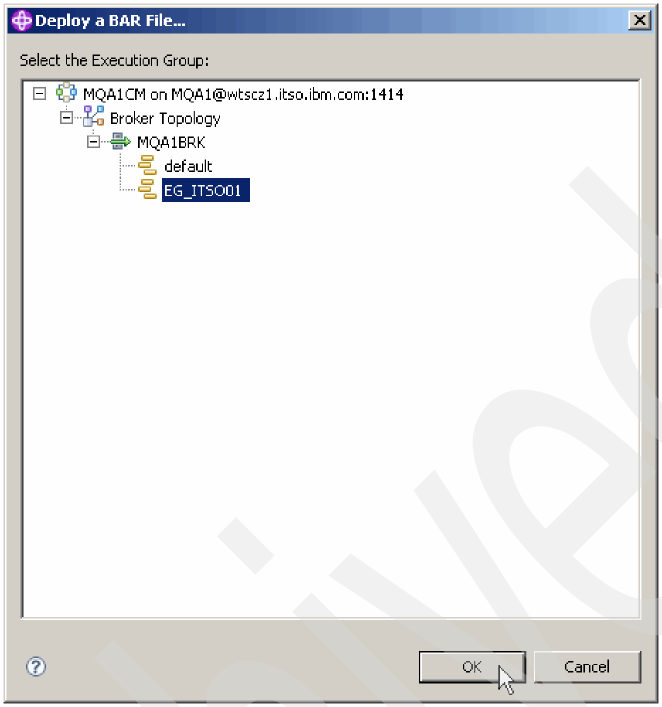


Figure 9-59 Start deployment

10. In the pop-up window, select the execution group that you want. Refer to Figure 9-60 on page 279.

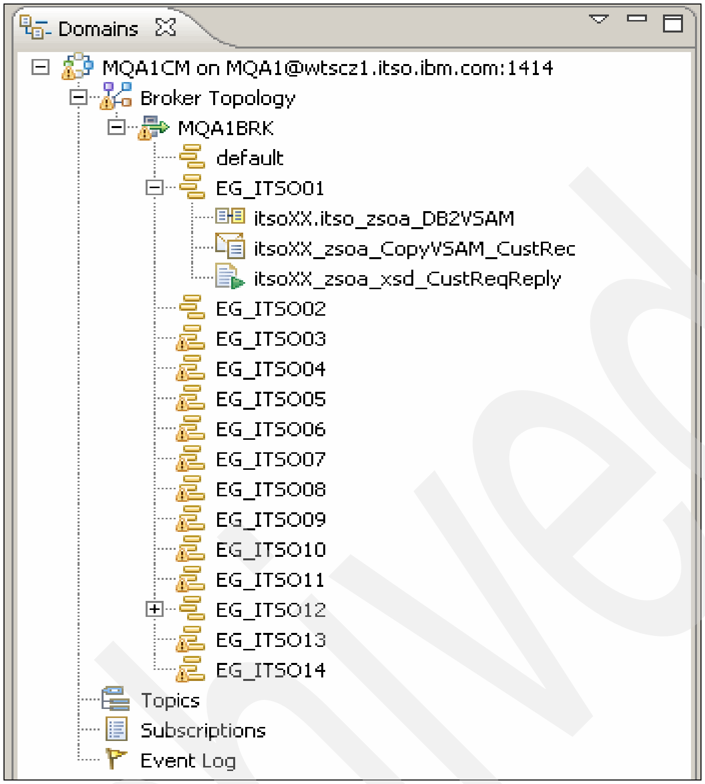


Select the Execution Group:

MQA1CM on MQA1@wtscz1.itso.ibm.com:1414
Broker Topology
MQA1BRK
default
EG_ITSO01

Figure 9-60 Select the execution group for deployment

Click **OK** to continue. An information window appears confirming that your .bar file has been deployed. You can click **OK** to dismiss this window also. Notice a few seconds later that your flow and message set names now appear in the Broker topology display in the Domains pane under your execution group name. Refer to Figure 9-61 on page 280.



```
MQA1CM on MQA1@wtscz1.itso.ibm.com:1414
  Broker Topology
    MQA1BRK
      default
      EG_ITSO01
        itsoXX.itso_zsoa_DB2VSAM
        itsoXX_zsoa_CopyVSAM_CustRec
        itsoXX_zsoa_xsd_CustReqReply
      EG_ITSO02
      EG_ITSO03
      EG_ITSO04
      EG_ITSO05
      EG_ITSO06
      EG_ITSO07
      EG_ITSO08
      EG_ITSO09
      EG_ITSO10
      EG_ITSO11
      EG_ITSO12
      EG_ITSO13
      EG_ITSO14
  Topics
  Subscriptions
  Event Log
```

Figure 9-61 Flow and message set deployed to execution group

You can now test your new flow.

9.2.7 Testing the flow

You can test the message flow in various ways:

- Using the Web Services Explorer, which is built into the WebSphere Message Broker Toolkit. You can follow this procedure if you have a SOAP node in your message flow. In that case, your request is a SOAP message. Refer to "Testing using the Web Services Explorer" on page 281.
- Using the RFHUTILC utility, which is a popular tool for testing applications using WebSphere MQ. You can use this tool to send a request message to the input queue for the message flow and then read a reply message from the reply queue of the message flow. Refer to "Testing using RFHUTILC" on page 284.

- Using the nettool. The nettool is an open source tool for testing Web applications. In this example, you can use the nettool to send an XML message to the SOAP node of the message flow.

Testing using the Web Services Explorer

To test the message flow with the Web Services Explorer, follow these steps:

1. Click **Window** → **Open perspective** → **Other**.
2. Select **Web perspective** and click **OK**.
3. Expand the **itsoXX_zsoa_xsd_CustReq_Reply** folder until you see the WSDL file that is used for the SOAP node.
4. Select the WSDL file and right-click it, which opens a pop-up window.
5. In the pop-up window, select **Web Services** → **Test with Web Services Explorer**, as shown in Figure 9-62 on page 282.

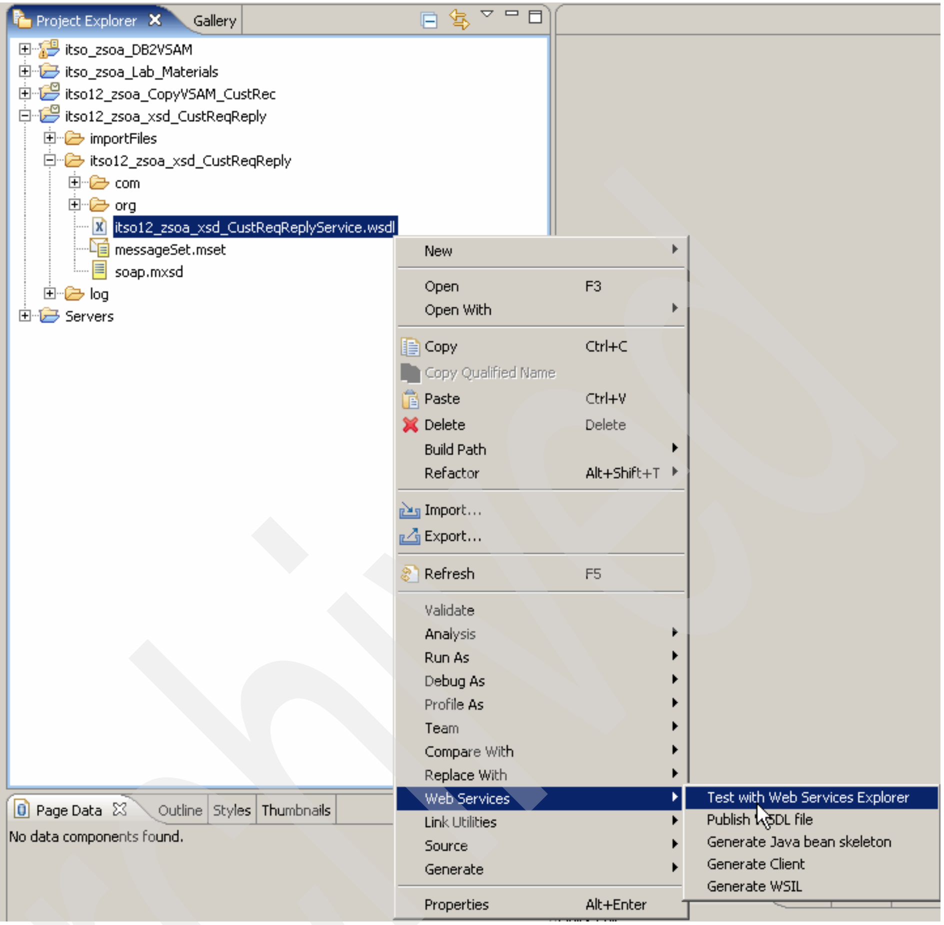
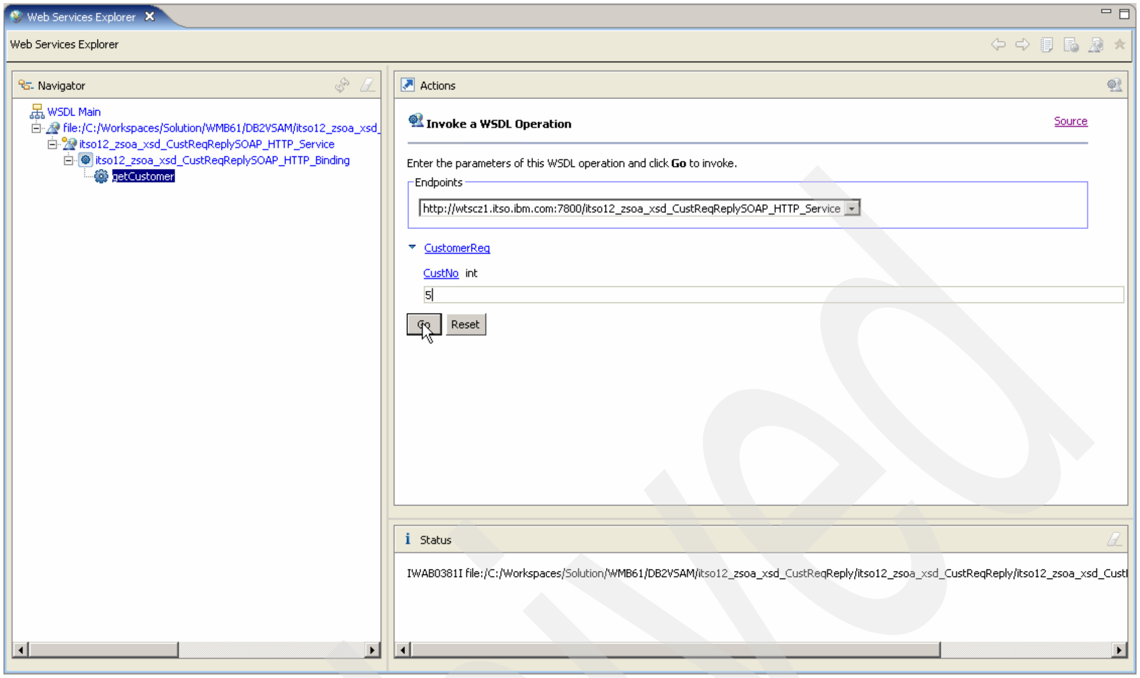


Figure 9-62 Selecting the Web Services Explorer

6. In the Web Services Explorer pane, expand the WSDL Main tree in the Navigator until you get to the `getCustomer` method. Click **getCustomer** and you see an input field for Customer number on the right side. Fill in a value and click **Go**, as shown in Figure 9-63 on page 283.


Web Services Explorer
Web Services Explorer
Navigator
WSDL Main
file:/C:/Workspaces/Solution/WMB61/DB2VSAM/itso12_zsoa_xsd_
itso12_zsoa_xsd_CustReqReplySOAP_HTTP_Service
itso12_zsoa_xsd_CustReqReplySOAP_HTTP_Binding
getCustomer
Actions
Invoke a WSDL Operation
Source

Enter the parameters of this WSDL operation and click **Go** to invoke.

Endpoints: http://wtscz1.itso.ibm.com:7800/itso12_zsoa_xsd_CustReqReplySOAP_HTTP_Service

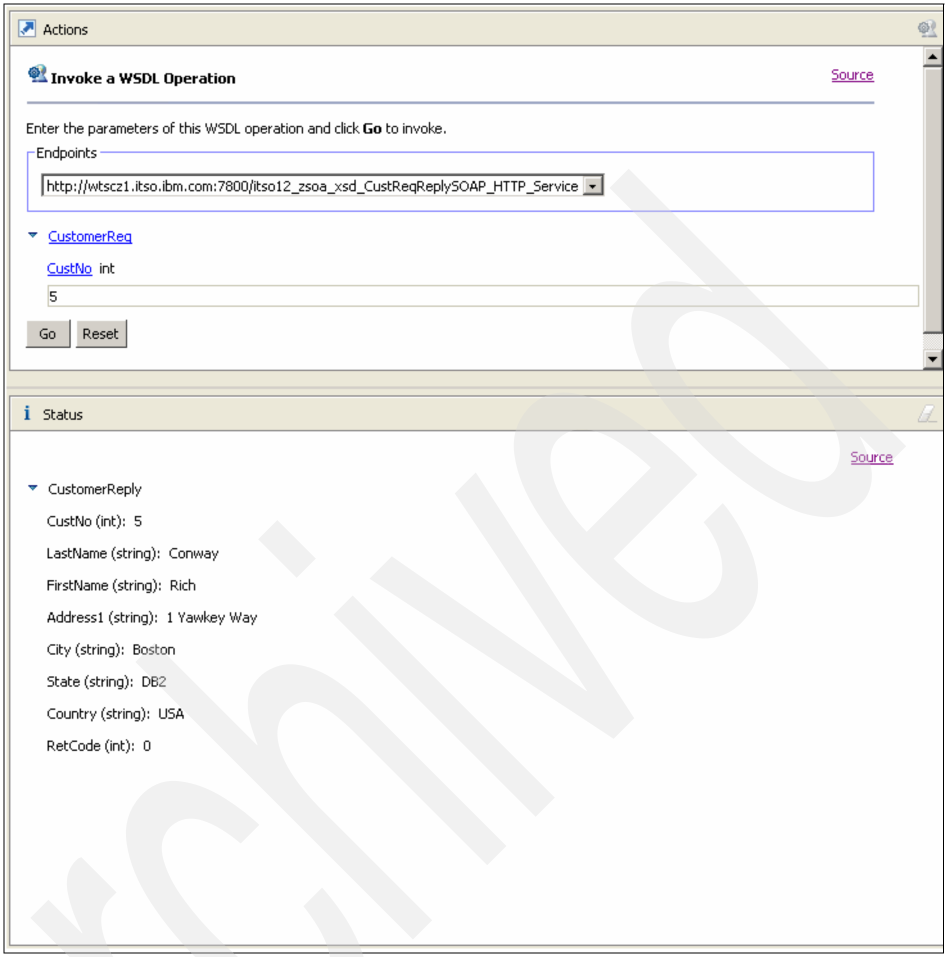
CustomerReq

CustNo int: 5

IWAB0381I file:/C:/Workspaces/Solution/WMB61/DB2VSAM/itso12_zsoa_xsd_CustReqReply/itso12_zsoa_xsd_CustReqReply/itso12_zsoa_xsd_Custl

Figure 9-63 Testing with the Web Services Explorer

7. The output is shown in Figure 9-64 on page 284.



Enter the parameters of this WSDL operation and click **Go** to invoke.

Endpoints: http://wtscz1.itso.ibm.com:7800/itso12_zsoa_xsd_CustReqReplySOAP_HTTP_Service

CustomerReq

CustNo int

5

CustomerReply

CustNo (int): 5

LastName (string): Conway

FirstName (string): Rich

Address1 (string): 1 Yawkey Way

City (string): Boston

State (string): DB2

Country (string): USA

RetCode (int): 0

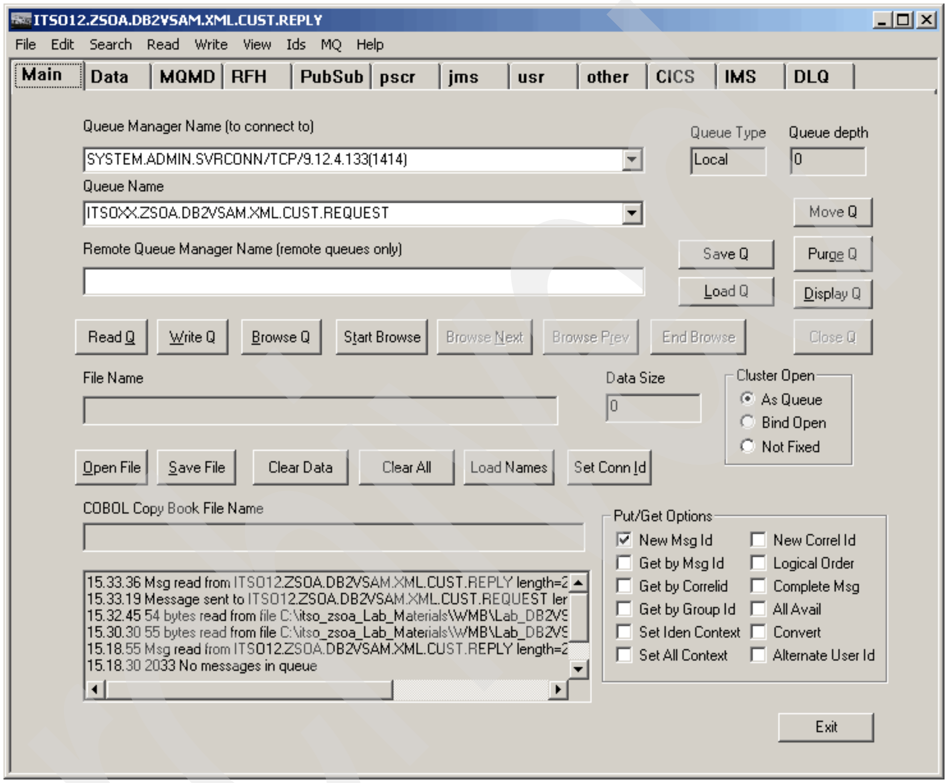
Figure 9-64 Output

Testing using RFHUTILC

To test the message flow with RFHUTILC, follow these steps:

1. Start the RFHUTILC tool by double-clicking the shortcut. The RFHUTILC window opens. Make sure that the **Main** tab is selected.
2. Type the Queue Name, which is the name of the queue that you will use for the request message. In our example, this name is `ITSOXX.ZSOA.DB2VSAM.XML.CUST.REQUEST`. Refer to Figure 9-65 on page 285.

Note: The queue name specified here is the queue name that we also specified in the DB2VSAM.XML.REQUEST node in “DB2VSAM.XML.REQUEST node” on page 258.



Queue Manager Name (to connect to): SYSTEM.ADMIN.SVRCONN/TCP/9.12.4.133(1414)

Queue Name: ITSOXX.ZSOA.DB2VSAM.XML.CUST.REQUEST

Remote Queue Manager Name (remote queues only):

Queue Type: Local

Queue depth: 0

File Name:

Data Size: 0

Cluster Open: ● As Queue ○ Bind Open ○ Not Fixed

COBOL Copy Book File Name:

Put/Get Options:
☑ New Msg Id □ New Correl Id
□ Get by Msg Id □ Logical Order
□ Get by Correlid □ Complete Msg
□ Get by Group Id □ All Avail
□ Set Iden Context □ Convert
□ Set All Context □ Alternate User Id

```
15.33.36 Msg read from ITSO12.ZSOA.DB2VSAM.XML.CUST.REPLY length=2
15.33.19 Message sent to ITSO12.ZSOA.DB2VSAM.XML.CUST.REQUEST ler
15.32.45 54 bytes read from file C:\itso_zsoa_Lab_Materials\WMB\Lab_DB2VS
15.30.30 55 bytes read from file C:\itso_zsoa_Lab_Materials\WMB\Lab_DB2VS
15.18.55 Msg read from ITSO12.ZSOA.DB2VSAM.XML.CUST.REPLY length=2
15.18.30 2033 No messages in queue
```

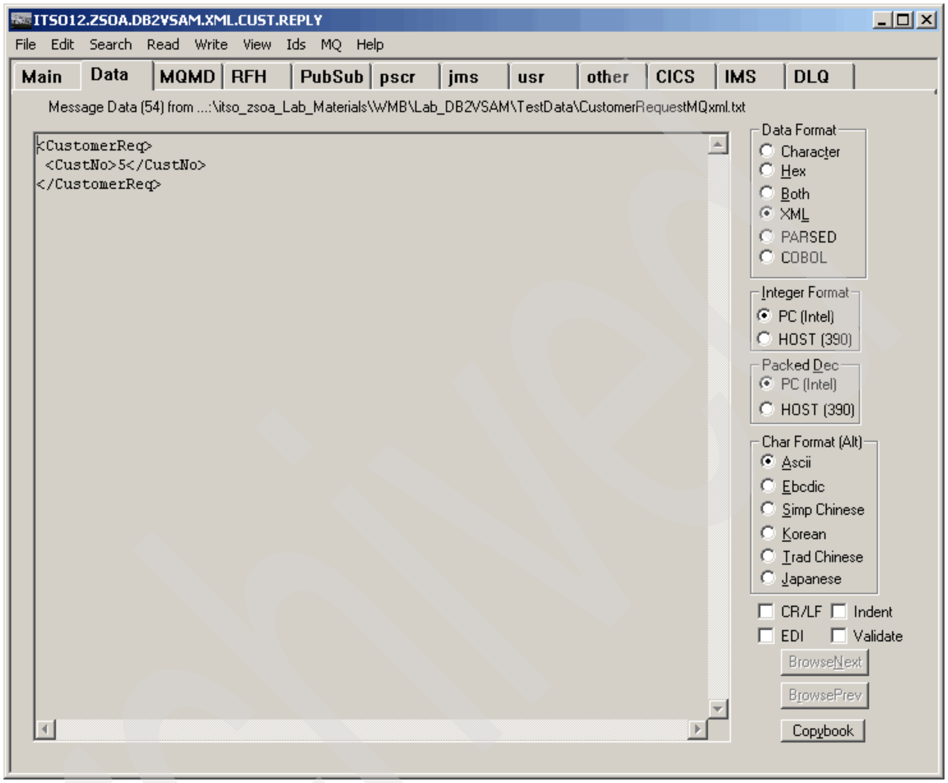
Figure 9-65 RFHUTILC: Specifying the queue name

3. Click **Open File**.
4. Navigate to the file that you are using with test data. In our case, we used a file with XML test data, as shown in Example 9-10.

Example 9-10 XML test data

```
<CustomerReq>
   <CustNo>5</CustNo>
</CustomerReq>
```

5. Click the **Data** tab. You now see the test data in raw format. To be able to see the test data in the original (XML) format, click **XML** on the right side of the pane. Refer to Figure 9-66.


ITSO12.ZSOA.DB2VSAM.XML.CUST.REPLY
File Edit Search Read Write View Ids MQ Help
Main Data MQMD RFH PubSub pscr jms usr other CICS IMS DLQ
BrowseNext
BrowsePrev
Copybook

Message Data (54) from ....:\itso_zsoa_Lab_Materials\WMB\Lab_DB2VSAM\TestData\CustomerRequestMQxml.txt

```
<CustomerReq>
 <CustNo>5</CustNo>
</CustomerReq>
```

Data Format: ○ Character ○ Hex ○ Both ● XML ○ PARSED ○ COBOL

Integer Format: ● PC (Intel) ○ HOST (390)

Packed Dec: ● PC (Intel) ○ HOST (390)

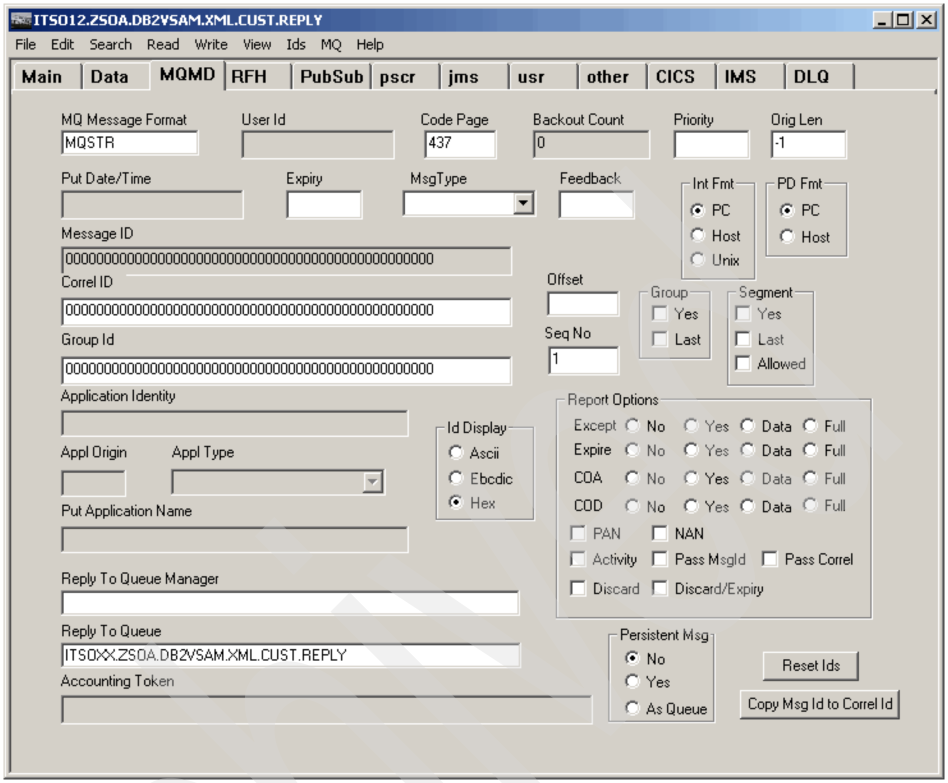
Char Format (Alt): ● Ascii ○ Ebcdic ○ Simp Chinese ○ Korean ○ Trad Chinese ○ Japanese

□ CR/LF □ Indent □ EDI □ Validate

Figure 9-66 XML test data in RFHUTILC

6. Click the **MQMD** tab.
7. In the MQ Message Format field, type `MQSTR`, which indicates STRING.
8. In the Reply to Queue field, type the name of the reply queue. In our example, we used `ITSOXX.ZSOA.DB2VSAM.XML.CUST.REPLY`.

   Refer to Figure 9-67 on page 287.

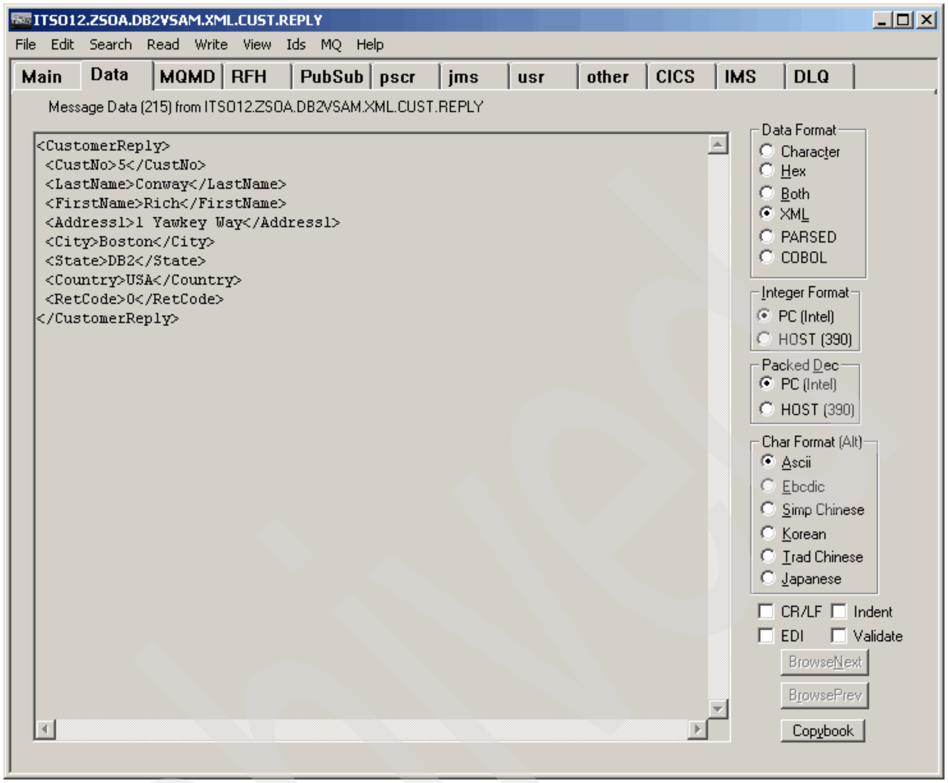

ITSO12.ZSOA.DB2VSAM.XML.CUST.REPLY
File Edit Search Read Write View Ids MQ Help
Main Data MQMD RFH PubSub pscr jms usr other CICS IMS DLQ
Reset Ids
Copy Msg Id to Correl Id

MQ Message Format: MQSTR
User Id:
Code Page: 437
Backout Count: 0
Priority:
Orig Len: -1
Put Date/Time:
Expiry:
MsgType:
Feedback:
Int Fmt: ● PC ○ Host ○ Unix
PD Fmt: ● PC ○ Host
Message ID: 000000000000000000000000000000000000000000000000
Correl ID: 000000000000000000000000000000000000000000000000
Group Id: 000000000000000000000000000000000000000000000000
Offset:
Seq No: 1
Group: □ Yes □ Last
Segment: □ Yes □ Last □ Allowed
Application Identity:
Id Display: ○ Ascii ○ Ebcdic ● Hex
Appl Origin:
Appl Type:
Put Application Name:
Report Options:
Except ○ No ○ Yes ○ Data ○ Full
Expire ○ No ○ Yes ○ Data ○ Full
COA ○ No ○ Yes ○ Data ○ Full
COD ○ No ○ Yes ○ Data ○ Full
□ PAN □ NAN
□ Activity □ Pass MsgId □ Pass Correl
□ Discard □ Discard/Expiry
Reply To Queue Manager:
Reply To Queue: ITSOXX.ZSOA.DB2VSAM.XML.CUST.REPLY
Accounting Token:
Persistent Msg: ● No ○ Yes ○ As Queue

Figure 9-67 RFHUTILC: MQMD tab

9. Click the **Main** tab, and click **Write Q**.
10. Change the Queue Name to the name of reply queue. In our example, we used `ITSOXX.ZSOA.DB2VSAM.XML.CUST.REPLY`.
11. Click **Read Q**.
12. Go to the **Data** tab, and you can see the reply message.

    Refer to Figure 9-68 on page 288.



ITSO12.ZSOA.DB2VSAM.XML.CUST.REPLY
File Edit Search Read Write View Ids MQ Help
Main Data MQMD RFH PubSub pscr jms usr other CICS IMS DLQ
BrowseNext
BrowsePrev
Copybook

Message Data (215) from ITSO12.ZSOA.DB2VSAM.XML.CUST.REPLY

```
<CustomerReply>
 <CustNo>5</CustNo>
 <LastName>Conway</LastName>
 <FirstName>Rich</FirstName>
 <Address1>1 Yawkey Way</Address1>
 <City>Boston</City>
 <State>DB2</State>
 <Country>USA</Country>
 <RetCode>0</RetCode>
</CustomerReply>
```

Data Format
○ Character
○ Hex
○ Both
● XML
○ PARSED
○ COBOL

Integer Format
● PC (Intel)
○ HOST (390)

Packed Dec
● PC (Intel)
○ HOST (390)

Char Format (Alt)
● Ascii
○ Ebcdic
○ Simp Chinese
○ Korean
○ Trad Chinese
○ Japanese

□ CR/LF □ Indent
□ EDI □ Validate

Figure 9-68 Output

10

Exposing an IMS application as a Web service

In this chapter, we describe a sample of an IMS application that is enabled as a Web service using IMS SOAP Gateway and Rational Developer for System z.

10.1 Introduction

To expose an IMS application as a Web service, you first need to create a *Web Services Description Language (WSDL)* file. A WSDL file is an XML document that describes a Web service. WSDL files are used by other clients (for example, the client that invokes the service) to discover the service and to understand how to invoke the service. The WSDL specifies the location of the service and the operations that the service exposes.

The *Enterprise Service Tools (EST)* wizard in Rational Developer for System z can be used to generate the WSDL file that is needed to enable your IMS application to run as a Web service provider.

You must have a description of the format of the input and output messages for your IMS application, also known as a *copybook*.

For using IMS SOAP Gateway, you must have Rational Developer for System z (RDz) Version 7.1.1 or later.

10.2 Steps

To expose an IMS application as a Web service through IMS SOAP Gateway, perform the following steps using RDz. We explain each step in more detail in a separate section:

1. Create a new IMS SOAP Gateway project.

   In this step, we create a project in RDz and import the copybook. The copybook is everything you need to go through the process.

2. Generate the IMS SOAP Gateway Resources.

   In this step, we create a number of artifacts that are needed to deploy the service, such as the WSDL file and the XML converter.

3. Compile the XML converter.

   The *XML converter* is a COBOL program that needs to be compiled, link-edited, and implemented on z/OS.

4. Enable the IMS application as a Web service.

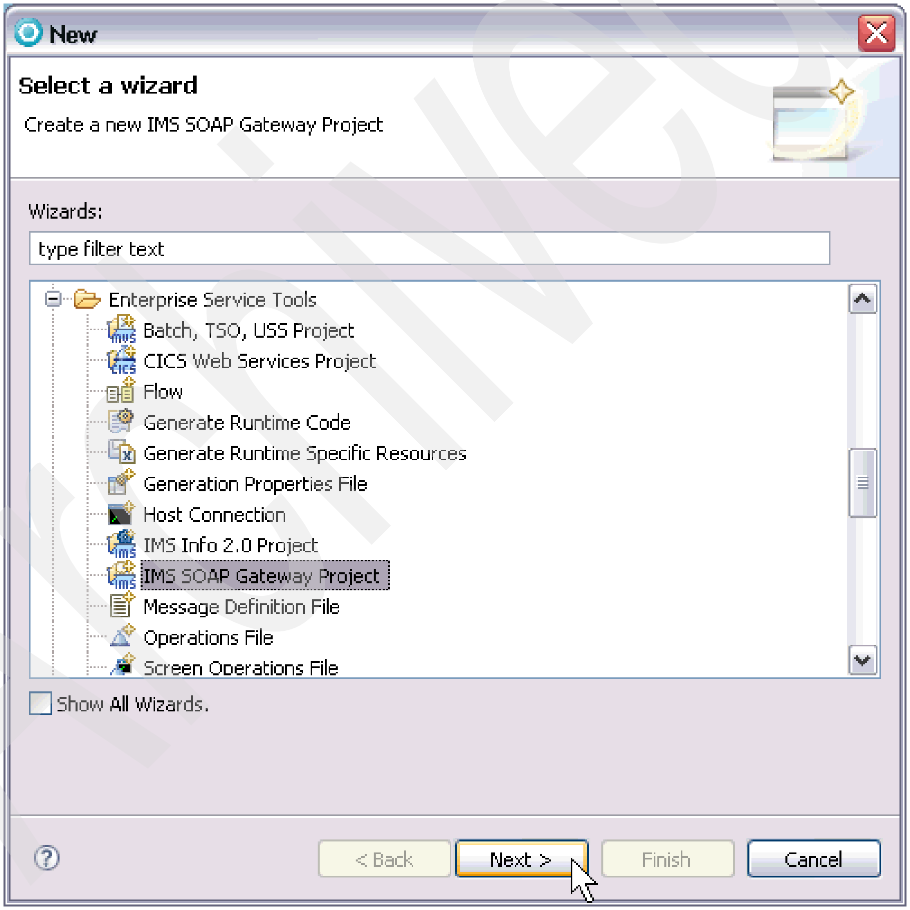
   After the artifacts have been created, you need to deploy the Web service to the IMS SOAP Gateway.

10.2.1 Create a new IMS SOAP Gateway project

Create a new IMS SOAP Gateway project and import the COBOL copybook:

1. Start Rational Developer for System z, and open the Enterprise Service Tools (EST) perspective.
2. Select a wizard by selecting **File** → **New** → **Other** from the menu. In the Select a wizard panel, expand **Enterprise Service Tools** and select **IMS SOAP Gateway Project**.
3. Click **Next** to open the New IMS SOAP Gateway project wizard.

   Refer to Figure 10-1.



New

Select a wizard

Create a new IMS SOAP Gateway Project

Wizards: type filter text

Figure 10-1 Select a wizard

4. In the New IMS SOAP Gateway Project wizard:

   a. In the Choose the project name field, type a name for the project, for example, `MyProject`.

   b. Click **Next** to open the import source files.

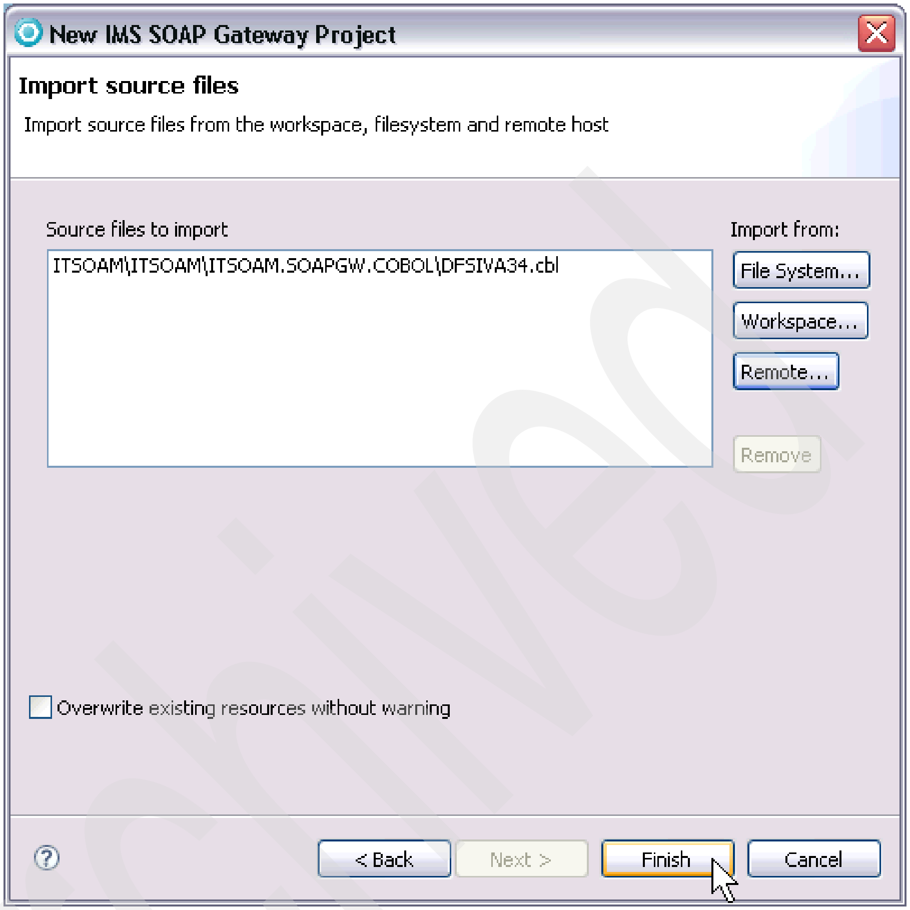
   c. In the Import source files panel, click **Remote**.

   d. In the Browse For File panel, expand **COBOL source library**, select the **COBOL copybook**, and click **OK** to open the Check Dependencies dialog.

   > **Note:** The COBOL copybook is part of the additional material. Refer to Appendix B, “Additional material” on page 485 for instructions to obtain the copybook.

   e. In the Check Dependencies panel, select **Import the selected source only**, and click **OK.**

   f. Click **Finish** to create the new IMS SOAP Gateway project.



New IMS SOAP Gateway Project

Import source files

Import source files from the workspace, filesystem and remote host

Source files to import

ITSOAM\ITSOAM\ITSOAM.SOAPGW.COBOL\DFSIVA34.cbl

□ Overwrite existing resources without warning

Figure 10-2 New IMS SOAP Gateway Project

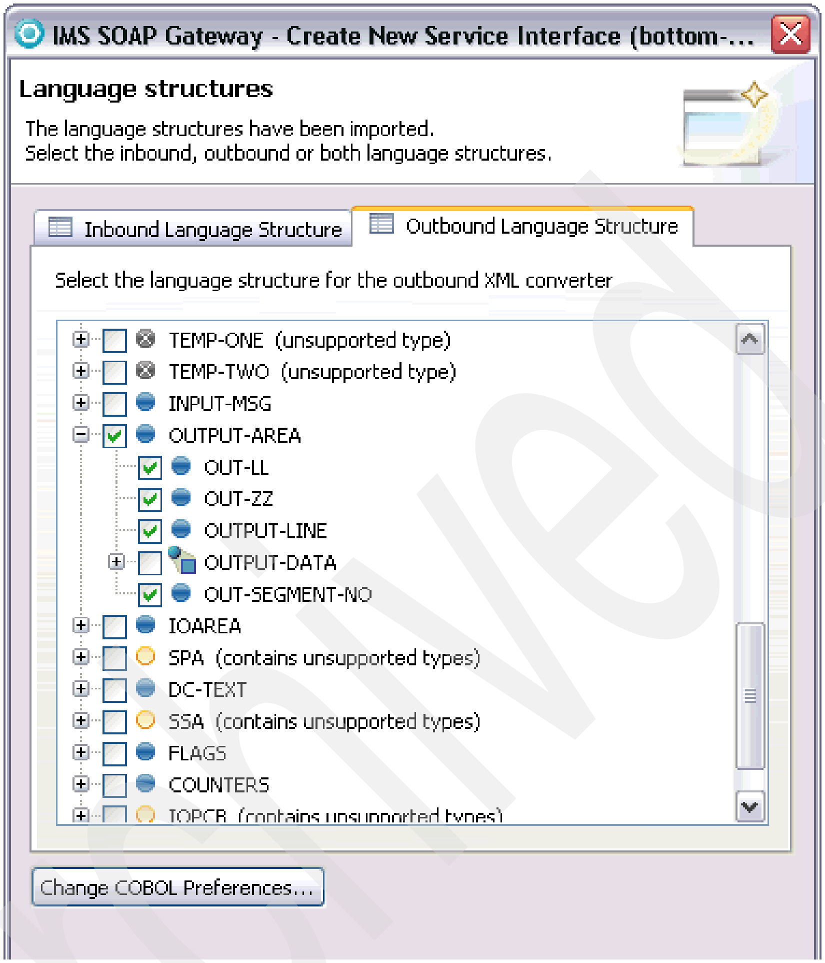
10.2.2 Generate the IMS SOAP Gateway Resources

Perform the following steps to generate the IMS SOAP Gateway artifacts:

1. Start the Enterprise Service Tools (EST) Wizard Launchpad:
   - In the Navigator view, click **Project** → **Source** and right-click the imported source file that contains the input and output data structure statement of your application.
   - Select **Generate IMS SOAP Gateway resources.**
   - Click **Start** to open the Language structures page of the wizard.

2. In the Language structures page of wizard:
   a. Change the COBOL Preferences by clicking **Change COBOL Preferences**. The COBOL Preferences window opens and displays the COBOL preferences in the right pane. In the **General** tab, expand the **Platform** list box and select **z/OS**. Leave other options unchanged. Click **OK** to close the Preferences window.
   b. Under the **Inbound Language Structure** tab, select the COBOL structure that is the input structure for your IMS application.
   c. Under the **Outbound Language Structure** tab select the COBOL structure that is the output structure for your IMS application.
   d. Click **Next** to open the Generation Options page of the wizard.

   Refer to Figure 10-3 on page 295.



IMS SOAP Gateway - Create New Service Interface (bottom-...

Language structures

The language structures have been imported.
Select the inbound, outbound or both language structures.

Select the language structure for the outbound XML converter

- ☐ TEMP-ONE (unsupported type)
- ☐ TEMP-TWO (unsupported type)
- ☐ INPUT-MSG
- ☑ OUTPUT-AREA
  - ☑ OUT-LL
  - ☑ OUT-ZZ
  - ☑ OUTPUT-LINE
  - ☐ OUTPUT-DATA
  - ☑ OUT-SEGMENT-NO
- ☐ IOAREA
- ☐ SPA (contains unsupported types)
- ☐ DC-TEXT
- ☐ SSA (contains unsupported types)
- ☐ FLAGS
- ☐ COUNTERS
- ☐ IOPCB (contains unsupported types)

Figure 10-3 Language structures page of wizard

3. In the Generation options page of the wizard:

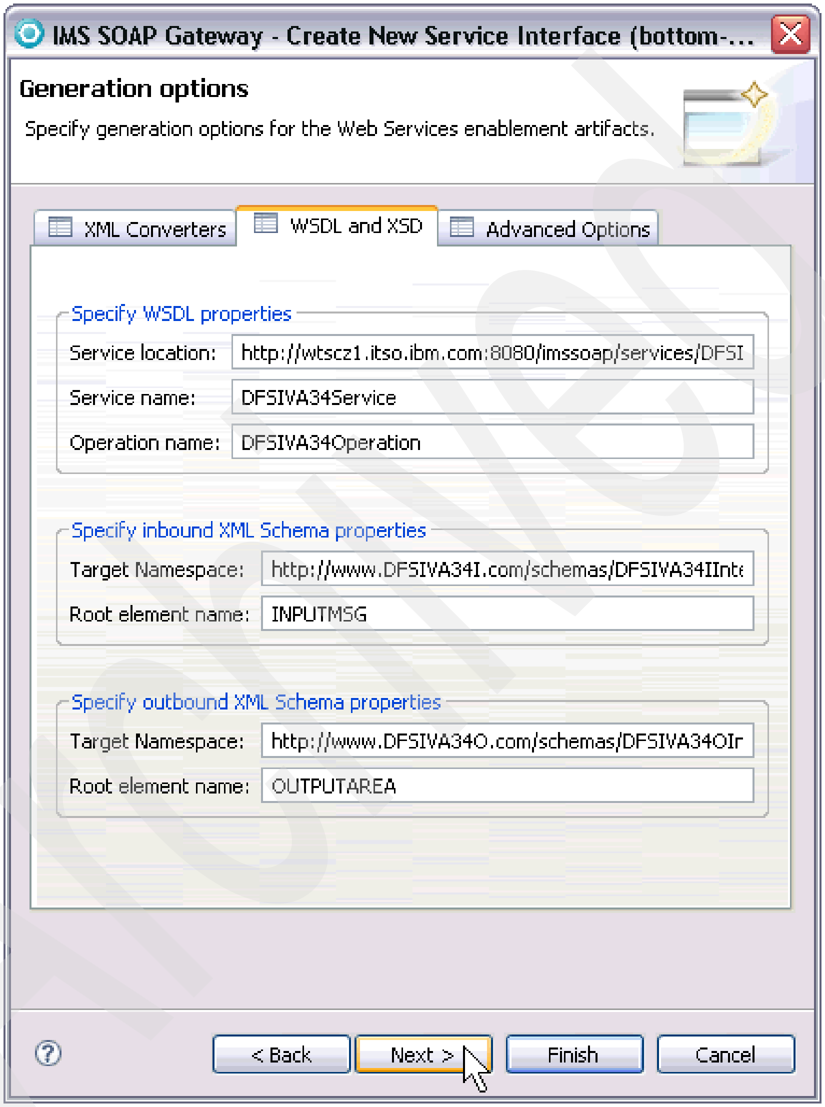
   a. Under the **XML Converter** tab, select or specify the following settings if necessary:

      - Host code page: Select the code page that the host uses.
      - Inbound code page and outbound code page: Leave it at the default value, 1208 Unicode, UTF-8. IMS SOAP Gateway supports only UTF-8.

   b. Under the **WSDL and XSD** tab, in the Service location input field, change the host name and port number to the location of your IMS SOAP Gateway and leave the other fields unchanged.

c. Click **Next** to open the IMS SOAP Gateway Web Service Provider page of the wizard.

Refer to Figure 10-4.



IMS SOAP Gateway - Create New Service Interface (bottom-...

Generation options

Specify generation options for the Web Services enablement artifacts.

Specify WSDL properties

Service location: http://wtscz1.itso.ibm.com:8080/imssoap/services/DFSI

Service name: DFSIVA34Service

Operation name: DFSIVA34Operation

Specify inbound XML Schema properties

Target Namespace: http://www.DFSIVA34I.com/schemas/DFSIVA34IInte

Root element name: INPUTMSG

Specify outbound XML Schema properties

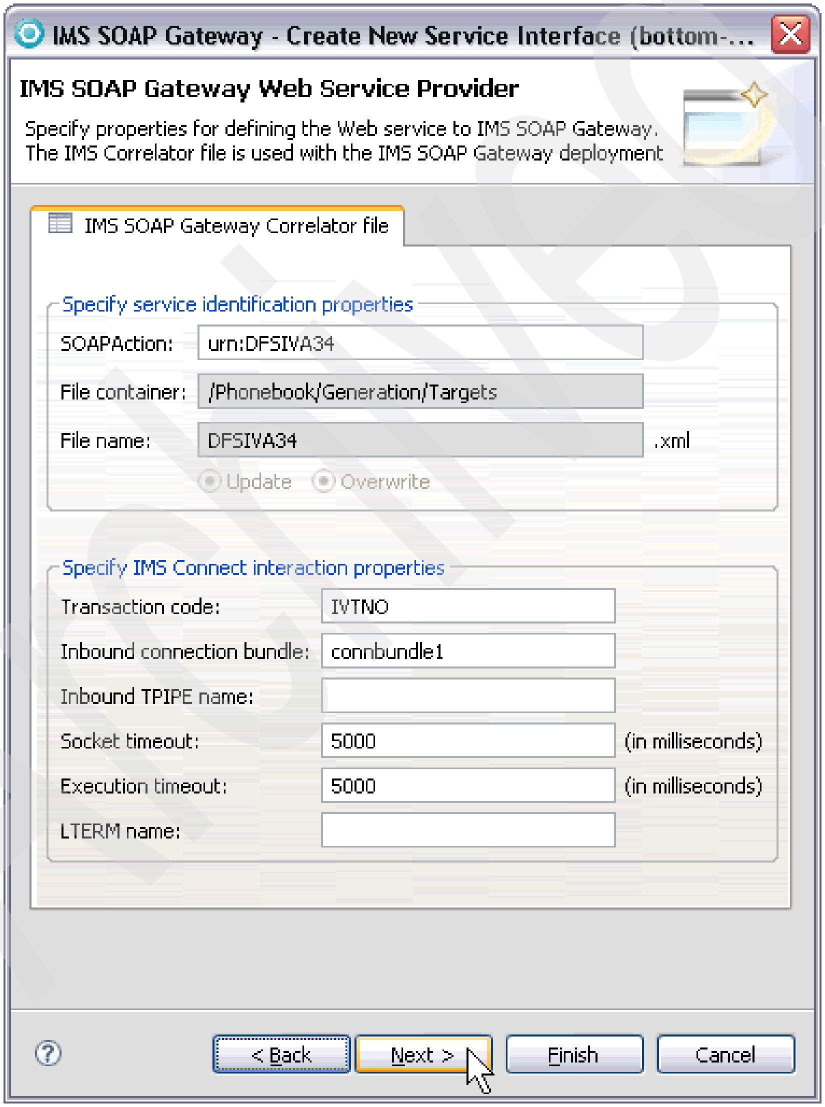
Target Namespace: http://www.DFSIVA34O.com/schemas/DFSIVA34OIr

Root element name: OUTPUTAREA

Figure 10-4 Generation options page of the wizard

4. In the IMS SOAP Gateway Web Service Provider page of the wizard:
   a. In the Specify IMS Connect Interaction properties section, you specify the parameters relevant for IMS Connect. You can specify or alter these values later using the IMS SOAP Gateway Deployment utility.
   b. Click **Next** to open the File, data set, or member selection page of the wizard.

   Refer to Figure 10-5.



IMS SOAP Gateway - Create New Service Interface (bottom-...

IMS SOAP Gateway Web Service Provider

Specify properties for defining the Web service to IMS SOAP Gateway.
The IMS Correlator file is used with the IMS SOAP Gateway deployment

IMS SOAP Gateway Correlator file

Specify service identification properties

SOAPAction: urn:DFSIVA34

File container: /Phonebook/Generation/Targets

File name: DFSIVA34 .xml

○ Update ○ Overwrite

Specify IMS Connect interaction properties

Transaction code: IVTNO

Inbound connection bundle: connbundle1

Inbound TPIPE name:

Socket timeout: 5000 (in milliseconds)

Execution timeout: 5000 (in milliseconds)

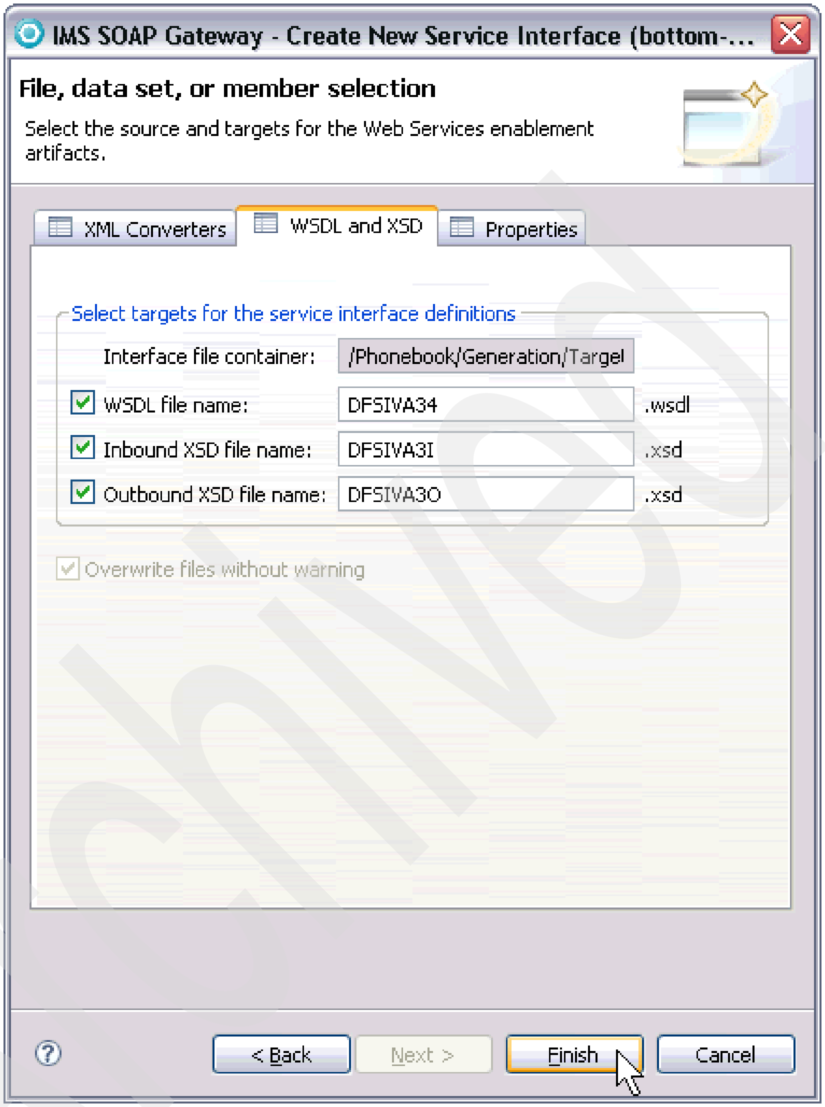
LTERM name:

Figure 10-5 IMS SOAP Gateway Web Service Provider page of the wizard

5. In the File, data set, or member selection page of the wizard, perform the following steps and change fields only when necessary:

   - Under the **XML Converters** tab, select **Generate all to driver**. This selection causes all the generated Web service programs (driver, inbound converter, and outbound converter) to be placed in the same file.
   - Under the **WSDL and XSD** tab, RDz sets the first seven characters of the COBOL copybook as default values and uses the COBOL copybook name in the endpoint URI as the default value as well.
   - In the **WSDL and XSD** tab, also make sure that the check box preceding the input file WSDL file name is selected.
   - Click **Finish** to generate the following IMS SOAP Gateway resources:
     - WDSL (.wsdl) file, which is the only file that you need to enable your IMS application as a Web service provider by using IMS SOAP Gateway
     - Correlator file (.xml)
     - The generated file containing the Web service driver and runtime XML converter (.cbl)
     - The input and output data mapping XDS files (.xsd)

   Refer to Figure 10-6 on page 299.



File, data set, or member selection

Select the source and targets for the Web Services enablement artifacts.

Select targets for the service interface definitions

Interface file container: /Phonebook/Generation/Target

☑ WSDL file name: DFSIVA34 .wsdl

☑ Inbound XSD file name: DFSIVA3I .xsd

☑ Outbound XSD file name: DFSIVA3O .xsd

☑ Overwrite files without warning

Figure 10-6 File, data set, or member selection page of wizard

10.2.3 Compile the XML converter

To start:

1. Upload the generated XML converter to your COBOL source library, which can be any partitioned data set (PDS) set on z/OS with the right format.
2. Compile and link-edit the generated XML converter so that it can be accessed by IMS Connect, which means that the converter needs to be placed in a load library part of the IMS Connect JCL. Note that the XML converter must have alias name suffix “`X`”.

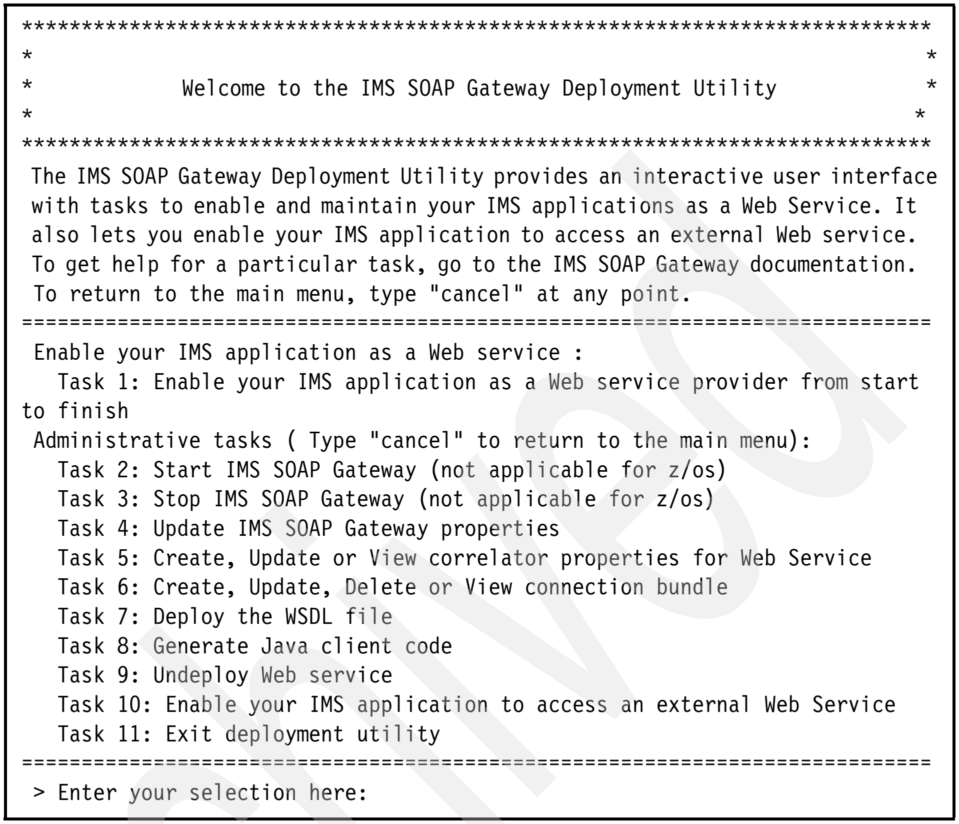
10.2.4 Enable the IMS application as a Web service

The next steps are needed to define the Web service to the IMS SOAP Gateway. You can use the IMS SOAP Gateway Deployment Utility to perform the following steps:

1. Upload the WSDL file by using RDz using a drag and drop technique, by using FTP from the command line ,or by using an FTP tool. Note that you have to upload the WSDL file in binary mode.
2. Start the IMS SOAP Gateway Deployment Utility from the UNIX System Services command line. You can bring up a Telnet emulation from RDz, or alternatively, you can log on to z/OS and go into OMVS mode. When you are in the Uniform Symbol Specification, perform these tasks:
   a. Run **iogdeploy.sh** in the `installation_dir/deploy` directory.
   The IMS SOAP Gateway Deployment Utility menu opens.
   b. Follow the instructions to enable your IMS application as a Web service from start to finish.

   For more information about the IMS SOAP Gateway Deployment Utility, refer to *IMS SOAP Gateway User’s Guide and Reference,* SC19-1290.

   The main menu of the utility is shown in Figure 10-7 on page 301.

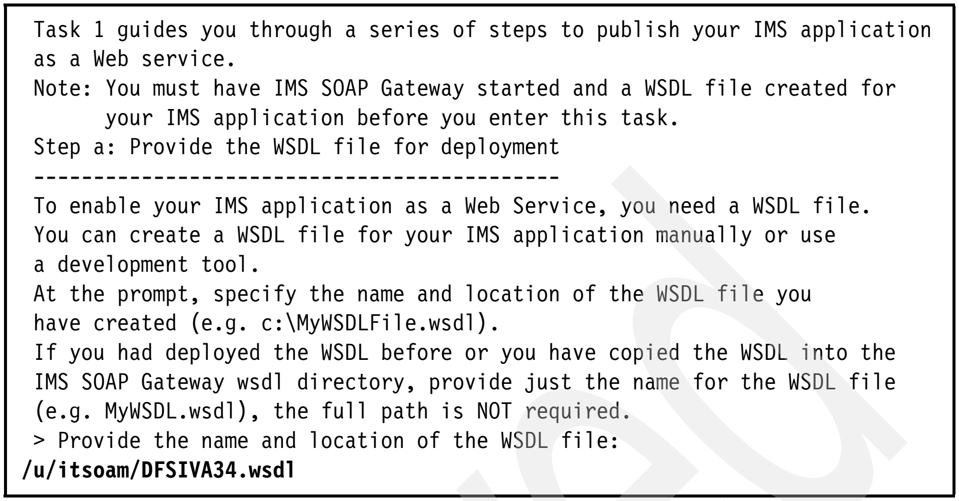


```
****************************************************************************
*                                                                          *
*            Welcome to the IMS SOAP Gateway Deployment Utility            *
*                                                                         *
****************************************************************************
 The IMS SOAP Gateway Deployment Utility provides an interactive user interface
 with tasks to enable and maintain your IMS applications as a Web Service. It
 also lets you enable your IMS application to access an external Web service.
 To get help for a particular task, go to the IMS SOAP Gateway documentation.
 To return to the main menu, type "cancel" at any point.
============================================================================
 Enable your IMS application as a Web service :
   Task 1: Enable your IMS application as a Web service provider from start
to finish
 Administrative tasks ( Type "cancel" to return to the main menu):
   Task 2: Start IMS SOAP Gateway (not applicable for z/os)
   Task 3: Stop IMS SOAP Gateway (not applicable for z/os)
   Task 4: Update IMS SOAP Gateway properties
   Task 5: Create, Update or View correlator properties for Web Service
   Task 6: Create, Update, Delete or View connection bundle
   Task 7: Deploy the WSDL file
   Task 8: Generate Java client code
   Task 9: Undeploy Web service
   Task 10: Enable your IMS application to access an external Web Service
   Task 11: Exit deployment utility
============================================================================
 > Enter your selection here:
```

Figure 10-7 The IMS SOAP Gateway Deployment Utility main menu

c. From the IMS SOAP Gateway Deployment Utility menu, type `1` and press Enter.

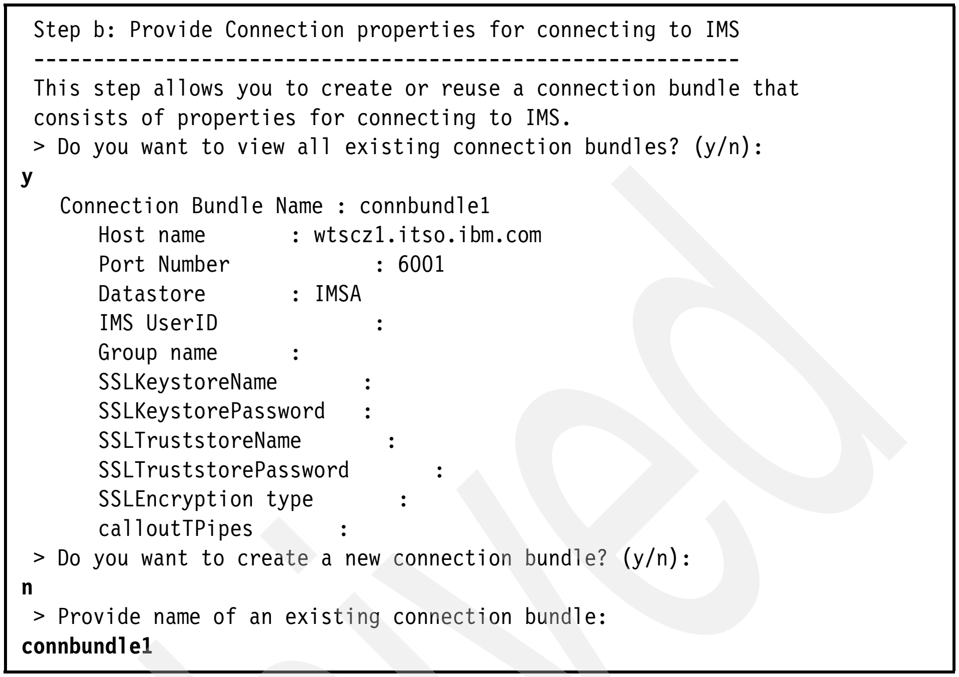
d. Type the name and location of the generated WSDL file, as shown in Figure 10-8 on page 302.



```
Task 1 guides you through a series of steps to publish your IMS application
as a Web service.
Note: You must have IMS SOAP Gateway started and a WSDL file created for
      your IMS application before you enter this task.
Step a: Provide the WSDL file for deployment
--------------------------------------------
To enable your IMS application as a Web Service, you need a WSDL file.
You can create a WSDL file for your IMS application manually or use
a development tool.
At the prompt, specify the name and location of the WSDL file you
have created (e.g. c:\MyWSDLFile.wsdl).
If you had deployed the WSDL before or you have copied the WSDL into the
IMS SOAP Gateway wsdl directory, provide just the name for the WSDL file
(e.g. MyWSDL.wsdl), the full path is NOT required.
> Provide the name and location of the WSDL file:
/u/itsoam/DFSIVA34.wsdl
```

Figure 10-8 Provide the WSDL file

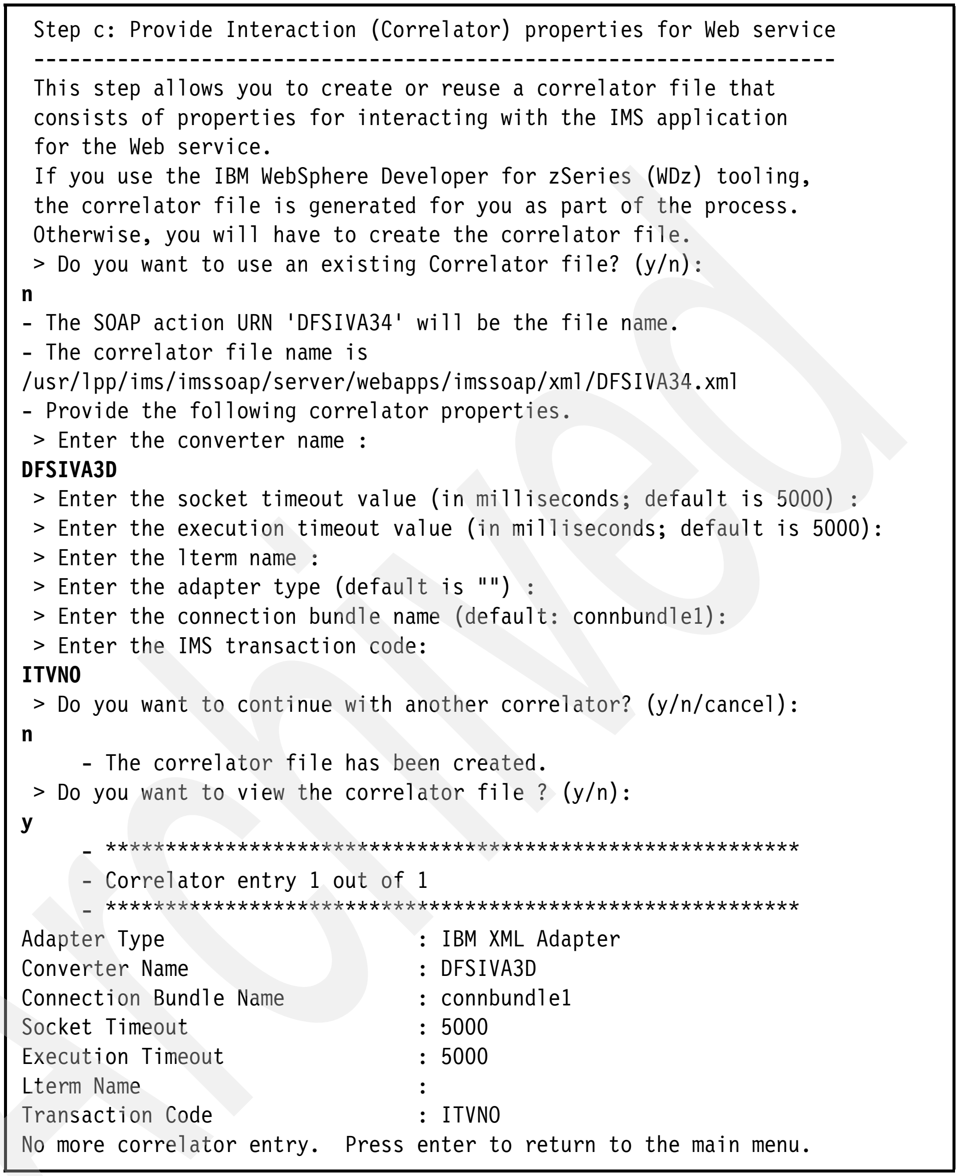
e. In Provide Connection properties for connecting to IMS, specify the connection and security information for the Web service to create or reuse a connection bundle, as shown in Figure 10-9 on page 303. In this case, we reuse a connection bundle.



```
 Step b: Provide Connection properties for connecting to IMS
 -----------------------------------------------------------
 This step allows you to create or reuse a connection bundle that
 consists of properties for connecting to IMS.
 > Do you want to view all existing connection bundles? (y/n):
y
   Connection Bundle Name : connbundle1
      Host name        : wtscz1.itso.ibm.com
      Port Number             : 6001
      Datastore        : IMSA
      IMS UserID              :
      Group name       :
      SSLKeystoreName        :
      SSLKeystorePassword    :
      SSLTruststoreName        :
      SSLTruststorePassword        :
      SSLEncryption type        :
      calloutTPipes        :
 > Do you want to create a new connection bundle? (y/n):
n
 > Provide name of an existing connection bundle:
connbundle1
```

Figure 10-9 Provide Connection properties

f. Provide Interaction (Correlator) properties for the Web service by specifying the correlator file name or creating a new correlator file, as shown in Figure 10-10 on page 304. In this case, we create a file.



```
 Step c: Provide Interaction (Correlator) properties for Web service
 -------------------------------------------------------------------
 This step allows you to create or reuse a correlator file that
 consists of properties for interacting with the IMS application
 for the Web service.
 If you use the IBM WebSphere Developer for zSeries (WDz) tooling,
 the correlator file is generated for you as part of the process.
 Otherwise, you will have to create the correlator file.
 > Do you want to use an existing Correlator file? (y/n):
n
- The SOAP action URN 'DFSIVA34' will be the file name.
- The correlator file name is
/usr/lpp/ims/imssoap/server/webapps/imssoap/xml/DFSIVA34.xml
- Provide the following correlator properties.
 > Enter the converter name :
DFSIVA3D
 > Enter the socket timeout value (in milliseconds; default is 5000) :
 > Enter the execution timeout value (in milliseconds; default is 5000):
 > Enter the lterm name :
 > Enter the adapter type (default is "") :
 > Enter the connection bundle name (default: connbundle1):
 > Enter the IMS transaction code:
ITVNO
 > Do you want to continue with another correlator? (y/n/cancel):
n
     - The correlator file has been created.
 > Do you want to view the correlator file ? (y/n):
y
     _ **********************************************************
     - Correlator entry 1 out of 1
     _ **********************************************************
Adapter Type                     : IBM XML Adapter
Converter Name                   : DFSIVA3D
Connection Bundle Name           : connbundle1
Socket Timeout                   : 5000
Execution Timeout                : 5000
Lterm Name                       :
Transaction Code                 : ITVNO
No more correlator entry.  Press enter to return to the main menu.
```

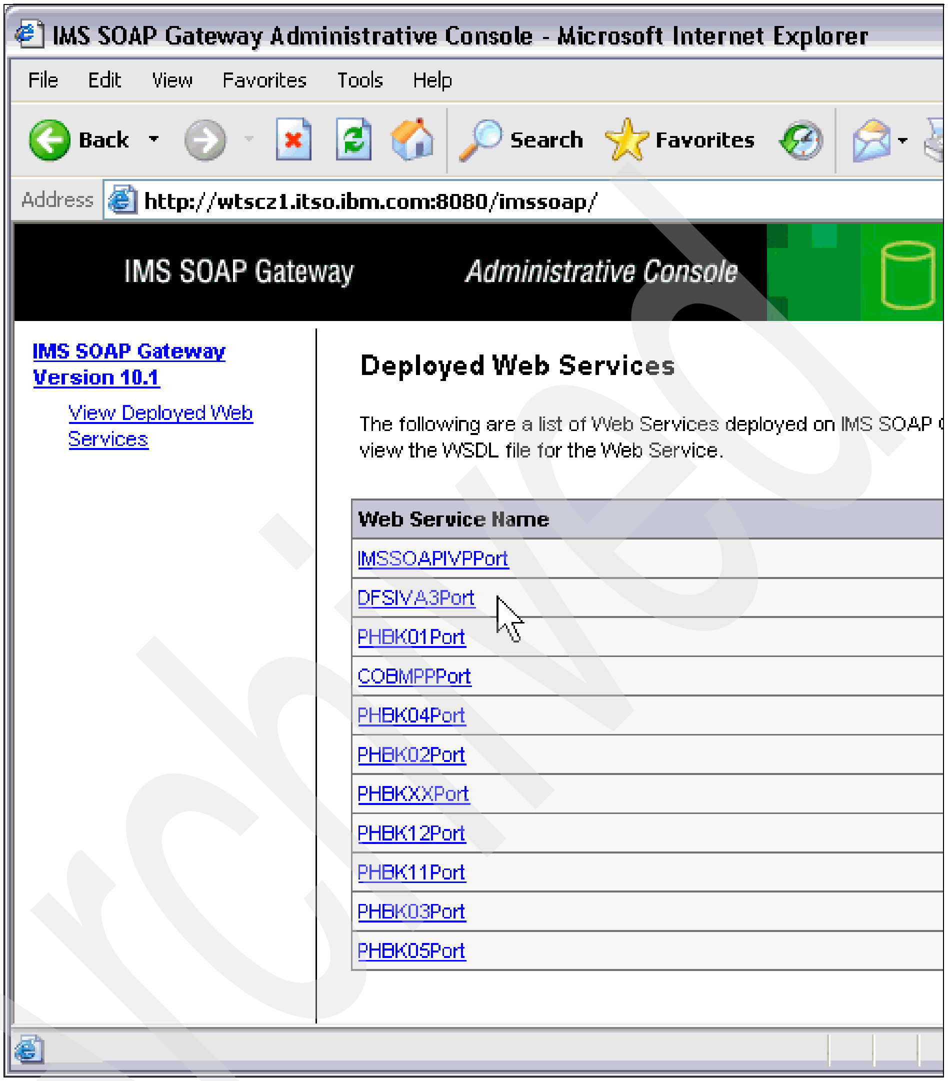
Figure 10-10 Provide Interaction (Correlator) properties

g. Deploy the WSDL to IMS SOAP Gateway as shown in Figure 10-11 on page 305. Ensure that IMS SOAP Gateway is already started.

```
 Step d: Deploy the WSDL to IMS SOAP Gateway
 --------------------------------------------
 This step deploys the WSDL file and make your IMS application
 accessible as a Web service.
 Note: Ensure that IMS SOAP gateway is already started.
 > Do you want to deploy the WSDL file to IMS SOAP gateway ? (y/n):
y
```

Figure 10-11 Deploy the WSDL to IMS SOAP Gateway

3. To verify that the Web service was deployed successfully, open the IMS *SOAP Gateway Administrative Console* and ensure that the deployed Web service is listed, as shown in Figure 10-12 on page 306.


IMS SOAP Gateway Administrative Console - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back
Search
Favorites
Address

http://wtscz1.itso.ibm.com:8080/imssoap/

IMS SOAP Gateway Administrative Console

IMS SOAP Gateway Version 10.1

View Deployed Web Services

Deployed Web Services

The following are a list of Web Services deployed on IMS SOAP
view the WSDL file for the Web Service.

Web Service Name
IMSSOAPIVPPort
DFSIVA3Port
PHBK01Port
COBMPPPort
PHBK04Port
PHBK02Port
PHBKXXPort
PHBK12Port
PHBK11Port
PHBK03Port
PHBK05Port

Figure 10-12 IMS SOAP Gateway Administrative Console

The Web service is now ready to be called by sending a SOAP request from a Web service consumer. A Web service consumer can be created or generated using the WSDL document that we used earlier.

11

Building composite CICS services using the Service Flow Feature

In this chapter, we show you how to use the Service Flow Feature to build composite CICS services.

11.1 Introduction

Many enterprises run Customer Information Control System (CICS)-based applications on IBM System z servers to support their business operations. These organizations made huge investments in CICS application code and skills. As these enterprises start adopting a service-oriented architecture (SOA), they face the challenge of embracing new technologies while leveraging existing application assets. Often, they have to decide between rewriting or reusing these applications. In most cases, reusing existing applications in a noninvasive manner provides a more cost-effective and lower impact approach to integrating existing applications into a SOA than rewriting.

The integrated Web Services support of CICS Transaction Server for z/OS Version 3.1 and 3.2 (CICS TS) enables existing CICS communication area (COMMAREA)-based applications to become service providers. The *Service Flow Feature (SFF)* of CICS TS enables applications and services external to CICS TS to use and integrate existing 3270 applications, COMMAREA, channels and containers, external Web services, and other applications as callable services. SFF consists of the *Service Flow Runtime (SFR)* component and the *Service Flow Modeler (SFM)* development tool. SFM is part of IBM Rational Developer for System z Version 7.1 (RDz) and higher.

RDz supports the creation of CICS-based services through its *Enterprise Service Tools (EST)*. EST enables the transformation of existing CICS-based applications into Web services by creating applications that run using the integrated Web Services and Service Flow capabilities of CICS TS.

In this section, we focus on the use of RDz to create a Service Flow application that will be deployed to and run on the SFR. RDz supports the creation of a comprehensive Web service that aggregates data and results from multiple sources, including CICS non-terminal applications, CICS terminal applications, and Web services. This support is provided through Service Flow projects.

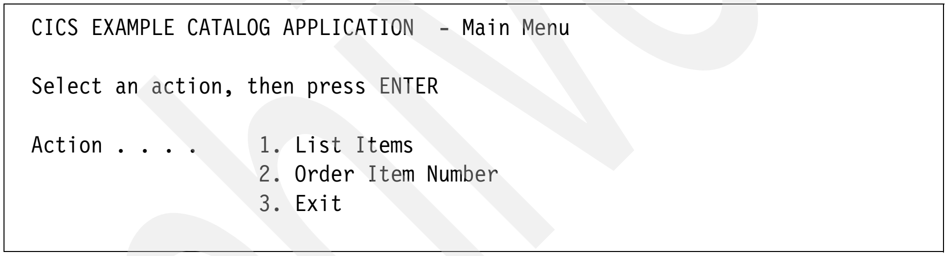
A *Service Flow project* enables you to model a business service from existing CICS applications where one Web service interface is defined and described. This single Web service interface will be backed by multiple CICS-based applications. Consider the use of the single-service project if you only need to create a Web service interface that will be mapped to only one non-terminal or COMMAREA-based application.

Service Flow projects support either bottom-up or meet-in-the-middle development approaches. A *bottom-up approach* is used when the objective is to create a service from existing applications. A *meet-in-the-middle approach* is used when both the Web Services Description Language (WSDL) file describing the service and the implementation components representing the application exist and additional support code that maps the two together needs to be created.

11.1.1 Introducing this sample

This sample will take the *meet-in-the-middle approach* by starting with a WSDL that describes the intended Web service interface. This WSDL describes the structures of the input and output messages associated with the Web service. We will then map the described interfaces to the data and results that will be aggregated from invoking an outbound Web service (CICS as a service requester) and interacting with an existing terminal-based application.

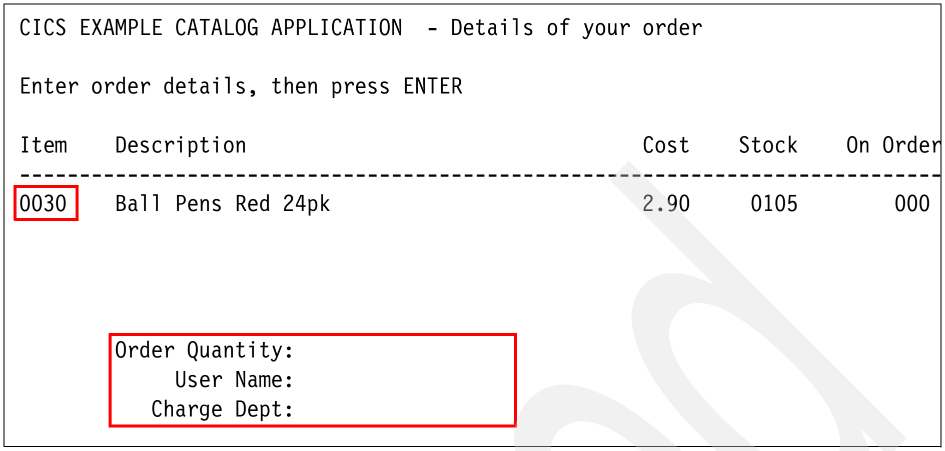
The CICS TS sample Catalog Manager application is the existing terminal-based application that we will use. This application is invoked from a CICS terminal through the EGUI transaction. We will refer to this application as the EGUI application. You can list available catalog items from the EGUI application. You can then place an order for an item. Figure 11-1 shows the menu options.



```
CICS EXAMPLE CATALOG APPLICATION  - Main Menu

Select an action, then press ENTER

Action . . . .      1. List Items
                    2. Order Item Number
                    3. Exit
```

Figure 11-1 Example Catalog Application (EGUI)

To place an order, you need to provide the item number, the order quantity, a user name, and the department to charge for the order. Refer to Figure 11-2 on page 310 for the original basic mapping support (BMS) map.



```
CICS EXAMPLE CATALOG APPLICATION  - Details of your order

Enter order details, then press ENTER

Item    Description                                   Cost     Stock     On Order
-----------------------------------------------------------------------------------
0030    Ball Pens Red 24pk                            2.90      0105          000




        Order Quantity:
             User Name:
           Charge Dept:
```

Figure 11-2 Ordering an item

We will create a Service Flow application that will process an order based on an input request that consists of a customer number, an item number, and the quantity to be ordered. The expected output response will be a description of the item ordered, the total cost of the order, the status of the order, and the name associated with the customer number for this order.

This scenario assumes that a list of catalog items has previously been obtained (perhaps from another Web service call or another Service Flow application). Other information required for placing an order will be obtained by invoking a customer lookup Web service. This Web service has been deployed to a WebSphere Application Server.

We will therefore model a Service Flow that consists of two steps. The first step is to invoke a Web service to get customer data based on the customer number that is passed. The second step is to place an order by interacting with the EGUI application. Figure 11-3 shows the flow that we will create in RDz.

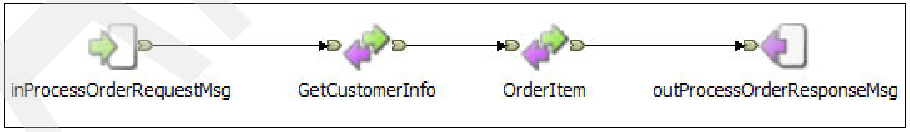


Figure 11-3 Service Flow for ordering an item

11.1.2 Objective

At the end of this sample, you will have an understanding of the capabilities of the Enterprise Service Tools of RDz and the Service Flow Runtime of CICS to transform existing CICS-based applications into Web services with the appropriate level of service granularity.

11.1.3 Prerequisite

In order to perform this sample, access is needed to a z/OS system with a CICS Transaction Server for z/OS region, Version 3.2, with the CICS Service Flow Runtime installed. The sample instructions are written based on access to a z/OS 1.9 system, which is referred to as "`z1`". You will also need to have Rational Developer for System z Version 7.1 installed on your workstation. You will also need to have built and deployed a GetCustomer service to WebSphere Application Server, as described in Example 11-1.

Example 11-1 SQL for Customer lookup by Customer Number

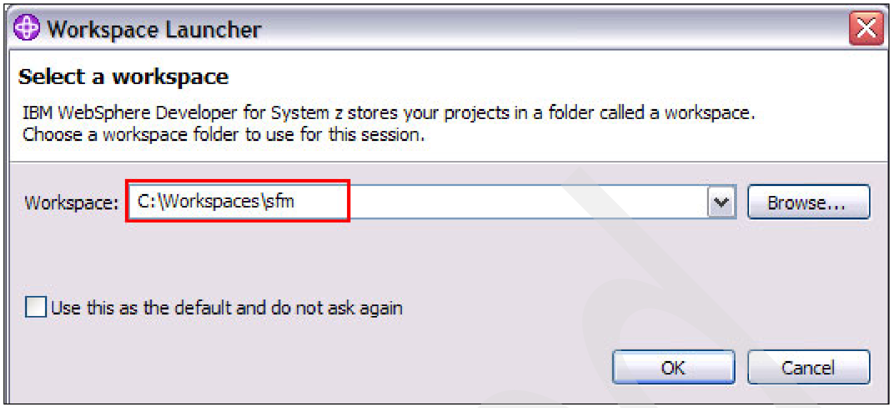
```
SELECT CUST_ADDR1, CUST_CITY, CUST_NO, DEPT, CUST_FN, CUST_LN
  FROM ITSOOC.EOTCUST
  WHERE CUST_NO = :CUST_NO
```

We also assume that you are familiar with using an Eclipse-based development environment, such as RDz.

11.2 Creating a Service Flow project

The first step is to create a Service Flow project in RDz:

1. Start Rational Developer for System z (RDz).
2. On the Workspace Launcher dialog, specify the workspace name that you want to use and click **OK**. We used **C:\Workspaces\sfm** as the workspace.You can use **Browse** if necessary. Refer to Figure 11-4 on page 312.


Workspace Launcher

Select a workspace

IBM WebSphere Developer for System z stores your projects in a folder called a workspace.
Choose a workspace folder to use for this session.

Workspace: C:\Workspaces\sfm

☐ Use this as the default and do not ask again

Figure 11-4 Workspace Launcher window

3. Switch to the **Enterprise Service Tools** perspective (if you are already there, proceed to the next step).

   If the Welcome view is open, close it. Click the Open Perspective icon (⊞) and select **Other** from the list.

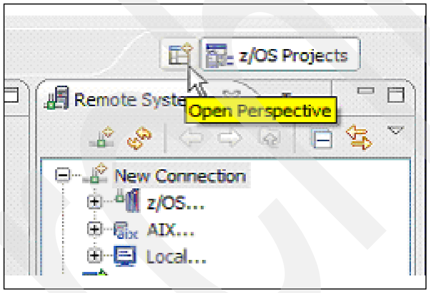


Figure 11-5 Open Perspective

4. From the Open Perspective dialog, select **Enterprise Service Tools** and click **OK**, as shown in Figure 11-6 on page 313.

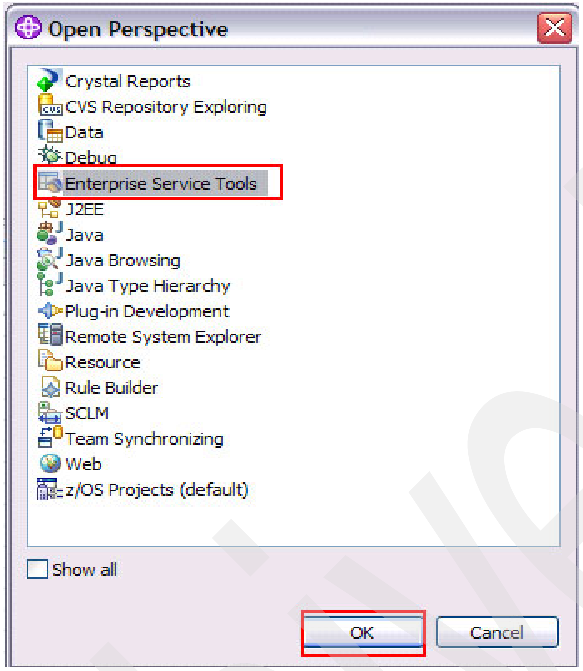


Figure 11-6 Selecting the Enterprise Service Tools perspective

You now see a window similar to Figure 11-7.

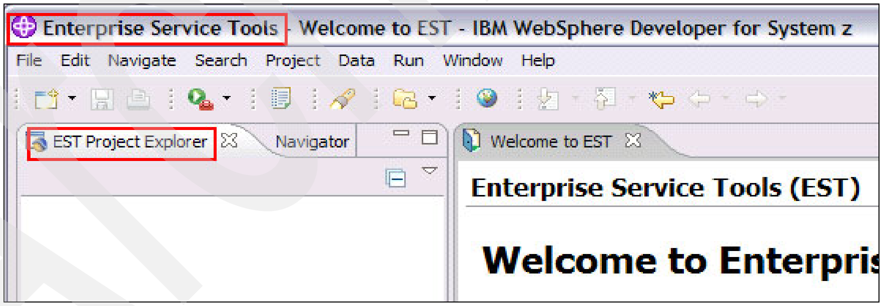

Enterprise Service Tools - Welcome to EST - IBM WebSphere Developer for System z
File Edit Navigate Search Project Data Run Window Help
EST Project Explorer
Navigator
Welcome to EST
Enterprise Service Tools (EST)
Welcome to Enterpris

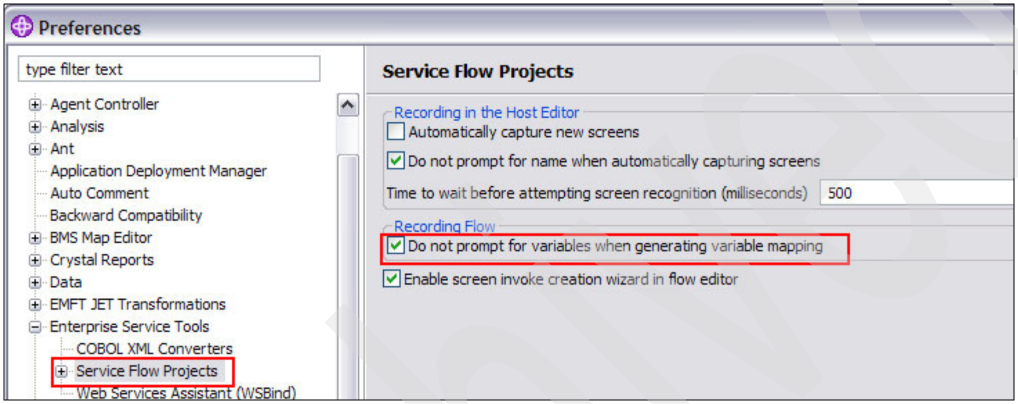
Figure 11-7 Enterprise Service Tools perspective

Notice the EST Project Explorer view, which is where EST-related projects will be organized and where the tools related to Service Flow development are launched.

5. Set preferences for Service Flow projects:

   a. Click **Window** → **Preferences** on the menu bar to bring up the Preferences dialog.

b. On the left pane of the Preferences dialog, navigate to the entry for Enterprise Service Tools. Click the **+** (addition symbol) to expand the subentries. Select **Service Flow Projects**, and on the right pane, be sure that **Do not prompt for variable when generating variable mapping** in the Recording Flow section is selected. Refer to Figure 11-8. By setting this preference, you are choosing to have automatic field names, originating from the BMS source, created for you during flow recording of the terminal interactions. If you choose not to set this preference, you are prompted to supply the field names each time that data is entered on a window or extracted from a window.



Preferences

type filter text

- ⊞ Agent Controller
- ⊞ Analysis
- ⊞ Ant
- Application Deployment Manager
- Auto Comment
- Backward Compatibility
- ⊞ BMS Map Editor
- ⊞ Crystal Reports
- ⊞ Data
- ⊞ EMFT JET Transformations
- ⊟ Enterprise Service Tools
  - COBOL XML Converters
  - ⊞ Service Flow Projects
  - Web Services Assistant (WSBind)

Service Flow Projects

Recording in the Host Editor

☐ Automatically capture new screens

☑ Do not prompt for name when automatically capturing screens

Time to wait before attempting screen recognition (milliseconds) 500

Recording Flow

☑ Do not prompt for variables when generating variable mapping

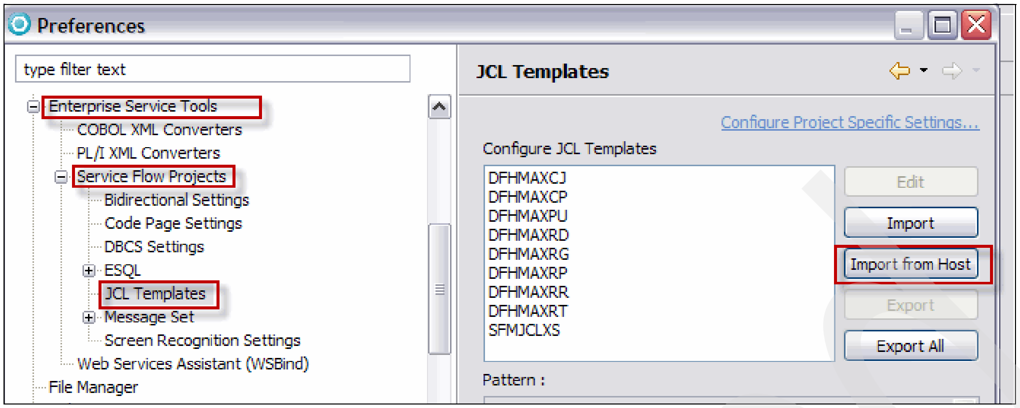
☑ Enable screen invoke creation wizard in flow editor

Figure 11-8 Setting preferences for Service Flow Project

c. There is a set of JCL templates that is used by SFM to generate the jobs that will be used to build and deploy the Service Flow applications. You can modify these templates manually or import these templates from your target host system. In most cases, your host systems programmer has updated these templates to reflect where libraries, such as the COBOL compiler and Language Environment® (LE), are installed.

d. Click the **+** (addition symbol) beside **Service Flow Projects** to expand its subentries.

e. Select **JCL Templates** and you see a window similar to Figure 11-9 on page 315.

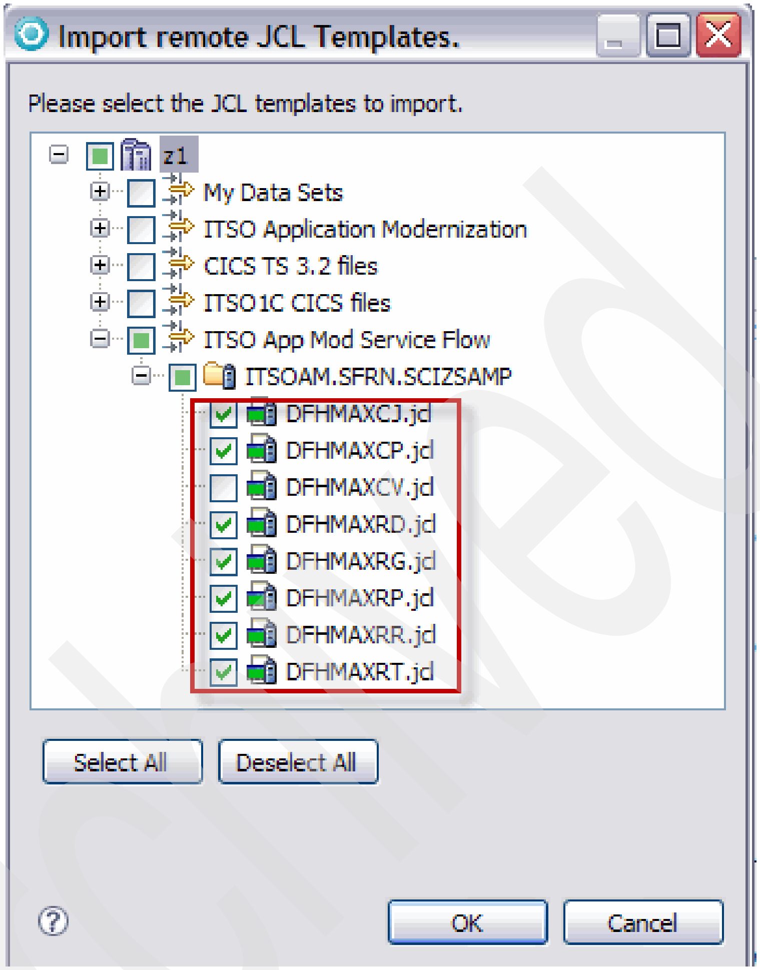


DFHMAXCJ
DFHMAXCP
DFHMAXPU
DFHMAXRD
DFHMAXRG
DFHMAXRP
DFHMAXRR
DFHMAXRT
SFMJCLXS

Figure 11-9 Service Flow JCL Templates

You can edit the templates in place, import from a local directory, or import copies from a host system. Importing from a host system requires that you have defined a system connection using the remote systems capability of RDz and are connected to that remote system. In this sample, we will show you the scenario when importing from a host system.

f. Click **Import from Host**. You see a window similar to Figure 11-10 on page 316. On that dialog, navigate to the remote system that you will use. For this sample, we show a system `z1`, which when expanded has a set of data sets available. In this instance, we will import the selected members from data set `ITSOAM.SFRN.SCIZSAMP`. Click **OK** to start importing.

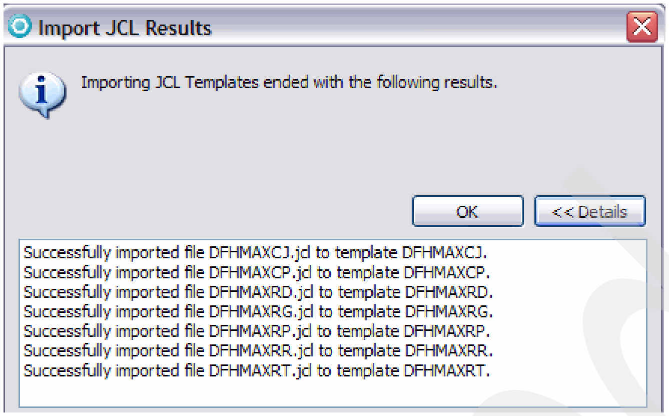

Import remote JCL Templates.

Please select the JCL templates to import.

- ■ z1
  - □ My Data Sets
  - □ ITSO Application Modernization
  - □ CICS TS 3.2 files
  - □ ITSO1C CICS files
  - ■ ITSO App Mod Service Flow
    - ■ ITSOAM.SFRN.SCIZSAMP
      - ☑ DFHMAXCJ.jcl
      - ☑ DFHMAXCP.jcl
      - □ DFHMAXCV.jcl
      - ☑ DFHMAXRD.jcl
      - ☑ DFHMAXRG.jcl
      - ☑ DFHMAXRP.jcl
      - ☑ DFHMAXRR.jcl
      - ☑ DFHMAXRT.jcl

Figure 11-10 Importing remote JCL Templates

After the import is complete, you see results dialog similar to Figure 11-11 on page 317. You can click **Details** to see additional status information.



Importing JCL Templates ended with the following results.

```
Successfully imported file DFHMAXCJ.jcl to template DFHMAXCJ.
Successfully imported file DFHMAXCP.jcl to template DFHMAXCP.
Successfully imported file DFHMAXRD.jcl to template DFHMAXRD.
Successfully imported file DFHMAXRG.jcl to template DFHMAXRG.
Successfully imported file DFHMAXRP.jcl to template DFHMAXRP.
Successfully imported file DFHMAXRR.jcl to template DFHMAXRR.
Successfully imported file DFHMAXRT.jcl to template DFHMAXRT.
```

Figure 11-11 Results of importing JCL templates

g. Click **OK** to save your changes and dismiss the Preferences dialog.

6. Create a Service Flow project. Click anywhere in the EST Project Explorer view. Right-click anywhere in the view and select **New** → **Service Flow Project** from the context-sensitive menu, as shown in Figure 11-12.

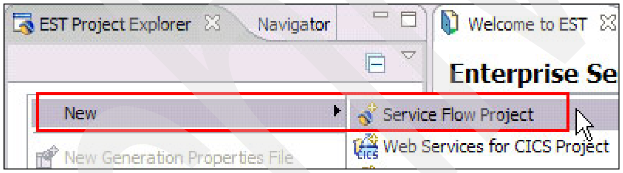
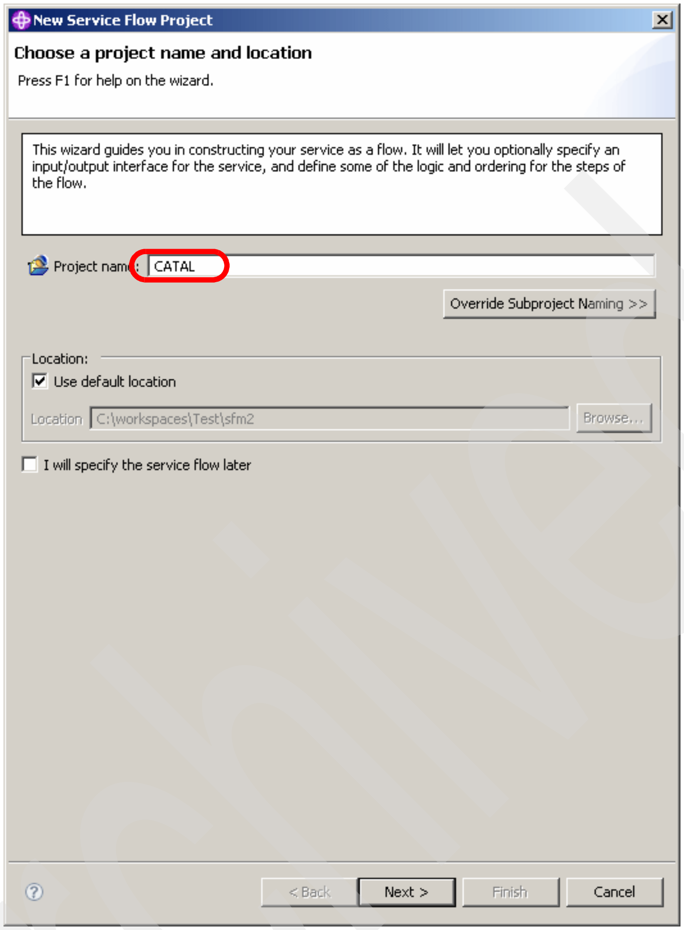


Figure 11-12 Creating a New Service Flow project

7. In the New Service Flow Project dialog, type `CATAL`, as shown in Figure 11-13 on page 318. Click **Next**.


New Service Flow Project

Choose a project name and location

Press F1 for help on the wizard.

This wizard guides you in constructing your service as a flow. It will let you optionally specify an input/output interface for the service, and define some of the logic and ordering for the steps of the flow.

Project name: CATAL

Location:

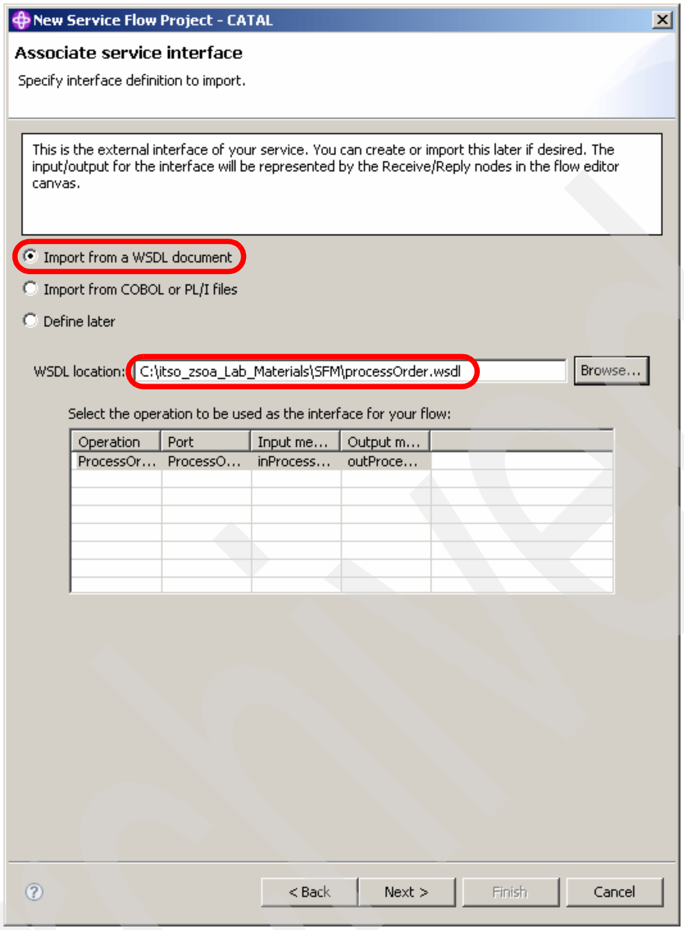
☑ Use default location

Location C:\workspaces\Test\sfm2

□ I will specify the service flow later

Figure 11-13 Naming the Service Flow project

8. On the Associate service interface dialog, select **Import from a WSDL document** and click **Browse** beside the WSDL location entry field. Navigate to the directory where you downloaded the additional materials for this book and select **processOrder.wsdl**, which is shown in Figure 11-14 on page 319. Click **Next**.


New Service Flow Project - CATAL

Associate service interface

Specify interface definition to import.

This is the external interface of your service. You can create or import this later if desired. The input/output for the interface will be represented by the Receive/Reply nodes in the flow editor canvas.

● Import from a WSDL document

○ Import from COBOL or PL/I files

○ Define later

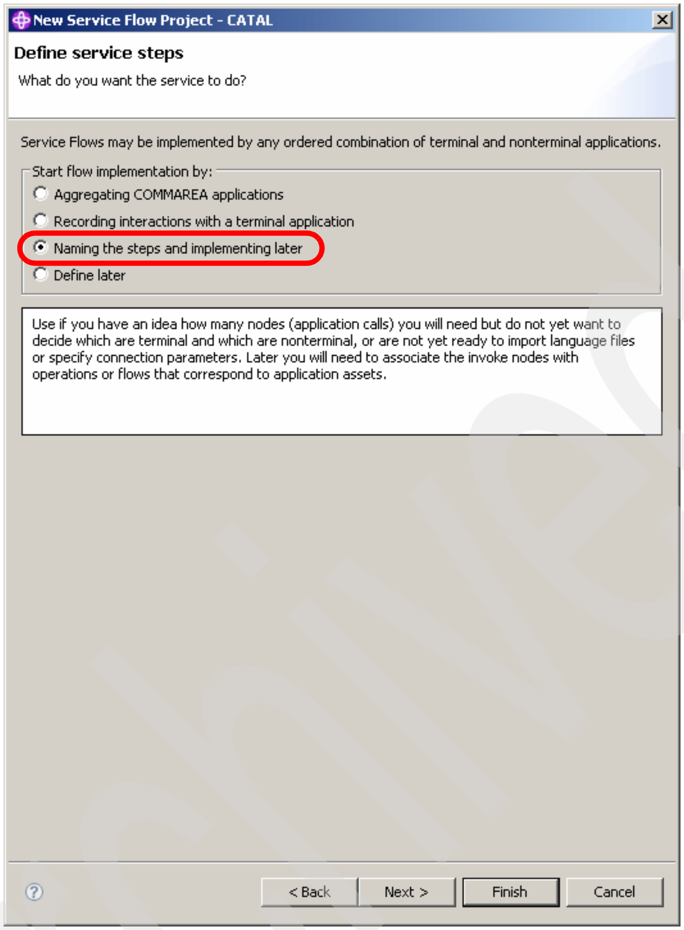
WSDL location: C:\itso_zsoa_Lab_Materials\SFM\processOrder.wsdl

Select the operation to be used as the interface for your flow:

Operation	Port	Input me...	Output m...
ProcessOr...	ProcessO...	inProcess...	outProce...

Figure 11-14 Importing service specification from the processOrder.wsdl file

9. In the Define service steps dialog, select **Naming the steps and implementing later**, as shown in Figure 11-15 on page 320. Click **Next**.



Define service steps

What do you want the service to do?

Service Flows may be implemented by any ordered combination of terminal and nonterminal applications.

Start flow implementation by:

○ Aggregating COMMAREA applications

○ Recording interactions with a terminal application

● Naming the steps and implementing later

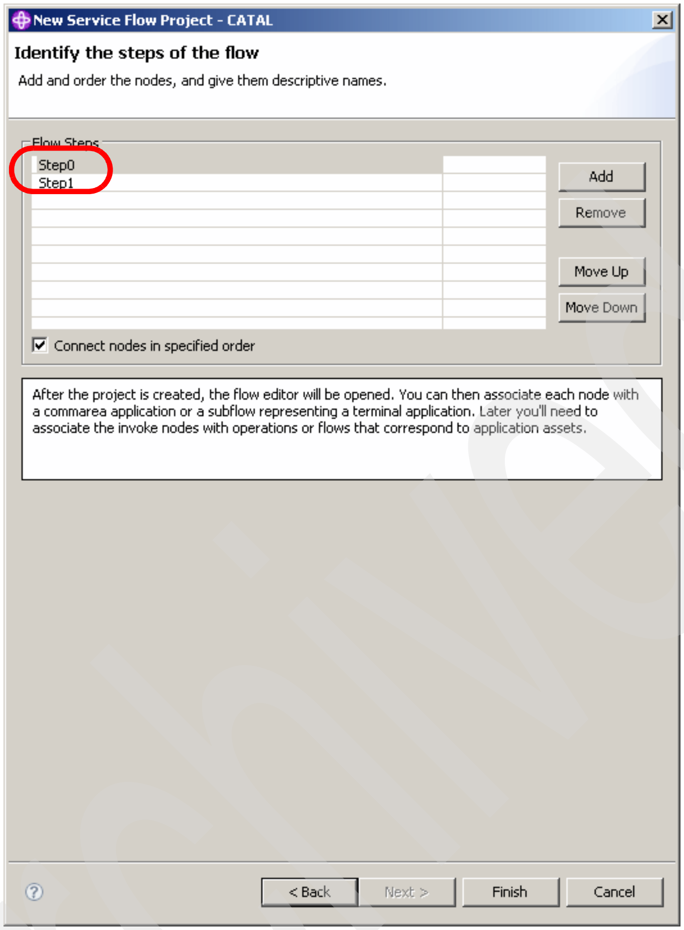
○ Define later

Use if you have an idea how many nodes (application calls) you will need but do not yet want to decide which are terminal and which are nonterminal, or are not yet ready to import language files or specify connection parameters. Later you will need to associate the invoke nodes with operations or flows that correspond to application assets.

Figure 11-15 Define the service steps window

10. On the “Identify the steps of the flow” dialog, click **Add** *twice*.

    This action creates two steps with default names of Step0 and Step1, as shown in Figure 11-16 on page 321, to represent the processing nodes in our flow. We will rename the steps to more descriptive names.



New Service Flow Project - CATAL

Identify the steps of the flow

Add and order the nodes, and give them descriptive names.

Flow Steps

Step0

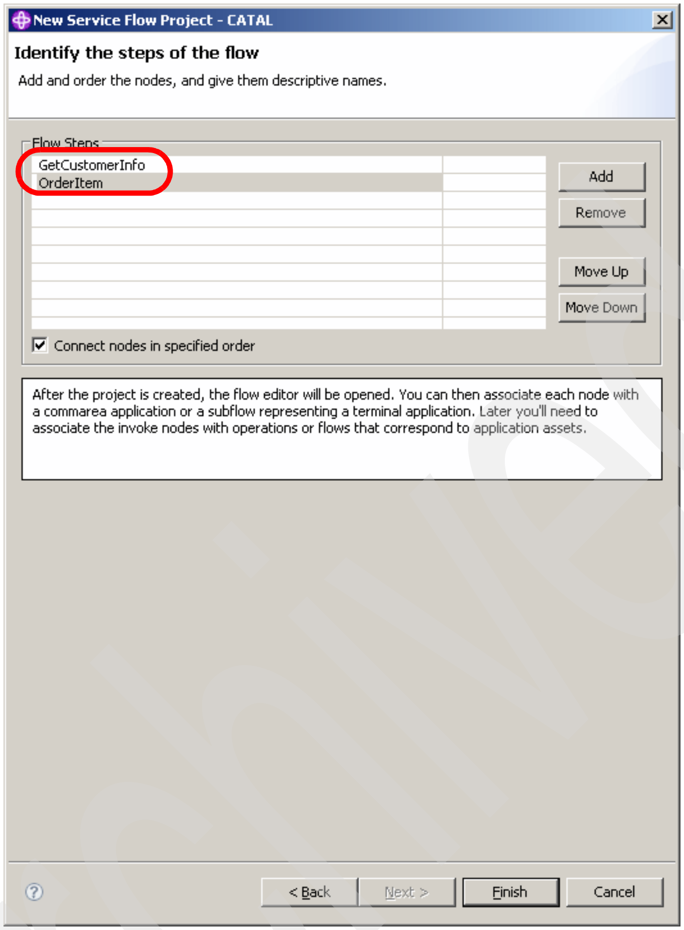
Step1

☑ Connect nodes in specified order

After the project is created, the flow editor will be opened. You can then associate each node with a commarea application or a subflow representing a terminal application. Later you'll need to associate the invoke nodes with operations or flows that correspond to application assets.

Figure 11-16 Identify the steps of the flow window

11. Click **Step0** and replace the name by typing over it with `GetCustomerInfo`, as shown in Figure 11-17 on page 322. Click **Step1** and replace it with `OrderItem`, as shown in Figure 11-17 on page 322. Click **Finish.**


New Service Flow Project - CATAL
Identify the steps of the flow
Add and order the nodes, and give them descriptive names.
Flow Steps
GetCustomerInfo
OrderItem
Add
Remove
Move Up
Move Down
☑ Connect nodes in specified order
< Back
Next >
Finish
Cancel

After the project is created, the flow editor will be opened. You can then associate each node with a commarea application or a subflow representing a terminal application. Later you'll need to associate the invoke nodes with operations or flows that correspond to application assets.

Figure 11-17 Identify the steps of the flow window

If the Enterprise Service Tools Tip dialog appears, select **Not to show any Tips** and click **OK** to dismiss that dialog.

You see a flow diagram similar to what is shown in Figure 11-18 on page 323.

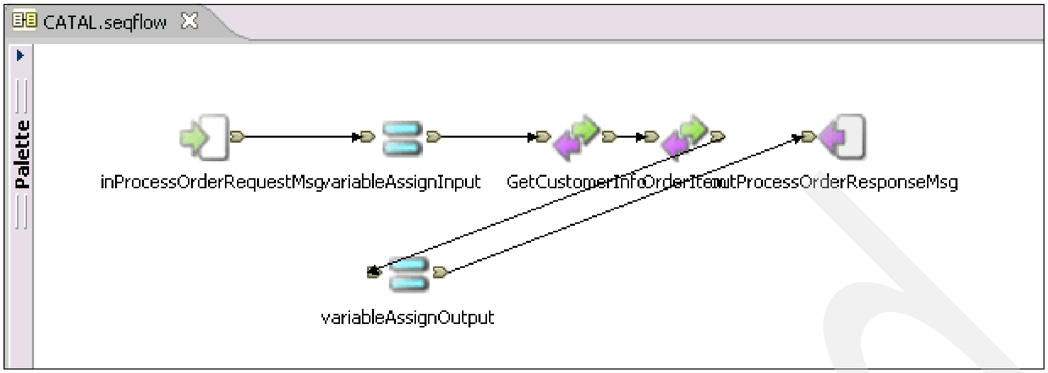


Figure 11-18 Initial flow in the canvas

12. If your flow is not laid out properly, click anywhere in the flow editor. Right-click and select **Layout** → **Left to Right** from the context menu, which will give you a layout as shown in Figure 11-19.

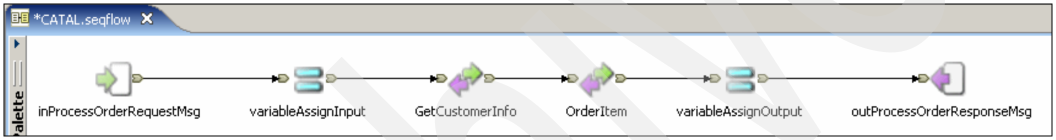


Figure 11-19 CATAL Service Flow with proper layout

Note that the CATAL Service Flow project is now in the EST Project Explorer view and that the flow editor is opened showing the flow that you have modeled so far.

Before proceeding with further refinement of the flow, let us explore the structure of a Service Flow project. You have the items as shown in Figure 11-20.

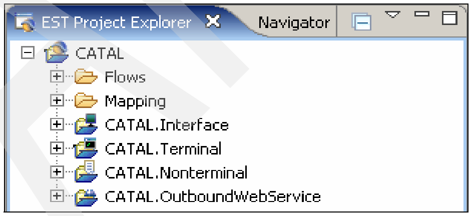


Figure 11-20 Structure of a Service Flow project

11.2.1 Understanding the Service Flow project structure

A *Service Flow project* provides the framework to organize the source and generated files associated with a Service Flow. Various artifacts are stored in a predefined set of folders and subprojects. A *folder* is used to store a single class or type of artifact. Table 11-1 shows the folders.

Table 11-1 Folders

Folder	Description
Flows	Used to store flows where a flow is a sequence of operations, assignments, and conditionals that are connected into a programmed unit that can be invoked.
Mapping	Used to store mappings that are used to manipulate data while a flow is performed.
Expressions	Used to store expressions written in ESQL that are used to control the sequencing of a flow.
Generation	Used to store generation properties files and generated runtime code files.

A *subproject* contains operations and messages that are used to invoke a particular type of entity or application. Table 11-2 shows these subproject types.

Table 11-2 Subproject types

Subproject type	Contents
Interface definition (CATAL.**Interface**)	Operations and messages invoking flows
Terminal applications (CATAL.**Terminal**)	Operations and messages for invoking terminal or window-based applications
Nonterminal applications (CATAL.**Nonterminal**)	Operations and messages for invoking nonterminal (non-window-based or COMMAREA-based) applications
Outbound Web services (CATAL.**OutboundWebService**)	Operations and messages for invoking outbound Web services

If you are interested in more details, launch the Help facility and look in Contents for Enterprise Service Tools for Web services and SOA → Developing Service Flow projects.

11.3 Defining the GetCustomerInfo flow step

So far, we have modeled a basic flow for the application that will process a customer order. We identified two steps as part of modeling the flow. These steps are represented in the flow diagram as nodes, called *invoke* nodes.

There are two invoke nodes, *GetCustomerInfo* and *OrderItem*, that correspond to the two steps that are needed to process an order. At this point, these invoke nodes are abstract notions that are not yet associated with any concrete applications. The sample will walk you through describing and associating the invoke nodes with actual applications.

In our discussion of the scenario in the introductory section, we mentioned that the customer information will be obtained by invoking a customer lookup Web service. This Web service is described in a WSDL that is provided. We will associate the WSDL file that is provided with the GetCustomerInfo invoke node.

Because this step will involve an outbound Web service call (outbound from the perspective of CICS, where CICS is acting as a service requester), we will be importing the WSDL describing the Web service into the outbound Web service subproject (`CATAL.OutboundWebService`):

1. In the EST Project Explorer view, select the **CATAL.OutboundWebService** subproject. Right-click it and select **Import CICS Web Service** from the context menu, as shown in Figure 11-21.

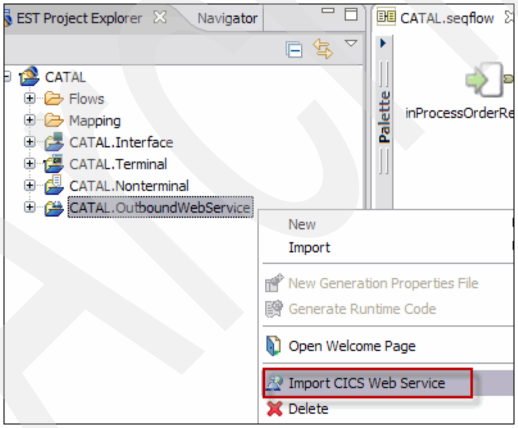


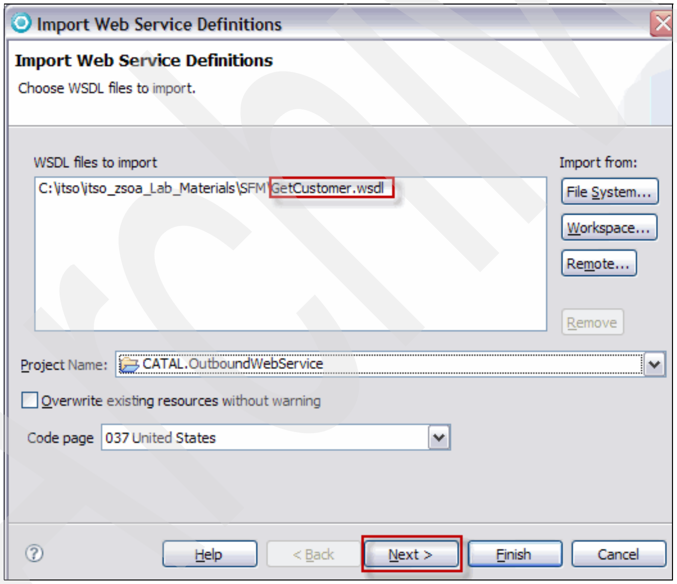
Figure 11-21 Importing a Web service description (WSDL)

2. In the Import Web Service Definitions dialog, click **File System** to import the WSDL. Navigate to the directory where you downloaded the additional materials and select **GetCustomer.wsdl.** Refer to Figure 11-22 on page 326. Click **Next**.

Important: We assume that you have deployed a GetCustomer service to a WebSphere Application Server. The GetCustomer service performs a database lookup of customer information based on a supplied customer number. The table is `EOTCUST`. The additional materials that you downloaded (refer to Appendix B, “Additional material” on page 485) contain the Data Definition Language (DDL) to create this table and a sample set of data that you load into the table.

Refer to Chapter 7, “Exposing DB2 data as a service” on page 159 for instructions to generate a Web service to access DB2 data from WebSphere Application Server. Make sure that you retrieve the columns in the following order: CUST_ADDR1, CUST_CITY, CUST_NO, DEPT, CUST_FN, and CUST_LN. The resulting SQL needs to look similar to:

```
SELECT CUST_ADDR1, CUST_CITY, CUST_NO, DEPT, CUST_FN, CUST_LN
  FROM ITSOOC.EOTCUST
  WHERE CUST_NO = :CUST_NO
```



Import Web Service Definitions

Import Web Service Definitions

Choose WSDL files to import.

WSDL files to import

C:\itso\itso_zsoa_Lab_Materials\SFM\GetCustomer.wsdl

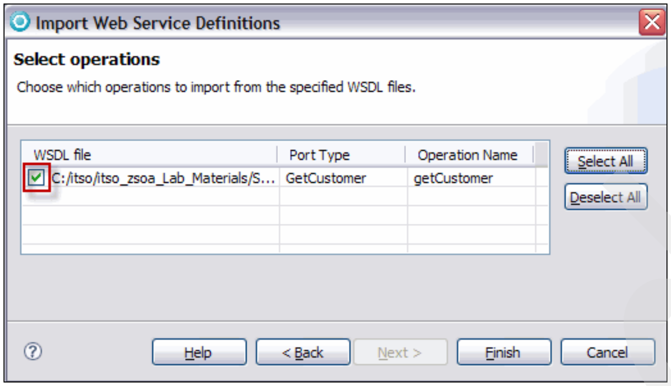
Project Name: CATAL.OutboundWebService

☐ Overwrite existing resources without warning

Code page 037 United States

Figure 11-22 Import Web Service Definitions window

3. In the Select operations dialog, as shown in Figure 11-23 on page 327, note that there is only one operation, `getCustomer`, defined in the WSDL, and thus, this operation is already selected. Click **Finish**.



Import Web Service Definitions

Select operations

Choose which operations to import from the specified WSDL files.

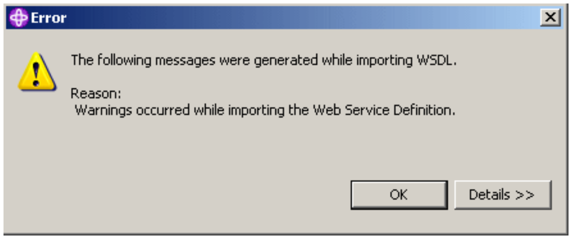
WSDL file	Port Type	Operation Name
☑ C:/itso/itso_zsoa_Lab_Materials/S...	GetCustomer	getCustomer

Figure 11-23   Select operation window

Note: The Service Flow tools will generate COBOL programs that represent the flow being modeled. COBOL requires that array structures are not dynamic and must have a fixed number. You might get an error if your WSDL contains a complex type sequence, that is, with `maxOccurs` and `minOccurs` fields where either or both is 0. This situation is the case if the WSDL was generated by IBM Data Studio Developer (Data Studio). You have to edit the generated WSDL before it can be consumed by the Service Flow tools.

For your reference, the additional materials that you downloaded (refer to Appendix B, “Additional material” on page 485) contain the original copy of the `GetCustomer.wsdl` file as generated by Data Studio. This file was edited to change minOccurs=“0” to minOccurs=“1” and to remove the `nillable=“true”` attribute from CUST_NO as reflected in the `GetCustomer.wsdl` file.

4. Depending on the wsdl file that is imported, you might receive an error message, as shown in Figure 11-24 on page 328, indicating that messages were generated while importing the WSDL. Click **Details** for that dialog and note that the warning is related to the use of the COBOL reserved words, such as `address` as an element name, and that the affected elements have been changed, for example, from `address` to `xaddress`.



Error

The following messages were generated while importing WSDL.

Reason:
Warnings occurred while importing the Web Service Definition.

Figure 11-24 Error pop-up window

Click **OK** to dismiss the error dialog.

5. In the EST Project Explorer view, expand the **CATAL.OutboundWebService** subproject and its folders.

   Notice the additional artifacts shown in Figure 11-25 on page 329 that were created from importing the `GetCustomer.wsdl` file.

   The Operations folder contains a single operation, `getCustomer`, which will be used to associate the abstract invoke node `GetCustomerInfo` with an actual outbound Web Service invocation.

   The Message folder contains a single message file, `GetCustomerMessages.mxsd`, which is actually an XML schema definition of the input and output messages that were defined in the WSDL that you imported.

   The Services folder contains two files: one file is the WSDL that you imported and the other file is a WSBind file that was generated from processing the WSDL file. If an equivalent WSBind file has not already been deployed to CICS TS, this file can be used. Recall that a WSBind file is a CICS runtime artifact that is required when dealing with Web Services. Because this file is for an outbound Web Service call, this WSBind file must be associated with a service requester pipeline in CICS as opposed to a service provider pipeline. We will come back to this topic in the deployment section of this sample.

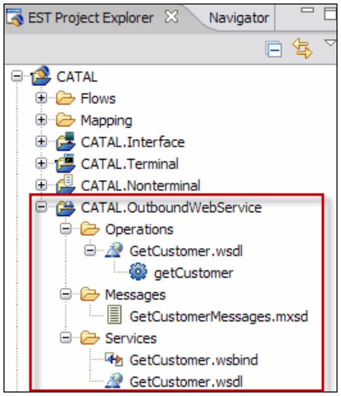


Figure 11-25 OutboundWebService subproject and associated artifacts

Now that you have imported the WSDL for the customer lookup Web service, you will associate the getCustomer operation with the GetCustomerInfo node by selecting **getCustomer** (getCustomer) under **Operations** from the EST Project Explorer view and dragging and dropping this operation onto the GetCustomerInfo invoke node in the flow editor. Notice that the icon for the GetCustomerInfo invoke node changed from GetCustomerInfo to getCustomer .

6. Click anywhere in the flow editor to give it focus. Press Ctrl+s to save your changes.

11.4 Defining the OrderItem flow step

We now define the details of the `OrderItem` flow step for this segment of the sample. The details involve the terminal interactions needed with the EGUI application in order to place an order. We record those terminal interactions as a terminal subflow.

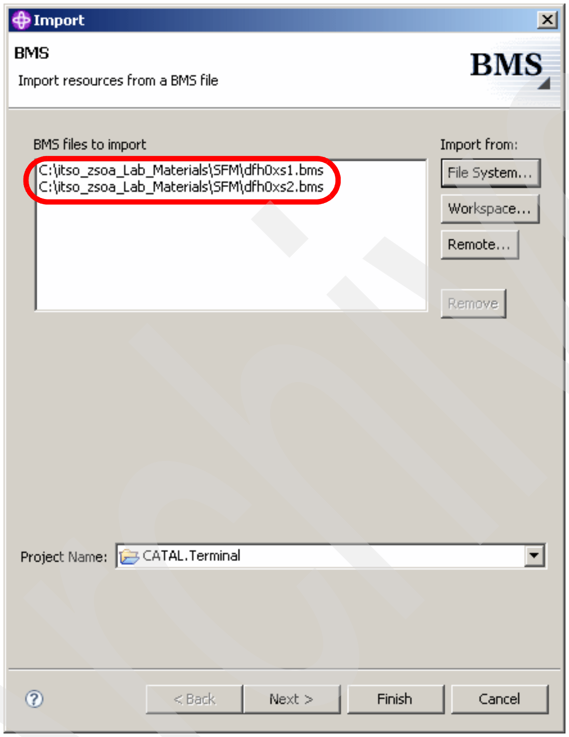
To facilitate the recording of the terminal interactions and the creation of the terminal subflow, we import the BMS map definitions corresponding to the windows with which we will interact.

This segment assumes that you access a CICS system that has the sample Catalog Manager application installed. This sample was created using the `CITS014` region running on `z1`.

11.4.1 Importing BMS

Import the BMS map definitions for the EGUI application:

1. In the EST Project Explorer view, select the **CATAL.Terminal** subproject, right-click it, and select **Import** → **BMS** from the context menu.
2. In the Import BMS dialog, click **File System** and navigate to the directory where you downloaded the additional materials (refer to Appendix B, “Additional material” on page 485). Select both **dfh0xs1.bms** and **dfh0xs2.bms**. Refer to Figure 11-26.



BMS files to import:
C:\itso_zsoa_Lab_Materials\SFM\dfh0xs1.bms
C:\itso_zsoa_Lab_Materials\SFM\dfh0xs2.bms

Project Name: CATAL.Terminal

Figure 11-26 Import BMS map definitions window

3. Click **Finish**.

   Three messages are created now, as shown in Figure 11-27 on page 331. Two messages are associated with map definitions (`EXMENU` and `EXORDR`) in mapset `DFH0XS1`, and one message is associated with one map definition (`EXINQC`) in mapset `DFH0XS2`.

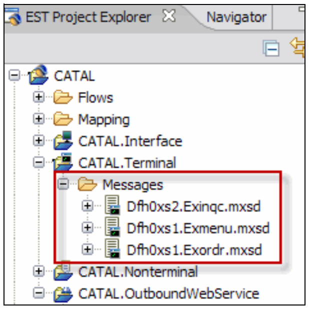
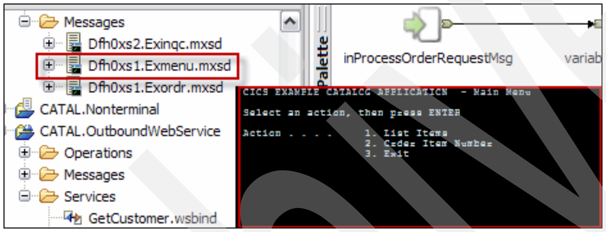


Figure 11-27 Messages for BMS maps

4. You can hover your cursor over a message and get a rendering of the screen view, as shown in Figure 11-28.



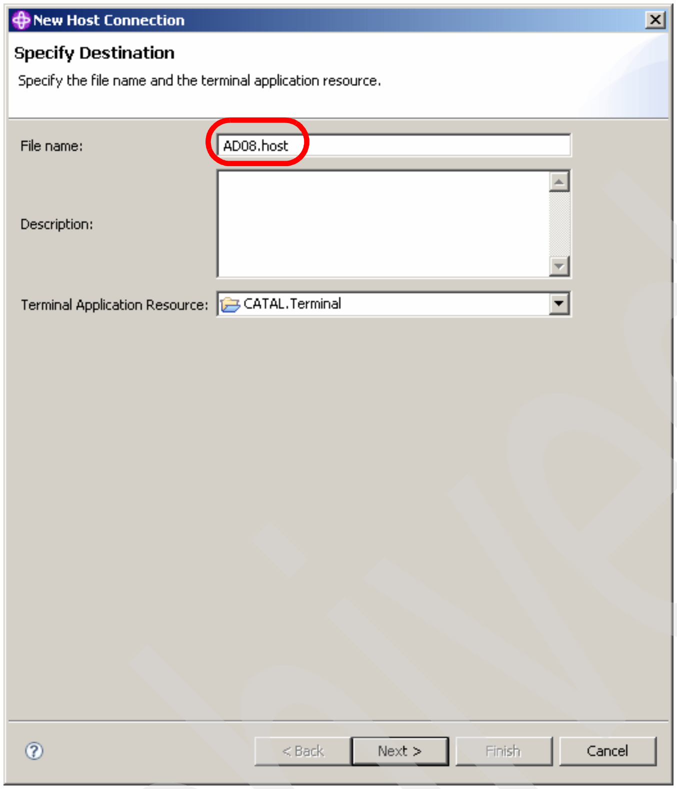
```
CICS EXAMPLE CATALOG APPLICATION  - Main Menu

Select an action, then press ENTER

Action . . . .         1. List Items
                       2. Order Item Number
                       3. Exit
```

Figure 11-28 Hovering over a message to get a view of the screen

11.4.2 Defining a host connection

Define a host connection with the z/OS system:

1. Select the **CATAL.Terminal** subproject, right-click it, and select **New** → **Host Connection**.
2. In the Specify Destination dialog, specify a file name that reflects the z/OS system, for example, `AD08.host`, and click **Next**, as shown in Figure 11-29 on page 332.



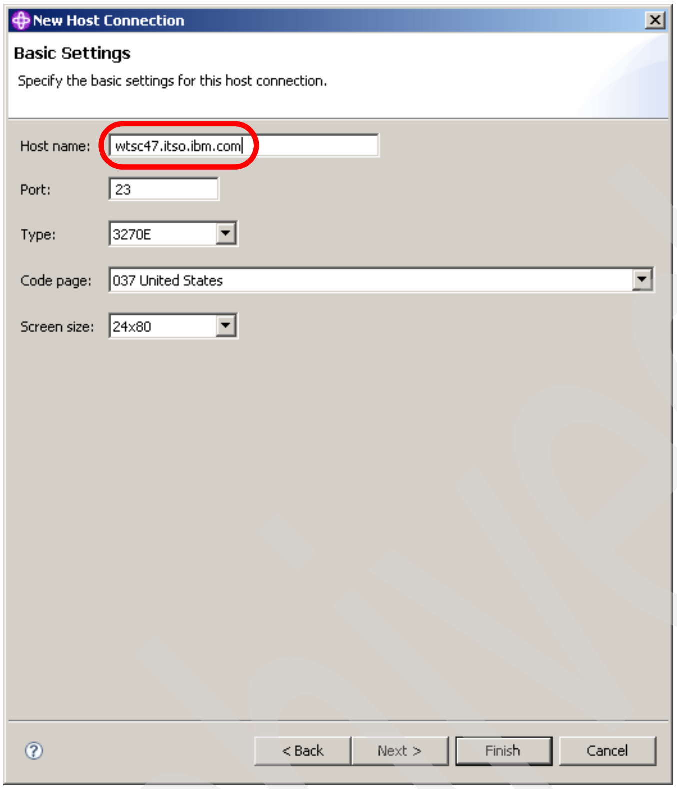
File name: AD08.host

Description:

Terminal Application Resource: CATAL.Terminal

Figure 11-29 Specifying the file name for a new host connection

3. On the Basic Settings dialog, specify the host name or IP address of your z/OS system. Modify the other settings as needed in order to connect to your z/OS system. Refer to Figure 11-30 on page 333.



Basic Settings

Specify the basic settings for this host connection.

Host name: wtsc47.itso.ibm.com

Port: 23

Type: 3270E

Code page: 037 United States

Screen size: 24x80

Figure 11-30 Specifying Host name for New Host Connection

4. Click **Finish**.

You see the usual application logon or selection window for your system.

11.4.3 Recording 3270 terminal screens

In the following steps, we record a Terminal Flow. The *Terminal Flow recording* is used to define the dependencies between screens and define all input and output fields. Eventually, you can map these fields.

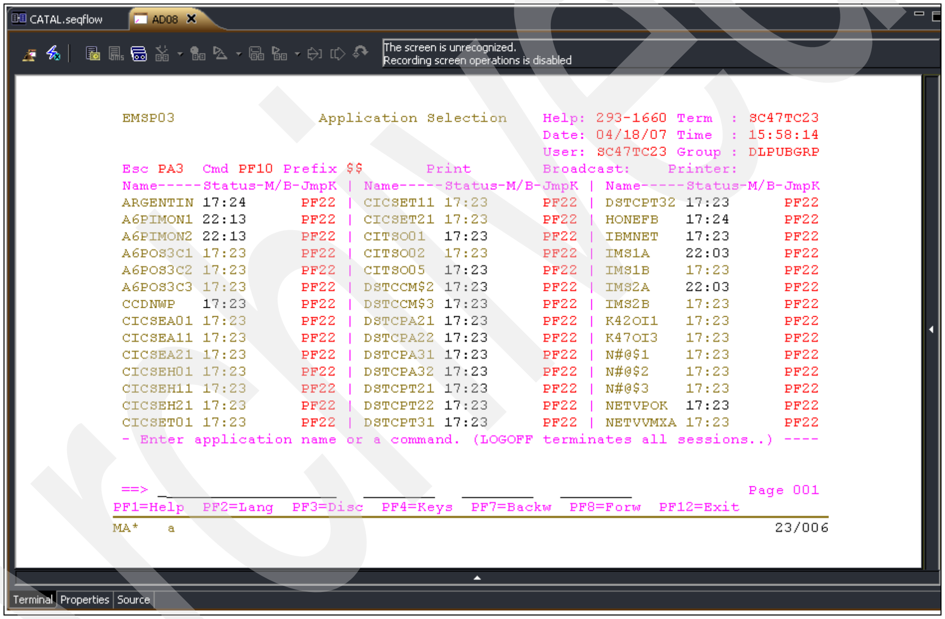
Before starting to record the Terminal Flow, we need to get to the point, that is, the screen, where we want to start the recording. At a minimum, you need to log on to CICS, but most likely, you will need to advance to the main menu of the application. In our case, we need to first get to the main menu of the Catalog Manager Order application.

Log on to CICS:

1. Select the CICS region that you will use for this sample from your application selection screen. Navigate until you have signed on to your target CICS system to the point where you can enter transactions. For this sample, you need to enter the EGUI transaction. Note that the Enter key is the right Ctrl key.

   > **Tip**: There is a slide out drawer built into the host editor that can be opened to reveal a keypad for all the automatic initiate descriptor (AID) keys typically found on terminal emulators.

   An example of an application selection screen is shown in Figure 11-31.



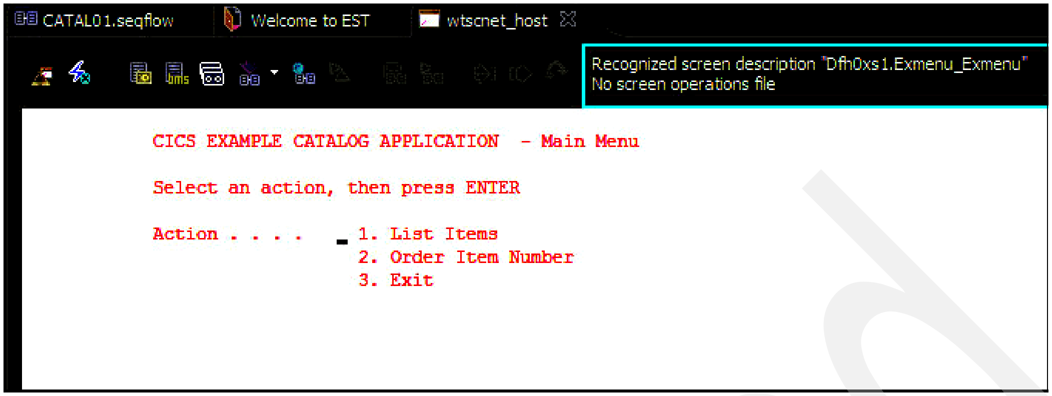
The screen is unrecognized.
Recording screen operations is disabled

```
EMSP03                Application Selection     Help: 293-1660 Term  : SC47TC23
                                                Date: 04/18/07 Time  : 15:58:14
                                                User: SC47TC23 Group : DLPUBGRP
Esc PA3  Cmd PF10 Prefix $$       Print         Broadcast:    Printer:
Name-----Status-M/B-JmpK | Name-----Status-M/B-JmpK | Name-----Status-M/B-JmpK
ARGENTIN 17:24      PF22 | CICSET11 17:23      PF22 | DSTCPT32 17:23      PF22
A6PIMON1 22:13      PF22 | CICSET21 17:23      PF22 | HONEFB   17:24      PF22
A6PIMON2 22:13      PF22 | CITSO01  17:23      PF22 | IBMNET   17:23      PF22
A6POS3C1 17:23      PF22 | CITSO02  17:23      PF22 | IMS1A    22:03      PF22
A6POS3C2 17:23      PF22 | CITSO05  17:23      PF22 | IMS1B    17:23      PF22
A6POS3C3 17:23      PF22 | DSTCCM$2 17:23      PF22 | IMS2A    22:03      PF22
CCDNWP   17:23      PF22 | DSTCCM$3 17:23      PF22 | IMS2B    17:23      PF22
CICSEA01 17:23      PF22 | DSTCPA21 17:23      PF22 | K42OI1   17:23      PF22
CICSEA11 17:23      PF22 | DSTCPA22 17:23      PF22 | K47OI3   17:23      PF22
CICSEA21 17:23      PF22 | DSTCPA31 17:23      PF22 | N#@$1    17:23      PF22
CICSEH01 17:23      PF22 | DSTCPA32 17:23      PF22 | N#@$2    17:23      PF22
CICSEH11 17:23      PF22 | DSTCPT21 17:23      PF22 | N#@$3    17:23      PF22
CICSEH21 17:23      PF22 | DSTCPT22 17:23      PF22 | NETVPOK  17:23      PF22
CICSET01 17:23      PF22 | DSTCPT31 17:23      PF22 | NETVVMXA 17:23      PF22
- Enter application name or a command. (LOGOFF terminates all sessions..) ----


==> ___________________  ________  ________  ________                Page 001
PF1=Help  PF2=Lang  PF3=Disc  PF4=Keys  PF7=Backw  PF8=Forw  PF12=Exit
MA*    a                                                               23/006
```

Figure 11-31   Application selection screen

2. Start the EGUI application by entering `EGUI` on the screen.

   You see the main menu of the EGUI application (Figure 11-32 on page 335). Note that the information area of the host editor indicates that it recognized the screen from the BMS maps that you imported earlier.



Recognized screen description "Dfh0xs1.Exmenu_Exmenu"
No screen operations file

```
CICS EXAMPLE CATALOG APPLICATION  - Main Menu

Select an action, then press ENTER

Action . . . .  _  1. List Items
                   2. Order Item Number
                   3. Exit
```

Figure 11-32   EGUI application Main Menu

We are now ready to start recording the terminal interactions. We will use the Host Editor to record the terminal interactions. The Host Editor has a toolbar, an information area, and a terminal emulation area.

Important: Be extremely careful with the following steps. You might want to read through the steps describing the recording process one time before actually performing these steps. Proceed slowly. If you do make a mistake, you might have to restart this process.

The steps to start recording the terminal interactions are:

1. On the Host Editor Toolbar, click the **Start Recording Flow** icon, as shown in Figure 11-33.

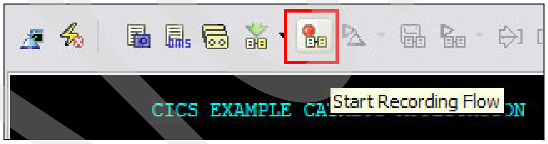
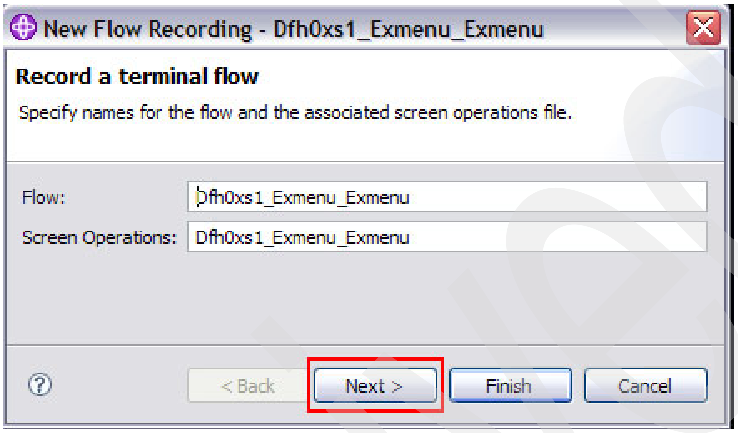


Figure 11-33   Start recording Terminal Flow

2. In the Record a terminal flow dialog, take the default names for the flow name and screen operations file name, and click **Next**, as shown in Figure 11-34 on page 336.

   A flow file will be created that contains a graphical representation of the sequence of terminal interactions, as well as the data input and output from both the flow itself and the screen invoke nodes that represent these terminal interactions.

A screen operations file will also be created that contains the screen operations captured during the recording of a sequence of terminal interactions. A *screen operation* is the definition of an input screen and its association with possible output (next) screens based on an interaction (input data and AID key combination) with the input screen.



New Flow Recording - Dfh0xs1_Exmenu_Exmenu

Record a terminal flow

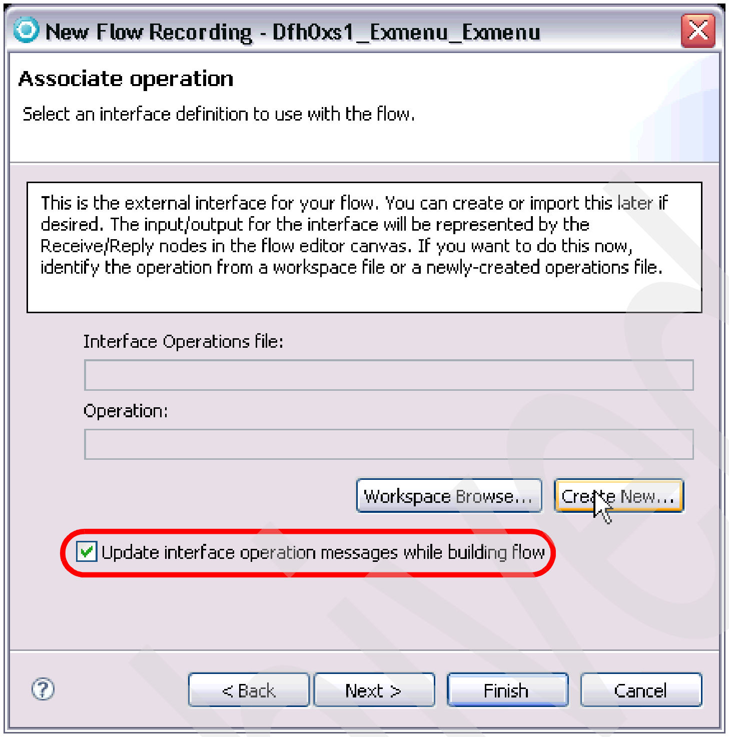
Specify names for the flow and the associated screen operations file.

Flow: Dfh0xs1_Exmenu_Exmenu

Screen Operations: Dfh0xs1_Exmenu_Exmenu

Figure 11-34 Specifying name of the flow and screen operations

3. In the next window, the Associate operation dialog, click **Create New**, as shown in Figure 11-35 on page 337. Make sure that **Update interface operation messages while building flow** is selected. By selecting this option, you choose to have the fields, which are used for data input during flow recording of the terminal interactions, automatically included as input fields for the flow itself. If you elect not to select this option, the fields to be used as input and output for the flow itself need to be defined separately from the recording of the terminal interactions.



New Flow Recording - Dfh0xs1_Exmenu_Exmenu

Associate operation

Select an interface definition to use with the flow.

This is the external interface for your flow. You can create or import this later if desired. The input/output for the interface will be represented by the Receive/Reply nodes in the flow editor canvas. If you want to do this now, identify the operation from a workspace file or a newly-created operations file.

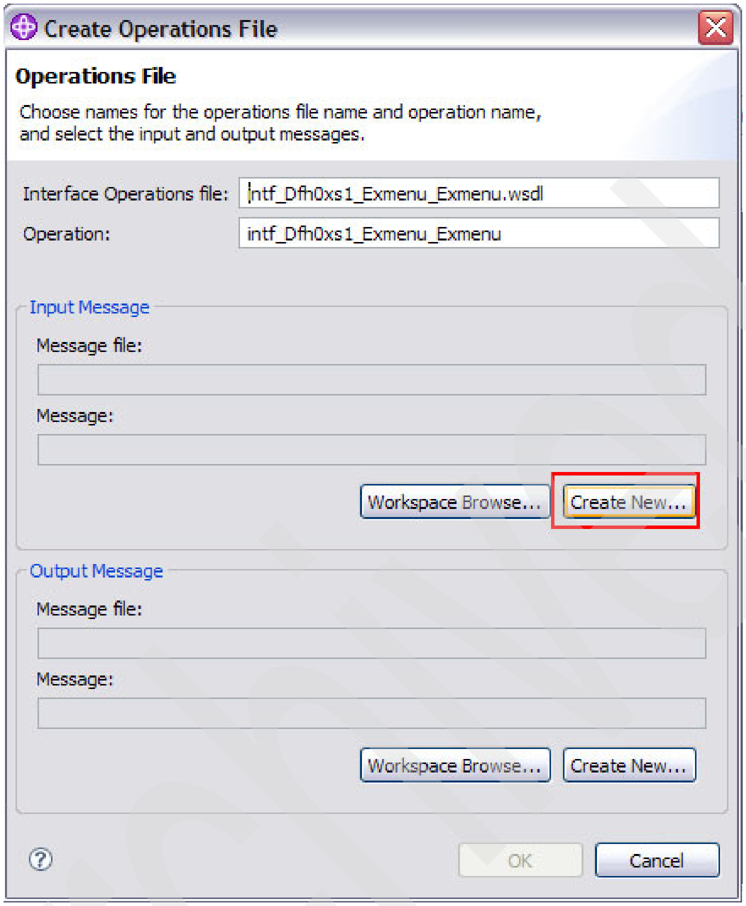
Interface Operations file:

Operation:

☑ Update interface operation messages while building flow

Figure 11-35 Associating operation with flow

4. In the Create Operations File pane, as shown in Figure 11-36 on page 338, take the default names for the Interface Operations file and Operation. An *operation* is associated with input and output messages. Click **New** to create one message to associate with this operation. Then, click **New** again. *You must click New twice to create messages for both the input and output.*



Create Operations File

Operations File

Choose names for the operations file name and operation name, and select the input and output messages.

Interface Operations file: intf_Dfh0xs1_Exmenu_Exmenu.wsdl

Operation: intf_Dfh0xs1_Exmenu_Exmenu

Input Message

Message file:

Message:

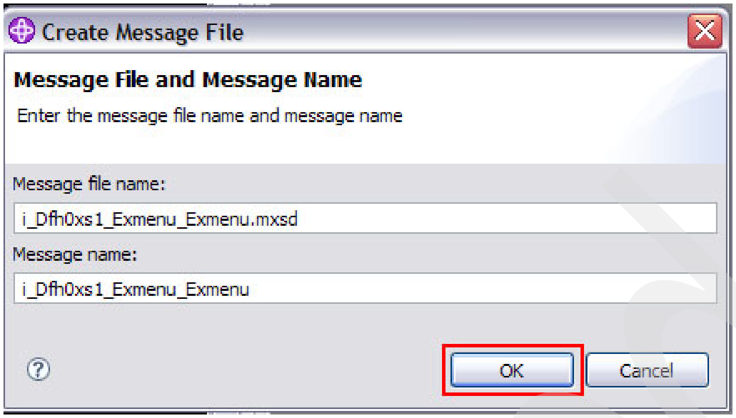
Output Message

Message file:

Message:

Figure 11-36 Creating Operations File dialog

5. In the Message File and Message Name dialog, take the default message file name and message name, as shown in Figure 11-37 on page 339. Click **OK**.


Create Message File

Message File and Message Name

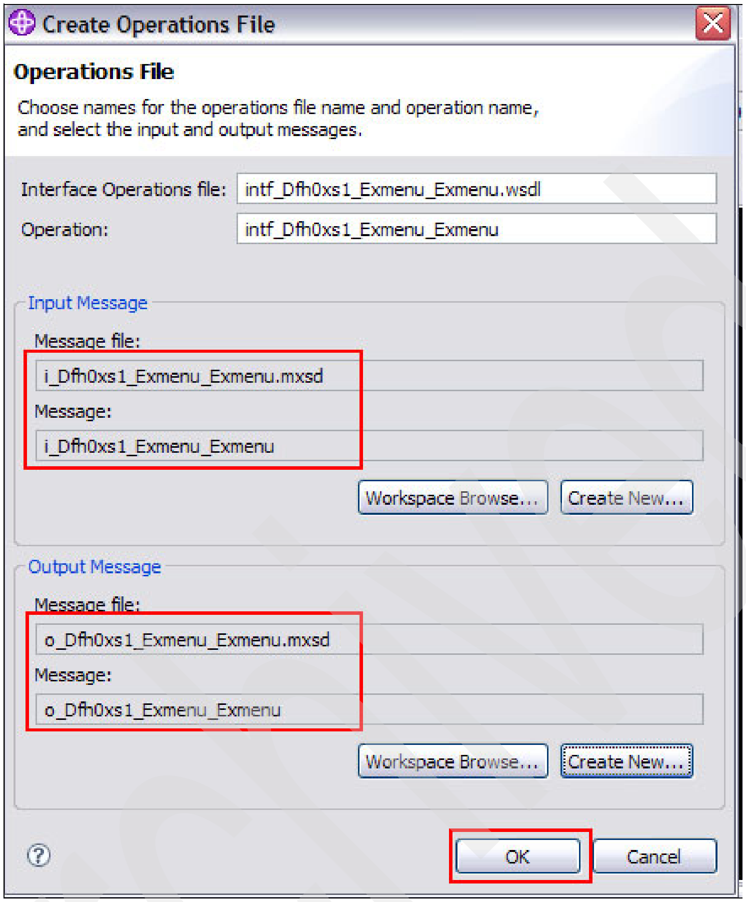
Enter the message file name and message name

Message file name: i_Dfh0xs1_Exmenu_Exmenu.mxsd

Message name: i_Dfh0xs1_Exmenu_Exmenu

Figure 11-37 Create Message File window

6. Repeat the process to create an output message file. After you finish, the Operations File dialog looks like what is shown in Figure 11-38 on page 340.



Create Operations File

Operations File

Choose names for the operations file name and operation name, and select the input and output messages.

Interface Operations file: intf_Dfh0xs1_Exmenu_Exmenu.wsdl

Operation: intf_Dfh0xs1_Exmenu_Exmenu

Input Message

Message file: i_Dfh0xs1_Exmenu_Exmenu.mxsd

Message: i_Dfh0xs1_Exmenu_Exmenu

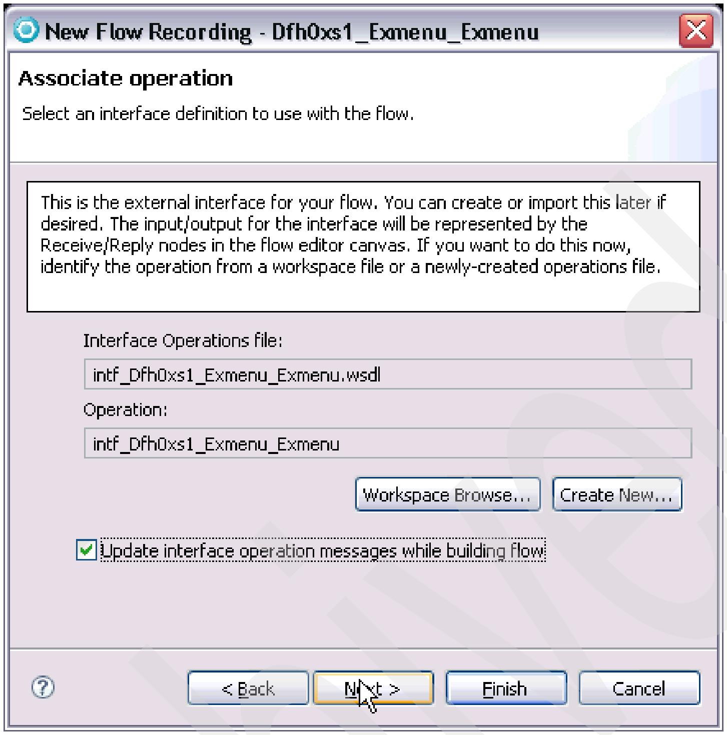
Output Message

Message file: o_Dfh0xs1_Exmenu_Exmenu.mxsd

Message: o_Dfh0xs1_Exmenu_Exmenu

Figure 11-38 Operations File with Input Message and Output Message

7. Click **OK** to apply the changes and dismiss the Operations File dialog. This action brings the focus back on the Associate operation dialog, which shows the Interface Operations file and Operation entry fields filled, as shown in Figure 11-39 on page 341. Click **Next**.



New Flow Recording - Dfh0xs1_Exmenu_Exmenu

Associate operation

Select an interface definition to use with the flow.

This is the external interface for your flow. You can create or import this later if desired. The input/output for the interface will be represented by the Receive/Reply nodes in the flow editor canvas. If you want to do this now, identify the operation from a workspace file or a newly-created operations file.

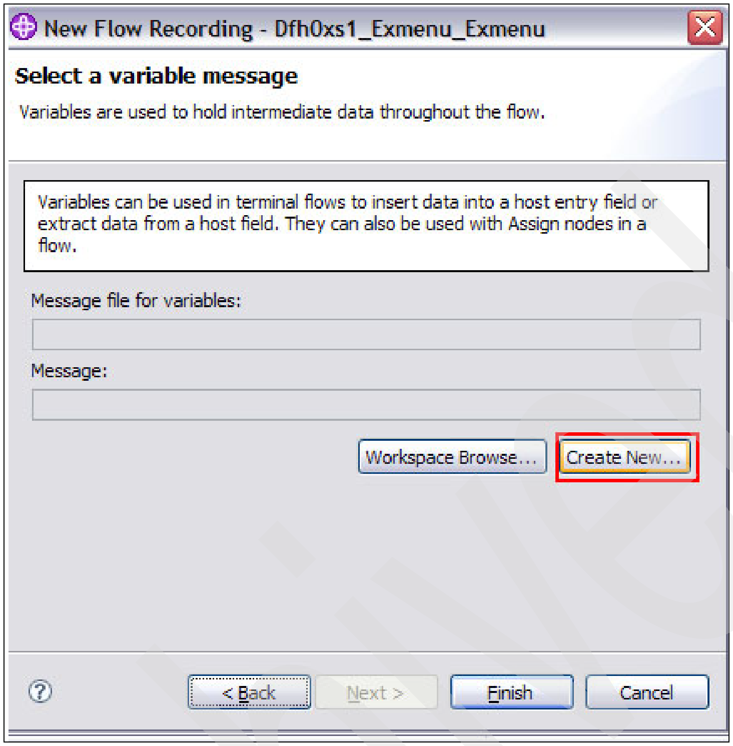
Interface Operations file: intf_Dfh0xs1_Exmenu_Exmenu.wsdl

Operation: intf_Dfh0xs1_Exmenu_Exmenu

☑ Update interface operation messages while building flow

Figure 11-39 Defined operation

8. On the Select a variable message dialog, click **Create New** to create a new variable message, as shown in Figure 11-40 on page 342.



New Flow Recording - Dfh0xs1_Exmenu_Exmenu

Select a variable message

Variables are used to hold intermediate data throughout the flow.

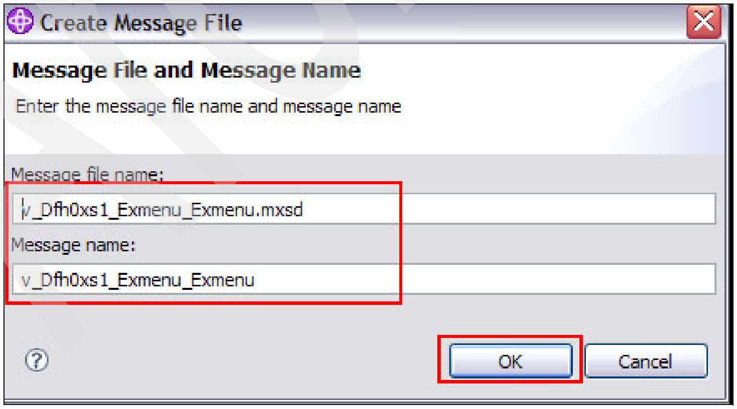
Variables can be used in terminal flows to insert data into a host entry field or extract data from a host field. They can also be used with Assign nodes in a flow.

Message file for variables:

Message:

Figure 11-40 Creating a variable message

9. On the Message File and Message Name dialog, take the defaults and click **OK**, as shown in Figure 11-41.



Create Message File

Message File and Message Name

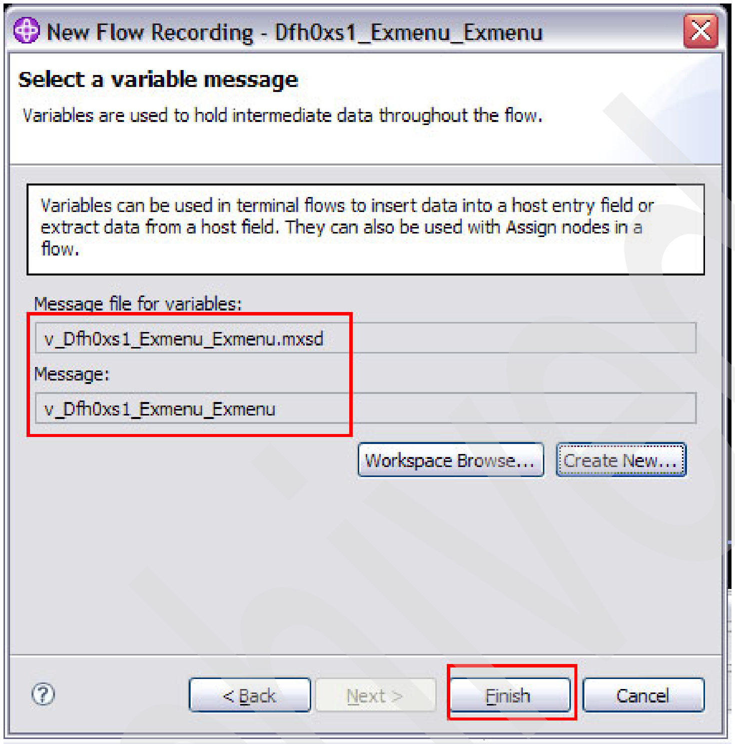
Enter the message file name and message name

Message file name: v_Dfh0xs1_Exmenu_Exmenu.mxsd

Message name: v_Dfh0xs1_Exmenu_Exmenu

Figure 11-41 Message File and Message Name dialog

10. Back on the Select a variable message dialog, you see a window similar to Figure 11-42. Click **Finish**.



Select a variable message

Variables are used to hold intermediate data throughout the flow.

Variables can be used in terminal flows to insert data into a host entry field or extract data from a host field. They can also be used with Assign nodes in a flow.

Message file for variables: v_Dfh0xs1_Exmenu_Exmenu.mxsd

Message: v_Dfh0xs1_Exmenu_Exmenu

Figure 11-42 Defined variable message

You are now ready to begin the actual recording of the terminal interactions. This recording involves entering input that is captured directly, specifying which fields will have data inserted into them and which fields you will be extracting data from.

> **Important:** Be careful with the following steps. Read them slowly to prevent incorrect actions. If you make a mistake, you must start this process again.

To capture data, just enter it as you normally interact with the application:

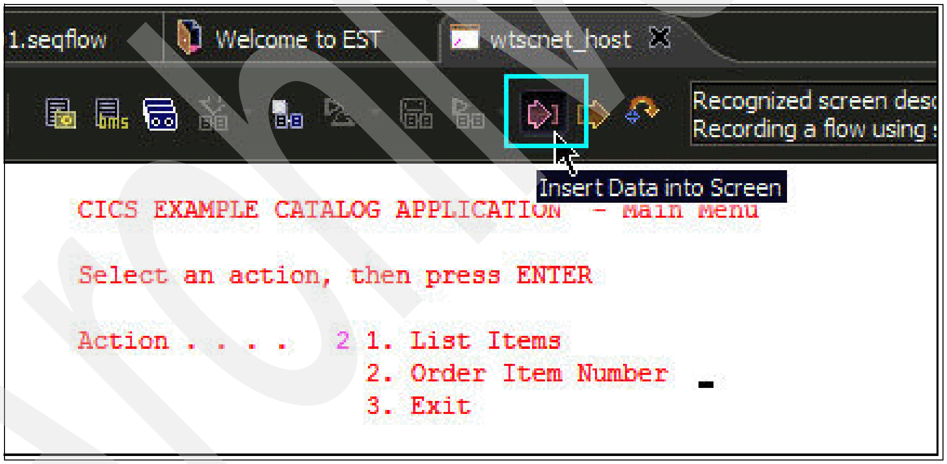
– To specify that a field will have data inserted into it, you must click the **Insert Data into Screen** icon (▷) on the toolbar first and then select the actual entry field followed by the entry of representative data. This data becomes variable at run time, which differs from data that is inserted into a screen field *without* clicking the **Insert Data into Screen** icon, which becomes static hard-coded data used at run time. For example, in the next step, you enter `2`, which will become static hard-coded data that will always be used as the value for the Action screen field, while the value `0040` that you specify in subsequent steps is representative data that becomes a variable at run time.

– To specify that data will be extracted from a field, you must click the **Extract Data from Screen** icon ( ) on the toolbar first and then select the actual entry field containing the data to be extracted.

> **Important:** *In the following steps, do not press Enter (right Ctrl) unless explicitly mentioned.* Pressing Enter (right Ctrl) at the wrong moment or too early creates errors in your recorded flow, which can only be fixed by recording the flow again from the beginning.

11. Type `2` in the Action field, as shown in Figure 11-43.

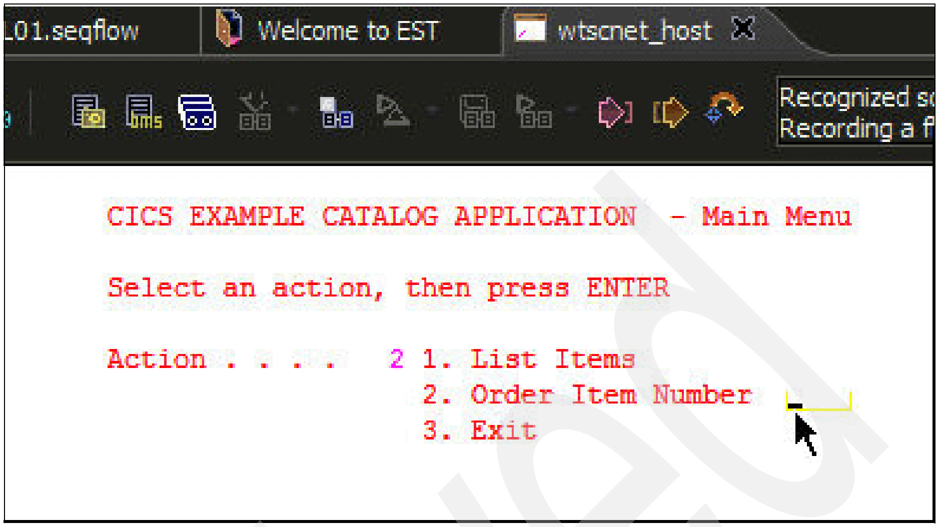
12. Click the **Insert Data into Screen** icon on the toolbar, as shown in Figure 11-43.



```
CICS EXAMPLE CATALOG APPLICATION  - Main Menu

Select an action, then press ENTER

Action . . . .   2 1. List Items
                   2. Order Item Number
                   3. Exit
```

Figure 11-43 Inserting data into screen

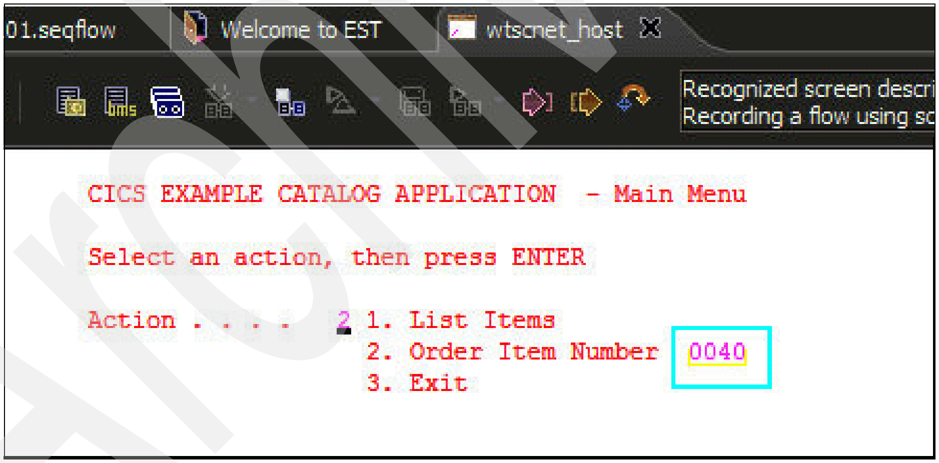
13. Click the **Order Item Number** entry field (*not the text field*). You see the entry field outlined (Figure 11-44 on page 345). Make sure that the cursor is at the start of the entry field.



```
CICS EXAMPLE CATALOG APPLICATION  - Main Menu

Select an action, then press ENTER

Action . . . .    2 1. List Items
                    2. Order Item Number
                    3. Exit
```

Figure 11-44 Selecting the entry field for inserting data

14. Type `0040` in the Order Item Number entry field, as shown in Figure 11-45.



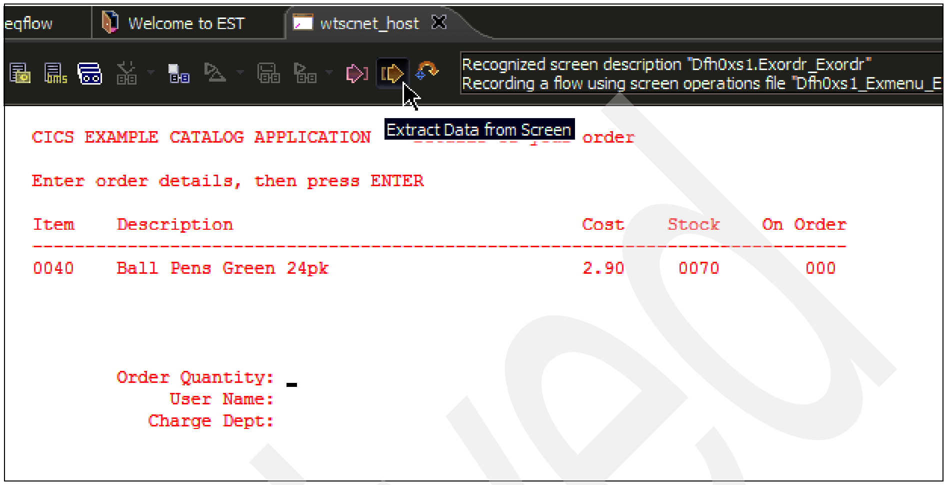
```
CICS EXAMPLE CATALOG APPLICATION  - Main Menu

Select an action, then press ENTER

Action . . . .    2 1. List Items
                    2. Order Item Number  0040
                    3. Exit
```

Figure 11-45 Entering an order item number

15. Press Enter (Ctrl).

After you press Enter, you are brought to the Order details screen as shown in Figure 11-46 on page 346. On this screen, you need to first extract the item description and then the item cost. After specifying the extract, you then need to insert data into the Order Quantity, User Name, and Charge Dept fields.

16.Click the **Extract Data from Screen** icon on the toolbar, as shown in Figure 11-46.

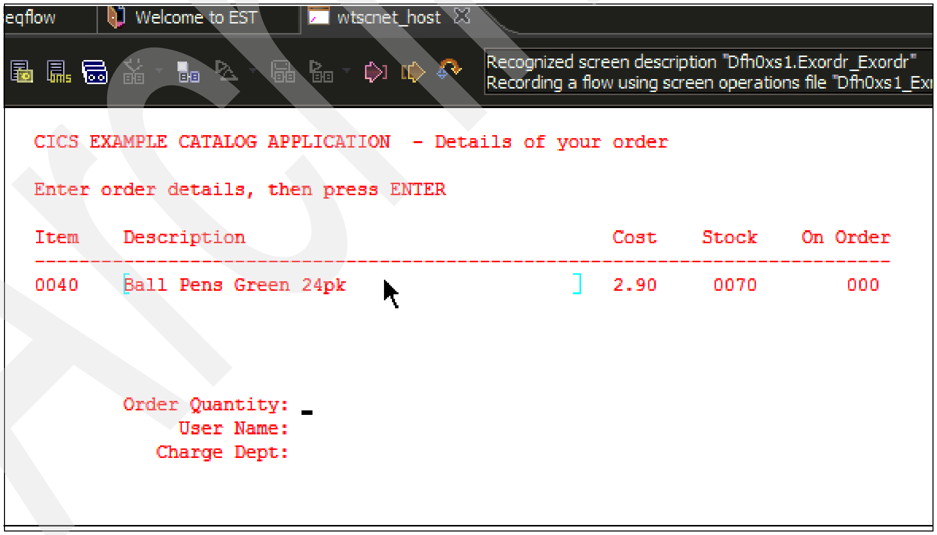


```
Recognized screen description "Dfh0xs1.Exordr_Exordr"
Recording a flow using screen operations file "Dfh0xs1_Exmenu_E
```

```
CICS EXAMPLE CATALOG APPLICATION                    order

Enter order details, then press ENTER

Item    Description                            Cost    Stock    On Order
-----------------------------------------------------------------------------
0040    Ball Pens Green 24pk                   2.90    0070          000



        Order Quantity: _
             User Name:
           Charge Dept:
```

Figure 11-46 Extracting data from the screen

17.Click the description for item 0040, **Ball Pens Green 24pk**. You see this read-only field framed with brackets (Figure 11-47).



```
Recognized screen description "Dfh0xs1.Exordr_Exordr"
Recording a flow using screen operations file "Dfh0xs1_Ex
```

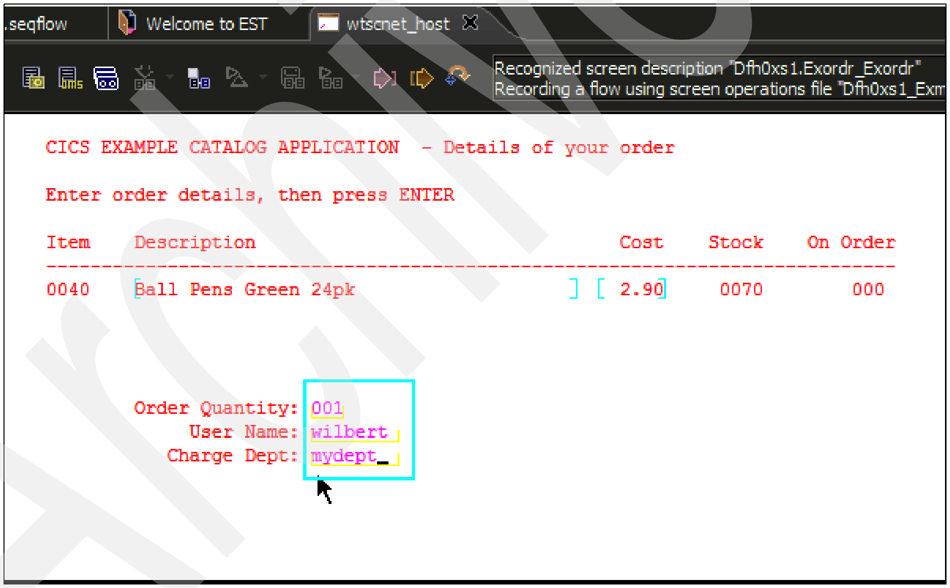
```
CICS EXAMPLE CATALOG APPLICATION  - Details of your order

Enter order details, then press ENTER

Item    Description                            Cost    Stock    On Order
-----------------------------------------------------------------------------
0040    [Ball Pens Green 24pk                 ] 2.90    0070          000



        Order Quantity: _
             User Name:
           Charge Dept:
```

Figure 11-47 Selecting item description for extraction

18.Repeat the process (steps 16 and 17) to extract the item cost.

After you have extracted the data for the description and the item cost fields, you need to insert data into the three input fields of this screen. Follow the process for inserting data (click the **Insert Data into Screen** icon on the toolbar, select the input field, and enter the representative data) for *each* of the three input fields. So, you need to repeat the same steps three times. Use Figure 11-48 as a guide for what data to enter.

> **Important:** A common error is only clicking the Insert Data into Screen icon one time and then entering three input fields at a time. *If you make this error, you will later discover that SFM cannot perform a proper input field mapping.*
>
> To avoid this error, make sure that you perform all three steps for *each* field separately: the first time for Order Quantity with a value of `001`, the second time for User Name with, for example, a value of `wilbert`, and the third time for Charge Dept with, for example, a value of `mydept`.



Recognized screen description "Dfh0xs1.Exordr_Exordr"
Recording a flow using screen operations file "Dfh0xs1_Exm

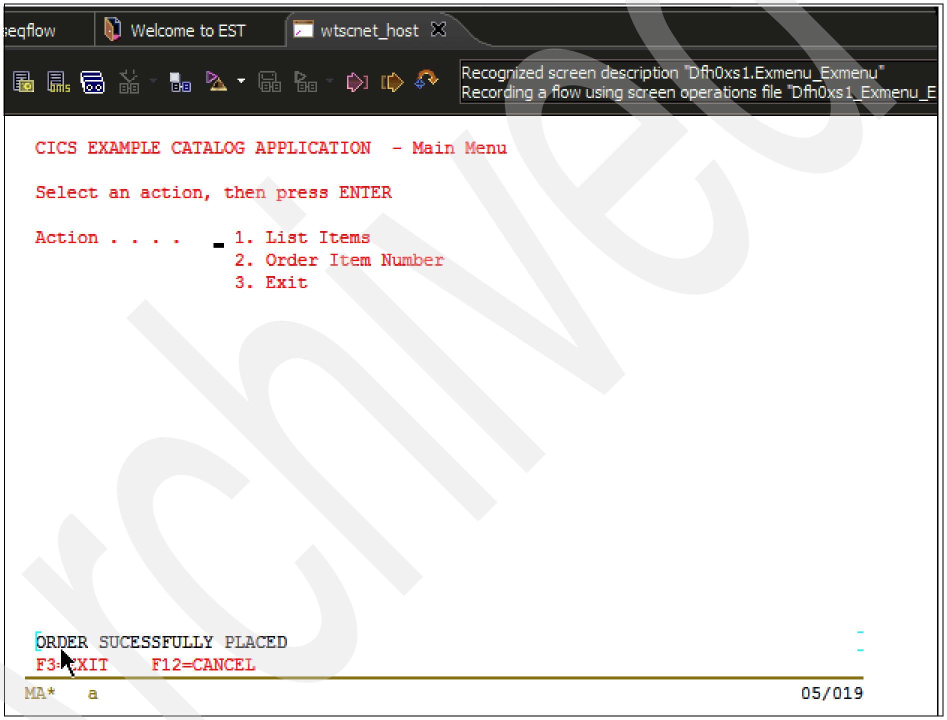
```
CICS EXAMPLE CATALOG APPLICATION  - Details of your order

Enter order details, then press ENTER

Item    Description                                 Cost     Stock    On Order
----------------------------------------------------------------------------
0040    Ball Pens Green 24pk                      ] [ 2.90]    0070        000



        Order Quantity: 001
             User Name: wilbert
           Charge Dept: mydept_
```

Figure 11-48 Specifying Extract and Insert information

After you have finished your extract and insert specifications, press Enter (Ctrl), which brings you back to the main menu with a status message indicating that the order was successfully placed.

Note: It might happen that stock runs out. In that case, you might get another message than the "ORDER SUCCESSFULLY PLACED" message. For SFM, it does not matter what exact message text is displayed; SFM only needs to know that there is an output text message in this screen. If you do get another message, just proceed with the steps.

19. You must now *extract* the status message. Follow steps 16 on page 346 and 17 on page 346 to extract the message but this time for the status message. Refer to Figure 11-49.



Recognized screen description "Dfh0xs1.Exmenu_Exmenu"
Recording a flow using screen operations file "Dfh0xs1_Exmenu_E

```
CICS EXAMPLE CATALOG APPLICATION  - Main Menu

Select an action, then press ENTER

Action . . . .    _ 1. List Items
                    2. Order Item Number
                    3. Exit




ORDER SUCESSFULLY PLACED
F3=EXIT    F12=CANCEL
MA*    a                                                       05/019
```

Figure 11-49 Extracting the status message

After you have specified the extraction of the status message, you are finished with the recording of the terminal interactions.

20. Click the **Stop Recording Flow** icon on the toolbar, as shown in Figure 11-50 on page 349.

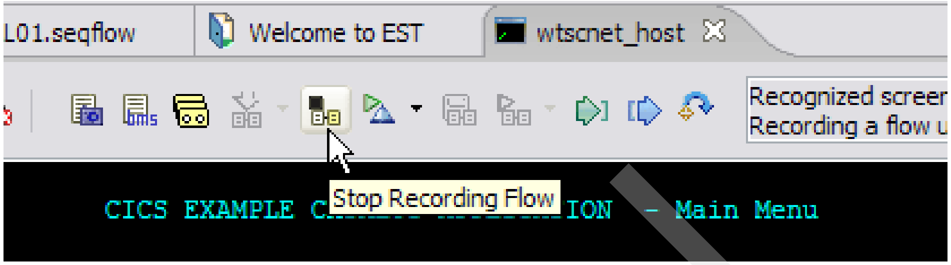


Figure 11-50 Stopping Flow recording

21. After you have stopped the recording, you need to save the flow by clicking the **Save Flow** icon on the toolbar, as shown in Figure 11-51.

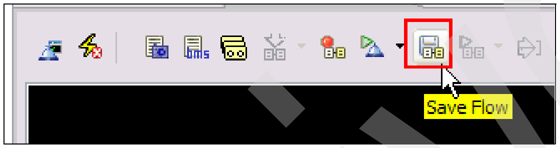
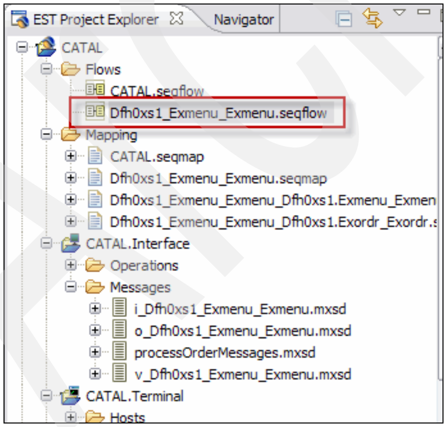


Figure 11-51 Saving recorded flow

Note that an additional flow, `Dfh0xs1_Exmenu_Exmenu.seqflow`, was created in the Flows folder. This flow represents the terminal interactions and will be considered as a subflow to the main flow, `CATAL.seqflow`. Refer to Figure 11-52.



```
CATAL
  Flows
    CATAL.seqflow
    Dfh0xs1_Exmenu_Exmenu.seqflow
  Mapping
    CATAL.seqmap
    Dfh0xs1_Exmenu_Exmenu.seqmap
    Dfh0xs1_Exmenu_Exmenu_Dfh0xs1.Exmenu_Exmen
    Dfh0xs1_Exmenu_Exmenu_Dfh0xs1.Exordr_Exordr.s
  CATAL.Interface
    Operations
    Messages
      i_Dfh0xs1_Exmenu_Exmenu.mxsd
      o_Dfh0xs1_Exmenu_Exmenu.mxsd
      processOrderMessages.mxsd
      v_Dfh0xs1_Exmenu_Exmenu.mxsd
  CATAL.Terminal
    Hosts
```

Figure 11-52 Flows associated with the CATAL Service Flow project

Let us examine the flow that we just recorded.

Note: The Terminal flow that we recorded and saved can also be loaded into the host editor using the Load Flow icon ( ) and then played back using the Play Flow icon ( ) to test the recorded terminal interactions with various input data and to verify the resulting output data.

22. Double-click **Dfh0xs1_Exmenu_Exmenu.seqflow**. It will open the subflow. You will see a window similar to Figure 11-53.

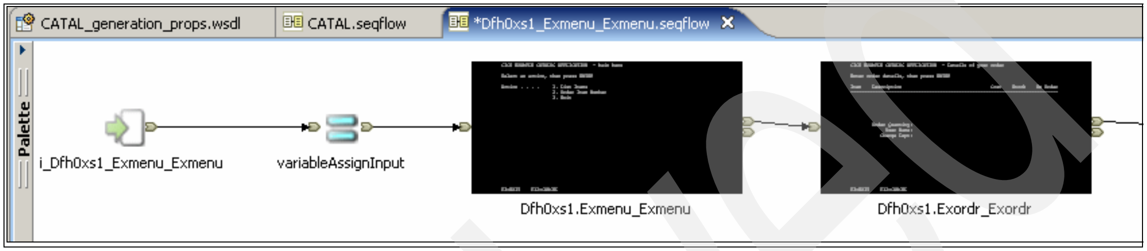
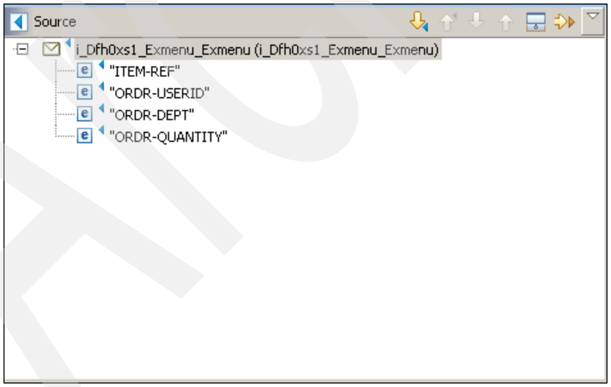


Figure 11-53 Dfh0xs1_Exmenu_Exmenu.seqflow window

Tip: If your flow is not laid out properly, click anywhere in the flow editor. Right-click and select **Layout** → **Left to Right** from the context menu.

23. Double-click **variableAssignInput**. You need to verify the Source fields using Figure 11-54.


Source

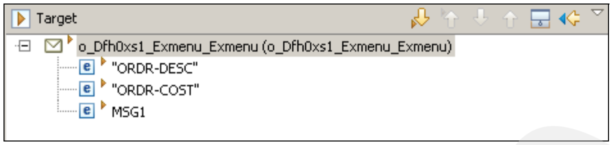
```
i_Dfh0xs1_Exmenu_Exmenu (i_Dfh0xs1_Exmenu_Exmenu)
    "ITEM-REF"
    "ORDR-USERID"
    "ORDR-DEPT"
    "ORDR-QUANTITY"
```

Figure 11-54 VariableAssignInput Source window

You only see exactly the following fields:

- ITEM-REF
- ORDR-USERID
- ORDR-DEPT
- ORDR-QUANTITY

24. Close this window and double-click **variableAssignOutput**. You need to verify the Target fields using Figure 11-55.



Target

o_Dfh0xs1_Exmenu_Exmenu (o_Dfh0xs1_Exmenu_Exmenu)
- "ORDR-DESC"
- "ORDR-COST"
- MSG1

Figure 11-55 VariableAssignOutput Target window

You only see exactly the following fields:

- ORDR-DESC
- ORDR-COST
- MSG1

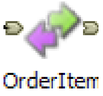
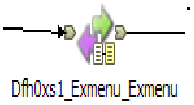
> **Important:** If any of the source fields or target fields lists differ from what is shown in Figure 11-54 and Figure 11-55, you might need to go back to the beginning of this section and rerecord the terminal flow. An alternative is to use the mapping editor (as discussed in 11.5, “Mapping the Data Flow” on page 352) to ensure that the correct source mapping inputs and target mapping outputs are used.

25. Close this window.

26. Close **Dfh0xs1_Exmenu_Exmenu.seqflow.**

27. Save this flow if prompted.

Next, you associate the `OrderItem` invoke node in the main flow with the created subflow.

28. Make sure that the main flow, **CATAL.seqflow**, is opened in the flow editor. Select **Dfh0xs1_Exmenu_Exmenu.seqflow** from the Flows folder in the EST Project Explorer view and drag and drop it onto the **OrderItem** invoke node of the main flow in the flow editor. You will see the icon of the invoke node change from:  to:  .

Click anywhere in the flow editor so it has focus. Press Ctrl+s to save your changes. Your main flow now looks like Figure 11-56.

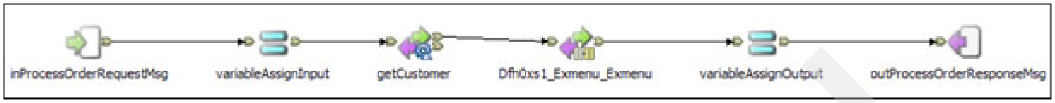


Figure 11-56 CATAL main flow after defining GetCustomerInfo and OrderItem

The next step is to specify how data will flow through the application.

11.5 Mapping the Data Flow

Before we proceed further in this segment, let us review the scenario (refer to Figure 11-56 for reference).

A Web service request will come in with an input request that consists of a customer number, an item number, and the quantity to be ordered. The Web service requester will expect an output response that consists of a description of the item ordered, the total cost of the order, the status of the order, and the name associated with the customer number for this order.

The input request will come into the flow application through the *Receive* node labeled `inProcessOrderRequestMsg`. The output response will be sent from the flow application through the *Reply* node labeled `outProcessOrderResponseMsg`. The two invoke nodes of the flow application expect different input data and will emit different output data. You need to specify how data will flow from one node to another node and also what kind of transformation might need to be performed during the flow (for example, character string data might need to be converted to integer format). You accomplish this transformation by using the mapping capabilities of the Service Flow tools.

Note that in the flow there are two nodes labeled `variableAssignInput` and `variableAssignOutput`. These are *Assign* nodes. An Assign node is associated with mapping routines that map or transform data as it flows from one node to another node. You will specify what those mapping routines look like. In addition, you will also create an Assign node between the two invoke nodes.

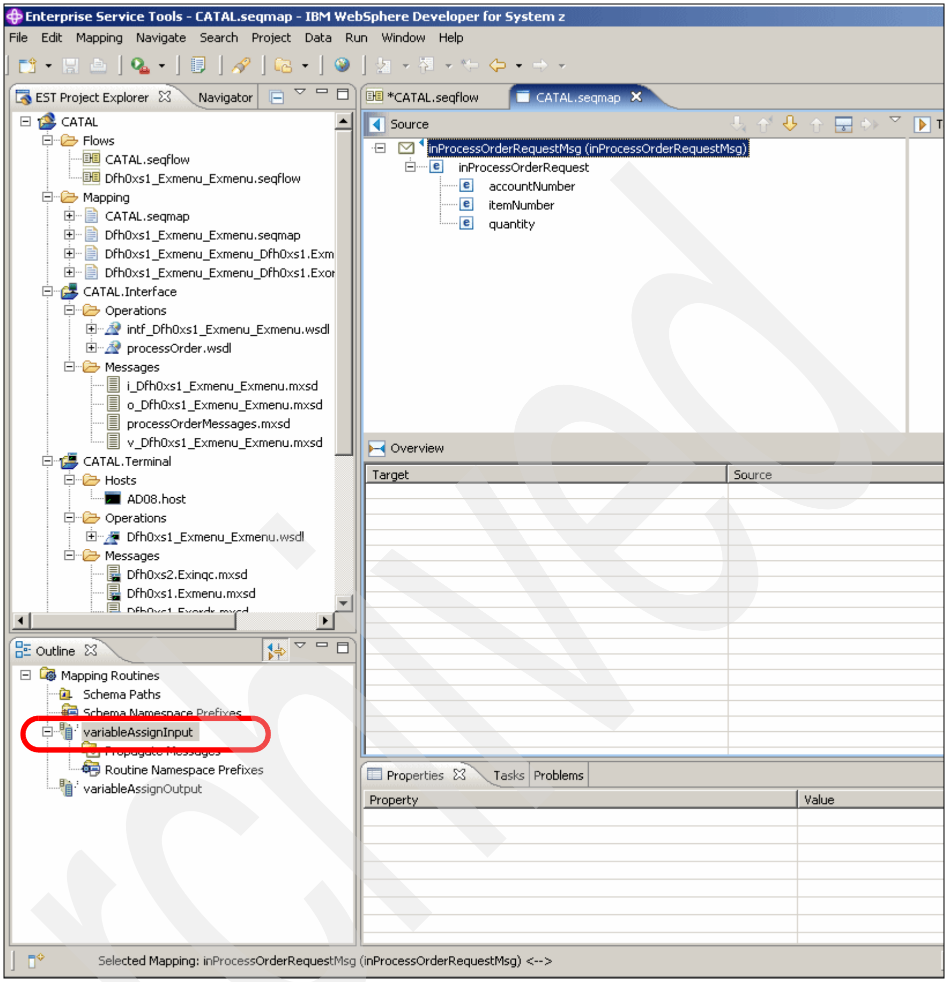
11.5.1 variableAssignInput node

Perform the following steps to specify the transformation for the variableAssignInput node:

1. In the flow editor, double-click the **variableAssignInput** node, which launches the mapping editor. Note that there is an Outline view associated with the mapping editor.

> **Important:** Make sure that variableAssignInput is the node that has the focus in the Outline view, because multiple mapping routines are stored in one mapping file.

2. In the Outline view, click **variableAssignInput**, as shown on Figure 11-57 on page 354. Note that the mapping editor has two sections called *Source* and *Target*.


Enterprise Service Tools - CATAL.seqmap - IBM WebSphere Developer for System z
File Edit Mapping Navigate Search Project Data Run Window Help
EST Project Explorer
Navigator
CATAL
Flows
CATAL.seqflow
Dfh0xs1_Exmenu_Exmenu.seqflow
Mapping
CATAL.seqmap
Dfh0xs1_Exmenu_Exmenu.seqmap
Dfh0xs1_Exmenu_Exmenu_Dfh0xs1.Exm
Dfh0xs1_Exmenu_Exmenu_Dfh0xs1.Exor
CATAL.Interface
Operations
intf_Dfh0xs1_Exmenu_Exmenu.wsdl
processOrder.wsdl
Messages
i_Dfh0xs1_Exmenu_Exmenu.mxsd
o_Dfh0xs1_Exmenu_Exmenu.mxsd
processOrderMessages.mxsd
v_Dfh0xs1_Exmenu_Exmenu.mxsd
CATAL.Terminal
Hosts
AD08.host
Operations
Dfh0xs1_Exmenu_Exmenu.wsdl
Messages
Dfh0xs2.Exinqc.mxsd
Dfh0xs1.Exmenu.mxsd
Outline
Mapping Routines
Schema Paths
Schema Namespace Prefixes
variableAssignInput
Propagate Messages
Routine Namespace Prefixes
variableAssignOutput
*CATAL.seqflow
CATAL.seqmap
Source
inProcessOrderRequestMsg (inProcessOrderRequestMsg)
inProcessOrderRequest
accountNumber
itemNumber
quantity
Overview
Target
Source
Properties
Tasks
Problems
Property
Value

Selected Mapping: inProcessOrderRequestMsg (inProcessOrderRequestMsg) <-->

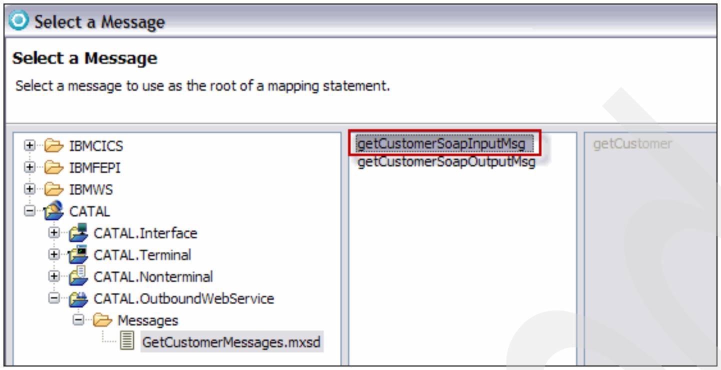
Figure 11-57 Mapping Editor window

3. In the Source section of the mapping editor, click the **+** (addition symbol) to the left of **inProcessOrderRequest**, which will show you the elements associated with it: `accountNumber`, `itemNumber`, and `quantity`. We will associate `accountNumber` with the input to `getCustomer`.

   Click anywhere in the Target section of the mapping editor to give it focus. Right-click and select **Add Message Mapping Output** from the pop-up menu.

4. On the Select a Message dialog, expand **CATAL** → **CATAL.OutboundWebService** → **Messages** and select

GetCustomerMessages.mxsd → **getCustomerSoapInputMsg**. Click **OK**. Refer to Figure 11-58.


Select a Message

Select a Message

Select a message to use as the root of a mapping statement.

Figure 11-58 Selecting Target message for variableAssignInput

When you expand **getCustomer**, the mapping editor looks like Figure 11-59.

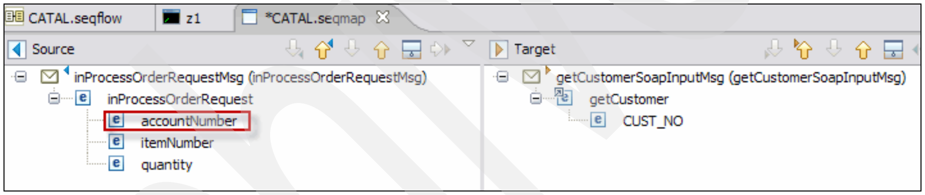
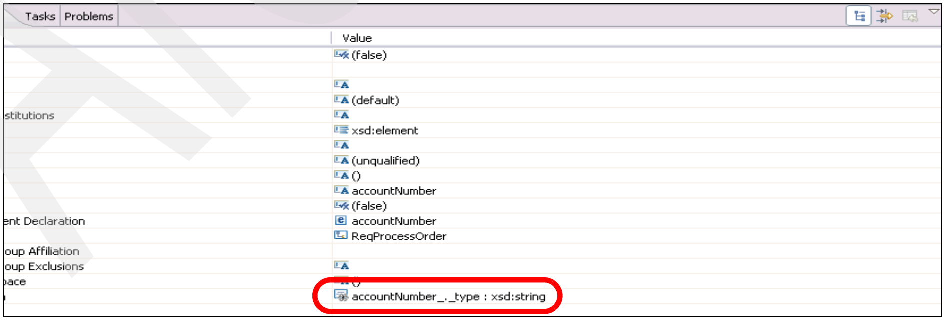


Figure 11-59 Source and Target mappings for variableAssignInput

5. Select **accountNumber** from the Source section. There is a Properties view at the bottom portion of RDz. As you scroll through the properties for `acountNumber`, note that it is defined as type string**.** Refer to Figure 11-60.



	Value
	(false)
	(default)
stitutions	
	xsd:element
	(unqualified)
	()
	accountNumber
	(false)
ent Declaration	accountNumber
	ReqProcessOrder
oup Affiliation	
oup Exclusions	
pace	()
	accountNumber_._type : xsd:string

Figure 11-60 Properties for a mapping element

6. Select **CUST_NO** from the Target section. Note that the Properties view shows it defined as type `int`, which tells us that transformation is needed to associate `accountNumber` with `CUST_NO`.
7. To associate (or map) `accountNumber` with `CUST_NO`, select **accountNumber** it from the Source section, then drag and drop it onto **CUST_NO** in the Target section.

   Notice the additional arrow decorators beside the elements to indicate that a mapping exists. Note also the Target value in the Overview section of the mapping editor. You need to modify that target value so that the correct type of `int` will be assigned.

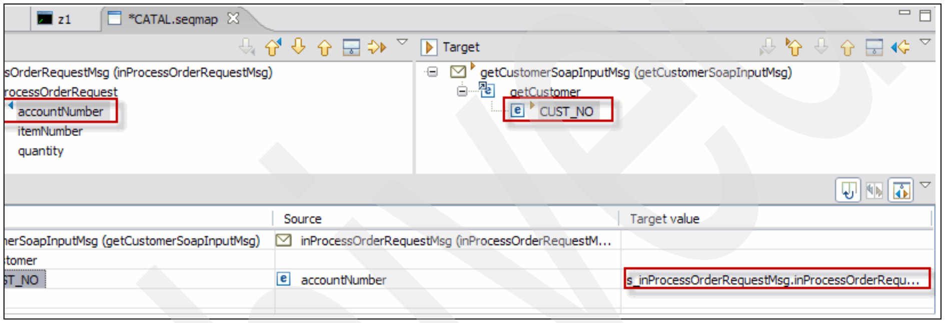

z1
*CATAL.seqmap
sOrderRequestMsg (inProcessOrderRequestMsg)
rocessOrderRequest
accountNumber
itemNumber
quantity
Target
getCustomerSoapInputMsg (getCustomerSoapInputMsg)
getCustomer
CUST_NO
Source
Target value
erSoapInputMsg (getCustomerSoapInputMsg)
inProcessOrderRequestMsg (inProcessOrderRequestM...
tomer
T_NO
accountNumber
s_inProcessOrderRequestMsg.inProcessOrderRequ...

Figure 11-61 Mapped elements for variableAssignInput

8. Click twice on the target value (highlighted) for CUST_NO in the Overview section of Figure 11-61. Notice the **...** (ellipsis) button that appears at the end of the target value. Click this button to launch the Compose Mapping Expression editor. Open the Compose Mapping Expression editor by clicking **...**, as shown in Figure 11-62.

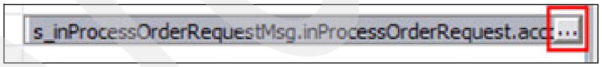
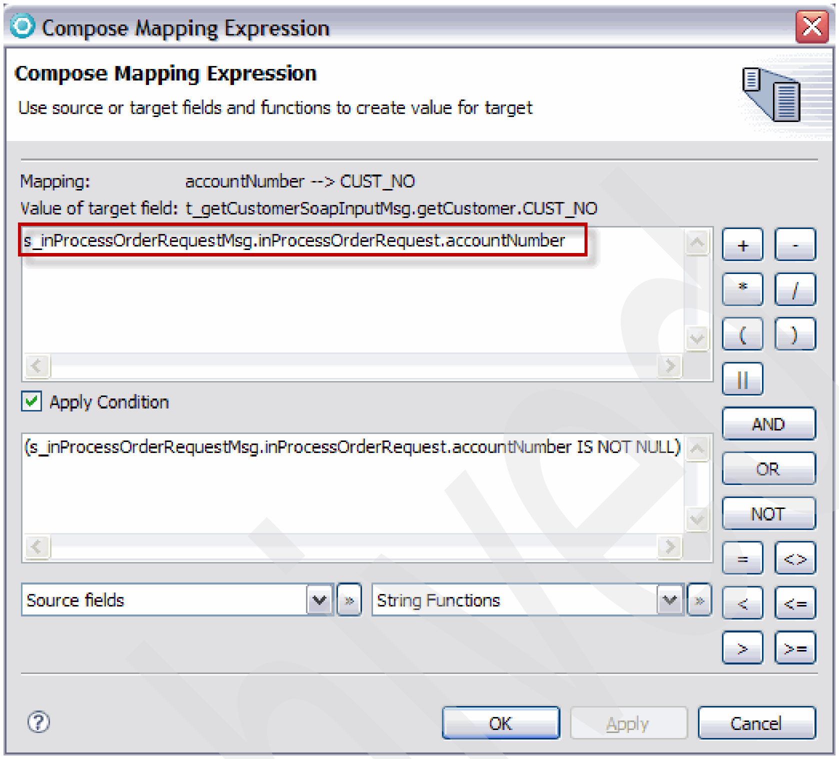


Figure 11-62 Editing the mapping

   Note that the target value for `CUST_NO` is a straight assignment from `accountNumber`. From the previous discussion, you know that there is a type mismatch between those two elements. With the Compose Mapping Expression editor, you can apply a set of functions to source values to perform data transformation. There is a miscellaneous function called CAST that can be used to force a `string` type into an `int` type.



Compose Mapping Expression

Compose Mapping Expression

Use source or target fields and functions to create value for target

Mapping: accountNumber --> CUST_NO

Value of target field: t_getCustomerSoapInputMsg.getCustomer.CUST_NO

```
s_inProcessOrderRequestMsg.inProcessOrderRequest.accountNumber
```

☑ Apply Condition

```
(s_inProcessOrderRequestMsg.inProcessOrderRequest.accountNumber IS NOT NULL)
```

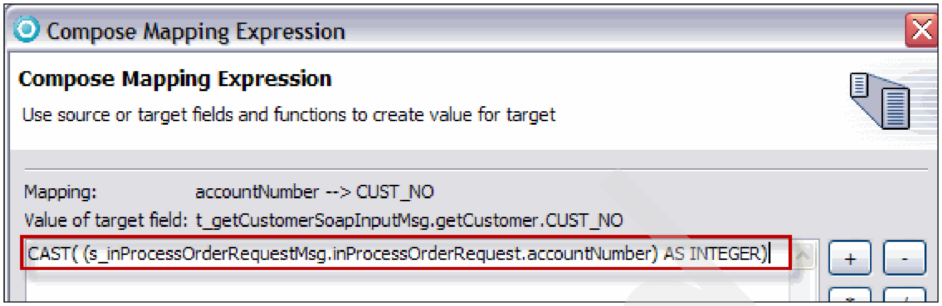
Source fields | String Functions

Figure 11-63 Compose Mapping Expression editor

9. In the Value of target field area, modify s_inProcessOrderRequestMsg.inProcessOrderRequest.accountNumber so that it now reads:

   ```
   CAST((s_inProcessOrderRequestMsg.inProcessOrderRequest.accountNumber
   ) AS INTEGER)
   ```

   Refer to Figure 11-64 on page 358.



Compose Mapping Expression

Compose Mapping Expression

Use source or target fields and functions to create value for target

Mapping: accountNumber --> CUST_NO

Value of target field: t_getCustomerSoapInputMsg.getCustomer.CUST_NO

```
CAST( (s_inProcessOrderRequestMsg.inProcessOrderRequest.accountNumber) AS INTEGER)
```

Figure 11-64 Compose Mapping Expression editor after CAST

10.Click **OK** to dismiss the editor and apply the changes.

11.Press Ctrl+s to save your changes.

11.5.2 variableAssignOutput Node

Perform the following steps to specify the transformation for the variableAssignOutput node:

1. From the Outline view, select **variableAssignOutput** to specify its mapping routine. Notice that the Source section is empty while the Target section shows outProcessOrderResponseMsg (highlighted), as shown in Figure 11-65.

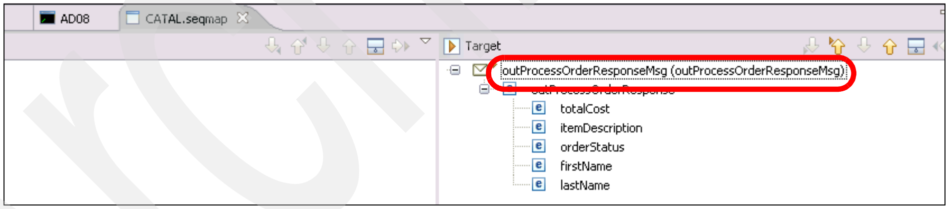
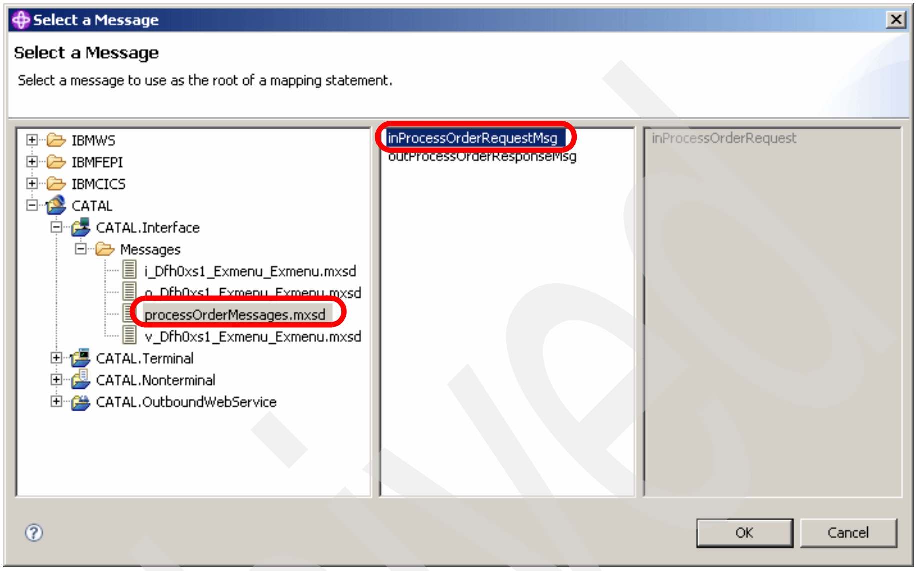


Figure 11-65 Mapping variableAssignOutput

2. Click anywhere in the Source section to give it focus. Right-click and select **Add Message Mapping Input** from the context-sensitive menu.
3. You will select three sources for your input. The input request message contains the order quantity that you will need to compute the total cost for the order. The response message from the outbound Web service call to the customer lookup service contains the first and last names associated with the customer number that was given. Lastly, the response from invoking the EGUI application contains the item description, the unit cost for the item, and the status of the order.

4. On the **Select a Message** dialog, expand **CATAL** → **CATAL.Interface** → **Messages** and select **processOrderMessages.mxsd** → **inProcessOrderRequestMsg**, as shown in Figure 11-66 and click **OK**.



Select a message to use as the root of a mapping statement.

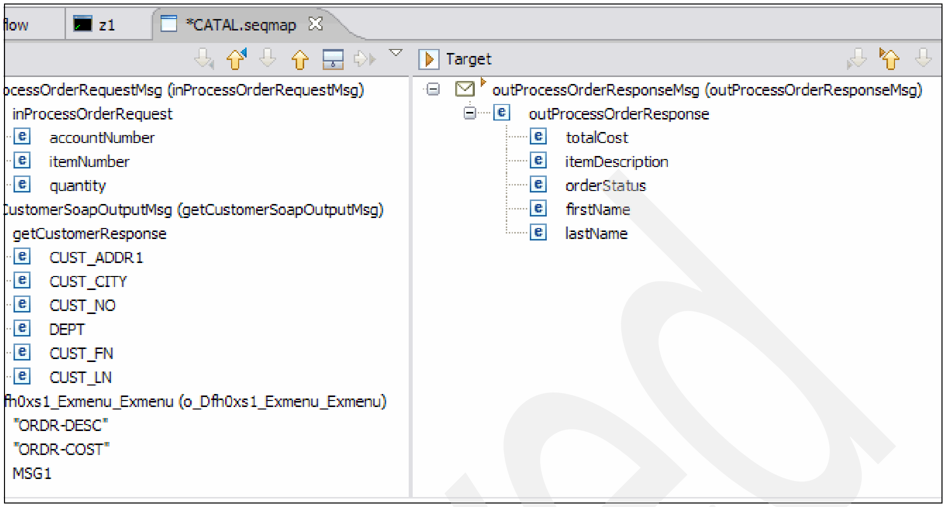
Figure 11-66 Selecting inProcessOrderRequestMsg as one input for variableAssignOutput

5. Repeat this process of adding a message mapping input *two* more times:

   – For the second time, expand **CATAL** → **CATAL.OutboundWebService** → **Messages** and select **GetCustomerMessages.mxsd** → **getCustomerSoapOutputMsg**.

   – For the third time, expand **CATAL** → **CATAL.Interface** → **Messages** and select **o_Dfh0xs1_Exmenu_Exmenu.mxsd** → **o_Dfh0xs1_Exmenu_Exmenu**.

   You see a window similar to what is shown in Figure 11-67 on page 360 after adding the three message mapping inputs.



```
low    z1    *CATAL.seqmap ☒
                                              Target
cessOrderRequestMsg (inProcessOrderRequestMsg)      outProcessOrderResponseMsg (outProcessOrderResponseMsg)
inProcessOrderRequest                                  outProcessOrderResponse
   accountNumber                                          totalCost
   itemNumber                                             itemDescription
   quantity                                               orderStatus
CustomerSoapOutputMsg (getCustomerSoapOutputMsg)          firstName
getCustomerResponse                                       lastName
   CUST_ADDR1
   CUST_CITY
   CUST_NO
   DEPT
   CUST_FN
   CUST_LN
fh0xs1_Exmenu_Exmenu (o_Dfh0xs1_Exmenu_Exmenu)
"ORDR-DESC"
"ORDR-COST"
MSG1
```

Figure 11-67 Source and Target Mappings for variableAssignOutput

6. Next, you use the information in Figure 11-67 and Table 11-3 as a guide to map between source and target elements. Use drag and drop (click the Source element, hold the left mouse button, drag the variable to the Target element, and release the left mouse button) to perform the mapping of all five variables. We will edit the mappings after the initial mapping is done.

Table 11-3 Mappings for the variableAssignOutput node

Source element	**Target element**
ORDR-DESC	itemDescription
ORDR-COST	totalCost
MSG1	orderStatus
CUST_FN	firstName
CUST_LN	lastName

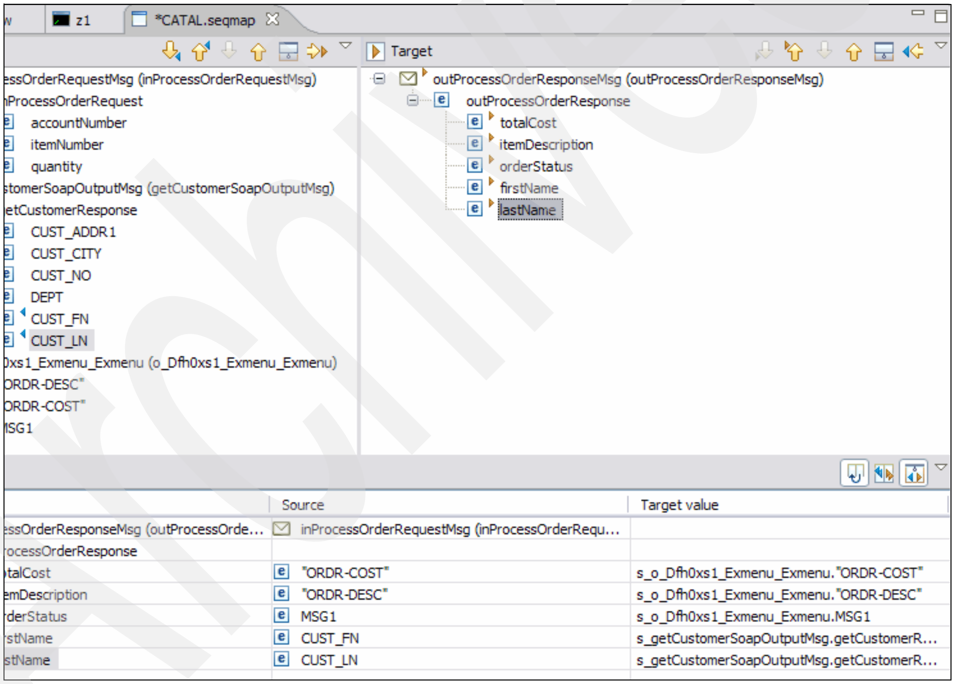
We will now further refine the target values for `totalCost`, `firstName`, and `lastName`.

For `totalCost`, we compute the value as the product of the item unit cost (`ORDR-COST`) and order quantity (`quantity`). Because both of these elements are defined as type `string`, we need to convert these element types to type `int` before they can be multiplied. We use the CAST function that we used in the previous mapping.

For the `firstName` element, the response from the Web service call actually has this value starting at offset 2. For the `lastName` element, the value starts at offset 3. We use the string function SUBSTRING to extract 20 characters starting at the appropriate offsets for those elements.

> **Note**: The Service Flow Modeler tool in RDz does not currently support nillable attributes in WSDL files. To compensate, we are using the substring function to ignore the byte positions that indicate whether an attribute is nillable or not. This support will be addressed in a future release of RDz. At the time of writing this book, RDz V7.5 has still not addressed this situation.

Figure 11-68 shows what the mapping routine looks like after performing the initial mapping.



	Source	Target value
essOrderResponseMsg (outProcessOrde...	inProcessOrderRequestMsg (inProcessOrderRequ...	
rocessOrderResponse		
otalCost	"ORDR-COST"	s_o_Dfh0xs1_Exmenu_Exmenu."ORDR-COST"
emDescription	"ORDR-DESC"	s_o_Dfh0xs1_Exmenu_Exmenu."ORDR-DESC"
rderStatus	MSG1	s_o_Dfh0xs1_Exmenu_Exmenu.MSG1
rstName	CUST_FN	s_getCustomerSoapOutputMsg.getCustomerR...
stName	CUST_LN	s_getCustomerSoapOutputMsg.getCustomerR...

Figure 11-68 Initial Mapping routine for variableAssignOutput

7. In the Overview section of the mapping editor, select **totalCost**, right-click, and select **Edit Mapping** from the context-sensitive menu. In the Value of target field area, replace s_o_Dfh0xs1_Exmenu_Exmenu."ORDR-COST" with `CAST((s_o_Dfh0xs1_Exmenu_Exmenu."ORDR-COST") AS FLOAT) *`

`CAST((s_inProcessOrderRequestMsg.inProcessOrderRequest.quantity) AS INTEGER).`

Click **OK** to apply the changes.

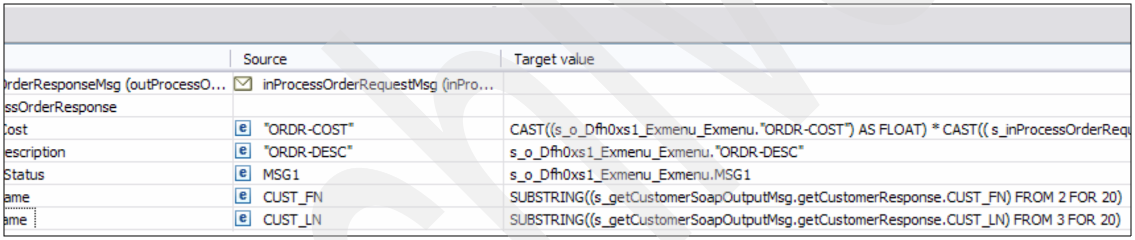
8. Select the target element **firstName** from the Overview section, right-click, and select **Edit Mapping** from the context-sensitive menu. Replace s_getCustomerSoapOutputMsg.getCustomerResponse.CUST_FN with `SUBSTRING((s_getCustomerSoapOutputMsg.getCustomerResponse.CUST_FN) FROM 2 FOR 20)`

   Click **OK** to apply the changes.

9. Select the target element **lastName** from the Overview section, right-click, and select **Edit Mapping** from the context-sensitive menu. Replace s_getCustomerSoapOutputMsg.getCustomerResponse.CUST_LN with `SUBSTRING((s_getCustomerSoapOutputMsg.getCustomerResponse.CUST_LN) FROM 3 FOR 20)`

   Click **OK** to apply the changes.

   The target values in the Overview section now look as shown in Figure 11-69.



	Source	Target value
rderResponseMsg (outProcessO…	✉ inProcessOrderRequestMsg (inPro…	
ssOrderResponse		
ost	e "ORDR-COST"	CAST((s_o_Dfh0xs1_Exmenu_Exmenu."ORDR-COST") AS FLOAT) * CAST((s_inProcessOrderRequ
escription	e "ORDR-DESC"	s_o_Dfh0xs1_Exmenu_Exmenu."ORDR-DESC"
Status	e MSG1	s_o_Dfh0xs1_Exmenu_Exmenu.MSG1
ame	e CUST_FN	SUBSTRING((s_getCustomerSoapOutputMsg.getCustomerResponse.CUST_FN) FROM 2 FOR 20)
ame	e CUST_LN	SUBSTRING((s_getCustomerSoapOutputMsg.getCustomerResponse.CUST_LN) FROM 3 FOR 20)

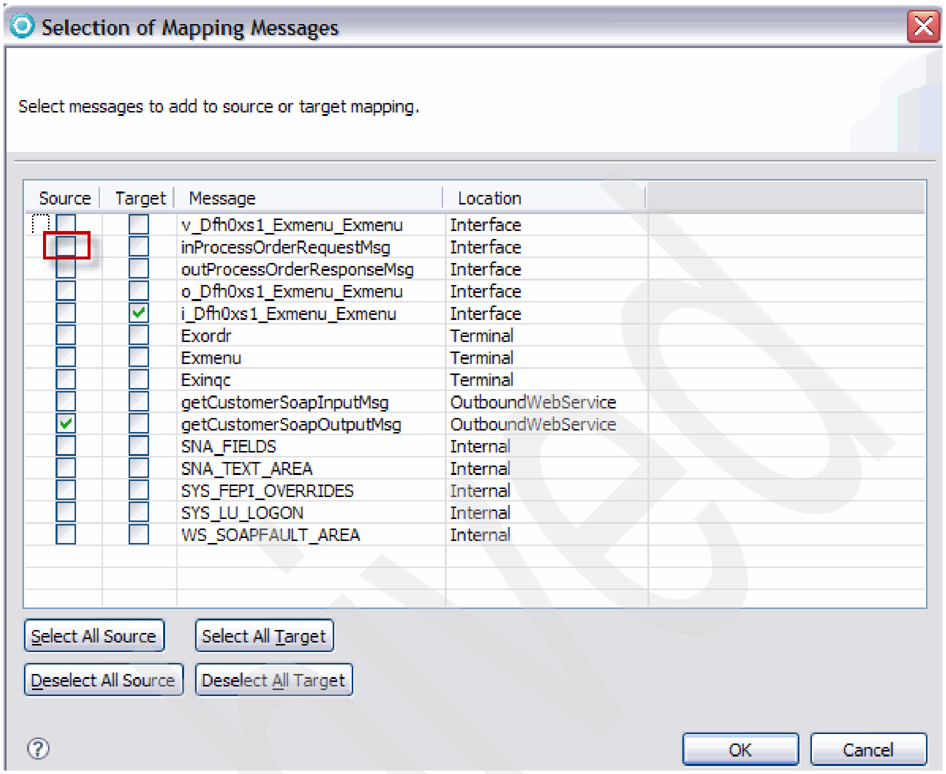
Figure 11-69 Target values after having customized mappings

10. Press Ctrl+s to save the changes.
11. Close the **CATAL.seqmap**.

11.5.3 Assign node

You must map the flow from the getCustomer node to the Dfh0xs1_Exmenu_Exmenu node:

1. A quick way to create the mapping is to select the connector on the **CATAL.seqflow** between those two nodes, right-click it, and select **Initialize Mapping** from the context-sensitive menu. Complete this action now, which brings up a dialog, as shown in Figure 11-70 on page 363.



Select messages to add to source or target mapping.

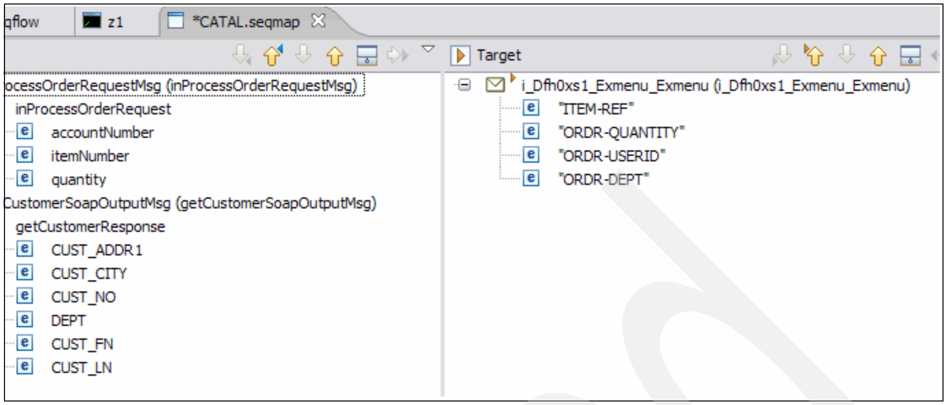
Source	Target	Message	Location
□	□	v_Dfh0xs1_Exmenu_Exmenu	Interface
□	□	inProcessOrderRequestMsg	Interface
□	□	outProcessOrderResponseMsg	Interface
□	□	o_Dfh0xs1_Exmenu_Exmenu	Interface
□	☑	i_Dfh0xs1_Exmenu_Exmenu	Interface
□	□	Exordr	Terminal
□	□	Exmenu	Terminal
□	□	Exinqc	Terminal
□	□	getCustomerSoapInputMsg	OutboundWebService
☑	□	getCustomerSoapOutputMsg	OutboundWebService
□	□	SNA_FIELDS	Internal
□	□	SNA_TEXT_AREA	Internal
□	□	SYS_FEPI_OVERRIDES	Internal
□	□	SYS_LU_LOGON	Internal
□	□	WS_SOAPFAULT_AREA	Internal

Figure 11-70 Selection of Mapping Messages for Assign node

Note: When you initialized the mapping, it created an Assign node named `Assign` and opened the mapping editor. The mapping editor shows inputs defined for both the source and target. However, you will need additional mapping input for the source in order to obtain the values for the item number and the order quantity. Recall that this data is passed in the input request message.

2. Check **inProcessOrderRequestMsg** in the Source column, and click **OK**.

   The CATAL.seqmap now looks like what is shown in Figure 11-71 on page 364.



```
ocessOrderRequestMsg (inProcessOrderRequestMsg)
  inProcessOrderRequest
    e  accountNumber
    e  itemNumber
    e  quantity
CustomerSoapOutputMsg (getCustomerSoapOutputMsg)
  getCustomerResponse
    e  CUST_ADDR1
    e  CUST_CITY
    e  CUST_NO
    e  DEPT
    e  CUST_FN
    e  CUST_LN
```

```
i_Dfh0xs1_Exmenu_Exmenu (i_Dfh0xs1_Exmenu_Exmenu)
  e  "ITEM-REF"
  e  "ORDR-QUANTITY"
  e  "ORDR-USERID"
  e  "ORDR-DEPT"
```

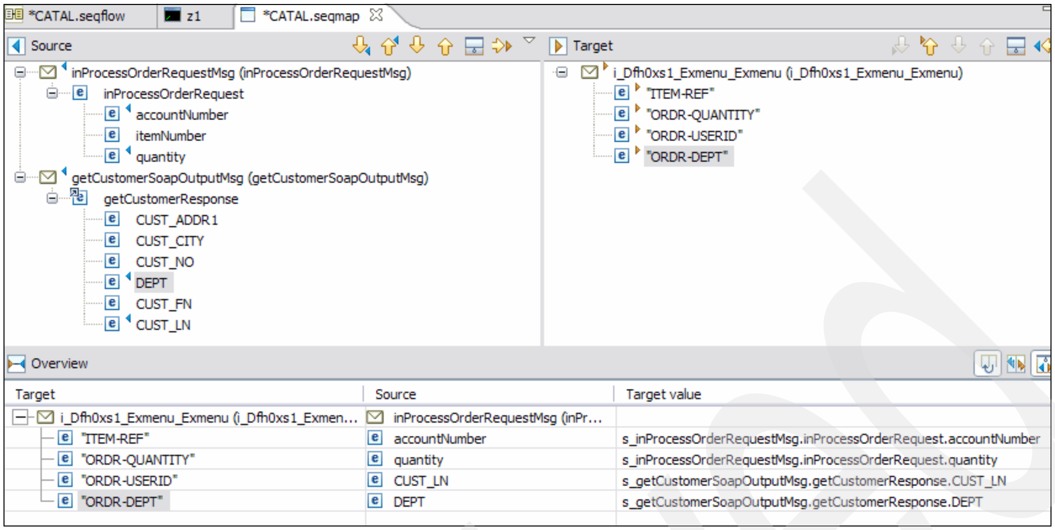
Figure 11-71 Source and target mapping for assign node after initialize mapping

3. Use Table 11-4 as a guide for your initial mapping by dragging and dropping from the source element to the related target element.

Table 11-4 Mappings

Source element	Target element
itemNumber	ITEM-REF
quantity	ORDR-QUANTITY
dept	ORDR-DEPT
CUST_LN	ORDR-USERID

The CATAL.seqmap now looks as shown in Figure 11-72 on page 365.



Source:

- inProcessOrderRequestMsg (inProcessOrderRequestMsg)
  - inProcessOrderRequest
    - accountNumber
    - itemNumber
    - quantity
- getCustomerSoapOutputMsg (getCustomerSoapOutputMsg)
  - getCustomerResponse
    - CUST_ADDR1
    - CUST_CITY
    - CUST_NO
    - DEPT
    - CUST_FN
    - CUST_LN

Target:

- i_Dfh0xs1_Exmenu_Exmenu (i_Dfh0xs1_Exmenu_Exmenu)
  - "ITEM-REF"
  - "ORDR-QUANTITY"
  - "ORDR-USERID"
  - "ORDR-DEPT"

Target	Source	Target value
i_Dfh0xs1_Exmenu_Exmenu (i_Dfh0xs1_Exmen…	inProcessOrderRequestMsg (inPr…	
"ITEM-REF"	accountNumber	s_inProcessOrderRequestMsg.inProcessOrderRequest.accountNumber
"ORDR-QUANTITY"	quantity	s_inProcessOrderRequestMsg.inProcessOrderRequest.quantity
"ORDR-USERID"	CUST_LN	s_getCustomerSoapOutputMsg.getCustomerResponse.CUST_LN
"ORDR-DEPT"	DEPT	s_getCustomerSoapOutputMsg.getCustomerResponse.DEPT

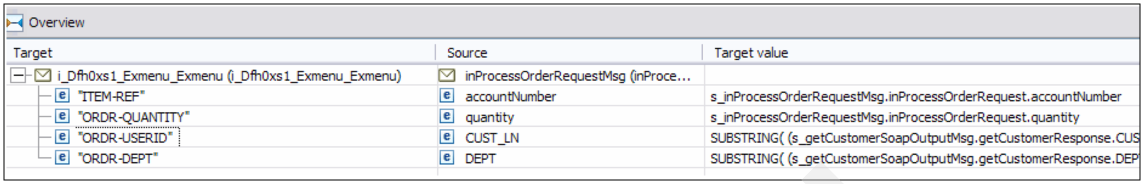
Figure 11-72 CATAL.seqmap after mappings

We will further refine the target values for `ORDR-DEPT` and `ORDR-USERID`.

We will use a substring of `CUST_LN` as the target value for `ORDR-USERID`. As discussed previously, the value of the `CUST_LN` source element starts at offset 3. Because `ORDR-USERID` is eight characters in length, we will use the SUBSTRING function to extract eight characters starting from offset 3.

4. In the Overview section of the mapping editor, select **ORDR-DEPT**, right-click it, and select **Edit Mapping**. In the Value of target field area, replace s_getCustomerSoapOutputMsg.getCustomerResponse.DEPT with `SUBSTRING((s_getCustomerSoapOutputMsg.getCustomerResponse.DEPT) FROM 1 FOR 8)`.
5. Click **OK** to apply the changes.
6. In the Overview section of the mapping editor, select **ORDR-USERID**, right-click it, and select **Edit Mapping**. In the Value of target field area, replace s_getCustomerSoapOutputMsg.getCustomerResponse.CUST_LN with
   `SUBSTRING((s_getCustomerSoapOutputMsg.getCustomerResponse.CUST_LN) FROM 3 FOR 8)`.
7. Click **OK** to apply the changes.
8. Press Ctrl+s to save your changes.

   The mapping for the Assign node Assign looks like Figure 11-73 on page 366.



Overview

Target	Source	Target value
i_Dfh0xs1_Exmenu_Exmenu (i_Dfh0xs1_Exmenu_Exmenu)	inProcessOrderRequestMsg (inProce...	
"ITEM-REF"	accountNumber	s_inProcessOrderRequestMsg.inProcessOrderRequest.accountNumber
"ORDR-QUANTITY"	quantity	s_inProcessOrderRequestMsg.inProcessOrderRequest.quantity
"ORDR-USERID"	CUST_LN	SUBSTRING((s_getCustomerSoapOutputMsg.getCustomerResponse.CUS
"ORDR-DEPT"	DEPT	SUBSTRING((s_getCustomerSoapOutputMsg.getCustomerResponse.DEP

Figure 11-73 Mapping for Assign

9. Close the mapping editor and select the flow editor. Because there were changes made to the flow, press Ctrl+s to save your changes.

   Your updated main flow needs to look like Figure 11-74.

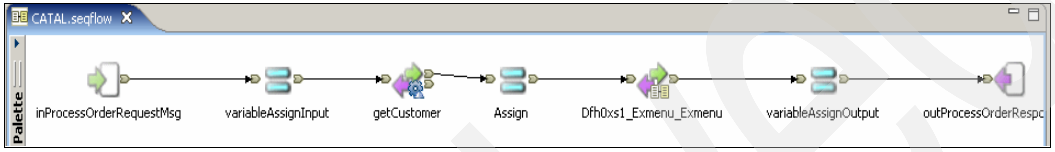


Figure 11-74 Updated CATAL main flow

10. Click **File** → **Save all**.

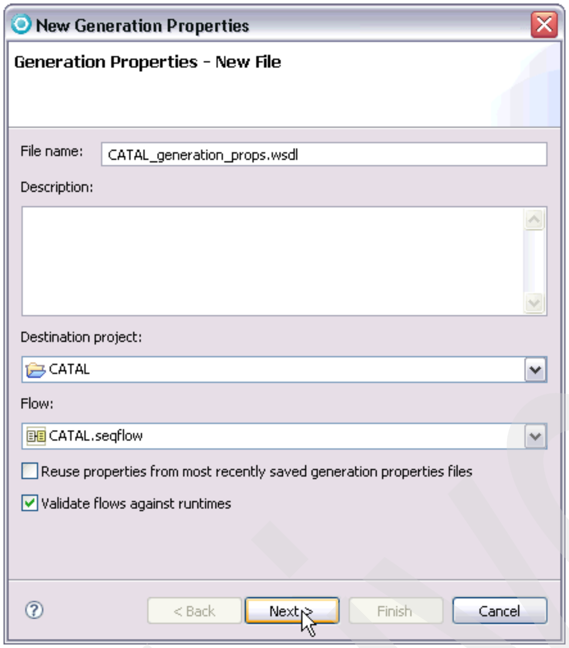
11.6 Generating the runtime artifacts

After modeling the Service Flow application, the next step is to generate the runtime artifacts that are needed to build, deploy, and run it You generate the runtime artifacts through the specification of *generation properties*. A *generation properties file* is associated with a Service Flow.

You have created two flows: a main flow for the Catalog Order (`CATAL`) and a subflow that represents the terminal interactions with the EGUI application. Therefore, you will need to create two generation properties files to govern the generation of the runtime artifacts for those components of the Service Flow application:

1. In the EST Project Explorer view, select the **CATAL.seqflow** file, right-click it, and select **New Generation Properties file**.

   On the Generation Properties - New File dialog, specify a File name of `CATAL_generation_props.wsdl`, as shown in Figure 11-75 on page 367, and click **Next**.



Generation Properties - New File

File name: CATAL_generation_props.wsdl

Description:

Destination project: CATAL

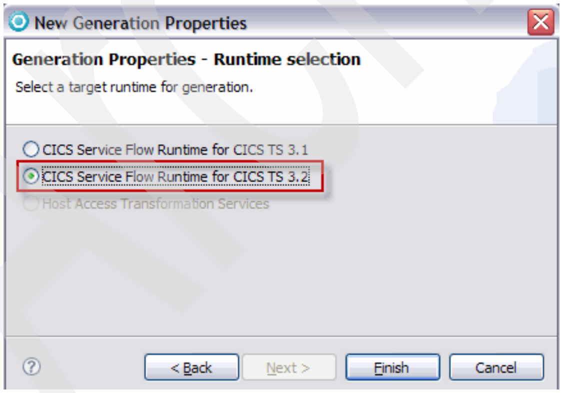
Flow: CATAL.seqflow

□ Reuse properties from most recently saved generation properties files

☑ Validate flows against runtimes

Figure 11-75 CATAL Generation Properties file

2. On the Generation Properties - Runtime selection dialog, select **CICS Service Flow Runtime for CICS TS 3.2,** and click **Finish** as shown in Figure 11-76.



Generation Properties - Runtime selection

Select a target runtime for generation.

○ CICS Service Flow Runtime for CICS TS 3.1

● CICS Service Flow Runtime for CICS TS 3.2

○ Host Access Transformation Services

Figure 11-76 Selecting a target run time for CATAL generation

3. The Generation Properties editor (Figure 11-77 on page 369) opens with Generate Runtime Code disabled, because there are additional items that must be specified:

   a. Make sure that the following values are specified:

      - For the Request Name and Transaction ID, use `IT01`.
      - Specify a Program Name of `CATAL`.
      - Select **Generate Internal Data Structures**.

   b. Select **Web Services for CICS** as the specification for Generate Web Service Files. You need this selection, because you will want to access the Service Flow application via a Web service interface.

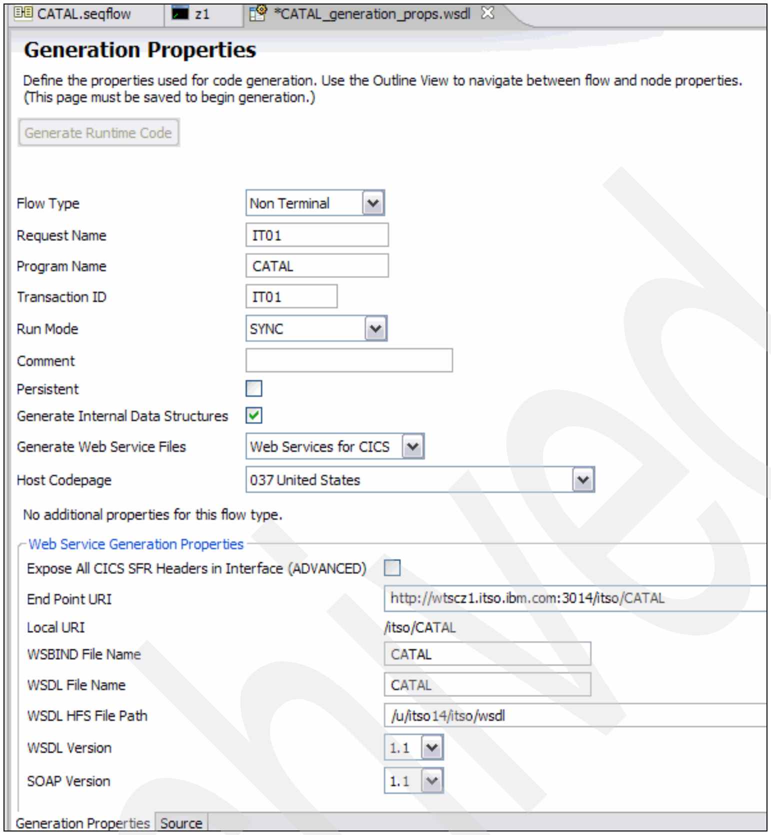
   c. Specify an End Point URI that maps to your CICS system, typically of the form: `http://`*`hostname`*`:`*`tcpipservice_port`*`/`*`local_URI`*, where *`hostname`* resolves to the z/OS system where a CICS TS region is running, *`tcpipservice_port`* is the port number specified by a TCPIPSERVICE resource on that CICS region, and *`local_URI`* is the resource path that will be used in an URIMAP resource.

      For example, we used `http://wtscz1.itso.ibm.com:3014/itso/CATAL`.

   d. Make sure that the WSBind and WSDL file names are `CATAL` in uppercase.

   e. Specify a Uniform Symbol Specification directory on your target z/OS system for WSDL HFS File Path, for example, `/u/itso14/itso/wsdl`.

      Refer to Figure 11-77 on page 369.



CATAL.seqflow | z1 | *CATAL_generation_props.wsdl

Generation Properties

Define the properties used for code generation. Use the Outline View to navigate between flow and node properties. (This page must be saved to begin generation.)

Generate Runtime Code

Flow Type: Non Terminal
Request Name: IT01
Program Name: CATAL
Transaction ID: IT01
Run Mode: SYNC
Comment:
Persistent: □
Generate Internal Data Structures: ☑
Generate Web Service Files: Web Services for CICS
Host Codepage: 037 United States

No additional properties for this flow type.

Web Service Generation Properties

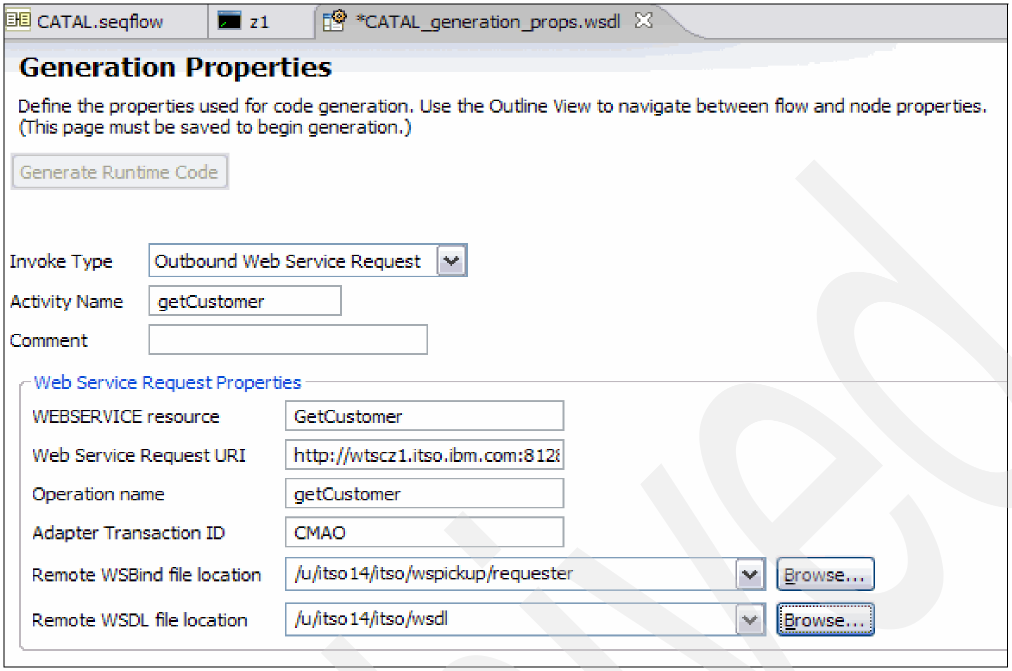
Expose All CICS SFR Headers in Interface (ADVANCED): □
End Point URI: http://wtscz1.itso.ibm.com:3014/itso/CATAL
Local URI: /itso/CATAL
WSBIND File Name: CATAL
WSDL File Name: CATAL
WSDL HFS File Path: /u/itso14/itso/wsdl
WSDL Version: 1.1
SOAP Version: 1.1

Generation Properties | Source

Figure 11-77 Generation Properties for the main CATAL flow

4. In the Outline view (left lower corner), click **getCustomer** to specify the generation properties for the Outbound Web service invoke node. Refer to Figure 11-78 on page 370 for details:

   - Specify a Uniform Symbol Specification directory on your z/OS system for the Remote WSBind file location. This directory is a pickup directory associated with a service requester pipeline in your CICS region. For example, we used `/u/itso14/itso/wspickup/requester`.
   - Specify a Uniform Symbol Specification directory for Remote WSDL file location, for example, `/u/itso14/wsdl`.



Generation Properties

Define the properties used for code generation. Use the Outline View to navigate between flow and node properties. (This page must be saved to begin generation.)

Invoke Type: Outbound Web Service Request

Activity Name: getCustomer

Comment:

Web Service Request Properties

WEBSERVICE resource: GetCustomer

Web Service Request URI: http://wtscz1.itso.ibm.com:812

Operation name: getCustomer

Adapter Transaction ID: CMAO

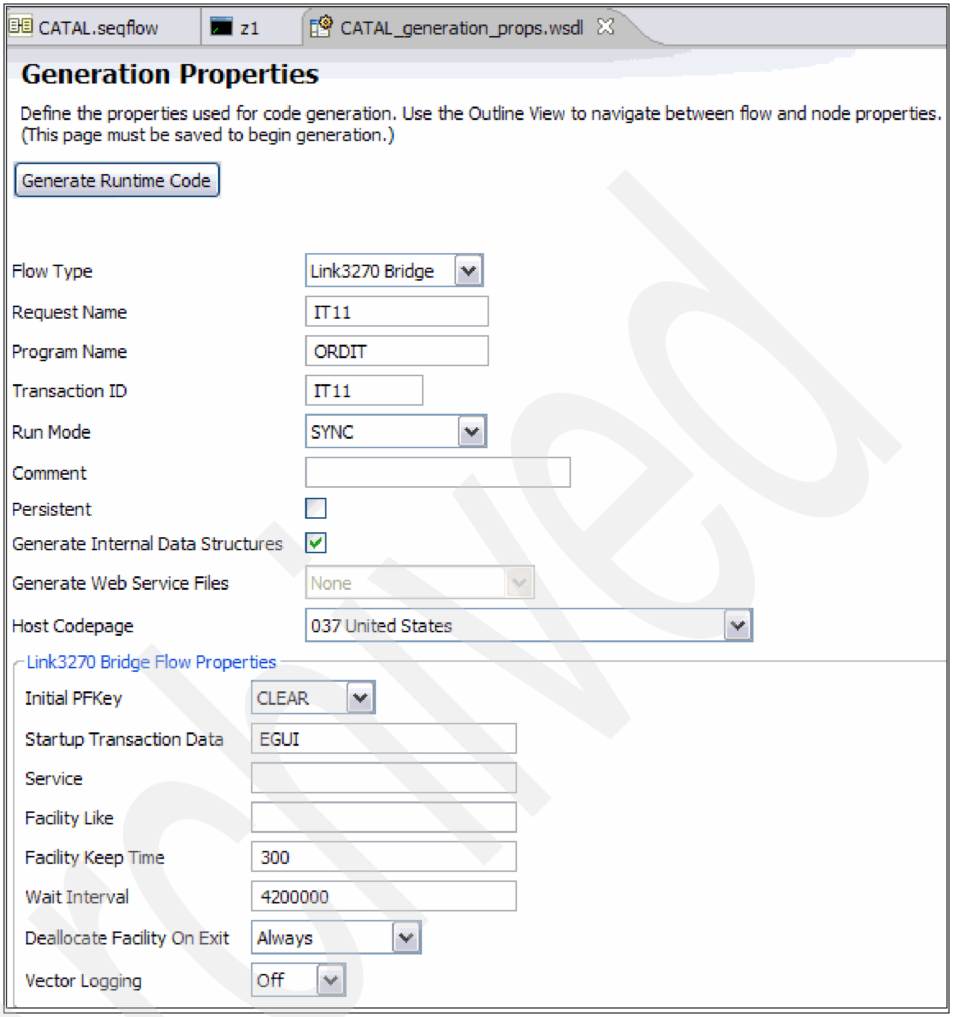
Remote WSBind file location: /u/itso14/itso/wspickup/requester

Remote WSDL file location: /u/itso14/itso/wsdl

Figure 11-78 Generation Properties for the main CATAL flow: getCustomer

> **Tip**: If the host component of RDz is set up, you have defined a host connection, and you are connected to a z/OS system, you can use Browse to navigate to the WSBind and WSDL file locations.

5. In the Outline view, click **Dfh0xs1_Exmenu_Exmenu (invalid)** to specify the generation properties for the Terminal Invoke node. Use Figure 11-79 on page 371 as a guide:
   - Specify a flow type of `Link3270 Bridge`.
   - Specify a Request Name and Transaction ID of `IT11`.
   - Specify a Program Name of `ORDIT`.
   - Select **Generate Internal Data Structures**.
   - The Initial PFKey setting must be **CLEAR**, and the Startup Transaction Data must be **EGUI**, which is the transaction ID that will initiate the sample catalog manager application.



Generation Properties

Define the properties used for code generation. Use the Outline View to navigate between flow and node properties. (This page must be saved to begin generation.)

Flow Type	Link3270 Bridge
Request Name	IT11
Program Name	ORDIT
Transaction ID	IT11
Run Mode	SYNC
Comment	
Persistent	□
Generate Internal Data Structures	☑
Generate Web Service Files	None
Host Codepage	037 United States

Link3270 Bridge Flow Properties

Initial PFKey	CLEAR
Startup Transaction Data	EGUI
Service	
Facility Like	
Facility Keep Time	300
Wait Interval	4200000
Deallocate Facility On Exit	Always
Vector Logging	Off

Figure 11-79 Specifying generation properties for terminal subflow

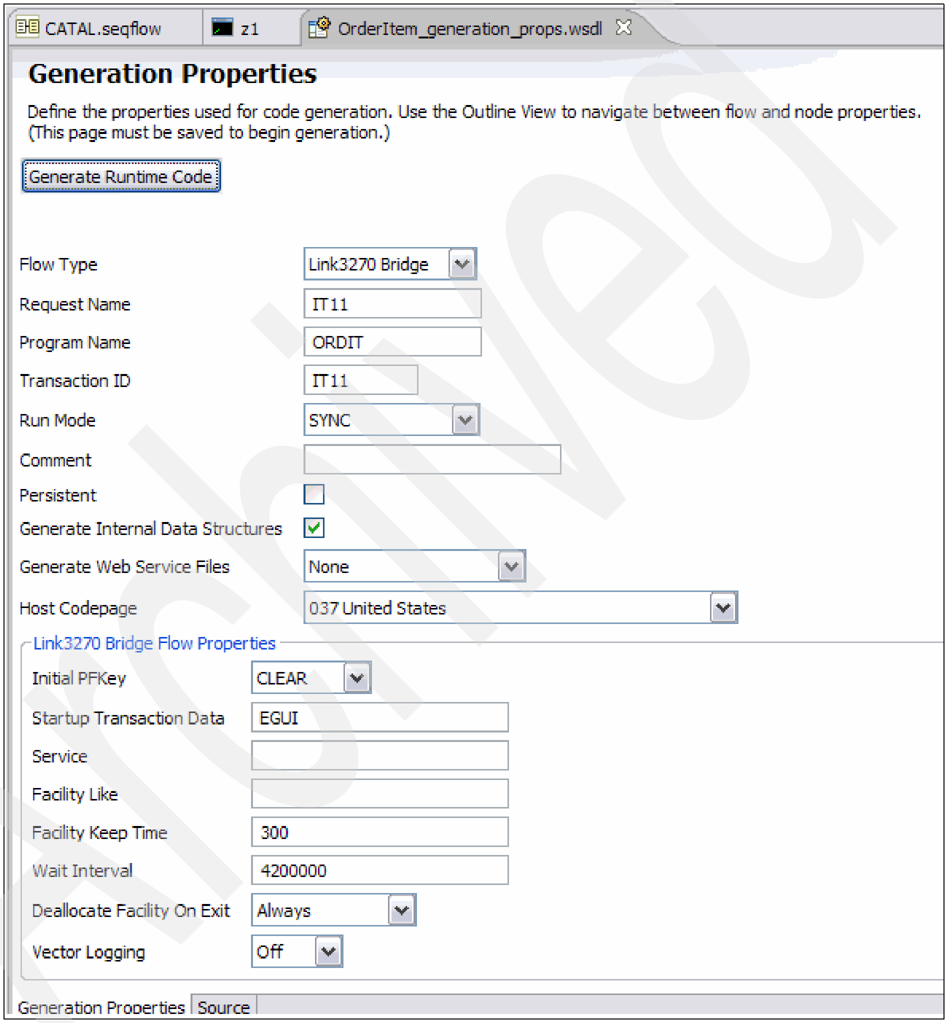
6. Press Ctrl+s to save your changes. Note that Generate Runtime Code is now enabled.

   Currently, when you generate the runtime code for a main flow, it does not generate the runtime code for the associated subflows, which means that you will have to re-specify the settings for the terminal subflow.

7. Close the Generation Properties editor.
8. In the EST Project Explorer view, select **CATAL** → **Flows** → **Dfh0xs1_Exmenu_Exmenu.seqflow** file, right-click it, and select **New Generation Properties** file.

9. On the Generation Properties - New File dialog, specify a File name of `OrderItem_generation_props.wsdl`. Select **Reuse properties from most recently saved generation properties files**. Click **Next**.

10. Specify **CICS Service Flow Runtime for CICSTS 3.2** as the target run time, and click **Finish**. Your OrderItem Generation Properties pane looks like Figure 11-80.



Generation Properties

Define the properties used for code generation. Use the Outline View to navigate between flow and node properties. (This page must be saved to begin generation.)

Flow Type	Link3270 Bridge
Request Name	IT11
Program Name	ORDIT
Transaction ID	IT11
Run Mode	SYNC
Comment	
Persistent	□
Generate Internal Data Structures	☑
Generate Web Service Files	None
Host Codepage	037 United States

Link3270 Bridge Flow Properties

Initial PFKey	CLEAR
Startup Transaction Data	EGUI
Service	
Facility Like	
Facility Keep Time	300
Wait Interval	4200000
Deallocate Facility On Exit	Always
Vector Logging	Off

Figure 11-80 Specifying OrderItem generation properties

11. Press Ctrl+s to save your changes. Note that Generate Runtime Code is now enabled.

12. Close the Generation Properties editor for all open windows.

You are now ready to generate the runtime artifacts that are needed to deploy a Service Flow application. These artifacts include COBOL programs, copybooks (not generated if “Generate Internal Data Structures” is selected in the generation properties), the WSBind file, and the jobs that are needed to define resources and build the Service Flow application. You have the option of generating these artifacts directly to the target z/OS system to facilitate the build and deployment. This option will also ensure that CICS Web Services artifacts, such as the WSBind file, are copied correctly to the appropriate Uniform Symbol Specification directory.

When you created the generation properties files, these files were placed in a new Generation folder under the CATAL Service Flow project. There will be a CICS SFR 3.2 subfolder, because you specified the CICS Service Flow Runtime for CICS TS 3.2 as the target run time.

13. In the EST Project Explorer view, select the **CATAL** → **Generation** → **CICS SFR 3.2** → **CATAL** → **CATAL_generation_props.wsdl** file, right-click it, and select **Generate Runtime Code**. Alternatively, if you had the generation properties file opened, you can click Generate Runtime Code.

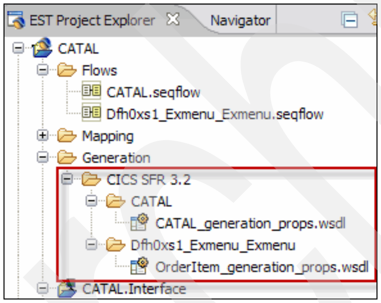
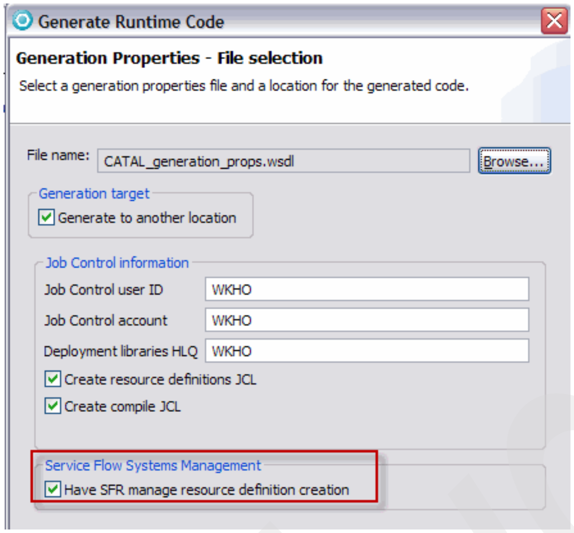


Figure 11-81 Generation folder

14. On the Generation Properties - File selection dialog, specify your z/OS user ID as the `Job Control user ID` and `Job Control account`.

15. For the deployment libraries HLQ, specify your user ID. The generation wizard assumes that the data sets <*HLQ*>`.USER.JCLLIB`, <HLQ>`.USER.SRCLIB`, <*HLQ*>`.USER.COPYLIB`, and <*HLQ*>`.USER.LINKLIB` exist, because these data sets will be referenced in certain jobs that the generation wizard generates.

    Also, select **Have SFR manage resource definition creation**, which lets the Service Flow run time install the required resource definitions (`TRANSACTION`, `PROGRAM`, and `PROCESSTYPE`) as it installs Service Flows. Refer to Figure 11-82 on page 374.


Generate Runtime Code

Generation Properties - File selection

Select a generation properties file and a location for the generated code.

File name: CATAL_generation_props.wsdl

Generation target

☑ Generate to another location

Job Control information

Job Control user ID: WKHO

Job Control account: WKHO

Deployment libraries HLQ: WKHO

☑ Create resource definitions JCL

☑ Create compile JCL

Service Flow Systems Management

☑ Have SFR manage resource definition creation

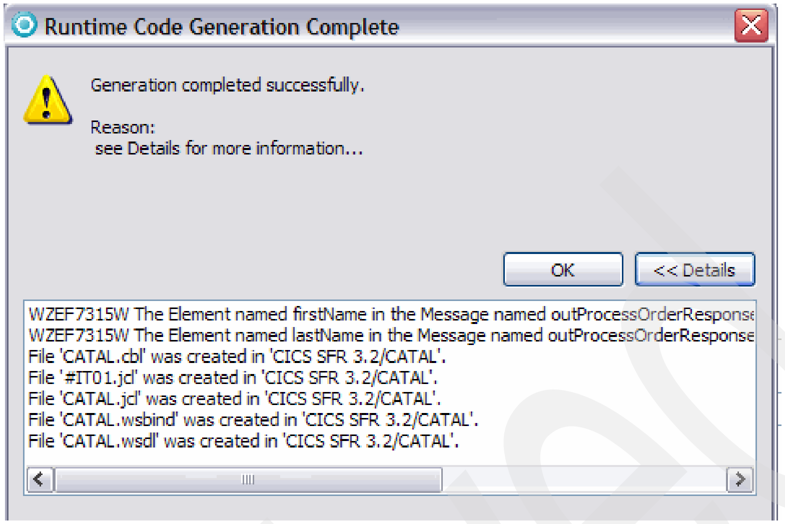
Figure 11-82 Generating runtime code

16. To simplify this sample, do not ask the generation wizard to deploy to a remote target location, so leave that box unselected. Click **Finish**.

> **Tip:** Using the remote connectivity facilities of RDz greatly simplifies the task of building and deploying the required development and runtime artifacts to the target z/OS and CICS system. If the remote facilities are configured and activated on your site and you are connected to the target system, the Service Flow runtime generation wizard guides you through selecting the target destinations on the remote system.

You see a Runtime Code Generation Complete dialog indicating that the generation was successful. Click **OK** to dismiss the dialog.

If you click Details, you see the same output as shown in Figure 11-83 on page 375.



Generation completed successfully.

Reason:
 see Details for more information...

```
WZEF7315W The Element named firstName in the Message named outProcessOrderResponse
WZEF7315W The Element named lastName in the Message named outProcessOrderResponse
File 'CATAL.cbl' was created in 'CICS SFR 3.2/CATAL'.
File '#IT01.jcl' was created in 'CICS SFR 3.2/CATAL'.
File 'CATAL.jcl' was created in 'CICS SFR 3.2/CATAL'.
File 'CATAL.wsbind' was created in 'CICS SFR 3.2/CATAL'.
File 'CATAL.wsdl' was created in 'CICS SFR 3.2/CATAL'.
```

Figure 11-83 Successful generation of flow

17. Repeat the generation process for the `OrderItem` generation properties file.

    In the EST Project Explorer view, notice the additional artifacts generated for CATAL, as shown in Figure 11-84 on page 376.

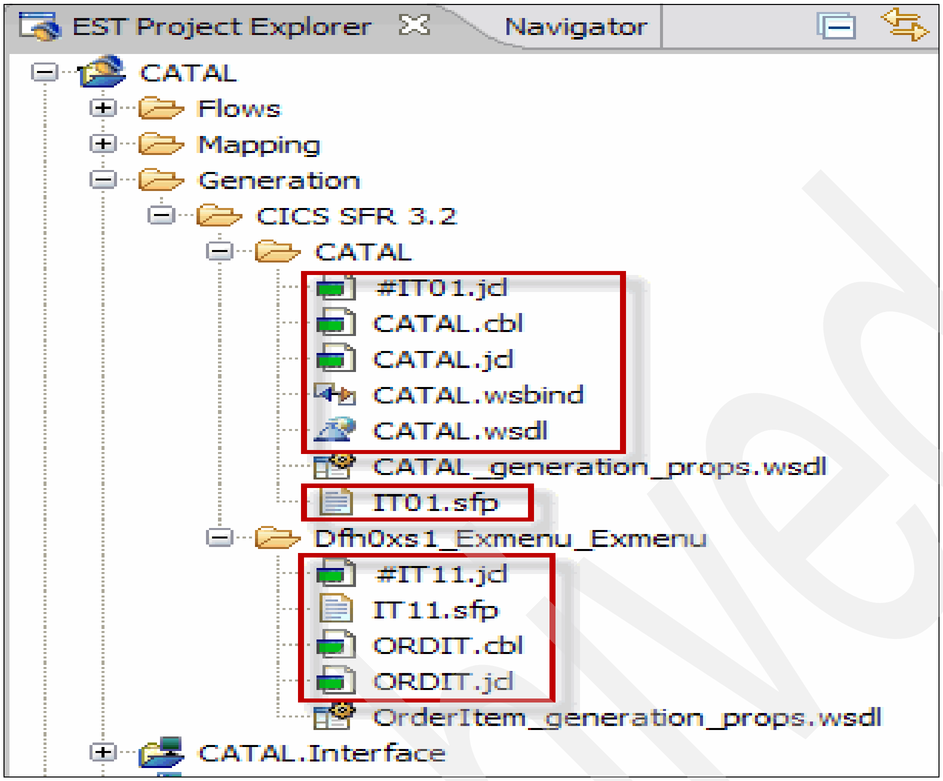


Figure 11-84 Generated runtime artifacts for CATAL and OrderItem

Table 11-5 on page 377 describes what has been generated for the main flow (`CATAL`).

Table 11-5 Generated components for the main flow

Generated artifact	Description
#IT01.jcl	This job defines the appropriate PROGRAM, TRANSACTION, and PROCESSTYPE resources to the target CICS system. You might want to modify the name of the resource group. If you had checked the box to have SFR manage resource definitions, this job might be skipped.
CATAL.cbl	This COBOL program represents the flow application (navigator, adapter).
CATAL.jcl	This Job compiles and link-edits CATAL into a load module.
CATAL.wsbind	This CICS Web service WSBind file describes the Web service interface to CATAL. It must be deployed to a pickup directory associated with a service provider pipeline.
CATAL.wsdl	This WSDL describes the CICS-based Web service. This WSDL is typically used to generate the client application that will access the flow application via the Web service interface. You will use this WSDL to test the flow using the built-in Web Services Explorer in RDz.
IT01.sfp	This file is the Service Flow properties file for the CATAL flow application. This file describes the modeled Service Flow and contains the definition of the server adapters, programs, and transactions that are required for the Service Flow to run. This file must be deployed to a Service Flow deployment directory on the Uniform Symbol Specification hierarchical file system (HFS) of the target z/OS system.

On successful generation of the subflow, you get the following four additional artifacts (Table 11-6 on page 378).

Table 11-6 Generated components for the subflow

Generated artifact	Description
#IT11.jcl	This job defines the appropriate PROGRAM, TRANSACTION, and PROCESSTYPE resources to the target CICS system for the OrderItem terminal subflow.
IT11.sfp	This file is the Service Flow properties file for the ORDIT subflow application.
ORDIT.cbl	This COBOL program represents the terminal subflow (Link3270 Bridge adapter) that interacts with the EGUI application.
ORDIT.jcl	This job compiles and link-edits ORDIT into a load module.

Note that there are no WSBind and WSDL files generated, because you did not specify to generate Web Service files, because this subflow application will be driven from the main flow.

18. You can browse the generated artifacts so you are familiar with them.
19. Close all open editors by pressing Ctrl+Shift+F4.

The next logical tasks, which we will discuss, are to modify the jobs, submit the jobs, copy the WSBind file to a CICS Web Services pickup directory, copy the sfp files to the Service Flow deployment directory, activate the newly defined CICS resources, and perform a CICS pipeline scan to pick up the new WEBSERVICE and URIMAP resources that are associated with `CATAL`. After you complete these actions, you can test the flow.

Tip: If you have a remote system definition for your z/OS system in the Remote Systems view, you can customize the Enterprise Service Tools perspective to include the Remote Systems view. From that view, you can connect to the host and enable the remote deployment facility when you generate the runtime artifacts. Being connected to your target z/OS system also facilitates the submission of the jobs to define and build the required CICS runtime resources. Also, note that RDz has host emulation support that enables you to connect to a target CICS system and perform tasks, such as activating (installing) resources via CEDA and performing PIPELINE scans. You might also want to investigate the use of the Application Deployment Manager (ADM), which is a new facility in RDz Version 7.

11.7 Deploying generated artifacts

We will discuss the tasks that you need to accomplish to build and deploy the generated artifacts to the target z/OS system at a high level. You can either use RDz or a combination of ftp and TSO/ISPF to perform most of these tasks:

1. Move or copy the COBOL files (`CATAL.cbl` and `ORDIT.cbl`) to a COBOL source data set on z/OS.
2. Move or copy the JCL files (`#IT01.jcl`, `CATAL.jcl`, `#IT11.jcl`, and `ORDIT.jcl`) to a JCL source data set on z/OS.
3. Move or copy the WSBind file (`CATAL.wsbind`) to a Uniform Symbol Specification pickup directory on z/OS that is associated with a CICS service provider pipeline. Be sure that the copy is done in binary mode.
4. Move or copy the Service Flow properties files (`IT01.sfp` and `IT11.sfp`) to a Uniform Symbol Specification deployment directory on z/OS that is associated with the Service Flow run time.
5. Move or copy the service requester WSBind file (at **CATAL.OutboundWebService** → **Services** → **GetCustomer.wsbind**) to a Uniform Symbol Specification pickup directory on z/OS that is associated with a CICS service requester pipeline. Be sure that the copy is done in binary mode.
6. Modify the compile and link-edit jobs for `CATAL` and `ORDIT` as appropriate and run these jobs. Copy the corresponding load modules to a load library that is part of the CICS DFHRPL concatenation.
7. Optionally, modify and submit the resource definition jobs (`#IT01.jcl` and `#IT11.jcl`). Be sure to add the resource group to your CICS startup resource list. Note that while SFR can manage the resource definitions, these definitions are not persisted in the CICS system definition data set (CSD).
8. Perform pipeline scans (CEMT PERFORM PIPELINE ... SCAN) to pick up the WSBind files that you just copied and to create the associated WEBSERVICE and URIMAP resources to CICS.

> **Assumption**: The appropriate TCPIPSERVICE and PIPELINE (both service provider and requester) resources have been defined and installed.

9. Install the Service Flows that you just deployed using the CMAN transaction.
10. Test the Service Flow application by using the Web Services Explorer in RDz.

11.8 Testing the Service Flow application

If you have successfully completed all the previous steps, you have reached the point to test the application. We assume that you have:

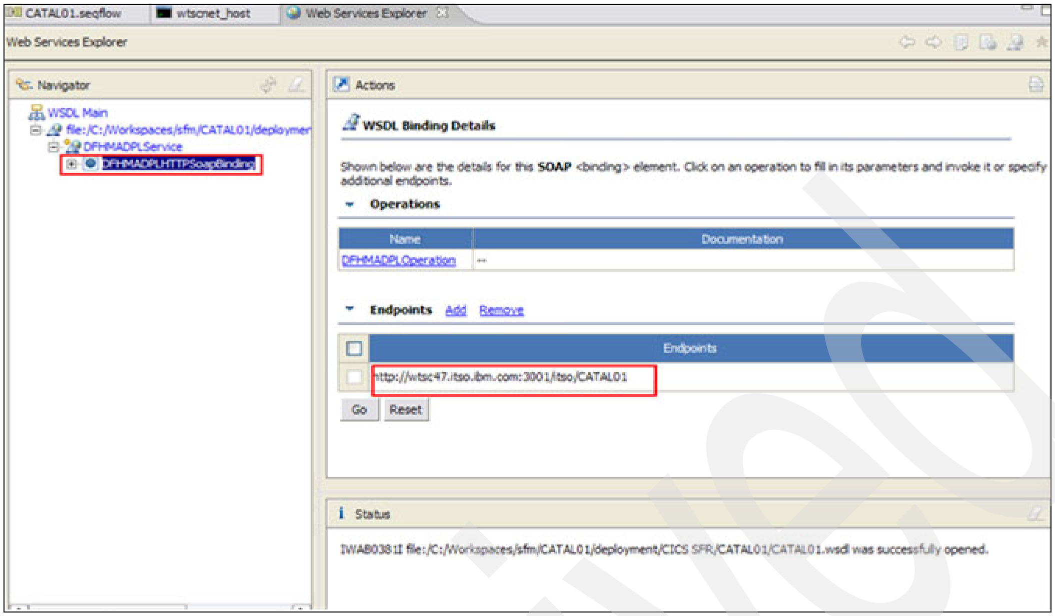
- Installed the Service Flows
- Installed the new resources (TRANSACTION, PROCESSTYPE, and PROGRAM)
- Activated the new WEBSERVICE resource by scanning the appropriate PIPELINEs
- Deployed the Service Flow applications to a load library that is part of the CICS DFHRPL concatenation

You are ready to test this new CICS-based service.

For this segment, you are interacting with the CICS TS region on z/OS:

1. In the Enterprise Service Tools perspective in the EST Project Explorer view, select **CATAL.wsdl**, right-click it, and select **Web Services** → **Test with Web Services Explorer**, which launches the Web Services Explorer in a Web browser.

   You see a window similar to what is shown in Figure 11-85 on page 381.



WSDL Binding Details

Shown below are the details for this **SOAP** <binding> element. Click on an operation to fill in its parameters and invoke it or specify additional endpoints.

Operations

Name	Documentation
DFHMADPLOperation	--

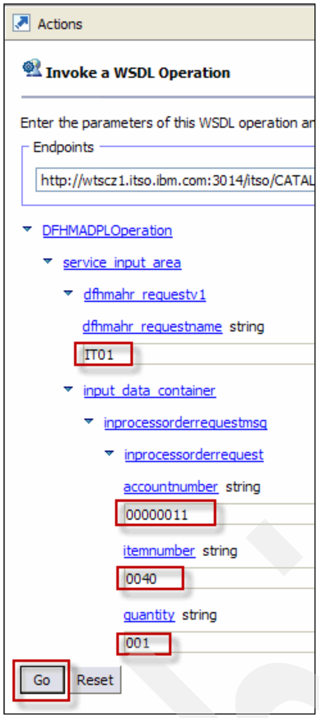
Endpoints Add Remove

□	Endpoints
□	http://wtsc47.itso.ibm.com:3001/itso/CATAL01

IWAB0381I file:/C:/Workspaces/sfm/CATAL01/deployment/CICS SFR/CATAL01/CATAL01.wsdl was successfully opened.

Figure 11-85 Using the Web Services Explorer to test CATAL

2. In the Navigator pane, click the **+** (addition symbol) to the left of **DFHMADPLHTTPSoapBinding**, which shows you an operation named DFHMADPLOperation.
3. Select **DFHMADPLOperation**. The Actions pane of the Web Services Explorer gives you entry fields for the input request message:
   a. Enter `IT01` for the request name (`dfhmahr_requestname`).
   b. Enter `00000011` for the account number (you can try 1 through 12; remember to enter all eight digits).
   c. Enter `0050` for the item number (you can try 0010 through 0060; remember to enter four characters, which means include leading zeros).
   d. Enter `001` for the quantity (you have to enter three characters, which means include leading zeros).
4. Click **Go** to invoke the Web service request.



Actions

Invoke a WSDL Operation

Enter the parameters of this WSDL operation ar

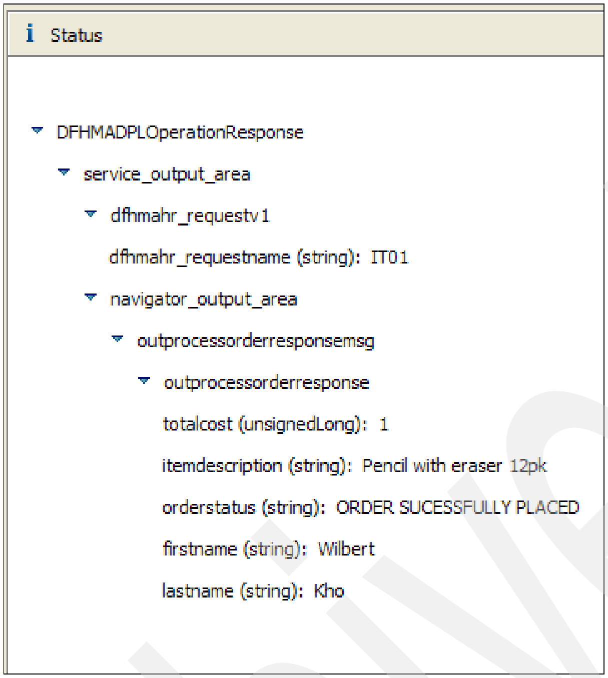
Endpoints

http://wtscz1.itso.ibm.com:3014/itso/CATAL

- DFHMADPLOperation
  - service_input_area
    - dfhmahr_requestv1
      - dfhmahr_requestname string: IT01
    - input_data_container
      - inprocessorderrequestmsg
        - inprocessorderrequest
          - accountnumber string: 00000011
          - itemnumber string: 0040
          - quantity string: 001

Figure 11-86 Invoking the CATAL Web Service request

Upon successful invocation, the Status pane of the Web Services Explorer shows you a window similar to Figure 11-87 on page 383.



```
DFHMADPLOperationResponse
  service_output_area
    dfhmahr_requestv1
      dfhmahr_requestname (string): IT01
    navigator_output_area
      outprocessorderresponsemsg
        outprocessorderresponse
          totalcost (unsignedLong): 1
          itemdescription (string): Pencil with eraser 12pk
          orderstatus (string): ORDER SUCESSFULLY PLACED
          firstname (string): Wilbert
          lastname (string): Kho
```

Figure 11-87 Results of CATAL Web service invocation

11.9 Summary

You have seen how you can use the Enterprise Service Tools (EST) capabilities of Rational Developer for System z (RDz) Version 7 to build a new Service Flow application that aggregates the data and results from various applications to present a single interaction to a Web service client. The CICS Service Flow Runtime provides the infrastructure to enable the aggregation of these applications, which can include non-terminal COMMAREA applications, terminal based-applications, and outbound Web service invocations.

11.10 Additional material

We included the workspace with the developed application in the additional material. Refer to Appendix B, “Additional material” on page 485 for instructions.

12

Integrating an external Web service with a CICS application

In this sample, we demonstrate how a CICS application can be easily integrated with external Web services. The assumption is that we already have external Web Services hosted in an application server, an enterprise service bus (ESB), or other middleware and that existing CICS applications will benefit from reusing the functionality that is implemented in these external Web services.

We use Rational Developer for System z (RDz) to create the CICS Web service artifacts and deploy them on z/OS.

We follow a top-down approach where we use the Web Services Description Language (WSDL) file of the existing Web service to create a COBOL copybook and a CICS service requester program.

This chapter includes the following topics:

- Introduction to the sample
- Prerequisites
- Extracting the WSDL from the existing Web Service
- Generating the CICS artifacts

- Updating the generated CICS service requester program
- Creating a test CICS client program
- Deploying the application to z/OS
- Testing the CICS Service requester program
- Handling complex CICS COMMAREA structures
- Summary

12.1 Introduction to the sample

We have an existing Web service that when provided with an input for department number, it returns the department name and the manager number. The CICS application needs to get this department name and the manager number for its business process. In this sample, we lead you through the following steps:

- Extracting the WSDL from the existing Web service
- Using the WSDL to generate the CICS artifacts
- Updating the generated CICS service requester program
- Creating a test CICS client program
- Deploying on z/OS
- Testing the CICS service requester program
- Handling complex CICS COMMAREA structures

Note: In case you do not yet have an existing external Web service, refer to Chapter 14, "Using DB2 as a Web service requester" on page 455 to create a Web service, which is basically the same Web service as the Web Service that we use in this sample.

12.2 Prerequisites

This sample has the following prerequisites:

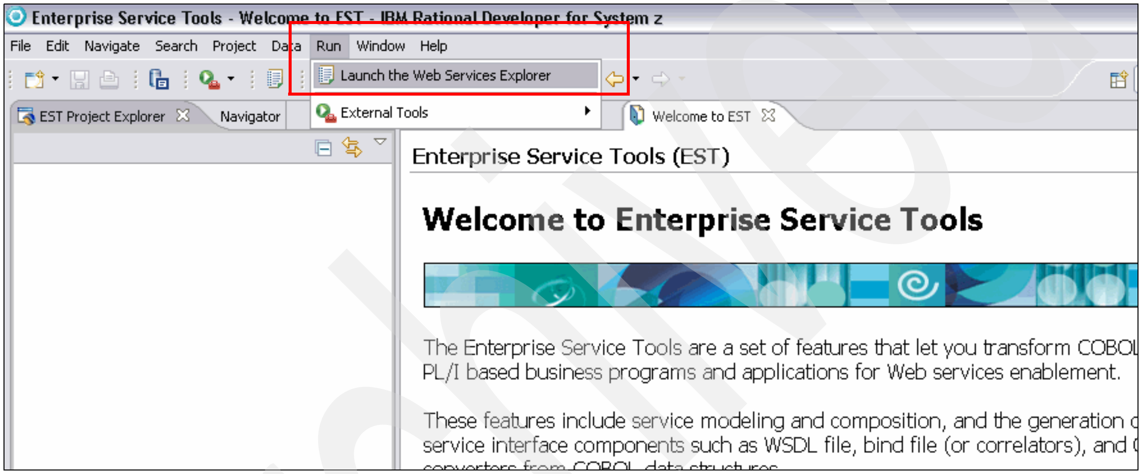
- Rational Developer for System z (RDz) V7.1
- CICS Transaction Server Version 3.1 or 3.2
- An external Web service

12.3 Extracting the WSDL from the existing Web Service

The starting point for the scenario used in this sample is an existing WSDL file. One of the techniques to obtain an existing WSDL file is to extract it from a URL of an external Web service. We extract it from Rational Developer for System z. We also test the WSDL using the Web Services Explorer in RDz to ensure that the Web service is accessible, and we verify the results of an invocation. Generally, a successful test with the RDz Web Services Explorer is evidence that the Web service is in working order and that the WSDL is the correct WSDL for that specific Web service.

Perform the following steps to obtain and test the WSDL:

1. Launch Rational Developer for System z (RDz).
2. Complete the following steps:
   - Create a workspace.
   - Create a z/OS connection to your z/OS host system.
3. In the Enterprise Service Tools (EST) perspective, launch the Web Services Explorer, as shown in Figure 12-1.


Enterprise Service Tools - Welcome to EST - IBM Rational Developer for System z
File
Edit
Navigate
Search
Project
Data
Run
Window
Help
Launch the Web Services Explorer
External Tools
EST Project Explorer
Navigator
Welcome to EST

Enterprise Service Tools (EST)

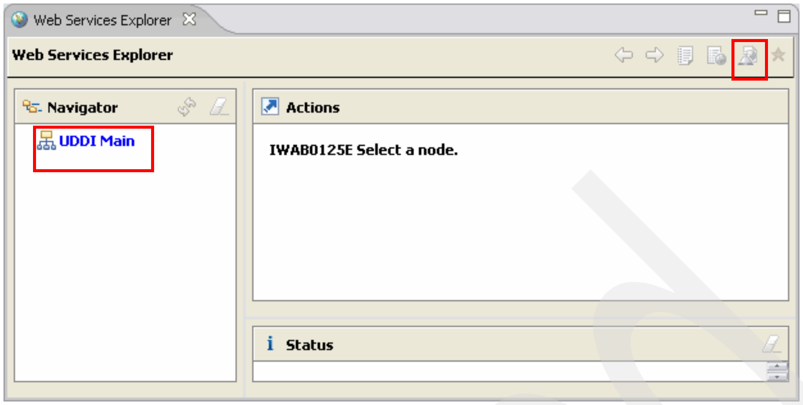
Welcome to Enterprise Service Tools

The Enterprise Service Tools are a set of features that let you transform COBOL PL/I based business programs and applications for Web services enablement.

These features include service modeling and composition, and the generation o service interface components such as WSDL file, bind file (or correlators), and c converters from COBOL data structures

Figure 12-1 Launching the Web Services Explorer

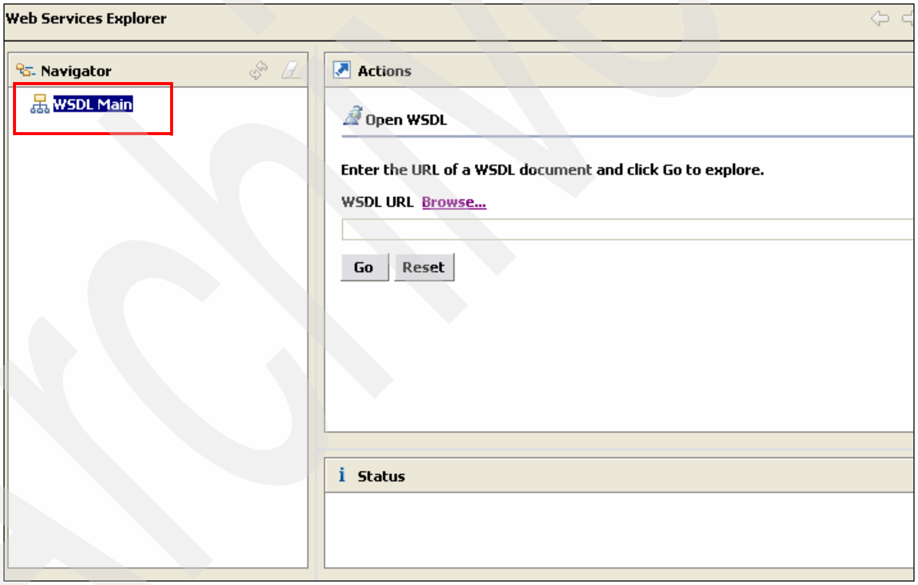
4. The default window that gets launched after you click Web Service Explorer is the Universal Description, Discovery, and Integration (UDDI) Main window. You need to, however, launch the WSDL Main window. Click the WSDL page, as shown in Figure 12-2 on page 389.



IWAB0125E Select a node.

Figure 12-2 Web Services Explorer default first window: UDDI Main

5. Click **WSDL Main**, as shown in Figure 12-3.



Enter the URL of a WSDL document and click Go to explore.

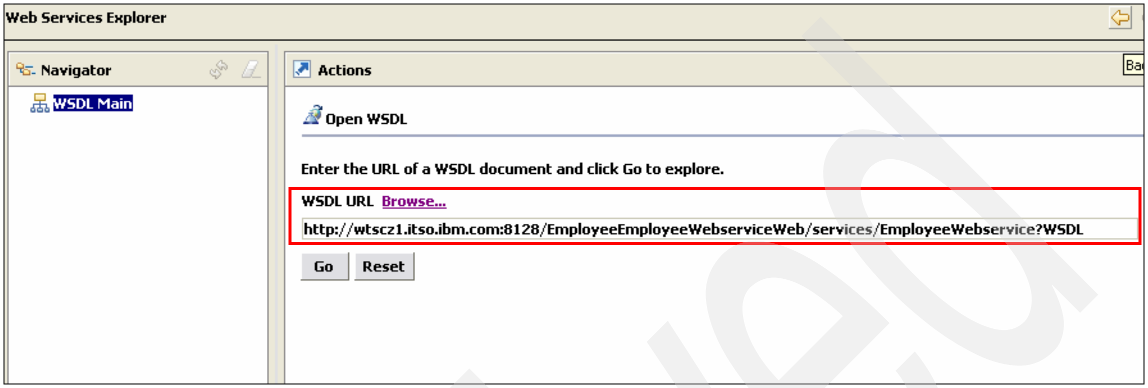
WSDL URL Browse...

Figure 12-3 Web Services Explorer WSDL Main window

6. The URL of our external Web service is: `http://wtscz1.itso.ibm.com:8128/EmployeeEmployeeWebserviceWeb/services/EmployeeWebservice`

   Copy this URL link in the WSDL URL box and suffix it with `?WSDL`, as shown in Figure 12-4 on page 390.

Note: Obviously, you will need to use your own specific host name and port number instead of the values that we used.



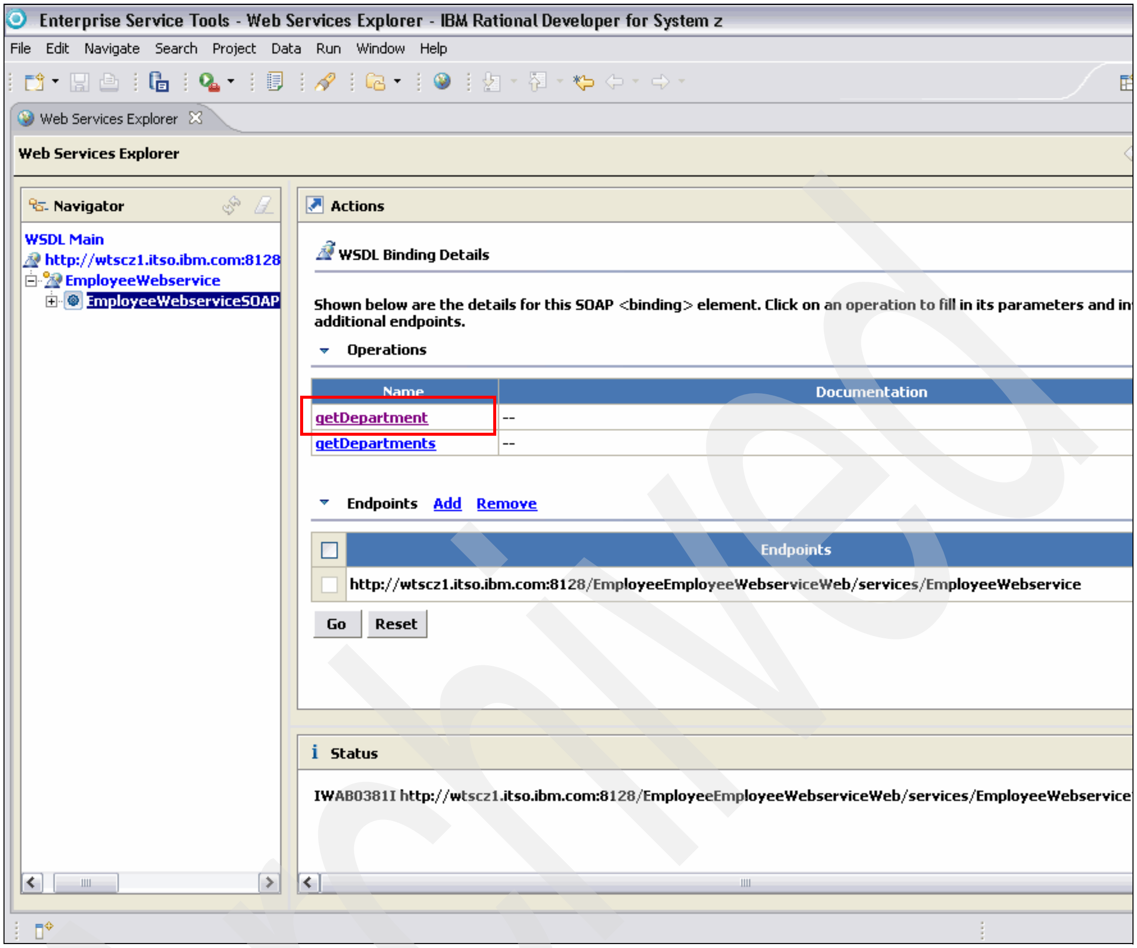
Enter the URL of a WSDL document and click Go to explore.

WSDL URL Browse...

http://wtscz1.itso.ibm.com:8128/EmployeeEmployeeWebserviceWeb/services/EmployeeWebservice?WSDL

Figure 12-4 Web Services Explorer WSDL Main: entering the WSDL URL

7. Click **Go**. The service that we will integrate is `getDepartment`. Refer to Figure 12-5 on page 391.


Enterprise Service Tools - Web Services Explorer - IBM Rational Developer for System z
File Edit Navigate Search Project Data Run Window Help
Web Services Explorer
Web Services Explorer
Navigator
WSDL Main
http://wtscz1.itso.ibm.com:8128
EmployeeWebservice
EmployeeWebserviceSOAP
Actions
WSDL Binding Details
Operations
Endpoints Add Remove
Go
Reset
Status

Shown below are the details for this SOAP <binding> element. Click on an operation to fill in its parameters and in additional endpoints.

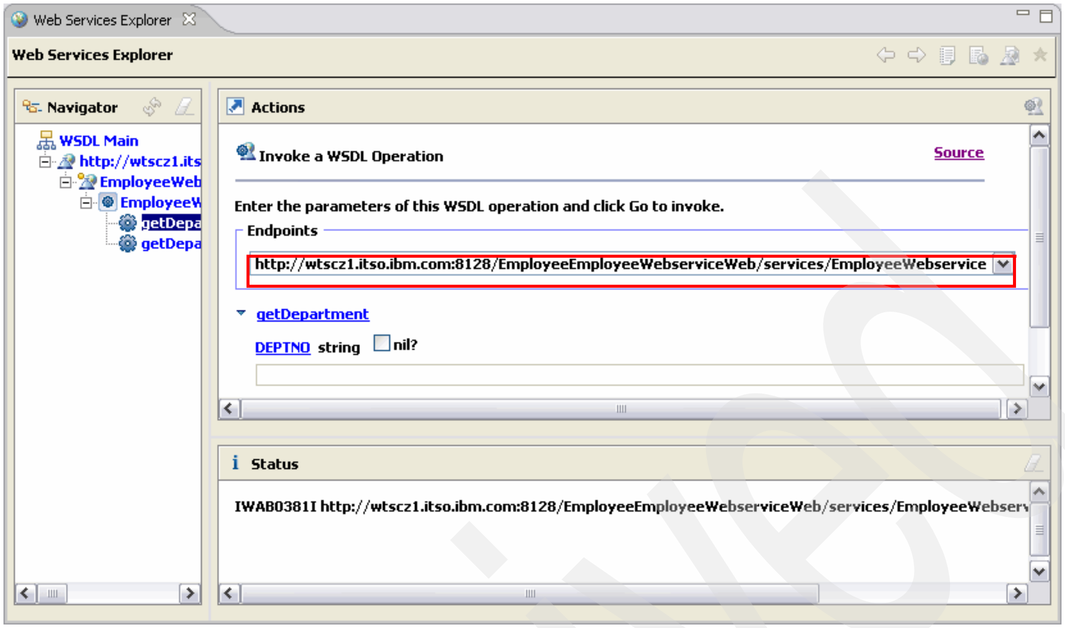
Name	Documentation
getDepartment	--
getDepartments	--

□	Endpoints
□	http://wtscz1.itso.ibm.com:8128/EmployeeEmployeeWebserviceWeb/services/EmployeeWebservice

IWAB0381I http://wtscz1.itso.ibm.com:8128/EmployeeEmployeeWebserviceWeb/services/EmployeeWebservice

Figure 12-5 Web Services Explorer WSDL Main: WSDL URL properties

8. Click **getDepartment**. Refer to Figure 12-6 on page 392.



Enter the parameters of this WSDL operation and click Go to invoke.

Endpoints

http://wtscz1.itso.ibm.com:8128/EmployeeEmployeeWebserviceWeb/services/EmployeeWebservice

getDepartment

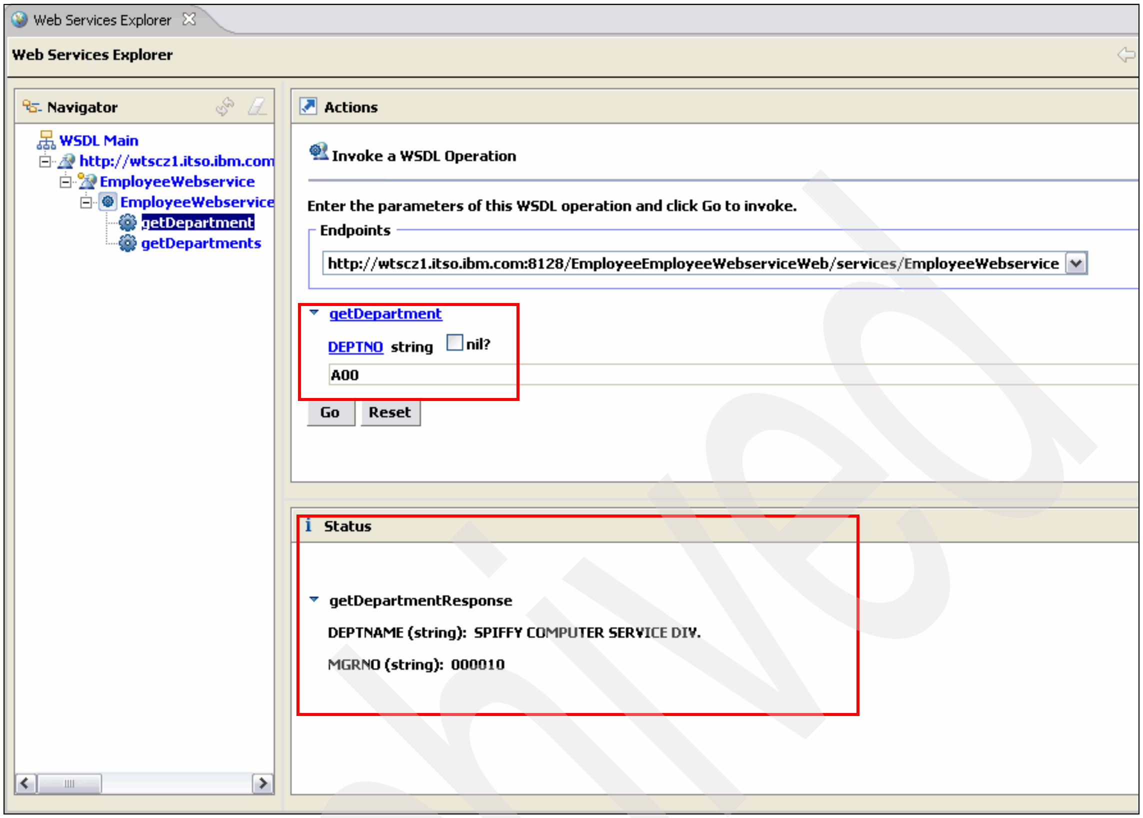
DEPTNO string □ nil?

Status

IWAB0381I http://wtscz1.itso.ibm.com:8128/EmployeeEmployeeWebserviceWeb/services/EmployeeWebserv

Figure 12-6 Web Services Explorer WSDL Main: Invoke WSDL operation

9. Enter `A00` in the DEPTNO field, and click **Go**. The Web service Explorer invokes the service and displays the result of the invocation in its Status pane (refer to Figure 12-7 on page 393).



Enter the parameters of this WSDL operation and click Go to invoke.

Endpoints

http://wtscz1.itso.ibm.com:8128/EmployeeEmployeeWebserviceWeb/services/EmployeeWebservice

getDepartment

DEPTNO string □ nil?

A00

getDepartmentResponse

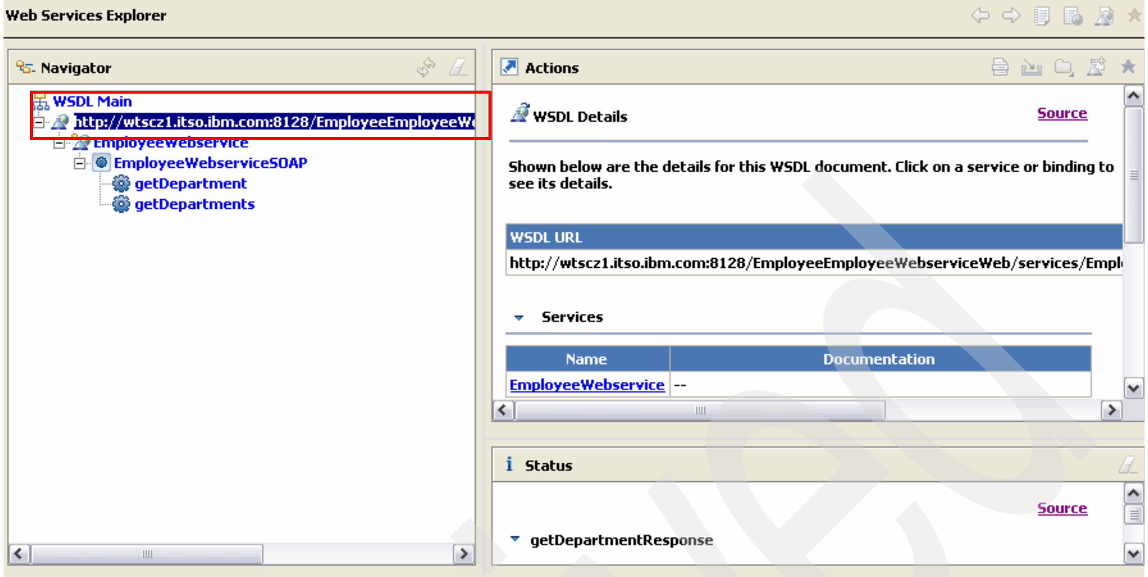
DEPTNAME (string): SPIFFY COMPUTER SERVICE DIV.

MGRNO (string): 000010

Figure 12-7 Web Services Explorer WSDL Main: WSDL operation results

The next step will be to extract the WSDL file from the Web service, which will be used to generate the CICS artifacts in the forthcoming steps.

Click the URL link beneath WSDL Main in the Navigator pane. Refer to Figure 12-8 on page 394.



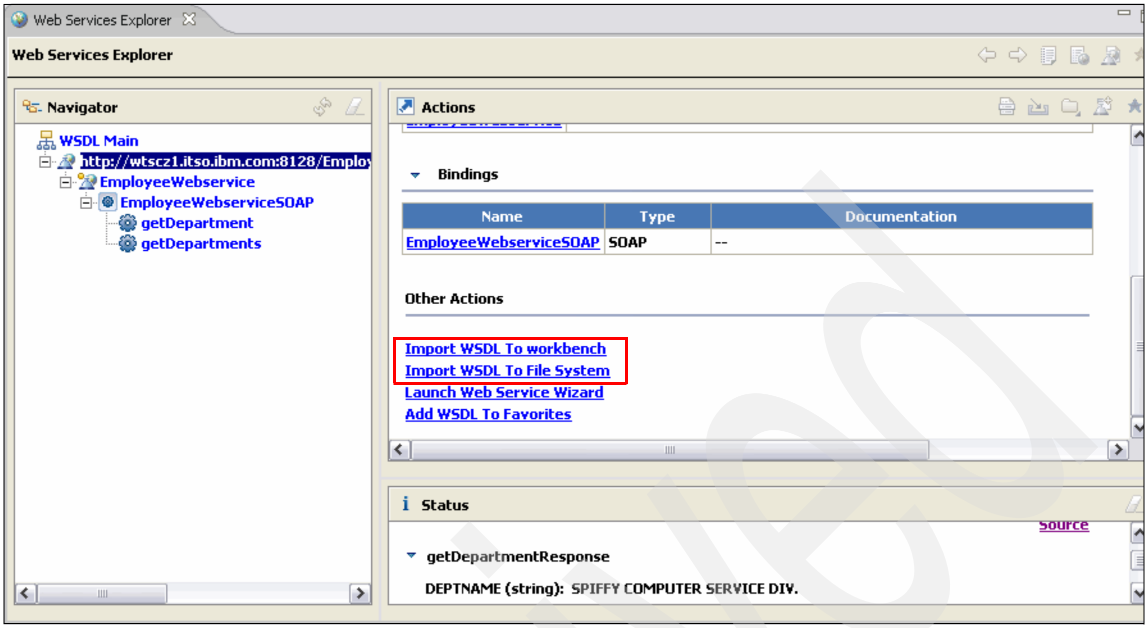
Shown below are the details for this WSDL document. Click on a service or binding to see its details.

WSDL URL
http://wtscz1.itso.ibm.com:8128/EmployeeEmployeeWebserviceWeb/services/Empl

Name	Documentation
EmployeeWebservice	--

Figure 12-8 Web Services Explorer WSDL Main: Navigator pane

Scroll down the Other Actions pane and find the Import WSDL links. You can either import to the workbench directly or import to your local disk on your PC and then add the WSDL file to your project in the RDz workspace. Refer to Figure 12-9 on page 395.



- WSDL Main
  - http://wtscz1.itso.ibm.com:8128/Employ
    - EmployeeWebservice
      - EmployeeWebserviceSOAP
        - getDepartment
        - getDepartments

Bindings

Name	Type	Documentation
EmployeeWebserviceSOAP	SOAP	--

Other Actions

Import WSDL To workbench
Import WSDL To File System
Launch Web Service Wizard
Add WSDL To Favorites

getDepartmentResponse

DEPTNAME (string): SPIFFY COMPUTER SERVICE DIV.

Figure 12-9 Web Services Explorer WSDL Main: Import WSDL links

You have extracted the WSDL file. We will use this WSDL file to generate CICS Web service artifacts in the following steps.

12.4 Generating the CICS artifacts

In the following steps, we create the artifacts that are needed for CICS:

1. In the EST perspective, create a new CICS Web Services project and import the WSDL file that you extracted in the previous steps (Figure 12-10 on page 396).

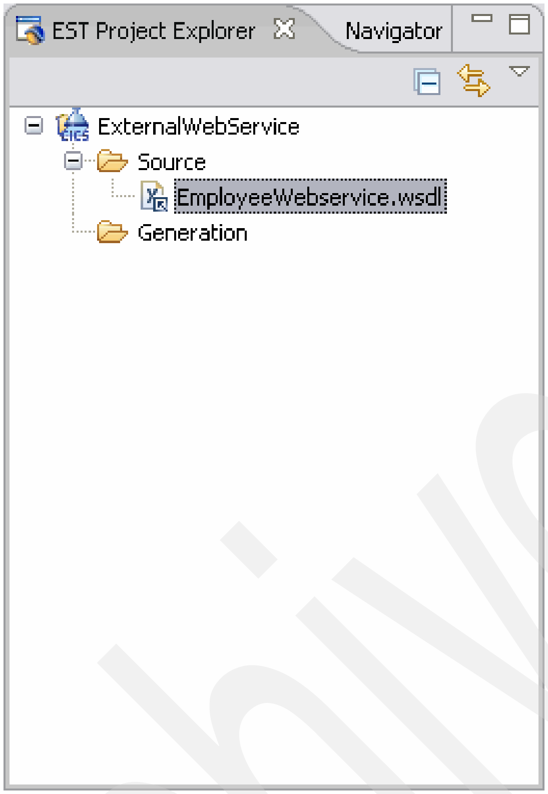


Figure 12-10 EST Project Explorer: Project with extracted WSDL file

2. Right-click **EmployeeWebservice.wsdl**, and select **Generate CICS Web Services for CICS resources**. Refer to Figure 12-11 on page 397.

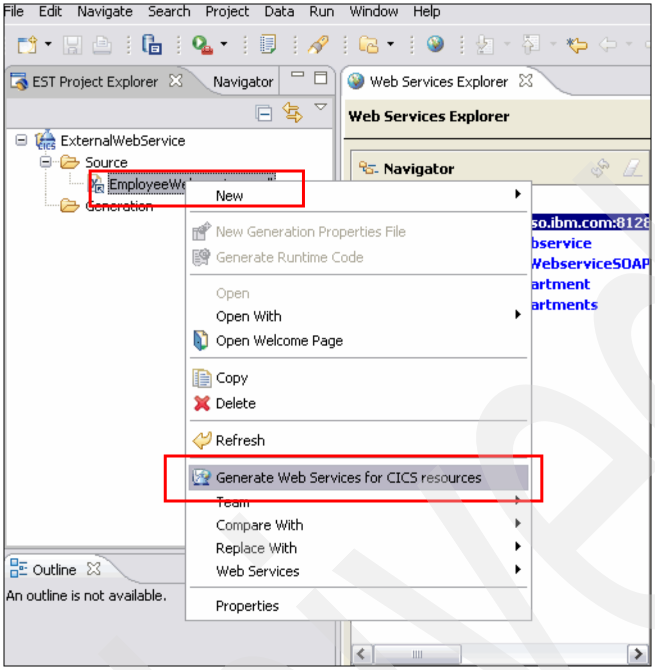
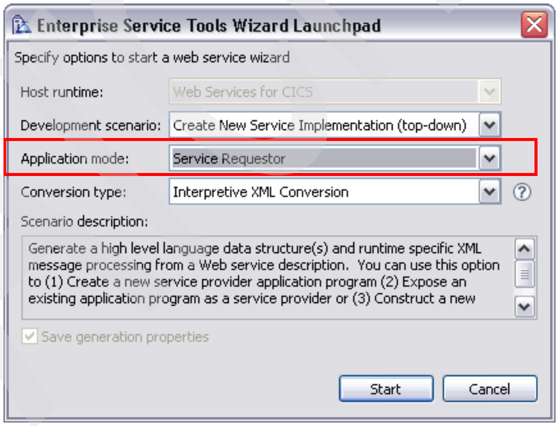


Figure 12-11   EST Project Explorer: Generate Web Services for CICS resources

3. This action launches the Enterprise Service Tools wizard. In the Application mode drop-down list box, select **Service Requestor** (Figure 12-12).


Enterprise Service Tools Wizard Launchpad

Specify options to start a web service wizard

Host runtime: Web Services for CICS

Development scenario: Create New Service Implementation (top-down)

Application mode: Service Requestor

Conversion type: Interpretive XML Conversion

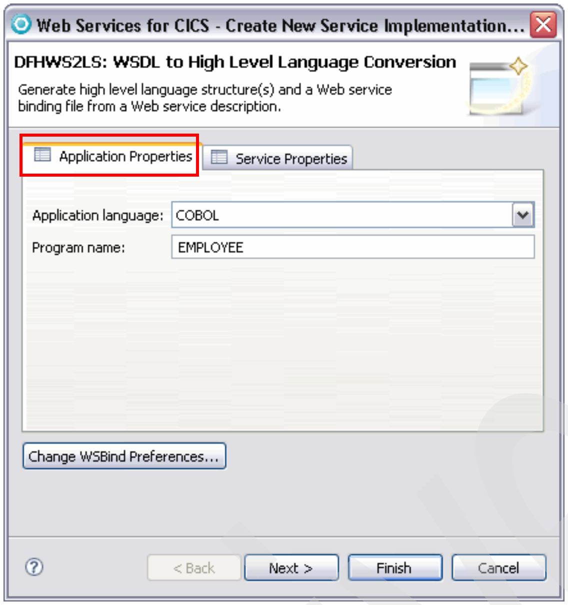
Scenario description:

Generate a high level language data structure(s) and runtime specific XML message processing from a Web service description. You can use this option to (1) Create a new service provider application program (2) Expose an existing application program as a service provider or (3) Construct a new

☑ Save generation properties

Figure 12-12   Enterprise Service Tools wizard Launchpad

4. Click **Start**. You see the Application Properties tab as is shown in Figure 12-13 on page 398.



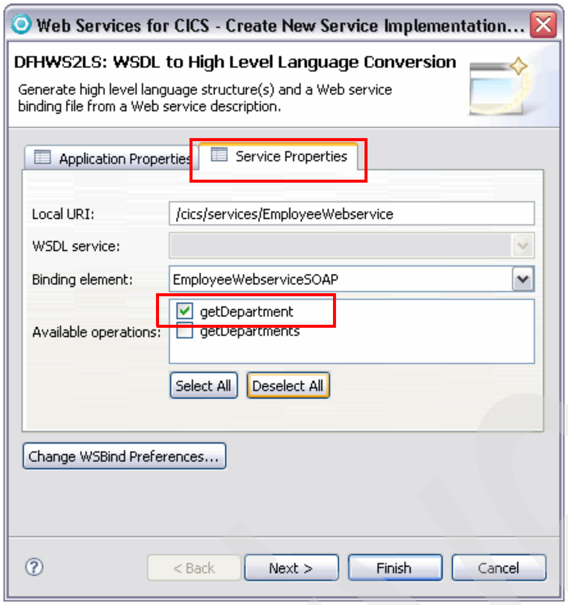
Web Services for CICS - Create New Service Implementation...
DFHWS2LS: WSDL to High Level Language Conversion
Generate high level language structure(s) and a Web service binding file from a Web service description.
Application Properties
Service Properties
Change WSBind Preferences...
< Back
Next >
Finish
Cancel

Application language: COBOL

Program name: EMPLOYEE

Figure 12-13 Web Services for CICS wizard: Application Properties tab

5. Switch to the **Service Properties** tab and ensure that you select the Web service that you want to integrate, that is, **getDepartment**, in our example. Click **Next**. Refer to Figure 12-14 on page 399.


Web Services for CICS - Create New Service Implementation...

DFHWS2LS: WSDL to High Level Language Conversion

Generate high level language structure(s) and a Web service binding file from a Web service description.

Local URI: /cics/services/EmployeeWebservice

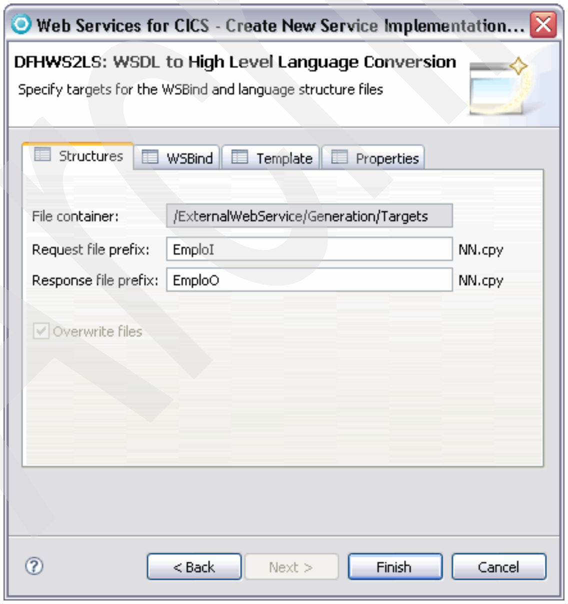
WSDL service:

Binding element: EmployeeWebserviceSOAP

Available operations:
☑ getDepartment
☐ getDepartments

Figure 12-14 Web Services for CICS wizard: Service Properties tab

6. In the next pane, you can accept the defaults. Refer to Figure 12-15.


Web Services for CICS - Create New Service Implementation...

DFHWS2LS: WSDL to High Level Language Conversion

Specify targets for the WSBind and language structure files

File container: /ExternalWebService/Generation/Targets

Request file prefix: EmploI NN.cpy

Response file prefix: EmploO NN.cpy

☑ Overwrite files

Figure 12-15 Web Services for CICS wizard: WSDL to High Level Language Conversion

7. Click **Finish**.

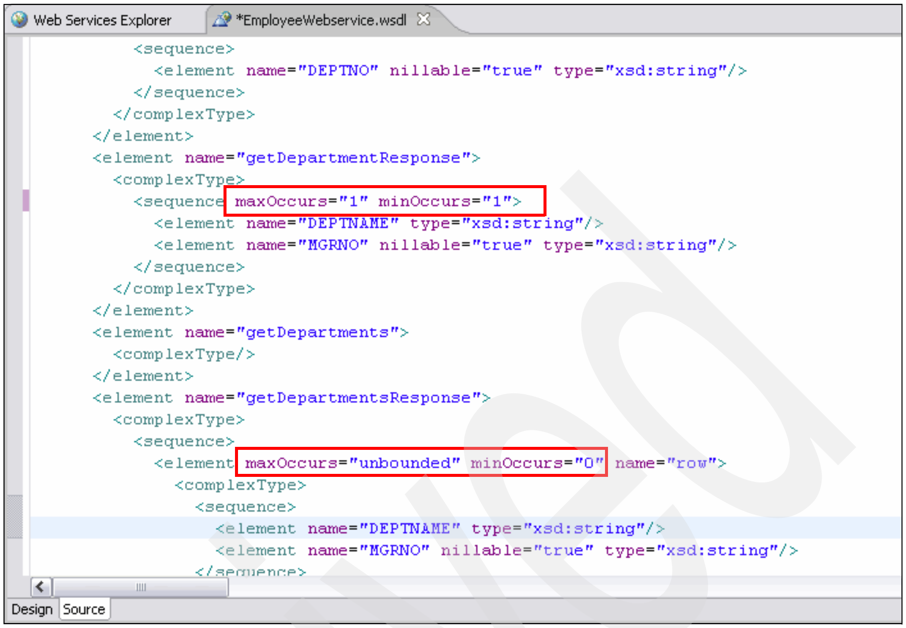
> **Note:** You might get an error if your WSDL contains a complex type sequence with `maxOccurs` or `minOccurs` attributes. RDz does not support WSDL if either `maxOccurs` or `minOccurs` is 0, because of a COBOL language limitation where array structures cannot be dynamic and must have a fixed number. This situation is not the case with XML data structures. You might get this error if you have this complex type in the WSDL file as shown in Example 12-1.

Example 12-1 Employeewebservice.log

```
Error Details:
--------------
com.ibm.cics.wsdl.CICSWSDLException: DFHPI9013E Schema model groups with maxOccurs or
minOccurs not equal to 1 are not supported. Problem found for type:
"getDepartmentResponse".
   at com.ibm.cics.wsdl.ws2ls.OperationToICM.getICM(Unknown Source)
   at com.ibm.cics.wsdl.ws2ls.ws2ls.doStuff(Unknown Source)
   at com.ibm.cics.wsdl.ws2ls.ws2ls.run(Unknown Source)
   at com.ibm.cics.wsdl.common.CICSWebServicesAssistant.callWSAssistant(Unknown
Source)
   at com.ibm.cics.wsdl.common.CICSWebServicesAssistant.DFHWS2LS(Unknown Source)
   at com.ibm.etools.xmlent.batch.util.cwsa.CWSAOperation.run(Unknown Source)
   at
com.ibm.etools.xmlent.batch.cwsa.gen.WS2LSSetGen.runWebServicesAssistant(Unknown
Source)
   at com.ibm.etools.xmlent.batch.cwsa.gen.WS2LSSetGen.generate(Unknown Source)
   at
com.ibm.etools.xmlent.batch.processing.BPServiceImplementationWrapper.createInterpret
iveImplementation(Unknown Source)
   at
com.ibm.etools.xmlent.batch.processing.BPServiceImplementationWrapper.processServiceI
mplementation(Unknown Source)
   at com.ibm.etools.xmlent.batch.processing.BPProjectWrapper.process(Unknown Source)
   at com.ibm.etools.xmlent.batch.processing.BatchProcess.run(Unknown Source)
   at
com.ibm.etools.xmlent.ui.operations.BatchProcessorWizardOperation.runBatchProcessor(U
nknown Source)
   at com.ibm.etools.xmlent.ui.operations.BatchProcessorWizardOperation.run(Unknown
Source)
   at org.eclipse.jface.operation.ModalContext$ModalContextThread.run(Unknown Source)
```

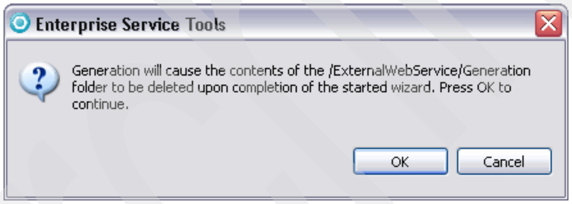
```
Caused by: com.ibm.cics.schema.ICMException: DFHPI9013E Schema model groups with
maxOccurs or minOccurs not equal to 1 are not supported. Problem found for type:
"getDepartmentResponse".
   at com.ibm.cics.schema.impl.ICMImplFromWSDL.getEffectiveElement(Unknown Source)
   at com.ibm.cics.schema.impl.ICMImplFromWSDL.getElementName(Unknown Source)
   at com.ibm.cics.schema.impl.ICMImplFromWSDL.processAList(Unknown Source)
   at com.ibm.cics.schema.impl.ICMImplFromWSDL.processParticle(Unknown Source)
   at com.ibm.cics.schema.impl.ICMImplFromWSDL.processComplexType(Unknown Source)
   at com.ibm.cics.schema.impl.ICMImplFromWSDL.processTypeDef(Unknown Source)
   at com.ibm.cics.schema.impl.ICMImplFromWSDL.processElementDeclaration(Unknown
Source)
   at
com.ibm.cics.schema.impl.ICMImplFromWSDL.processParticleIgnoreCardinality(Unknown
Source)
   at com.ibm.cics.schema.impl.ICMImplFromWSDL.processRepeatICMEntry(Unknown Source)
   at com.ibm.cics.schema.impl.ICMImplFromWSDL.processAnArray(Unknown Source)
   at com.ibm.cics.schema.impl.ICMImplFromWSDL.processParticle(Unknown Source)
   at com.ibm.cics.schema.impl.ICMImplFromWSDL.addElementDeclaration(Unknown Source)
   at com.ibm.cics.wsdl.ws2ls.OperationToICM.processMessage(Unknown Source)
   ... 15 more
DFHPI9013E Schema model groups with maxOccurs or minOccurs not equal to 1 are not
supported. Problem found for type: "getDepartmentResponse".
DFHPI9013E Schema model groups with maxOccurs or minOccurs not equal to 1 are not
supported. Problem found for type: "getDepartmentResponse".
DFHPI9558E ERRORS have been generated processing file "C:\Documents and
Settings\MrAdmin\My Documents\Naveed\EmployeeWebservice.wsdl".
```

If this error occurs, you need to edit the WSDL file and update the MINOCCURS to 1 and also ensure that MAXOCCURS is 1. Also, find the word “unbounded” and change it to 1 as highlighted in Figure 12-16 on page 402 is to ensure that only one elementary item is generated. In the case of COMMAREA arrays, just update both the fields with the number of OCCURS that you want in your COBOL copybook. Then, regenerate the CICS Web service artifacts. When you try to regenerate, you will get a warning message as shown in Figure 12-17 on page 402. Click **OK**, and then follow the steps as explained earlier in Figure 12-11 on page 397 to Figure 12-15 on page 399.



```
    <sequence>
      <element name="DEPTNO" nillable="true" type="xsd:string"/>
    </sequence>
  </complexType>
</element>
<element name="getDepartmentResponse">
  <complexType>
    <sequence maxOccurs="1" minOccurs="1">
      <element name="DEPTNAME" type="xsd:string"/>
      <element name="MGRNO" nillable="true" type="xsd:string"/>
    </sequence>
  </complexType>
</element>
<element name="getDepartments">
  <complexType/>
</element>
<element name="getDepartmentsResponse">
  <complexType>
    <sequence>
      <element maxOccurs="unbounded" minOccurs="0" name="row">
        <complexType>
          <sequence>
            <element name="DEPTNAME" type="xsd:string"/>
            <element name="MGRNO" nillable="true" type="xsd:string"/>
          </sequence>
```

Figure 12-16 Employeewebservice.wsdl file: maxOccurs and minOccurs



Generation will cause the contents of the /ExternalWebService/Generation folder to be deleted upon completion of the started wizard. Press OK to continue.

Figure 12-17 Enterprise Service Tools warning message

The following CICS Web service artifacts are generated (Figure 12-18 on page 403):

- Inbound COBOL copybook
- Outbound COBOL copybooks
- Template Service requester program
- WSBind files

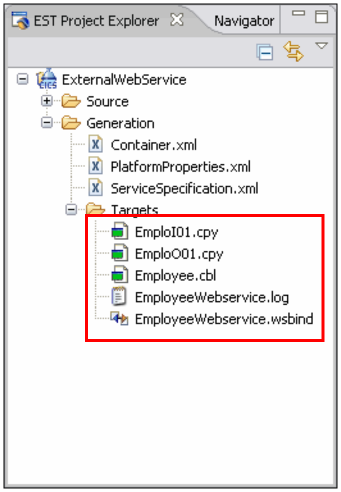
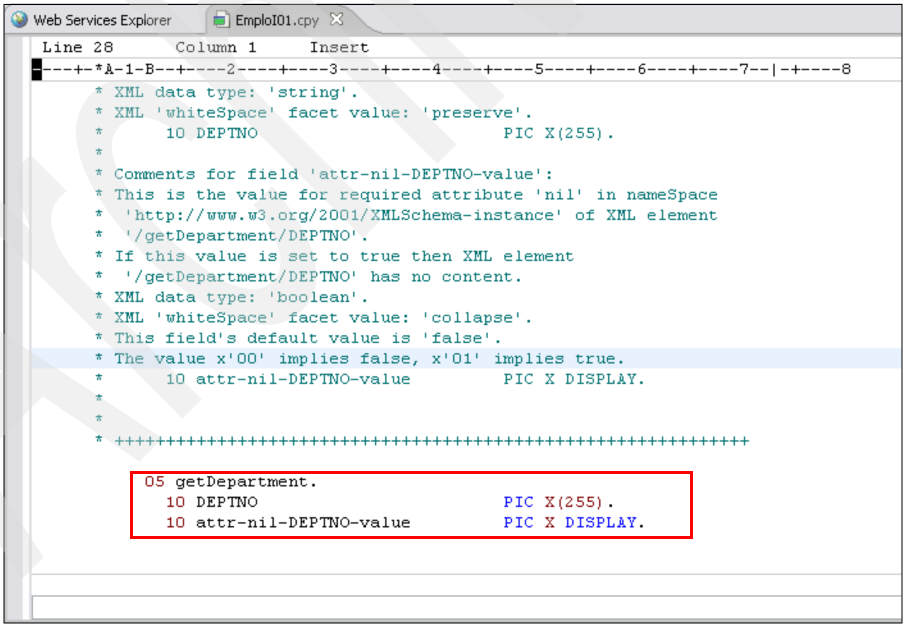


Figure 12-18   Generated CICS Web service artifacts

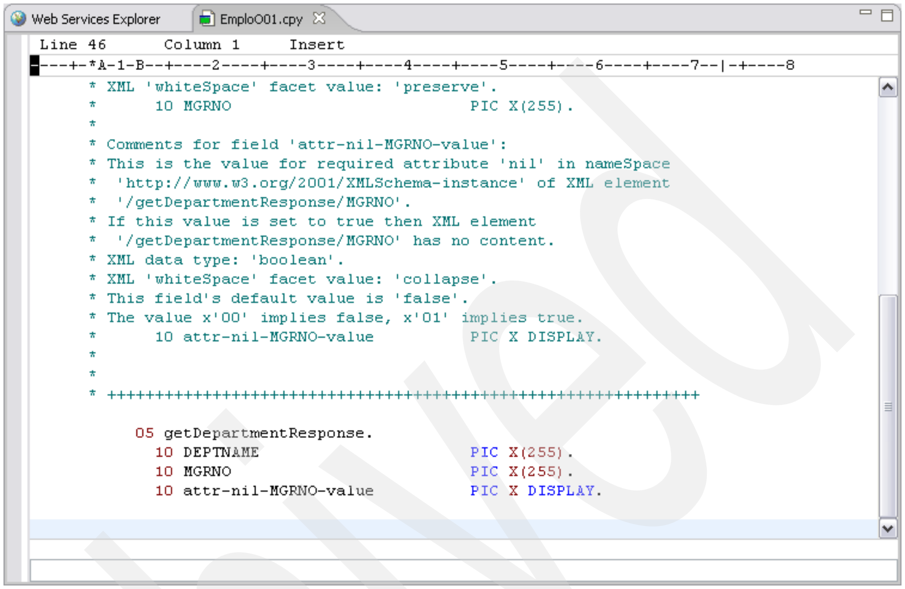
8. You can browse the input copybook, `EmploI01.cpy`, by double-clicking it. It has the Department number, which is the key field in the request structure. Refer to Figure 12-19.



```
 Line 28       Column 1      Insert
----+-*A-1-B--+----2----+----3----+----4----+----5----+----6----+----7--|-+----8
      * XML data type: 'string'.
      * XML 'whiteSpace' facet value: 'preserve'.
      *      10 DEPTNO                         PIC X(255).
      *
      * Comments for field 'attr-nil-DEPTNO-value':
      * This is the value for required attribute 'nil' in nameSpace
      *  'http://www.w3.org/2001/XMLSchema-instance' of XML element
      *  '/getDepartment/DEPTNO'.
      * If this value is set to true then XML element
      *  '/getDepartment/DEPTNO' has no content.
      * XML data type: 'boolean'.
      * XML 'whiteSpace' facet value: 'collapse'.
      * This field's default value is 'false'.
      * The value x'00' implies false, x'01' implies true.
      *      10 attr-nil-DEPTNO-value          PIC X DISPLAY.
      *
      *
      * ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

           05 getDepartment.
             10 DEPTNO                         PIC X(255).
             10 attr-nil-DEPTNO-value          PIC X DISPLAY.
```

Figure 12-19   EmploIO1.cpy

9. You can also browse the output copybook, `Emplo001.cpy`, by double-clicking it. It has the Department name and Manager number fields, which are the response structure from the external Web service. Refer to Figure 12-20.



```
 Line 46      Column 1      Insert
----+-*A-1-B--+----2----+----3----+----4----+----5----+----6----+----7--|-+----8
      * XML 'whiteSpace' facet value: 'preserve'.
      *      10 MGRNO                          PIC X(255).
      *
      * Comments for field 'attr-nil-MGRNO-value':
      * This is the value for required attribute 'nil' in nameSpace
      *  'http://www.w3.org/2001/XMLSchema-instance' of XML element
      *  '/getDepartmentResponse/MGRNO'.
      * If this value is set to true then XML element
      *  '/getDepartmentResponse/MGRNO' has no content.
      * XML data type: 'boolean'.
      * XML 'whiteSpace' facet value: 'collapse'.
      * This field's default value is 'false'.
      * The value x'00' implies false, x'01' implies true.
      *      10 attr-nil-MGRNO-value           PIC X DISPLAY.
      *
      *
      * ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

           05 getDepartmentResponse.
             10 DEPTNAME                       PIC X(255).
             10 MGRNO                          PIC X(255).
             10 attr-nil-MGRNO-value           PIC X DISPLAY.
```

Figure 12-20   EmploO01.cpy

12.5 Updating the generated CICS service requester program

Next, you need to modify the generated COBOL Web service requestor program.

Browse the **Employee.cbl** that got generated, as shown in Example 12-2 on page 405. You have to update the program to populate the required request and response language structures and update several error handing messages. Look for the comments “`Populate Request Language Structure`” and “`Process Response Language Structure`” in the generated COBOL source as shown in Example 12-2 on page 405. Those places are the only two places where code needs to be added according to your data structures, as well as updating conditions for error handling.

Example 12-2 Generated CICS Service requester program EMPLOYEE.cbl

```
*          *********************************************
       IDENTIFICATION DIVISION.
      *Begin Identification Divsion
        PROGRAM-ID. 'EMPLOYEE'.
        AUTHOR. WD4Z.
        INSTALLATION. 8.0.1.V200806191806.
        DATE-WRITTEN. 9/10/08 10:14 AM.
      *End Identification Divsion
       DATA DIVISION.
      *Begin Data Divsion
       WORKING-STORAGE SECTION.
      *Begin Working-Storage Section
      * *************************************************************
      *        Operations Available On The Remote Web Service
      * *************************************************************
       1 OPERATION-NAME-1.
       2 PIC X(13) USAGE DISPLAY
           VALUE 'getDepartment'.
      *End Working-Storage Section
       LOCAL-STORAGE SECTION.
      *Begin Local-Storage Section
      * *************************************************************
      *                    Program Work Variables
      * *************************************************************
       1 SOAP-PIPELINE-WORK-VARIABLES.
       2 WS-WEBSERVICE-NAME PIC X(32).
       2 WS-OPERATION-NAME PIC X(255).
       2 WS-CONTAINER-NAME PIC X(16).
       2 WS-CHANNEL-NAME PIC X(16).
       2 COMMAND-RESP PIC S9(8) COMP.
       2 COMMAND-RESP2 PIC S9(8) COMP.
      *Specify A URI To Override The Web Service Description
       1 URI-RECORD-STRUCTURE.
       2 FILLER PIC X(10).
       2 WS-URI-OVERRIDE PIC X(255).
      * *************************************************************
      *                     Language Structures
      * *************************************************************
       1 LANG-EMPLOI01.
           COPY EmploI01.
       1 LANG-EMPLO001.
           COPY Emplo001.
      *End Local-Storage Section
```

```
 LINKAGE SECTION.
*Begin Linkage Section
*End Linkage Section
*End Data Divsion
 PROCEDURE DIVISION
     .
*Begin Procedure Division
 MAINLINE SECTION.
* -------------------------------------------------------------
*                  Initialize Work Variables
* -------------------------------------------------------------
     INITIALIZE SOAP-PIPELINE-WORK-VARIABLES.
     INITIALIZE URI-RECORD-STRUCTURE.
* -------------------------------------------------------------
* Container 'DFHWS-DATA' Must Be Present When A Service Reques
* ter Program Issues An EXEC CICS INVOKE WEBSERVICE Command. W
* hen The Command Is Issued, CICS Converts The Data Structure
* That Is In The Container Into A SOAP Request. When The SOAP
* Response Is Received, CICS Converts It Into Another Data Str
* ucture That Is Returned To The Application In The Same Conta
* iner.
* -------------------------------------------------------------
     MOVE 'DFHWS-DATA'
       TO WS-CONTAINER-NAME
* -------------------------------------------------------------
*            Channel Passed To The Web Service Call
* -------------------------------------------------------------
     MOVE 'SERVICE-CHANNEL'
       TO WS-CHANNEL-NAME
* -------------------------------------------------------------
*      WEBSERVICE resource installed in this CICS region
* -------------------------------------------------------------
     MOVE 'EmployeeWebservice'
       TO WS-WEBSERVICE-NAME
* -------------------------------------------------------------
*        Operation To Invoke On The Remote Web Service
* -------------------------------------------------------------
     MOVE OPERATION-NAME-1
       TO WS-OPERATION-NAME
* -------------------------------------------------------------
*             Populate Request Language Structure
* -------------------------------------------------------------
     INITIALIZE LANG-EMPLOI01
* ....
* ....
* ....
* -------------------------------------------------------------
*      Put Request Language Structure Into SOAP Container
* -------------------------------------------------------------
     EXEC CICS PUT CONTAINER(WS-CONTAINER-NAME)
       CHANNEL(WS-CHANNEL-NAME)
       FROM(LANG-EMPLOI01)
     END-EXEC
     PERFORM CHECK-CONTAINER-COMMAND
* -------------------------------------------------------------
*                    Invoke The Web Service
* -------------------------------------------------------------
     EXEC CICS INVOKE WEBSERVICE(WS-WEBSERVICE-NAME)
       CHANNEL(WS-CHANNEL-NAME)
*  URI(WS-URI-OVERRIDE)
       OPERATION(WS-OPERATION-NAME)
       RESP(COMMAND-RESP) RESP2(COMMAND-RESP2)
     END-EXEC
     PERFORM CHECK-WEBSERVICE-COMMAND
* -------------------------------------------------------------
*             Receive Response Language Structure
* -------------------------------------------------------------
     EXEC CICS GET CONTAINER(WS-CONTAINER-NAME)
       CHANNEL(WS-CHANNEL-NAME)
       INTO(LANG-EMPLOO01)
     END-EXEC
     PERFORM CHECK-CONTAINER-COMMAND
* -------------------------------------------------------------
*             Process Response Language Structure
* -------------------------------------------------------------
* ....
* ....
* ....
* -------------------------------------------------------------
*                            Finished
* -------------------------------------------------------------
     EXEC CICS RETURN
     END-EXEC
     .
 CHECK-CONTAINER-COMMAND.
     EVALUATE COMMAND-RESP
       WHEN DFHRESP(CCSIDERR)
* ....
         CONTINUE
       WHEN DFHRESP(CONTAINERERR)
```

```
* ....
         CONTINUE
       WHEN DFHRESP(INVREQ)
* ....
         CONTINUE
       WHEN DFHRESP(LENGERR)
* ....
         CONTINUE
     END-EVALUATE
     .
 CHECK-WEBSERVICE-COMMAND.
     EVALUATE COMMAND-RESP
       WHEN DFHRESP(INVREQ)
* ....
         CONTINUE
       WHEN DFHRESP(NOTFND)
* ....
         CONTINUE
     END-EVALUATE
     .
*End Procedure Division
 END PROGRAM 'EMPLOYEE'.
```

Note: We have included the complete updated source code and all other relevant sources in the additional material section of this book. Refer to Appendix B, “Additional material” on page 485 for instructions.

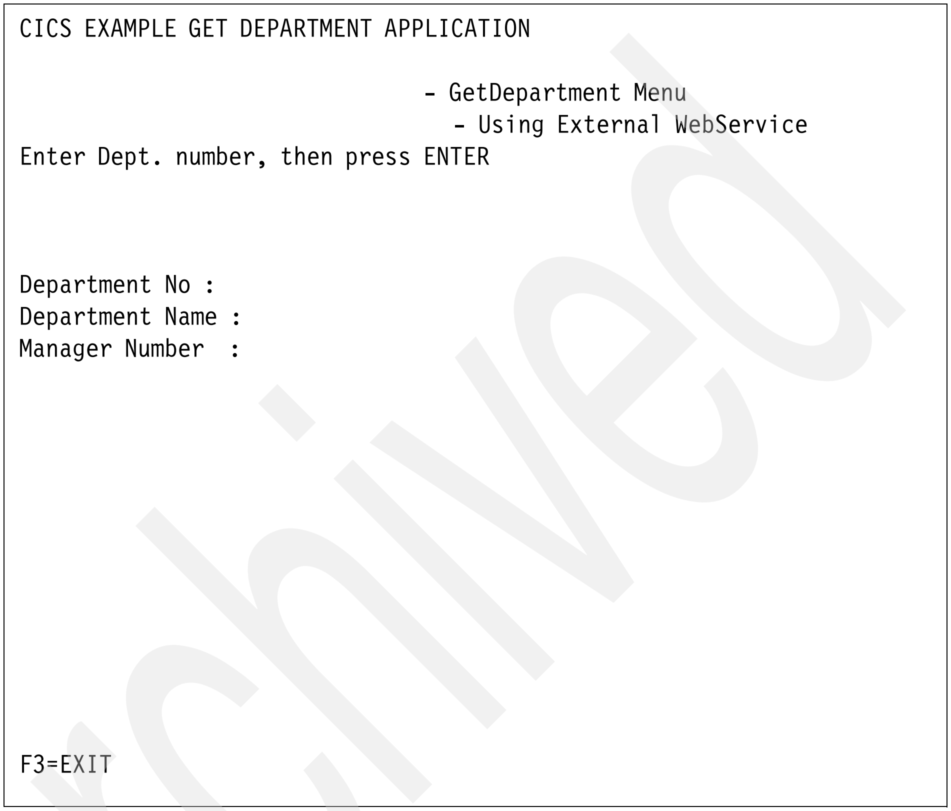
12.6 Creating a test CICS client program

Next, we show how to create a CICS client program that links to the generated COBOL program.

Create a simple CICS program that sends a basic mapping support (BMS) map to accept Department number as input and send Department name and Manager number as output. This CICS program will link to the previously explained CICS Web service requester program (EMPLOYEE) to invoke the external Web service program. Subsequently, the output received back from the external Web service will be passed back via the EMPLOYEE Web service requestor program and the CICS client program to the BMS map.

In our sample, we have named the CICS client program `DEPTXGUI`. This program is also included in the additional material appendix for this book.

Figure 12-21 shows the BMS map.



```
CICS EXAMPLE GET DEPARTMENT APPLICATION

                               - GetDepartment Menu
                                 - Using External WebService
Enter Dept. number, then press ENTER




Department No :
Department Name :
Manager Number  :












F3=EXIT
```

Figure 12-21 CICS test client program

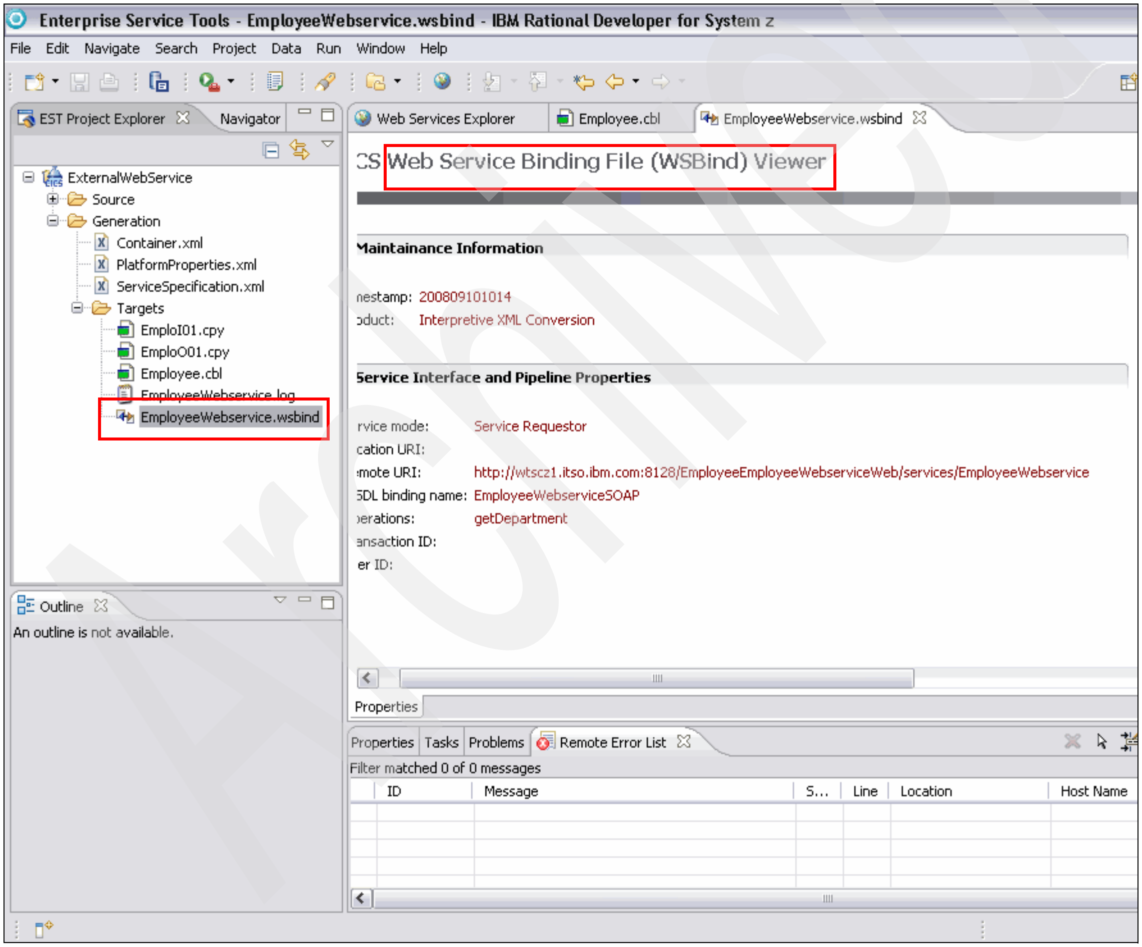
12.7 Deploying the application to z/OS

After all of the components have been prepared, we can deploy the solution to z/OS and run the application on z/OS. You need to perform the following tasks:

1. Compile and link-edit the CICS client program `DEPTXGUI` on z/OS.
2. Compile and link-edit the CICS Service requester program `EMPLOYEE` on z/OS.

> **Note:** We assume that you have completed all of the necessary setup for CICS Web Services support, including the hierarchical file system (HFS) directories and the CICS TS resource definitions, such as PIPELINE and TCPIPSERVICE. Refer to *Application Development for CICS Web Services,* SG24-7126, for more details about how to set up these CICS resources.

3. Copy the generated `Employeewebservice.wsbind` file to the pickup directory of your CICS Service requester pipeline. You can view the WSBind file using the WSBind Viewer, which is shown in Figure 12-22.


Enterprise Service Tools - EmployeeWebservice.wsbind - IBM Rational Developer for System z
File Edit Navigate Search Project Data Run Window Help
EST Project Explorer
Navigator
ExternalWebService
Source
Generation
Container.xml
PlatformProperties.xml
ServiceSpecification.xml
Targets
EmploI01.cpy
EmploO01.cpy
Employee.cbl
EmployeeWebservice.log
EmployeeWebservice.wsbind
Outline
An outline is not available.
Web Services Explorer
Employee.cbl
EmployeeWebservice.wsbind
CS Web Service Binding File (WSBind) Viewer
Properties
Properties Tasks Problems Remote Error List
Filter matched 0 of 0 messages
ID Message S... Line Location Host Name

Maintainance Information

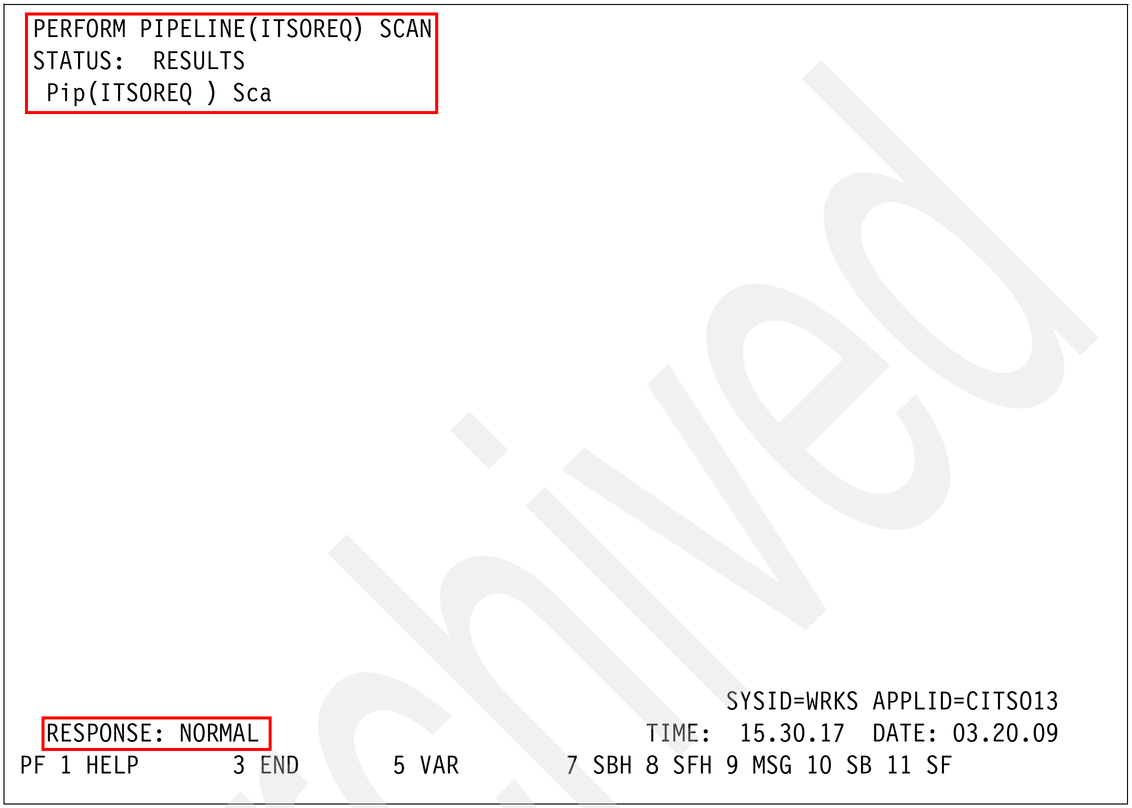
nestamp: 200809101014
oduct: Interpretive XML Conversion

Service Interface and Pipeline Properties

rvice mode: Service Requestor
cation URI:
emote URI: http://wtsc21.itso.ibm.com:8128/EmployeeEmployeeWebserviceWeb/services/EmployeeWebservice
SDL binding name: EmployeeWebserviceSOAP
perations: getDepartment
ansaction ID:
er ID:

Figure 12-22 WSBind Viewer

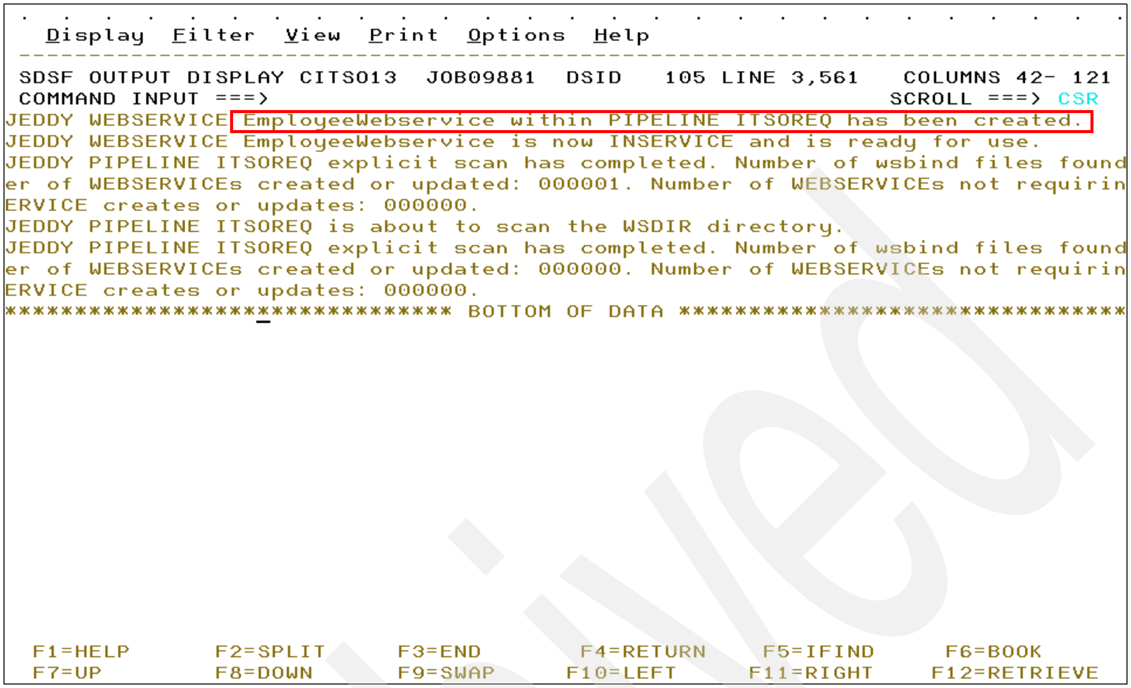
4. Perform a PIPELINE SCAN by entering the `CEMT PERFORM PIPELINE(`*`requester_pipeline_name`*`) SCAN` command. Make sure that the Response is `NORMAL`, as shown in Figure 12-23.



```
PERFORM PIPELINE(ITSOREQ) SCAN
STATUS:  RESULTS
 Pip(ITSOREQ ) Sca

















                                                       SYSID=WRKS APPLID=CITSO13
  RESPONSE: NORMAL                               TIME:  15.30.17  DATE: 03.20.09
PF 1 HELP       3 END       5 VAR       7 SBH 8 SFH 9 MSG 10 SB 11 SF
```

Figure 12-23 CEMT PERFORM PIPELINE SCAN

5. Additionally, check in the CICS Spool log to see whether the Web service was generated successfully (Figure 12-24 on page 412).

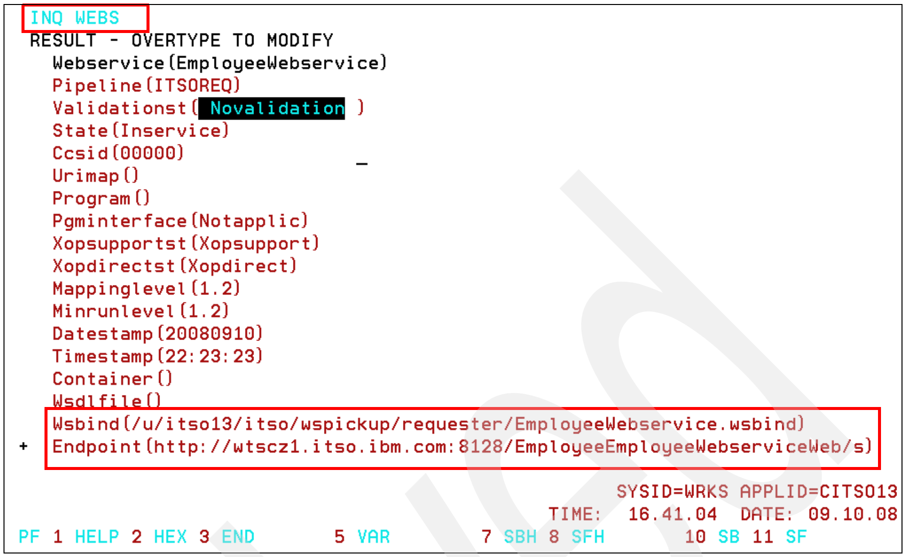


```
SDSF OUTPUT DISPLAY CITSO13  JOB09881  DSID   105 LINE 3,561   COLUMNS 42- 121
COMMAND INPUT ===>                                              SCROLL ===> CSR
JEDDY WEBSERVICE EmployeeWebservice within PIPELINE ITSOREQ has been created.
JEDDY WEBSERVICE EmployeeWebservice is now INSERVICE and is ready for use.
JEDDY PIPELINE ITSOREQ explicit scan has completed. Number of wsbind files found
er of WEBSERVICEs created or updated: 000001. Number of WEBSERVICEs not requirin
ERVICE creates or updates: 000000.
JEDDY PIPELINE ITSOREQ is about to scan the WSDIR directory.
JEDDY PIPELINE ITSOREQ explicit scan has completed. Number of wsbind files found
er of WEBSERVICEs created or updated: 000000. Number of WEBSERVICEs not requirin
ERVICE creates or updates: 000000.
******************************** BOTTOM OF DATA ********************************
```

F1=HELP F2=SPLIT F3=END F4=RETURN F5=IFIND F6=BOOK
F7=UP F8=DOWN F9=SWAP F10=LEFT F11=RIGHT F12=RETRIEVE

Figure 12-24 SDSF output of CICS region

6. Check in the CICS region by typing `CEMT INQ WEBSERVICE`.
7. Navigate to the `EmployeeWebservice` and press Enter to see the Web service details, as shown in Figure 12-25 on page 413.



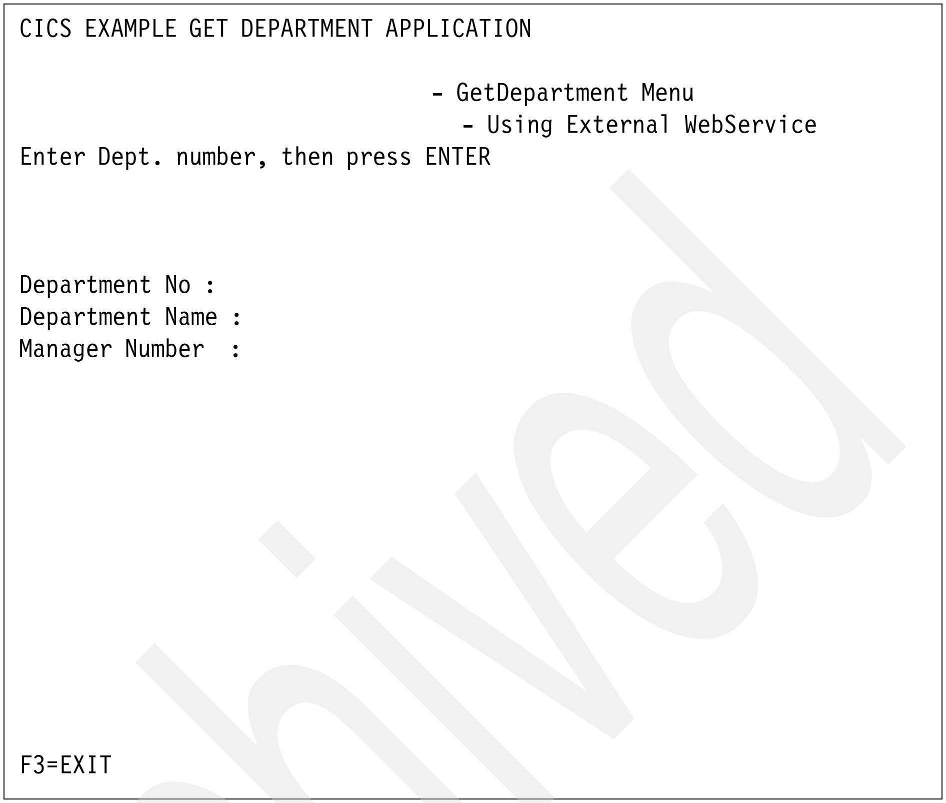
```
 INQ WEBS
 RESULT - OVERTYPE TO MODIFY
   Webservice(EmployeeWebservice)
   Pipeline(ITSOREQ)
   Validationst( Novalidation )
   State(Inservice)
   Ccsid(00000)                          _
   Urimap()
   Program()
   Pgminterface(Notapplic)
   Xopsupportst(Xopsupport)
   Xopdirectst(Xopdirect)
   Mappinglevel(1.2)
   Minrunlevel(1.2)
   Datestamp(20080910)
   Timestamp(22:23:23)
   Container()
   Wsdlfile()
   Wsbind(/u/itso13/itso/wspickup/requester/EmployeeWebservice.wsbind)
 + Endpoint(http://wtscz1.itso.ibm.com:8128/EmployeeEmployeeWebserviceWeb/s)

                                                   SYSID=WRKS APPLID=CITSO13
                                              TIME:  16.41.04  DATE: 09.10.08
PF 1 HELP 2 HEX 3 END        5 VAR         7 SBH 8 SFH        10 SB 11 SF
```

Figure 12-25 CEMT Inquire Web Service EmployeeWebservice

12.8 Testing the CICS Service requester program

To test the application, perform the following steps:

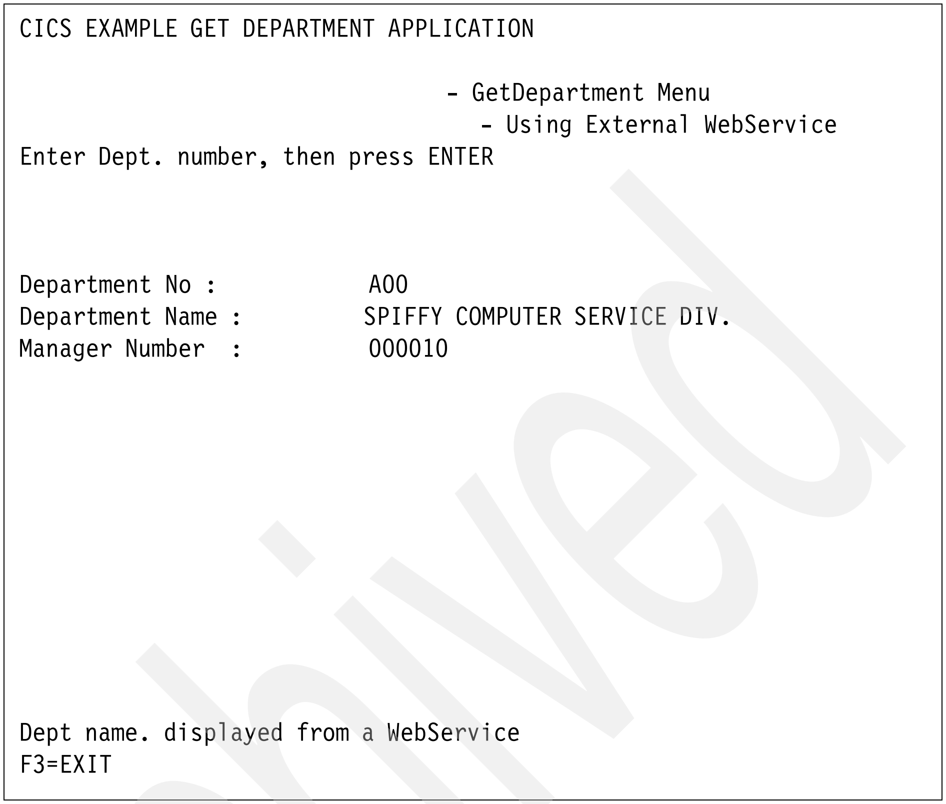
1. Type the Transaction ID associated with the CICS client program `DEPTXGUI`, which is `RGUI` in our example. Refer to Figure 12-26 on page 414.



```
CICS EXAMPLE GET DEPARTMENT APPLICATION

                               - GetDepartment Menu
                                 - Using External WebService
Enter Dept. number, then press ENTER



Department No :
Department Name :
Manager Number  :










F3=EXIT
```

Figure 12-26 CICS example getDepartment application window

2. Enter an existing Department number, such as A00, and press Enter. You see the result that was obtained from the Web service displayed on the window (Figure 12-27 on page 415).



```
CICS EXAMPLE GET DEPARTMENT APPLICATION

                                - GetDepartment Menu
                                  - Using External WebService
Enter Dept. number, then press ENTER



Department No :            A00
Department Name :          SPIFFY COMPUTER SERVICE DIV.
Manager Number  :          000010











Dept name. displayed from a WebService
F3=EXIT
```

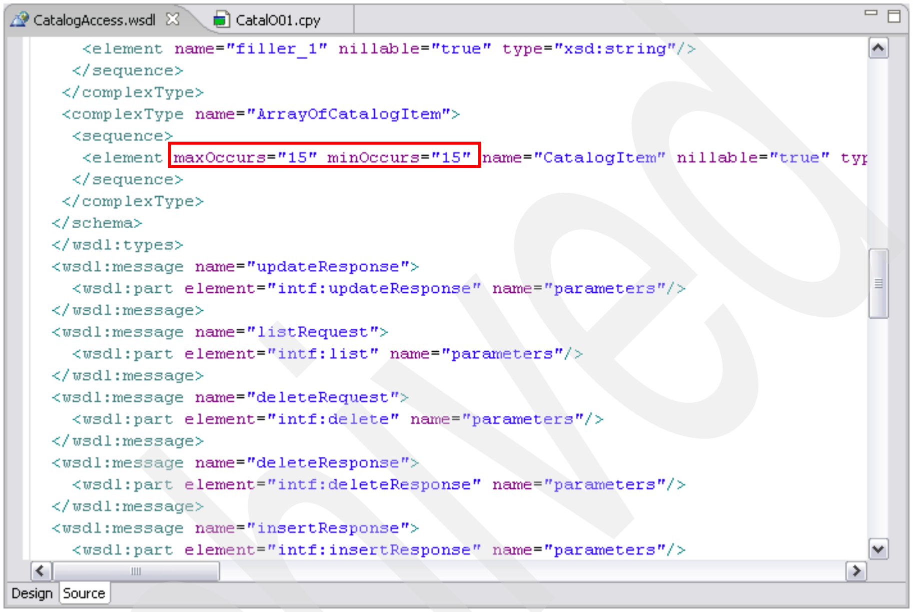
Figure 12-27 Example getDepartment application results displayed from an external Web service

The results of the Figure 12-27 and Figure 12-7 on page 393 will match.

12.9 Handling complex CICS COMMAREA structures

COBOL copybook structures are not known for dynamically creating data or interface structures as you can with XML data structures. The COBOL copybook needs to have fixed length records in case of arrays. The COBOL copybook has to know the number of times that a structure will repeat or occur. In case of XML data structures, however, you have the option to create dynamic structures by defining the option “unbounded” in the `maxoccurs` field and the `minoccurs` field as `0`. In terms of COBOL then, the array can have 0 to any number of occurrences depending on a parameter that can be set by the application; however, RDz will not support generation of CICS Web Services artifacts in cases with such dynamic structures. To be able to process WSDL documents with dynamic data structures, you need to edit the WSDL file first and update the `maxoccurs` and `minoccurs` fields to the actual number of `OCCURS` in your copybook.

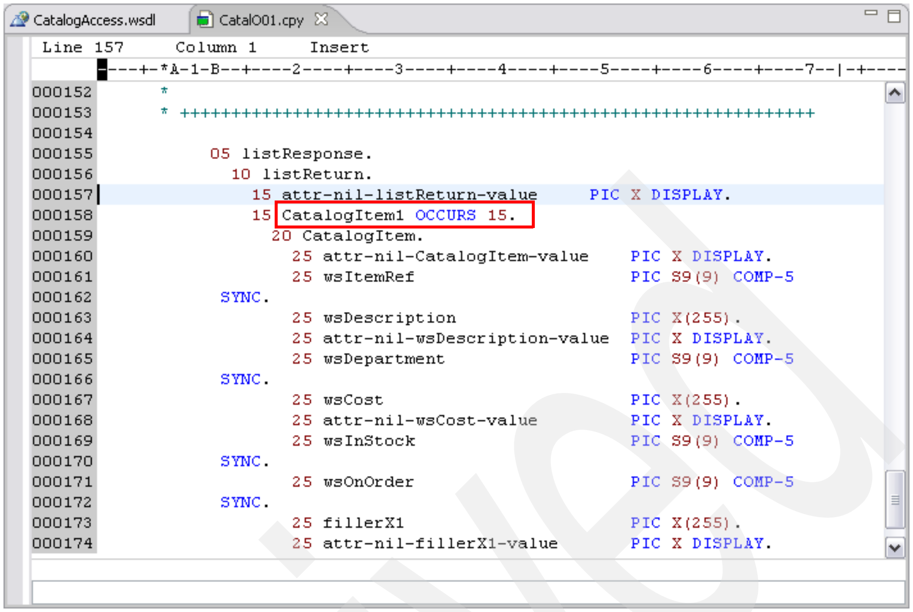
For example, if you want your response structure to have an `OCCURS` clause for a response structure of 15 times in your copybook, just edit the WSDL file and update the `maxoccurs` and `minoccurs` to `15` as shown in Figure 12-28.



```
   <element name="filler_1" nillable="true" type="xsd:string"/>
  </sequence>
 </complexType>
 <complexType name="ArrayOfCatalogItem">
  <sequence>
   <element maxOccurs="15" minOccurs="15" name="CatalogItem" nillable="true" typ
  </sequence>
 </complexType>
</schema>
</wsdl:types>
<wsdl:message name="updateResponse">
  <wsdl:part element="intf:updateResponse" name="parameters"/>
</wsdl:message>
<wsdl:message name="listRequest">
  <wsdl:part element="intf:list" name="parameters"/>
</wsdl:message>
<wsdl:message name="deleteRequest">
  <wsdl:part element="intf:delete" name="parameters"/>
</wsdl:message>
<wsdl:message name="deleteResponse">
  <wsdl:part element="intf:deleteResponse" name="parameters"/>
</wsdl:message>
<wsdl:message name="insertResponse">
  <wsdl:part element="intf:insertResponse" name="parameters"/>
```

Figure 12-28 XML structure with complexType

After updating the WSDL file and subsequently generating the COMMAREA in RDz, you will notice output as shown in Figure 12-29 on page 417.



```
      *
      * ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

           05 listResponse.
             10 listReturn.
               15 attr-nil-listReturn-value     PIC X DISPLAY.
               15 CatalogItem1 OCCURS 15.
                 20 CatalogItem.
                   25 attr-nil-CatalogItem-value    PIC X DISPLAY.
                   25 wsItemRef                     PIC S9(9) COMP-5
            SYNC.
                   25 wsDescription                 PIC X(255).
                   25 attr-nil-wsDescription-value  PIC X DISPLAY.
                   25 wsDepartment                  PIC S9(9) COMP-5
            SYNC.
                   25 wsCost                        PIC X(255).
                   25 attr-nil-wsCost-value         PIC X DISPLAY.
                   25 wsInStock                     PIC S9(9) COMP-5
            SYNC.
                   25 wsOnOrder                     PIC S9(9) COMP-5
            SYNC.
                   25 fillerX1                      PIC X(255).
                   25 attr-nil-fillerX1-value       PIC X DISPLAY.
```

Figure 12-29 Generated copybook with arrays

12.10 Summary

In this chapter, we have shown how an existing external Web service can be easily used from a CICS application by adopting a top-down approach. There might be situations where you have to write one or several wrapper programs to bridge the differences between the outside Web service and the already existing CICS programs. It is also possible that at the same time of integrating external Web services you want to refactor or re-architect existing CICS applications. Changes in both the WSDL of the external Web service and the existing CICS programs might be necessary to produce a flexible solution. This approach of bridging is referred to as the “meet-in-the-middle” approach.

Important: In this sample, we assume that the CICS application makes a direct call to a Web service implemented in an application server elsewhere. It also looks as though CICS service requestors might need to be adjusted to the external WSDL, or both the WSDL and the CICS service requestor might need to be adjusted to create a fit. Note, however, that discrepancies between service requestors in CICS and external Web services can also be perfectly resolved by an ESB.

13

Integrating an external Web service into an IMS application

There has been an increasing need for the IMS business functions to access new business logic running outside the IMS environment. IMS supports access to external Web services by means of *asynchronous callout* support. With this functionality, users can develop new applications or extend their existing IMS applications to access new business logic or data outside IMS and use state-of-the-art Web Services techniques. Web Services calls are routed from IMS via the IMS SOAP Gateway.

Rational Developer for System z (RDz) provides wizards that generate the XML converter and the correlator file that are needed to enable your IMS application to run as a Web Service consumer.

In this chapter, we discuss the following topics:

- Prerequisites
- Outbound Web Services overview
- Development and deployment steps

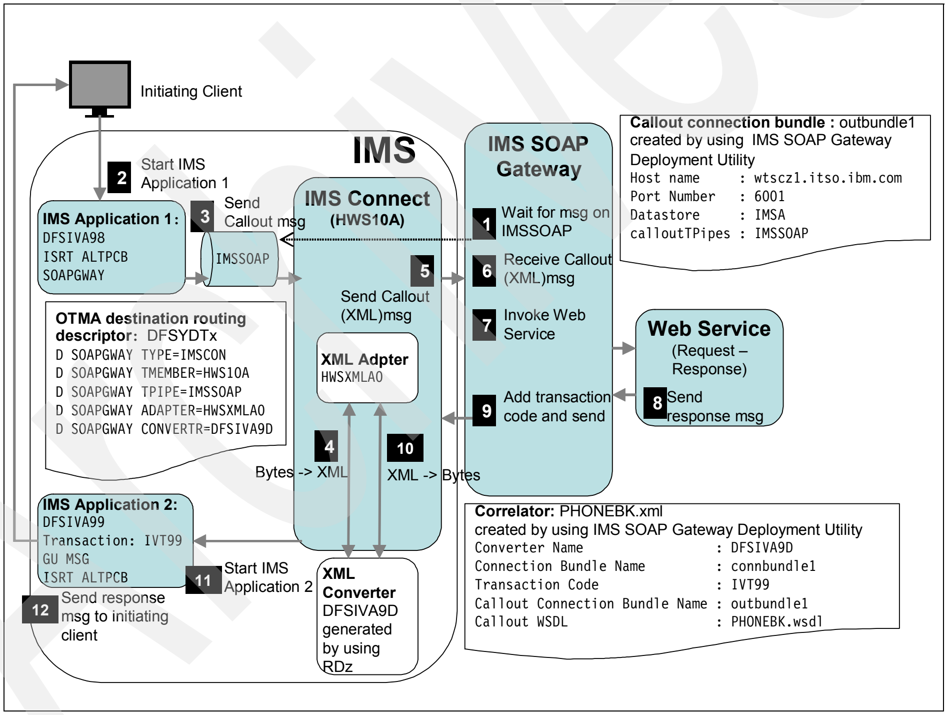
13.1 Prerequisites

You must have the following prerequisite software to develop and deploy this scenario:

- IMS Version 10 or later
- IMS SOAP Gateway Version 10.1 or later
- Rational Developer for System z (RDz) Version 7.1.1 or later

13.2 Outbound Web Services overview

This sample explains the callout to a Request-Response type of Web service. The process is depicted graphically in Figure 13-1.



OTMA destination routing descriptor: DFSYDTx

```
D SOAPGWAY TYPE=IMSCON
D SOAPGWAY TMEMBER=HWS10A
D SOAPGWAY TPIPE=IMSSOAP
D SOAPGWAY ADAPTER=HWSXMLA0
D SOAPGWAY CONVERTR=DFSIVA9D
```

Callout connection bundle : outbundle1 created by using IMS SOAP Gateway Deployment Utility

```
Host name     : wtsczl.itso.ibm.com
Port Number   : 6001
Datastore     : IMSA
calloutTPipes : IMSSOAP
```

Correlator: PHONEBK.xml created by using IMS SOAP Gateway Deployment Utility

```
Converter Name                : DFSIVA9D
Connection Bundle Name        : connbundle1
Transaction Code              : IVT99
Callout Connection Bundle Name : outbundle1
Callout WSDL                  : PHONEBK.wsdl
```

Figure 13-1 Outbound Web Services overview as used in our sample

The steps in Figure 13-1 are (the numbers in the diagram correspond to the numbers in the list):

1. Waiting for callout message.

When IMS SOAP Gateway starts a callout thread, IMS SOAP Gateway establishes a TCP/IP connection with IMS Connect and sends a request from the hold queue (the tpipe) to IMS Connect. The tpipe name is obtained from the callout connection bundle file.

2. Start IMS application 1.

   A client starts IMS application 1 DFSIVA98.

3. Send the callout message to IMS Connect.

   IMS application 1 inserts into the *ALTernate Program Control Block (ALTPCB)* using the Open Transaction Manager Access (OTMA) destination routing descriptor SOAPGWAY. The descriptor has the IMS Connect cross-system coupling facility (XCF) member name (`TMEMBER`), the hold queue name (`TPIPE`), the XML Adapter name (`ADAPTER`), and the XML converter name (`CONVERTR`). The XML converter is generated by using Rational Developer for System z.

   OTMA reads the descriptor SOAPGWAY that has a tpipe name of `IMSSOAP` and sends the callout message to the asynchronous hold queue `IMSSOAP`. The adapter name (`HWSXMLA0`) and converter name (`DFSIVA9D`) specified in the OTMA destination routing descriptor are copied to the OTMA header of the callout message.

4. Callout message transformation from COBOL application data to XML.

   IMS Connect retrieves the existing callout message from `IMSSOAP` as part of the request processing for IMS SOAP Gateway. IMS Connect reads the OTMA header for the adapter name and the converter name. And, it calls the adapter `HWSXMLA0` and the converter `DFSIVA9D` for XML processing. The converter `DFSIVA9D` performs the callout message transformation from COBOL application data to XML.

5. Send the callout message to IMS SOAP Gateway.

   After the converter converts the callout message successfully, IMS Connect sends the callout request message back to IMS SOAP Gateway.

6. Receive the callout message.

   IMS SOAP Gateway receives the callout request message in XML and parses the message to retrieve the service and payload data. IMS SOAP Gateway loads the corresponding correlator file and retrieves the Web service information and properties for invoking the Web service.

7. Invoke the Web service.

   IMS SOAP Gateway sends the callout message to the Web service using the SOAP/HTTP protocol.

8. Send response message.

   The Web service runs and generates a response message and sends it back to IMS SOAP Gateway.

9. Add transaction code and send response message.

   IMS SOAP Gateway adds the transaction code for IMS application 2, `IVT99`; the adapter name, `HWSXMLA0`; and the converter name, `DFSIVA9D` (all retrieved from the correlator file) and sends the response message to IMS Connect.

10. Response message transformation from XML to COBOL application data.

    IMS Connect receives the response message and loads the response converter, `DFSIVA9D`, for XML to bytes conversion. IMS Connect takes the transaction code value and adds it to the appropriate place (`LLZZTRCDDATA`) in the message.

11. Start IMS application 2.

    IMS invokes IMS application 2 `DFSIVA99` to process the output data.

12. Send response message to initiating client.

    The IMS application 2 sends a response message to the initiating client.

13.3 Development and deployment steps

In the following sections, we explain the steps to develop and deploy a solution with an IMS Web service consumer. We use Rational Developer for System z for most of the steps:

1. Step 1: Modify or create the IMS application for callout requests.

   You must modify or create your IMS application for sending a callout request and receiving a response message back from an external Web service.

2. Step 2: Define an OTMA destination routing descriptor for callout messages.

   The *OTMA destination routing descriptor* enables an IMS application to route callout requests to services that are accessible to the IMS SOAP Gateway without the need to code routing exits.

3. Step 3: Generate artifacts with Rational Developer for System z.

   Generate the mapping between the data structures in your IMS application and the external Web service, and generate the XML converter program by using Rational Developer for System z.

4. Step 4: Create a connection bundle for the callout function.

   Create a *connection bundle* for the callout function that describes the connection properties for accessing IMS. This bundle is created by using the IMS SOAP Gateway Deployment utility.

5. Step 5: Create a correlator file for the callout function.

   Create a *correlator file* for the callout function that describes the information to invoke the outbound Web service and return the response message back to IMS by using the IMS SOAP Gateway Deployment utility.

6. Step 6: Deploy artifacts to IMS SOAP Gateway.

   Use the IMS SOAP Gateway Deployment utility to deploy your IMS application.

7. Step 7: Start the callout threads.

   You must start a callout thread after you deploy your callout client.

13.3.1 Step 1: Modify or create the IMS application for callout requests

You must modify or create your IMS application in order to place the callout request on the OTMA asynchronous hold queue or route the request to an IMS Connect destination. In the example, the IMS application inserts into the alternate program control block (ALTPCB) using the OTMA destination routing descriptor SOAPGWAY.

Important: The destination of ALTPCB is the destination name of the OTMA destination routing descriptor, not the tpipe name.

The COBOL code for sending the callout request is shown in Example 13-1.

Example 13-1 Example of COBOL code for sending the callout request

```
01  EXTERNAL-SERVICE.
   02  EX-DEST        PICTURE X(8) VALUE 'SOAPGWAY'.

CALL 'CBLTDLI' USING CHNG, ALTPCB, EX-DEST.
MOVE LTERM-NAME TO IN-LTERM-NAME.
CALL 'CBLTDLI' USING ISRT, ALTPCB, INPUT-MSG.
CALL 'CBLTDLI' USING PURG, ALTPCB.
```

Note: The checks on the DL/I status code and the error processing are omitted.

You must modify or create the IMS application program to correlate the response to the original input transaction. It will likely require the application program to include a type of data to be used for correlation purposes in the outgoing callout request message and then to look for that same data in the response message. If a reply must be sent back to an LTERM, the LTERM name must also be stored in the database or copied in the callout message. The following code samples show examples of COBOL copybook data structures that might be used for the callout request and the callout response. The callout request data structure includes a correlator field, IN-LTERM-NAME, to send correlation data to the external Web service, as shown in Example 13-2.

Example 13-2 Example of COBOL copybook for the callout function

```
01  INPUT-MSG.
           02  IN-LL          PICTURE S9(3) COMP.
           02  IN-ZZ          PICTURE S9(3) COMP.
           02  IN-TRXCD       PICTURE X(8).
           02  IN-FILL        PICTURE X(2).
           02  IN-COMMAND     PICTURE X(8).
           02  TEMP-COMMAND REDEFINES IN-COMMAND.
               04  TEMP-IOCMD    PIC X(3).
               04  TEMP-FILLER   PIC X(5).
           02  IN-LAST-NAME   PICTURE X(10).
           02  IN-FIRST-NAME  PICTURE X(10).
           02  IN-EXTENSION   PICTURE X(10).
           02  IN-ZIP-CODE    PICTURE X(7).
           02  IN-LTERM-NAME  PICTURE X(8).
```

When the response is returned, the IN-LTERM-NAME field of the COBOL copybook data structure contains the same correlation data, which the IMS application can use to relate the response to the initial request, if needed (Example 13-3 on page 425).

Example 13-3 Example of COBOL copybook for the callout response

```
01  INPUT-MSG.
           02  IN-LL         PICTURE S9(3) COMP.
           02  IN-ZZ         PICTURE S9(3) COMP.
           02  IN-TRXCD      PICTURE X(8).
           02  IN-BLANK      PICTURE X(1).
           02  IN-LTERM-NAME PICTURE X(8).
           02  INPUT-LINE    PICTURE X(85).
           02  INPUT-DATA REDEFINES INPUT-LINE.
               04  IN-MESSAGE   PIC X(40).
               04  IN-COMMAND   PIC X(8).
               04  IN-DATA-TYPE.
                   06  IN-LAST-NAME   PIC X(10).
                   06  IN-FIRST-NAME  PIC X(10).
                   06  IN-EXTENSION   PIC X(10).
                   06  IN-ZIP-CODE    PIC X(7).
           02  IN-SEGMENT-NO  PICTURE X(4).
```

To route a response message to a terminal, the IMS application that issues the callout request can capture the LTERM name of the terminal. Upon receipt of the response message, the IMS application that processes the response can then identify the originating terminal by the LTERM name. The LTERM name can either be included as part of the data of the callout request and the response messages or the LTERM name can be saved in a temporary database that is accessible to the IMS application that processes the response.

After the response is returned, the IMS application can return the response to the initiating terminal by making a CHNG call and ISRT the response to the LTERM name captured by the IMS application program that issued initial callout request.

13.3.2 Step 2: Define an OTMA destination routing descriptor for callout messages

Use OTMA destination routing descriptors to allow OTMA clients, such as IMS Connect, or non-OTMA clients, such as SNA terminals or printers, to define message switch destinations from the ALTPCB. Instead of coding OTMA routing exit routines (DFSYPRX0 and DFSYDRU0), you can externalize the message switch definitions in the DFSYDTx member of the IMS.PROCLIB data set. The x on DFSYDTx is the IMS nucleus suffix.

Specify the ADAPTER and the CONVERTR values. The ADAPTER value must be set to `HWSXMLA0` if you want XML data transformation to be performed by IMS

Connect. Example 13-4 shows an example of the OTMA destination routing descriptor, which spans multiple lines.

Example 13-4 Example of OTMA destination routing descriptor for callout message

```
D SOAPGWAY TYPE=IMSCON TMEMBER=HWS1OA   TPIPE=IMSSOAP
D SOAPGWAY ADAPTER=HWSXMLA0 CONVERTR=DFSIVA9D
```

Note that:

- The descriptor for SOAPGWAY routes messages to IMS Connect TMEMBER `HWS1OA` with tpipe `IMSSOAP`.
- The ADAPTER value must be set to `HWSXMLA0` if you want XML data transformation to be performed by IMS Connect by using the IMS Connect XML adapter.
- The XML converter name is `DFSIVA9D`.

Important: The tpipe that you use for the IMS SOAP Gateway callout function must not be shared with another callout function, such as the callout function that is used in the IMS TM resource adapter.

If the initiating client is an SNA terminal, you must code OTMA destination routing descriptors or OTMA routing exit routines, because the response message is not routed to an SNA terminal but OTMA. An OTMA destination routing descriptor sample is shown in Example 13-5.

Example 13-5 OTMA destination routing descriptor for SNA terminal

```
D ltermname TYPE=NONOTMA
```

For more information, refer to the OTMA descriptors topic in *IMS Version 10 Communications and Connection Guide*, SC18-9703, and the DFSYDTx PROCLIB member in *IMS Version 10 System Definition Reference*, GC18-9966.

13.3.3 Step 3: Generate artifacts with RDz

Rational Developer for System z (RDz) provides a wizard that generates the correlator file and the XML converter that are needed to enable your IMS application to run as a Web services consumer.

For Rational Developer for System z to perform data mapping and create the mapping files between your IMS application and the Web service that you are accessing, you must have the file describing the data structure in your application and the Web service's Web Services Description Language (WSDL) file on your workstation:

- For inbound message mapping, the source files are WSDL, XML, or XSD files.
- For outbound message mapping, the source files are CBL files.

The artifacts generated are:

- The correlator file in XML (.xml)
- The XML converters in COBOL (.cbl)

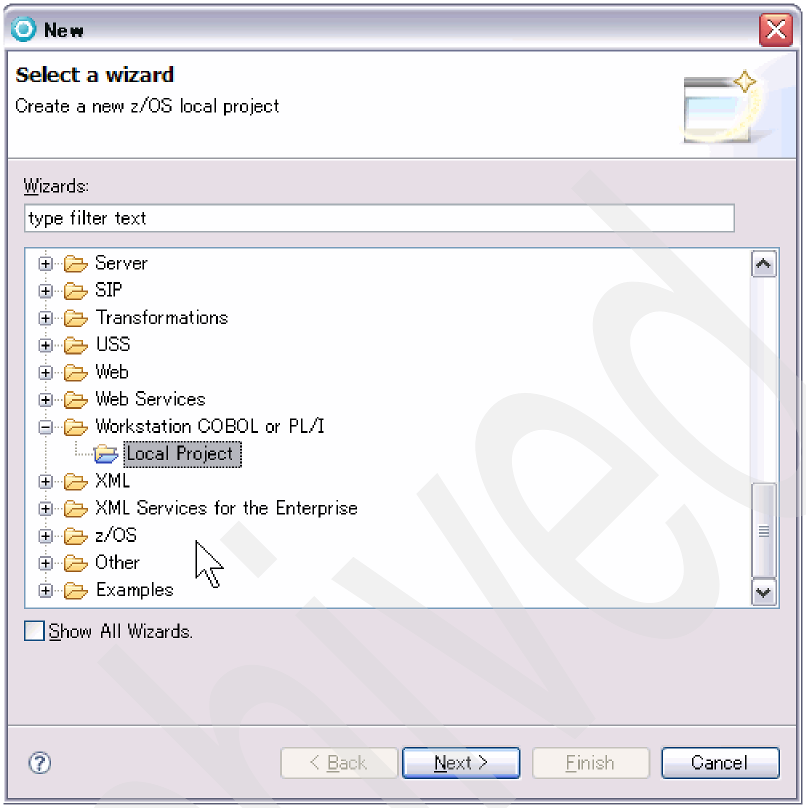
> **Note:** In our environment, we were not able to edit the mapping between the data structure of the IMS application and the Web service using RDz Version 7.1.1.2. In the following steps "Step 3a: Generate mapping data" on page 427 and "Step 3b: Generate Web service files" on page 439, we used RDz Version 7.1.0 instead. We did not test this scenario using RDz Version 7.5, and it is possible that this problem is fixed in Version 7.5.

Step 3a: Generate mapping data

Rational Developer for System z provides wizards that map the data structures between your IMS application and the Web service that the IMS application is accessing. In this step, we describe how the mapping is generated:

1. Start Rational Developer for System z and open the z/OS Projects perspective.
2. Create a new local COBOL project:
   a. Select **File** → **New** → **Project**.
   b. Expand the **Workstation COBOL or PL/I** folder.
   c. Select **Local Project**, and click **Next**.

   Refer to Figure 13-2 on page 428.



Select a wizard

Create a new z/OS local project

Figure 13-2 Create new local COBOL project

3. In the next window, type a name for the project, for example, `MyProject`.

   Click **Finish**. A new project called MyProject is now available in your workspace.

4. Create a folder for your source files:

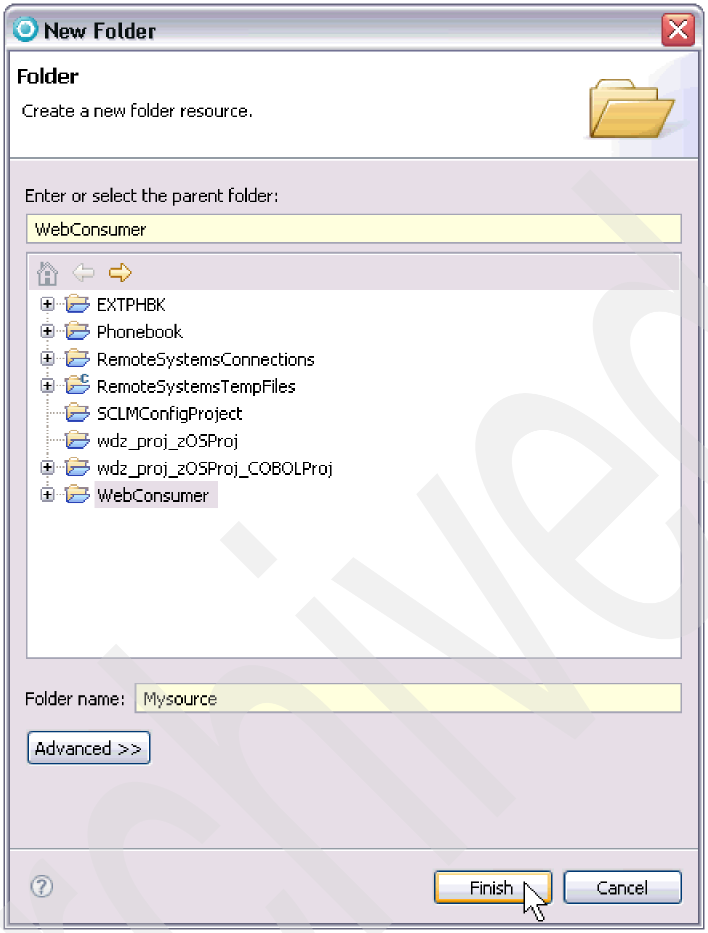
   a. In the z/OS Projects view, right-click the name of the new project that you just created.

   b. Select **New** → **Folder**. The New Folder wizard opens.

   c. In the New Folder wizard:

      - Select the project that you just created.
      - In the Folder name input field, type the name that you want to use for the new folder, for example, `MySource`.
      - Click **Finish**.The folder is created.

   Refer to Figure 13-3 on page 429.



New Folder

Folder

Create a new folder resource.

Enter or select the parent folder:

WebConsumer

Folder name: Mysource

Figure 13-3 Create a folder for your source files

5. Copy your source files from a directory on your workstation into the proper directory in the Navigator view:
   - Open the Navigator view:
     - Select **Window** → **Show View** → **Other**. The Show View wizard opens.
     - In the Show View window, expand **General** and select **Navigator**.
     - Click **OK**. The Navigator view opens.
   - In the Navigator view:
     - Expand your project, for example, **MyProject**.

    - Select the directory for the project, for example, **MySource**. The directory has the same name and path as the new folder in the z/OS Projects view (for example, `MyProject/MySource`).

  - Open the directory on your workstation that contains the COBOL copybook.
  - Drag the Web service WSDL file from the workstation directory to the new folder (for example, **MySource**) in the Navigator view.

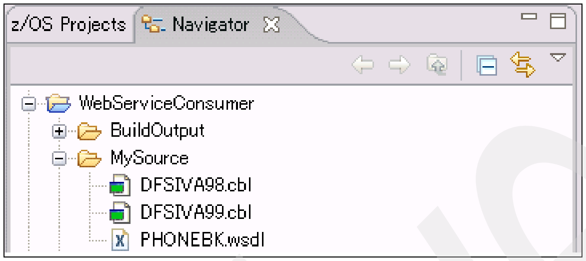
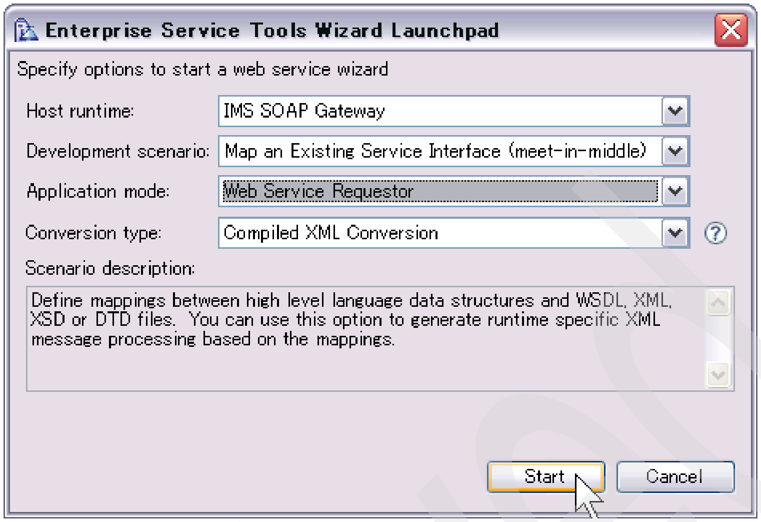


Figure 13-4 Copy your source files

6. Right-click the COBOL copybook and select **Enable Enterprise Web Service**. The Enterprise Service Tools Wizard Launchpad opens.
7. In the launchpad, as shown in Figure 13-5 on page 431, select the following settings:
   - Host runtime: **IMS SOAP Gateway**
   - Development scenario: **Map to an Existing Service Interface (meet-in-middle)**
   - Application mode: **Web Service Requestor**
   - Conversion type: **Compiled XML Conversion**
8. Click **Start**. Refer to Figure 13-5 on page 431. The New XML to COBOL Mapping wizard opens, as shown in Figure 13-6 on page 432.



Enterprise Service Tools Wizard Launchpad

Specify options to start a web service wizard

Host runtime: IMS SOAP Gateway

Development scenario: Map an Existing Service Interface (meet-in-middle)

Application mode: Web Service Requestor

Conversion type: Compiled XML Conversion

Scenario description:

Define mappings between high level language data structures and WSDL, XML, XSD or DTD files. You can use this option to generate runtime specific XML message processing based on the mappings.

Figure 13-5 Enterprise Service Tool Wizard Launchpad

9. In the New XML to COBOL Mapping page of the wizard, as shown in Figure 13-6 on page 432:

   – In the Mapping source field, the name of the copybook that you right-clicked is selected.

     If this name is not the file that you want to use for the source, use **Browse** to choose another source file.

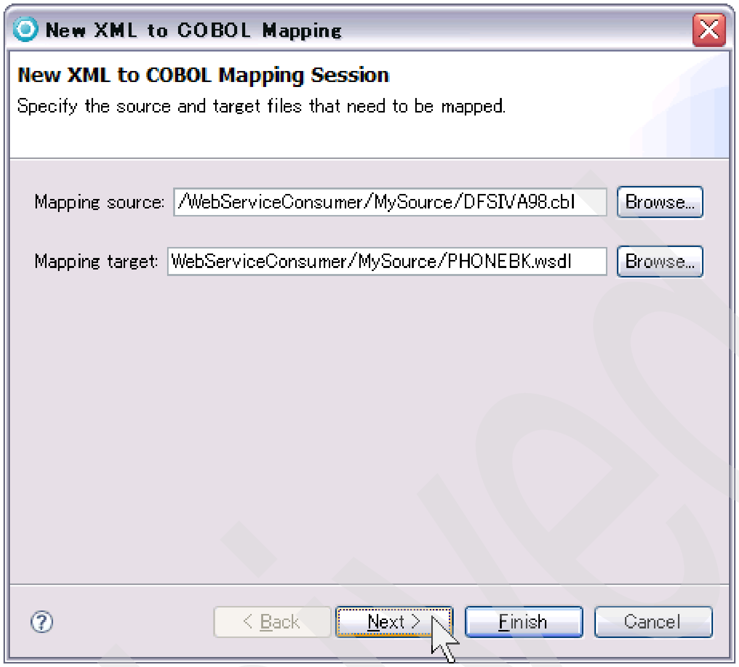
     > **Important**: If you specify a WSDL, XSD, or XML file for this field, the wizard changes to inbound mapping mode.

   – In the Mapping target field, specify the WSDL file for the Web service to which your IMS application is calling out.

     > **Important**: If you specify a high-level language file (such as a .cbl file) for this field, the wizard changes to outbound mapping mode.

   – Click **Next**.

   Refer to Figure 13-6 on page 432.



New XML to COBOL Mapping

New XML to COBOL Mapping Session

Specify the source and target files that need to be mapped.

Mapping source: /WebServiceConsumer/MySource/DFSIVA98.cbl

Mapping target: WebServiceConsumer/MySource/PHONEBK.wsdl

Figure 13-6 New XML to COBOL Mapping Session for outbound data mapping

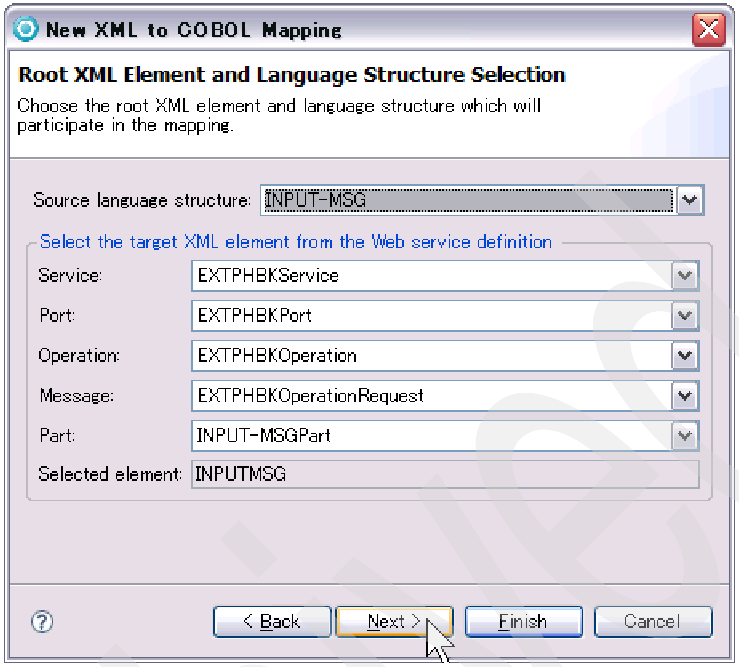
10. In the Root XML Element and Language Structure Selection page of the wizard, as shown in Figure 13-7 on page 433:

   – The fields are automatically filled in based on the COBOL copybook source and the WSDL target file that you specified.

     Adjust the values if they are not what you want by selecting from the selection drop-down lists.

   – Click **Next**.

   Refer to Figure 13-7 on page 433.


New XML to COBOL Mapping

Root XML Element and Language Structure Selection

Choose the root XML element and language structure which will participate in the mapping.

Source language structure: INPUT-MSG

Select the target XML element from the Web service definition

Service: EXTPHBKService

Port: EXTPHBKPort

Operation: EXTPHBKOperation

Message: EXTPHBKOperationRequest

Part: INPUT-MSGPart

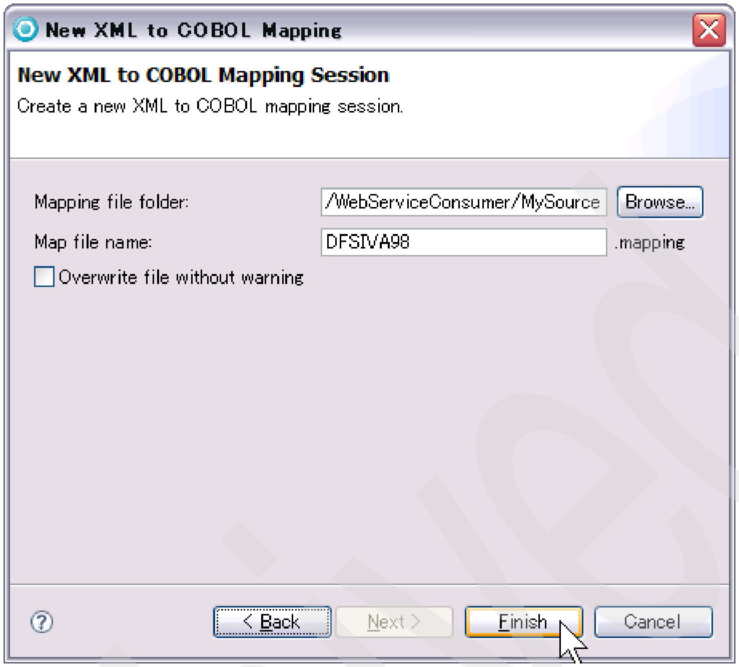
Selected element: INPUTMSG

Figure 13-7 Root XML Element and Language Structure Selection for outbound data mapping

11.On the New XML to COBOL Mapping Session page of the wizard, as shown in Figure 13-8 on page 434:

- In the Mapping file folder field, specify the path for the folder in which you want the new outbound mapping session file to be created.
- In the Map file name field, specify a name for the new outbound mapping session file.
- Click **Finish**.

Refer to Figure 13-8 on page 434. A mapping session file with a mapping extension is created in the file folder that you specified.



New XML to COBOL Mapping Session

Create a new XML to COBOL mapping session.

Mapping file folder: /WebServiceConsumer/MySource

Map file name: DFSIVA98 .mapping

□ Overwrite file without warning

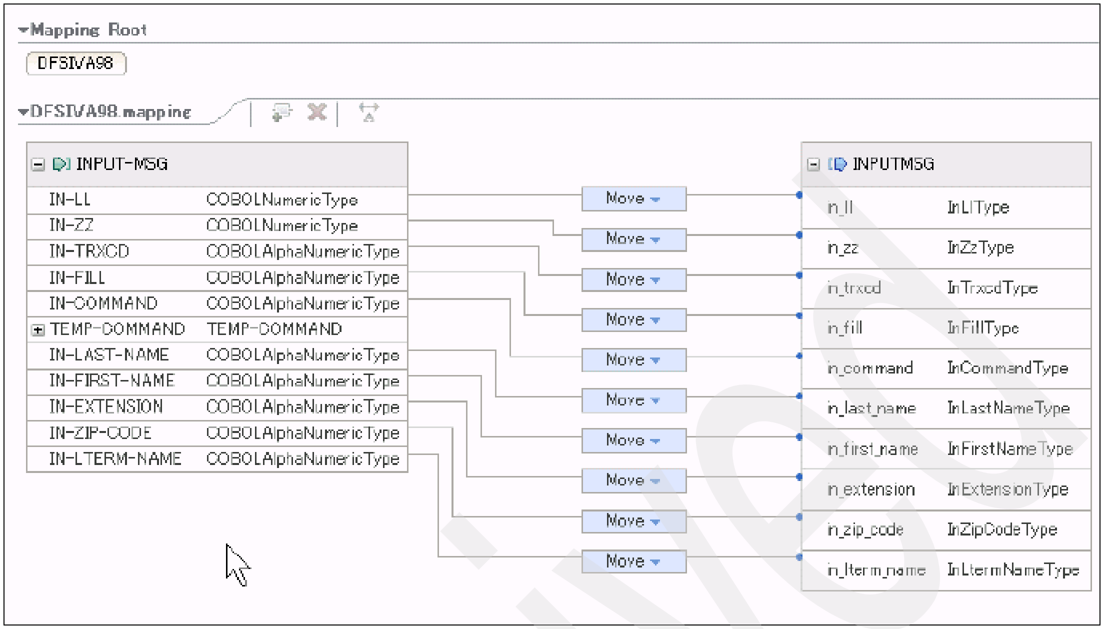
Figure 13-8 New XML to COBOL Mapping Session for outbound data mapping

12. Double-click the mapping session file that you want to edit. The mapping editor opens. In the mapping editor:

    – For each mapping that you want to create, drag an element in the source data to an element in the target data. The editor displays a connecting line between the source element and the target element to indicate that a mapping exists.

    – When you are finished creating the mapping, close the mapping editor.

    Refer to Figure 13-9 on page 435.



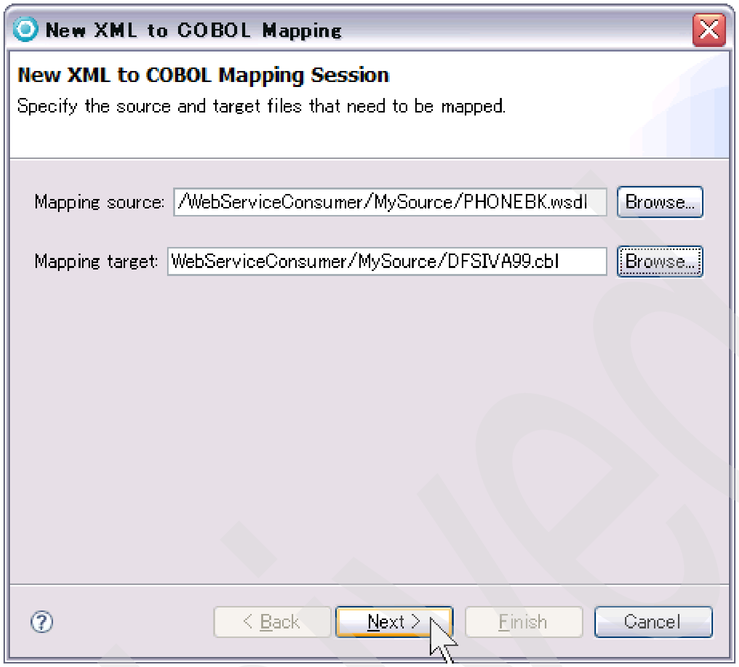
INPUT-MSG	
IN-LL	COBOLNumericType
IN-ZZ	COBOLNumericType
IN-TRXCD	COBOLAlphaNumericType
IN-FILL	COBOLAlphaNumericType
IN-COMMAND	COBOLAlphaNumericType
TEMP-COMMAND	TEMP-COMMAND
IN-LAST-NAME	COBOLAlphaNumericType
IN-FIRST-NAME	COBOLAlphaNumericType
IN-EXTENSION	COBOLAlphaNumericType
IN-ZIP-CODE	COBOLAlphaNumericType
IN-LTERM-NAME	COBOLAlphaNumericType

INPUTMSG	
in_ll	InLlType
in_zz	InZzType
in_trxcd	InTrxcdType
in_fill	InFillType
in_command	InCommandType
in_last_name	InLastNameType
in_first_name	InFirstNameType
in_extension	InExtensionType
in_zip_code	InZipCodeType
in_lterm_name	InLtermNameType

Figure 13-9 Mapping Editor to edit/create outbound data mapping

13. Repeat steps 9 on page 431 to 12 on page 434 to create the inbound message mappings from the Web service to the COBOL copybook. However:
    - Instead of starting from a COBOL copybook, right-click the WSDL file of the Web service to which you are calling out and select **Enable Enterprise Web service**.
    - In the New XML to COBOL Mapping wizard, as shown in Figure 13-10 on page 436:
        - For the Mapping source field, specify the WSDL file for the Web service
        - For the Mapping target field, specify the COBOL copybook.

    The two mapping session files now contain the mappings that you created.



New XML to COBOL Mapping Session

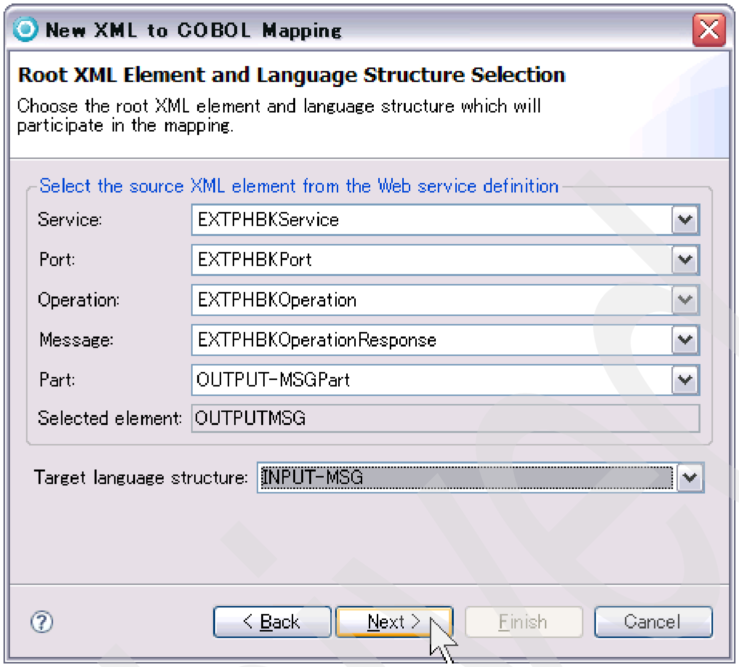
Specify the source and target files that need to be mapped.

Mapping source: /WebServiceConsumer/MySource/PHONEBK.wsdl

Mapping target: WebServiceConsumer/MySource/DFSIVA99.cbl

Figure 13-10 New XML to COBOL Mapping Session for inbound data mapping

Figure 13-11 on page 437 shows the Root XML Element and Language Structure Selection pane of the wizard for the inbound data mapping with the defaults.



New XML to COBOL Mapping

Root XML Element and Language Structure Selection

Choose the root XML element and language structure which will participate in the mapping.

Select the source XML element from the Web service definition

Service: EXTPHBKService

Port: EXTPHBKPort

Operation: EXTPHBKOperation

Message: EXTPHBKOperationResponse

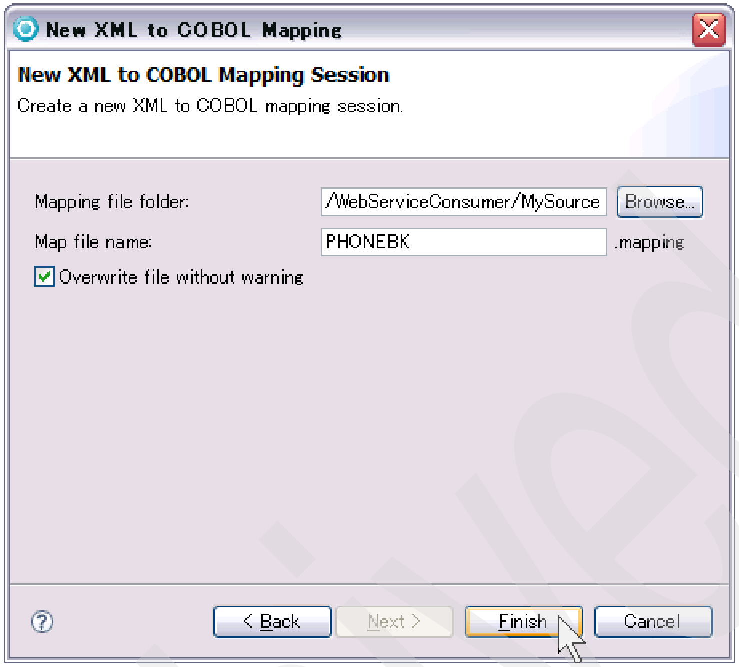
Part: OUTPUT-MSGPart

Selected element: OUTPUTMSG

Target language structure: INPUT-MSG

Figure 13-11 Root XML Element and Language Structure Selection for inbound data mapping

Figure 13-12 on page 438 shows the New XML to COBOL Mapping Session pane of the wizard for the inbound data mapping.


New XML to COBOL Mapping

New XML to COBOL Mapping Session

Create a new XML to COBOL mapping session.

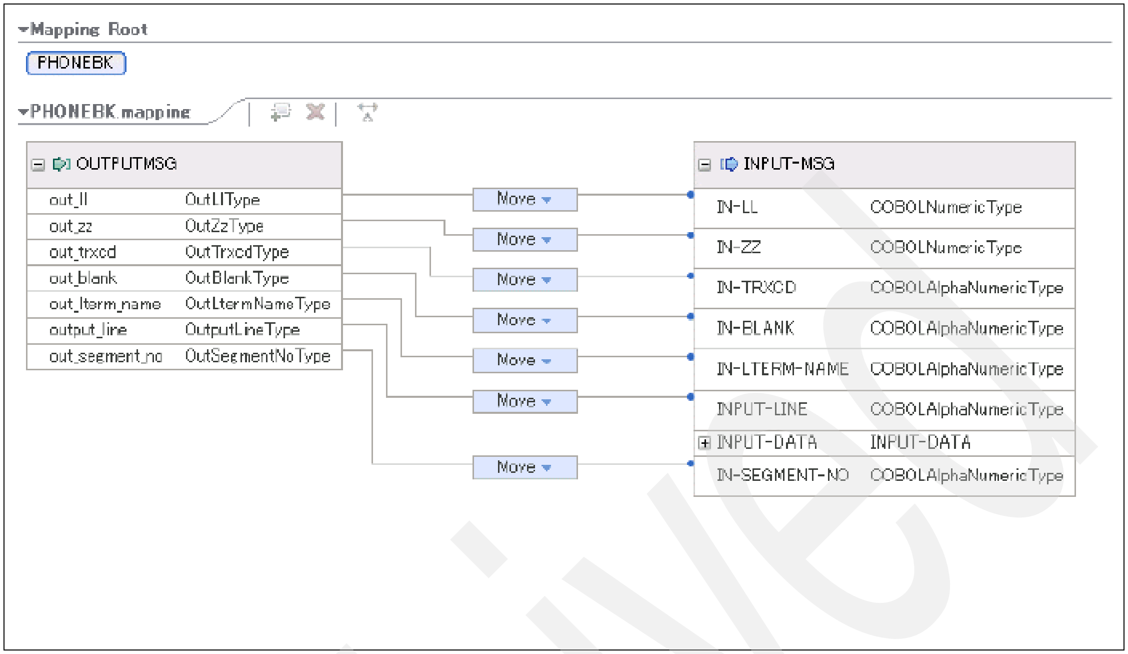
Mapping file folder: /WebServiceConsumer/MySource

Map file name: PHONEBK .mapping

☑ Overwrite file without warning

Figure 13-12 New XML to COBOL Mapping Session for inbound data mapping

Figure 13-13 on page 439 shows the Mapping Editor for the inbound data mapping.



OUTPUTMSG	
out_ll	OutLlType
out_zz	OutZzType
out_trxcd	OutTrxcdType
out_blank	OutBlankType
out_lterm_name	OutLtermNameType
output_line	OutputLineType
out_segment_no	OutSegmentNoType

INPUT-MSG	
IN-LL	COBOLNumericType
IN-ZZ	COBOLNumericType
IN-TRXCD	COBOLAlphaNumericType
IN-BLANK	COBOLAlphaNumericType
IN-LTERM-NAME	COBOLAlphaNumericType
INPUT-LINE	COBOLAlphaNumericType
INPUT-DATA	INPUT-DATA
IN-SEGMENT-NO	COBOLAlphaNumericType

Figure 13-13 Mapping Editor to edit/create the inbound data mapping

Step 3b: Generate Web service files

Use the Map an Existing Service Interface (meet-in-middle) wizard in Rational Developer for System z to generate the Web services files to enable your IMS application to run as a Web service consumer.

You must have already performed the data mapping task by using Rational Developer for System z as described in “Step 3a: Generate mapping data” on page 427.

In Rational Developer for System z, select the mapping session files that you have just created:

1. Right-click anywhere in the view that contains the mapping files.

   If you want the meet-in-middle wizard to create a bidirectional Web service, select an inbound mapping session file and an outbound mapping session file, as shown in Figure 13-14 on page 440.

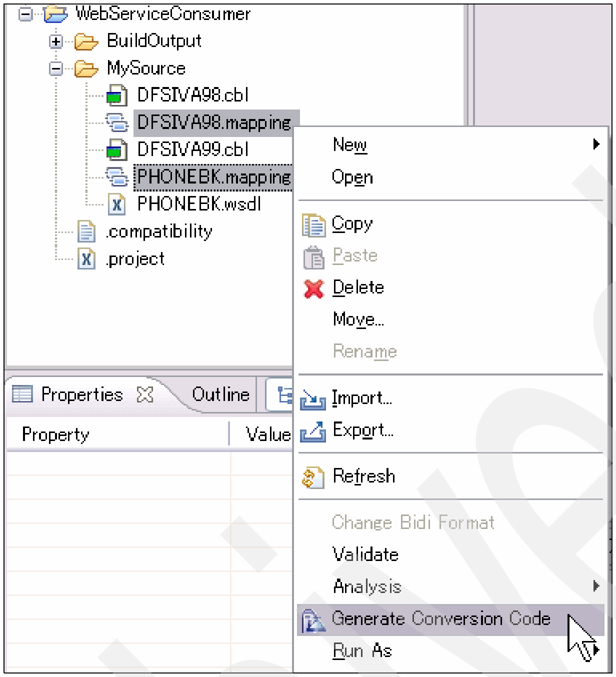
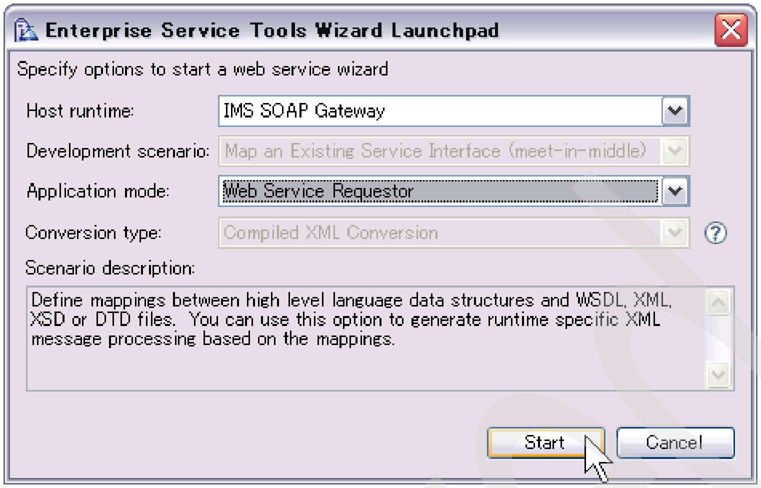


Figure 13-14 Open the Enterprise Service Tools wizard launchpad

2. Right-click the mapping files and select **Generate Conversion Code** from the pop-up menu, as shown in Figure 13-14. The Enterprise Service Tools Wizard Launchpad opens, as shown in Figure 13-15 on page 441.
3. In the launchpad, choose the following values:
   - In the Host runtime field, select **IMS SOAP Gateway**.
   - In the Application mode field, select **Web Service Requestor**.
4. Click **Start**. The Map an Existing Service Interface (meet-in-middle) wizard opens.



Enterprise Service Tools Wizard Launchpad

Specify options to start a web service wizard

Host runtime: IMS SOAP Gateway

Development scenario: Map an Existing Service Interface (meet-in-middle)

Application mode: Web Service Requestor

Conversion type: Compiled XML Conversion

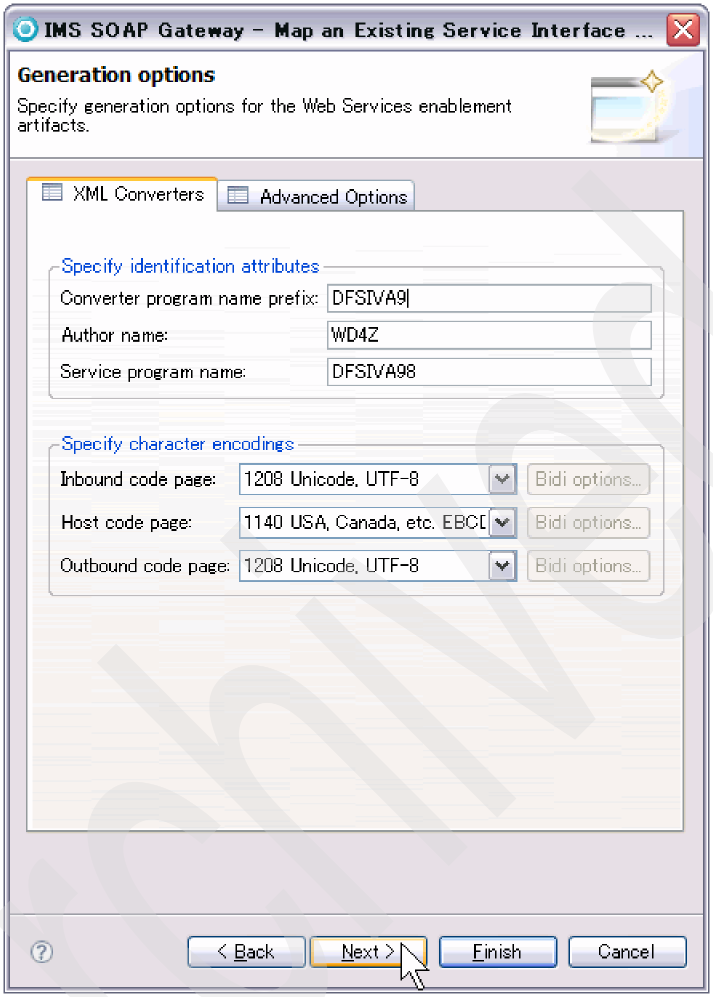
Scenario description:

Define mappings between high level language data structures and WSDL, XML, XSD or DTD files. You can use this option to generate runtime specific XML message processing based on the mappings.

Figure 13-15 Enterprise Service Tools Wizard Launchpad

5. In the Generation of conversion code page of the Map to an Existing Service Interface (meet-in-middle) wizard, verify that you have selected the correct mapping session files. Click **Next**.
6. In the Generation options page of the Map to an Existing Service Interface (meet-in-middle) wizard, in the XML Converters tab, as shown in Figure 13-16 on page 442:
   - In Specify identification attributes, specify attributes if necessary.
   - In Specify character encodings, select or change the following settings if necessary:
     - Host code page:
       Select the code page that the host uses.
     - Inbound code page and outbound code page:
       Default is 1208 Unicode, UTF-8. IMS SOAP Gateway supports only UTF-8, and therefore you cannot change this value.
   - Click **Next**.

   Refer to Figure 13-16 on page 442.



IMS SOAP Gateway - Map an Existing Service Interface ...

Generation options

Specify generation options for the Web Services enablement artifacts.

Specify identification attributes

Converter program name prefix: DFSIVA9

Author name: WD4Z

Service program name: DFSIVA98

Specify character encodings

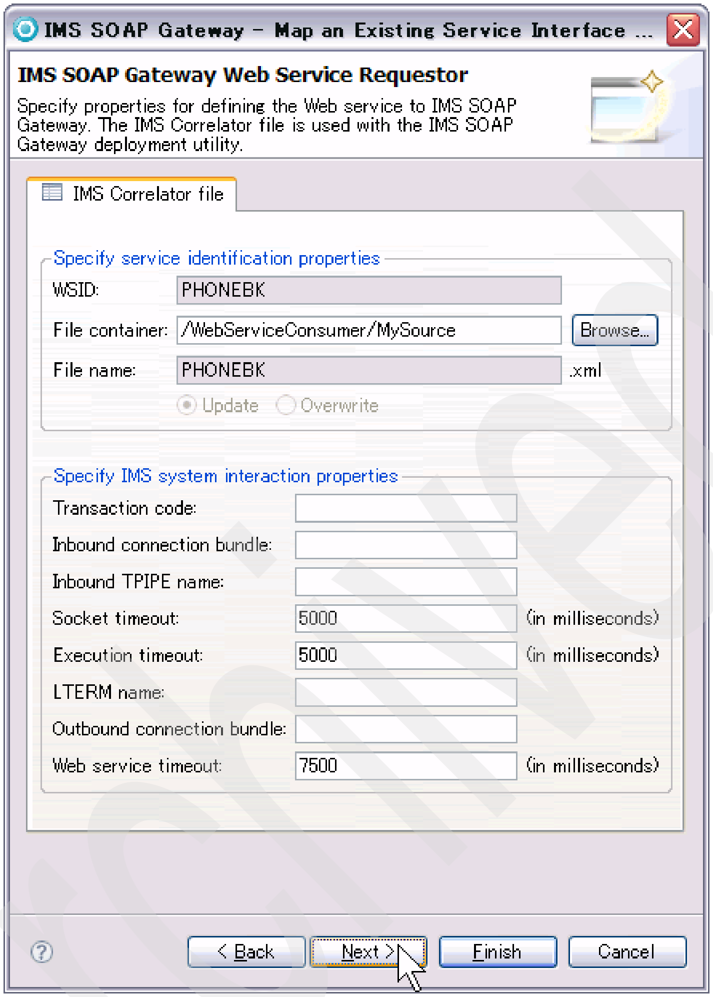
Inbound code page: 1208 Unicode, UTF-8

Host code page: 1140 USA, Canada, etc. EBCI

Outbound code page: 1208 Unicode, UTF-8

Figure 13-16 Generation options

7. On the IMS SOAP Gateway Web Service Requestor page, you can leave the defaults. You can use the IMS SOAP Gateway Deployment utility to create these correlator properties later. Click **Next**. Refer to Figure 13-17 on page 443.



IMS SOAP Gateway - Map an Existing Service Interface ...

IMS SOAP Gateway Web Service Requestor

Specify properties for defining the Web service to IMS SOAP Gateway. The IMS Correlator file is used with the IMS SOAP Gateway deployment utility.

IMS Correlator file

Specify service identification properties

WSID:	PHONEBK	
File container:	/WebServiceConsumer/MySource	Browse...
File name:	PHONEBK	.xml
	● Update ○ Overwrite	

Specify IMS system interaction properties

Transaction code:		
Inbound connection bundle:		
Inbound TPIPE name:		
Socket timeout:	5000	(in milliseconds)
Execution timeout:	5000	(in milliseconds)
LTERM name:		
Outbound connection bundle:		
Web service timeout:	7500	(in milliseconds)

Figure 13-17 IMS SOAP Gateway Web Service Requestor

8. In the File, data set, or member selection page (Figure 13-18 on page 444) of the wizard, specify the following fields if necessary:

   – For the converter file container, specify the folder and subfolder in which you want the converter file to be created.

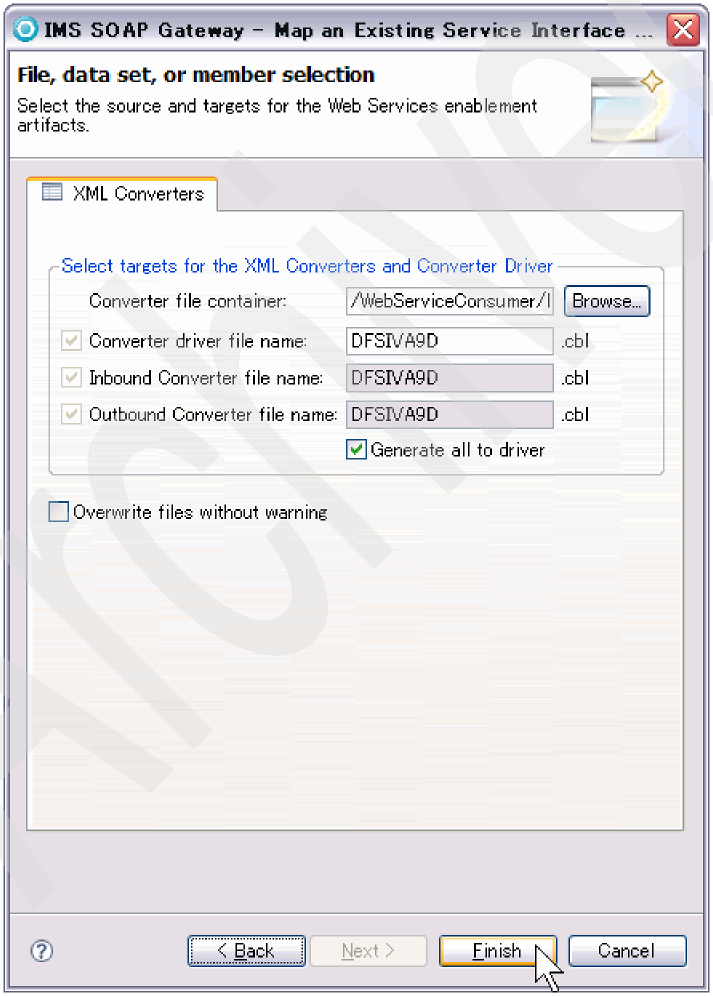
   – For the converter driver file name, specify the name in which you want the converter programs to be generated.

> **Note:** Ensure that **Generate all to driver** is selected. This selection causes all the generated Web service programs (driver, inbound converter, and outbound converter) to be placed in the same file.

Click **Finish**. The following files are generated in the directories and filenames that you specified:

– The file containing the Web service driver and runtime XML converter (.cbl).

– The correlator file (.xml).



IMS SOAP Gateway – Map an Existing Service Interface ...

File, data set, or member selection

Select the source and targets for the Web Services enablement artifacts.

XML Converters

Select targets for the XML Converters and Converter Driver

Converter file container: /WebServiceConsumer/I Browse...

☑ Converter driver file name: DFSIVA9D .cbl

☑ Inbound Converter file name: DFSIVA9D .cbl

☑ Outbound Converter file name: DFSIVA9D .cbl

☑ Generate all to driver

☐ Overwrite files without warning

Figure 13-18 File, data set, or member selection

Step 3c: Deploy artifacts to IMS Connect

After the artifacts have been generated, you can upload the artifacts that are required for IMS Connect to z/OS:

1. Upload the generated XML converter to your COBOL library on z/OS.
2. Compile and link-edit the generated XML converter so that it can be accessed by IMS Connect.

> **Note:** The XML converter must have “X” as the alias name suffix.

13.3.4 Step 4: Create a connection bundle for the callout function

In this step, a connection bundle is created that describes the connection properties for access to IMS by using the IMS SOAP Gateway Deployment utility. The connection bundles are stored in the `connbundle.xml` file. You must create a new connection bundle or modifying an existing connection bundle to specify:

- The connection properties for IMS Connect
- The names of the *tpipes* that hold the callout requests that are sent by your IMS application

If a response message is expected from the Web service, you might have to create additional connection bundles or reuse an existing connection bundle to specify connection properties for sending the output response message.

To create a connection bundle:

1. Start the IMS SOAP Gateway Deployment utility on z/OS by running **`iogdeploy.sh`** in the `installation_dir/deploy` directory by using the Uniform Symbol Specification shell Terminal Emulator in RDz.
2. Enable your IMS application to access an external Web service.

   Select **Task 10: Enable your IMS application to access an external Web service**.
3. Create a connection bundle for callout:
   a. From the callout menu, select **Task 9: Create, Update, Delete or View connection bundle for callout**.
   b. At the prompt, enter `c` to create a connection bundle. You will be prompted to enter the name for the bundle.
   c. When you are prompted, enter the following information:
      - Name for the connection bundle
      - IMS host name or IP address

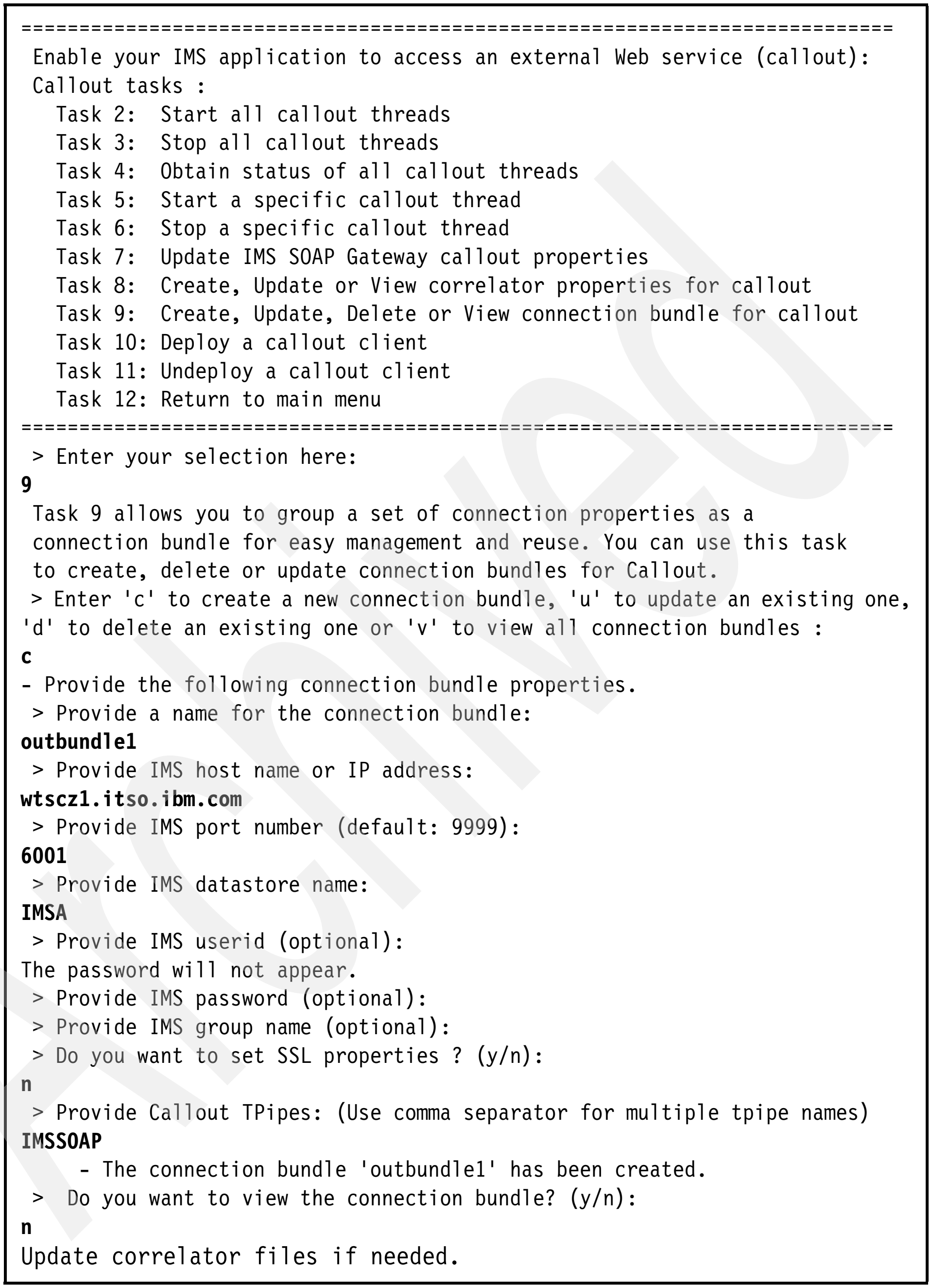
- IMS port number (default is 9999)
- IMS datastore name
- IMS user ID (optional)
- IMS password (optional)
- IMS group name (optional)

d. If you want to set Secure Sockets Layer (SSL) properties, at the prompt where the question is asked, enter y. At the prompt, enter the following information:

- SSL keystore name
- SSL keystore password
- SSL truststore name
- SSL truststore password
- SSL encryption type

e. At the prompt, enter the tpipe name. If there are multiple tpipes, separate the names with a comma.

Figure 13-19 on page 447 shows the dialog to create a connection bundle.



```
===========================================================================
 Enable your IMS application to access an external Web service (callout):
 Callout tasks :
   Task 2:  Start all callout threads
   Task 3:  Stop all callout threads
   Task 4:  Obtain status of all callout threads
   Task 5:  Start a specific callout thread
   Task 6:  Stop a specific callout thread
   Task 7:  Update IMS SOAP Gateway callout properties
   Task 8:  Create, Update or View correlator properties for callout
   Task 9:  Create, Update, Delete or View connection bundle for callout
   Task 10: Deploy a callout client
   Task 11: Undeploy a callout client
   Task 12: Return to main menu
===========================================================================
 > Enter your selection here:
9
 Task 9 allows you to group a set of connection properties as a
 connection bundle for easy management and reuse. You can use this task
 to create, delete or update connection bundles for Callout.
 > Enter 'c' to create a new connection bundle, 'u' to update an existing one,
'd' to delete an existing one or 'v' to view all connection bundles :
c
- Provide the following connection bundle properties.
 > Provide a name for the connection bundle:
outbundle1
 > Provide IMS host name or IP address:
wtscz1.itso.ibm.com
 > Provide IMS port number (default: 9999):
6001
 > Provide IMS datastore name:
IMSA
 > Provide IMS userid (optional):
The password will not appear.
 > Provide IMS password (optional):
 > Provide IMS group name (optional):
 > Do you want to set SSL properties ? (y/n):
n
 > Provide Callout TPipes: (Use comma separator for multiple tpipe names)
IMSSOAP
     - The connection bundle 'outbundle1' has been created.
 >  Do you want to view the connection bundle? (y/n):
n
Update correlator files if needed.
```

Figure 13-19 Creating a connection bundle for the callout function (sample)

13.3.5 Step 5: Create a correlator file for the callout function

You can create a correlator file by using the IMS SOAP Gateway Deployment utility. A *correlator file* provides the information to invoke the outbound Web service and return the response message back to IMS. The information includes:

- The WSDL file name for the Web service to be invoked
- The timeout value for waiting for a response from the Web service
- The IMS transaction code and the connection bundle name for returning the callout response

To create a correlator file:

1. Start the IMS SOAP Gateway Deployment utility on z/OS by running **`iogdeploy.sh`** in the `installation_dir/deploy` directory.
2. Create a correlator file for the callout function:
   a. Select **Task 10: Enable your IMS application to access an external Web Service**.

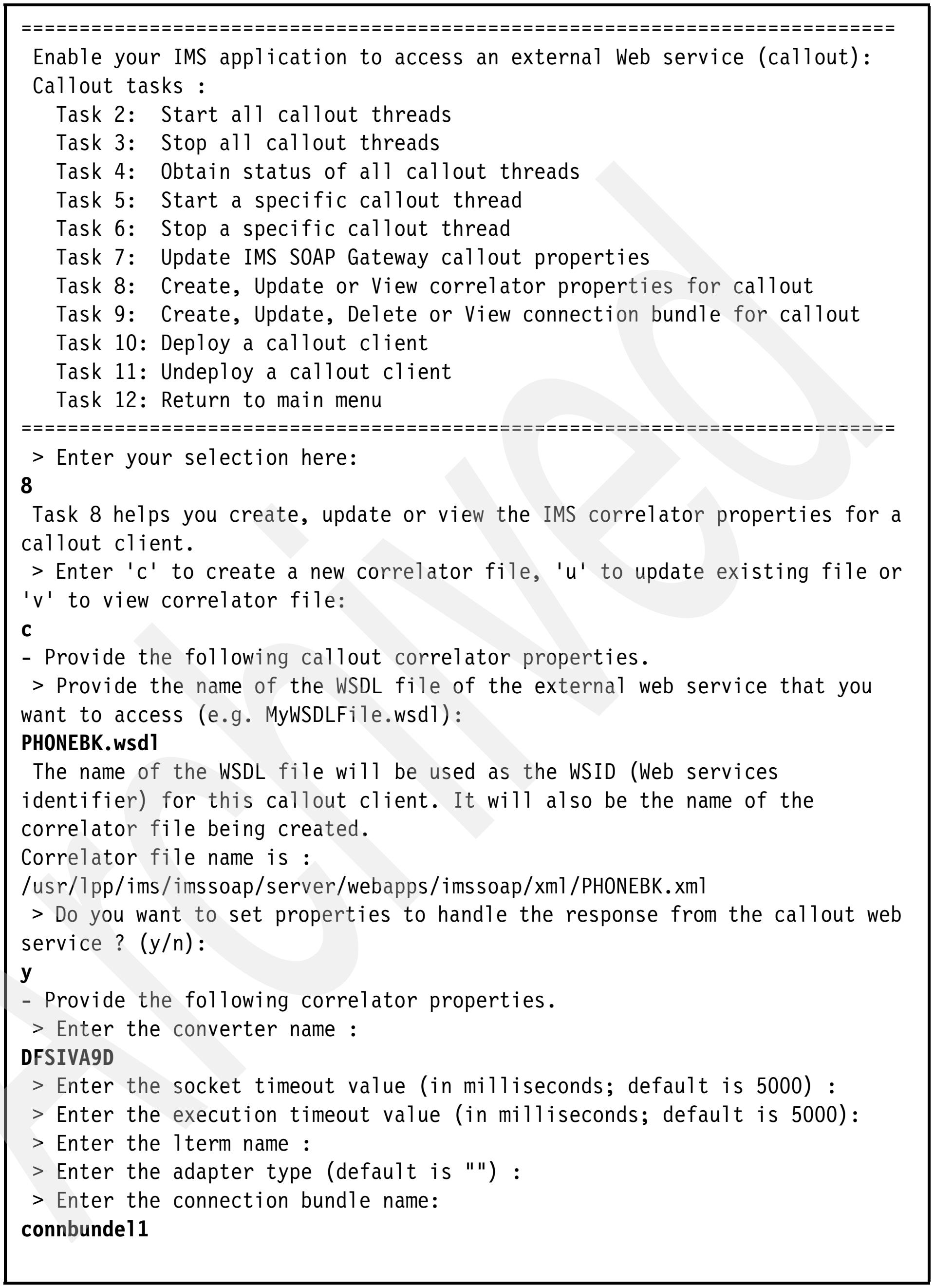
   b. From the callout menu, select **Task 8: Create, Update or View correlator properties for callout**.

   c. At the prompt, enter `c` to create a correlator file.

   d. At the prompt, enter the callout WSDL name. The file name must have `wsdl` as the extension. The file must exist and use valid schema.

   e. If you expect a response from the Web service that you are calling, answer `y` when you are asked if you want to update the response callout options. Enter the information as you are prompted.

   Figure 13-20 on page 449 and Figure 13-21 on page 450 show the dialog to create a correlator file.



```
===========================================================================
 Enable your IMS application to access an external Web service (callout):
 Callout tasks :
   Task 2:  Start all callout threads
   Task 3:  Stop all callout threads
   Task 4:  Obtain status of all callout threads
   Task 5:  Start a specific callout thread
   Task 6:  Stop a specific callout thread
   Task 7:  Update IMS SOAP Gateway callout properties
   Task 8:  Create, Update or View correlator properties for callout
   Task 9:  Create, Update, Delete or View connection bundle for callout
   Task 10: Deploy a callout client
   Task 11: Undeploy a callout client
   Task 12: Return to main menu
===========================================================================
 > Enter your selection here:
8
 Task 8 helps you create, update or view the IMS correlator properties for a
callout client.
 > Enter 'c' to create a new correlator file, 'u' to update existing file or
'v' to view correlator file:
c
- Provide the following callout correlator properties.
 > Provide the name of the WSDL file of the external web service that you
want to access (e.g. MyWSDLFile.wsdl):
PHONEBK.wsdl
 The name of the WSDL file will be used as the WSID (Web services
identifier) for this callout client. It will also be the name of the
correlator file being created.
Correlator file name is :
/usr/lpp/ims/imssoap/server/webapps/imssoap/xml/PHONEBK.xml
 > Do you want to set properties to handle the response from the callout web
service ? (y/n):
y
- Provide the following correlator properties.
 > Enter the converter name :
DFSIVA9D
 > Enter the socket timeout value (in milliseconds; default is 5000) :
 > Enter the execution timeout value (in milliseconds; default is 5000):
 > Enter the lterm name :
 > Enter the adapter type (default is "") :
 > Enter the connection bundle name:
connbundle1
```

Figure 13-20 Creating a correlator file for the callout function (sample) window 1 of 2

```
 > Enter the IMS transaction code:
IVT99
 > Enter the Web services timeout value for callout responses (in
milliseconds; default is 7500 ):
 > Enter the callout connection bundle name:
outbundle1
 > Enter the operation name (default is "DefaultOperationName") :
EXTPHBKOperation
 > Enter the service name (default is "DefaultServiceName") :
EXTPHBKService
 > Do you want to continue with another correlator? (y/n/cancel):
n
     - The correlator file has been created.
```

Figure 13-21 Creating a correlator file for the callout function (sample) window 2 of 2

13.3.6 Step 6: Deploy artifacts to IMS SOAP Gateway

Use the IMS SOAP Gateway Deployment Utility to deploy the artifacts for your IMS application. This task is also known as *deploying the callout client*.

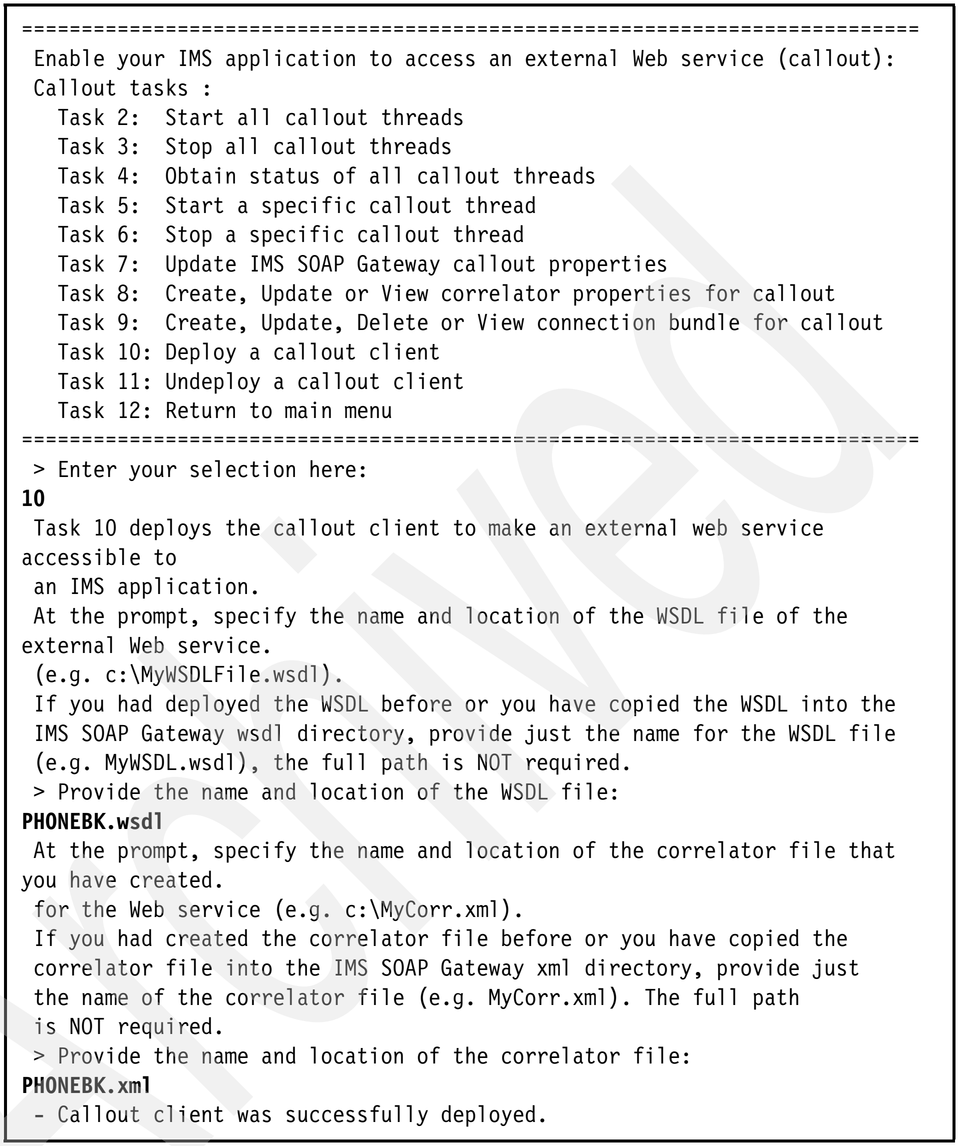
Before you start, make sure that you have the following files ready:

- WSDL file of the target Web service
- Correlator file that was created by using either Rational Developer for System z Version 7.1 or later, or Task 10-8: Create, Update or View correlator properties for callout in the IMS SOAP Gateway Deployment Utility

Perform the following steps:

1. Start the IMS SOAP Gateway Deployment Utility by running **`iogdeploy.sh`** in the `installation_dir/deploy` directory.
2. Deploy a callout client:
   a. Select **Task 10: Enable your IMS application to access an external Web Service**
   b. From the callout menu, select **Task 10: Deploy a callout client**.
   c. Enter the following information when you are prompted:
      - Name and the location of the WSDL file of the Web service that you want to access
      - Name and the location of the correlator file

   Figure 13-22 on page 451 shows the dialog to deploy the callout client.



```
===========================================================================
 Enable your IMS application to access an external Web service (callout):
 Callout tasks :
   Task 2:  Start all callout threads
   Task 3:  Stop all callout threads
   Task 4:  Obtain status of all callout threads
   Task 5:  Start a specific callout thread
   Task 6:  Stop a specific callout thread
   Task 7:  Update IMS SOAP Gateway callout properties
   Task 8:  Create, Update or View correlator properties for callout
   Task 9:  Create, Update, Delete or View connection bundle for callout
   Task 10: Deploy a callout client
   Task 11: Undeploy a callout client
   Task 12: Return to main menu
===========================================================================
 > Enter your selection here:
10
 Task 10 deploys the callout client to make an external web service
accessible to
 an IMS application.
 At the prompt, specify the name and location of the WSDL file of the
external Web service.
 (e.g. c:\MyWSDLFile.wsdl).
 If you had deployed the WSDL before or you have copied the WSDL into the
 IMS SOAP Gateway wsdl directory, provide just the name for the WSDL file
 (e.g. MyWSDL.wsdl), the full path is NOT required.
 > Provide the name and location of the WSDL file:
PHONEBK.wsdl
 At the prompt, specify the name and location of the correlator file that
you have created.
 for the Web service (e.g. c:\MyCorr.xml).
 If you had created the correlator file before or you have copied the
 correlator file into the IMS SOAP Gateway xml directory, provide just
 the name of the correlator file (e.g. MyCorr.xml). The full path
 is NOT required.
 > Provide the name and location of the correlator file:
PHONEBK.xml
 - Callout client was successfully deployed.
```

Figure 13-22 Deploy a callout client (sample)

13.3.7 Step 7: Start the callout thread

You must start a callout thread after you deploy your callout client.

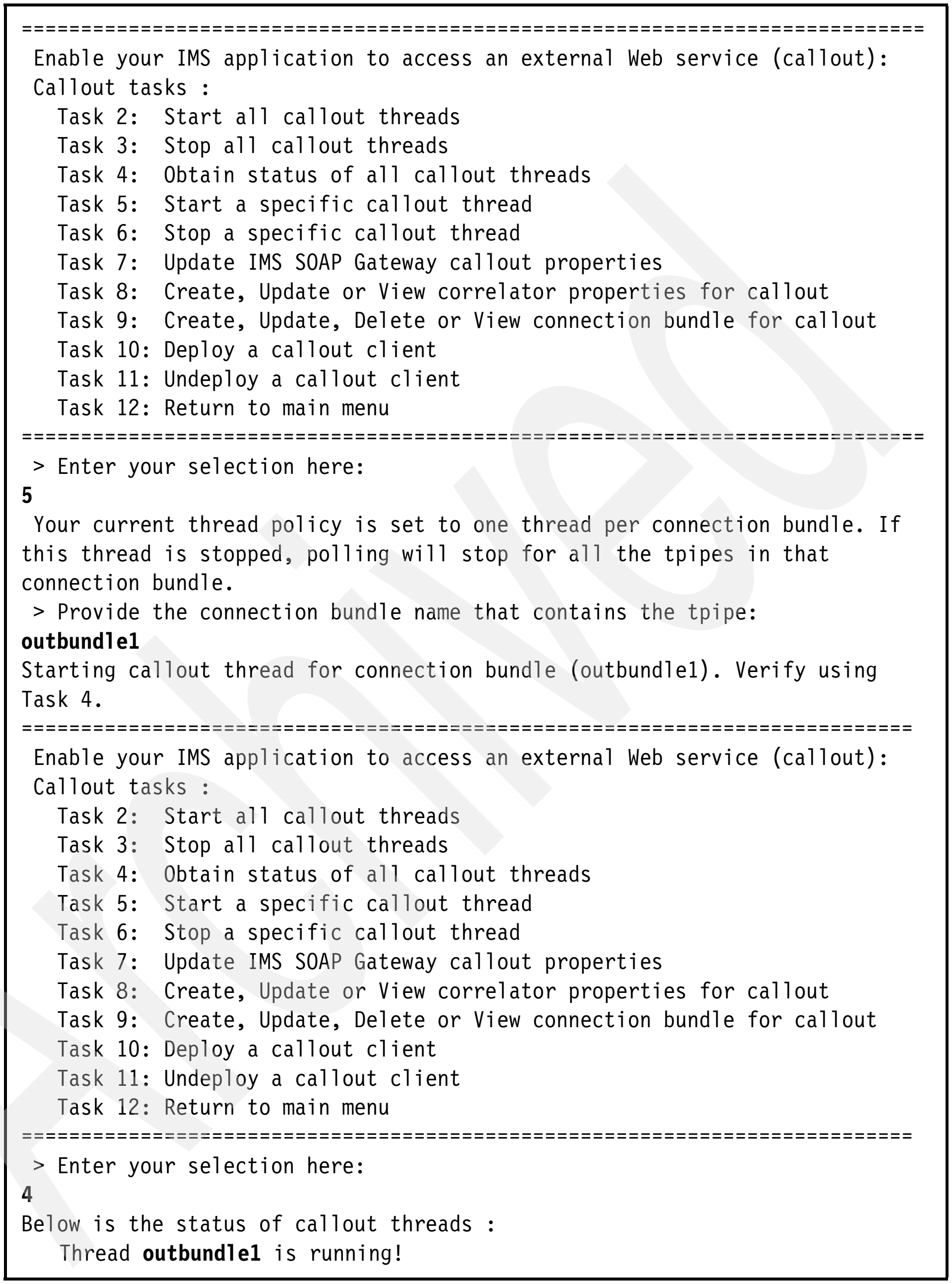
> **Important:** This task operates at the thread level. The behavior of this task depends on the thread policy that has been set. If the policy is to have one thread per tpipe, the start and stop action affects only that particular tpipe. If the thread policy is set to one thread per connection bundle, the start and stop action affects all of the tpipes that are associated with that connection bundle.

To start the callout thread:

1. Start the IMS SOAP Gateway Deployment Utility on z/OS by running **`iogdeploy.sh`** in the `installation_dir/deploy` directory.
2. Start a specific callout thread:
   a. From the utility's main menu, select **Task 10: Enable your IMS application to access an external Web Service**. The callout menu displays.
   b. From the callout menu, select the appropriate task.

      To start a specific resume tpipe thread, select **Task 5: Start a specific callout thread**.
   c. When you are prompted, enter the connection bundle name to start the callout thread.
   d. If the thread policy is one thread per tpipe, you are prompted to enter the name of the tpipe where the callout messages are held. Enter the tpipe name.
   e. The callout thread for the connection bundle and tpipe name that you specified are started. To verify that a resume tpipe thread has started, select **Task 4: Obtain status of all callout threads from the callout menu**.

   Figure 13-23 on page 453 shows the dialog to start a callout thread.



```
============================================================================
 Enable your IMS application to access an external Web service (callout):
 Callout tasks :
   Task 2:  Start all callout threads
   Task 3:  Stop all callout threads
   Task 4:  Obtain status of all callout threads
   Task 5:  Start a specific callout thread
   Task 6:  Stop a specific callout thread
   Task 7:  Update IMS SOAP Gateway callout properties
   Task 8:  Create, Update or View correlator properties for callout
   Task 9:  Create, Update, Delete or View connection bundle for callout
   Task 10: Deploy a callout client
   Task 11: Undeploy a callout client
   Task 12: Return to main menu
============================================================================
 > Enter your selection here:
5
 Your current thread policy is set to one thread per connection bundle. If
this thread is stopped, polling will stop for all the tpipes in that
connection bundle.
 > Provide the connection bundle name that contains the tpipe:
outbundle1
Starting callout thread for connection bundle (outbundle1). Verify using
Task 4.
===========================================================================
 Enable your IMS application to access an external Web service (callout):
 Callout tasks :
   Task 2:  Start all callout threads
   Task 3:  Stop all callout threads
   Task 4:  Obtain status of all callout threads
   Task 5:  Start a specific callout thread
   Task 6:  Stop a specific callout thread
   Task 7:  Update IMS SOAP Gateway callout properties
   Task 8:  Create, Update or View correlator properties for callout
   Task 9:  Create, Update, Delete or View connection bundle for callout
   Task 10: Deploy a callout client
   Task 11: Undeploy a callout client
   Task 12: Return to main menu
===========================================================================
 > Enter your selection here:
4
Below is the status of callout threads :
   Thread outbundle1 is running!
```

Figure 13-23   Start a specific callout thread (sample)

Your environment is now ready to use, and you can test the IMS Web service requestor application.

14

Using DB2 as a Web service requester

This chapter demonstrates how to consume Web services in DB2 applications using the SOAP user-defined functions (UDFs) in DB2 Version 9 for z/OS.

14.1 Overview

DB2 Version 9 for z/OS can act as a Web service consumer, allowing you to easily integrate external Web services in your DB2 applications.

The DB2 support for Web services invocation comes in the form of four *user-defined functions (UDFs)*. Actually, it is conceptually only one function, with four variations differing only in the return type and the type of the last parameter, with a choice of either VARCHAR or CLOB (Figure 14-1 on page 457). Which one you choose depends on the amount of data that you want to pass to a Web Service call and the amount of data that you expect will be returned from the Web service call.

The UDFs take the following parameters:

- ENDPOINT_URL: VARCHAR(256)

  This parameter is the endpoint information, in the form of a URL, of the Web service to invoke. You typically retrieve this information from the WSDL.

- SOAP_ACTION: VARCHAR(256)

  This parameter specifies a SOAP action URI reference. Depending on the Web server, this parameter might not be needed. If it is required, the value to be used is defined in the Web Services Description Language (WSDL) of the Web service. If not, pass an empty string.

- SOAP_INPUT: VARCHAR(32672) or character large object (CLOB)

  This parameter is the complete SOAP request message in the form of an XML document.

Depending on the expected size of the SOAP return message, you use either the `SOAPHTTPNV` or the `SOAPHTTPNV` variant. For `SOAPHTTPNV`, the output is returned as VARCHAR(32672); for `SOAPHTTPNC`, it is returned as CLOB.

> **Note:** There are two other UDFs with similar names: SOAPHTTPC and SOAPHTTPV. In contrast to SOAPHTTPNC and SOAPHTTPNV, these functions do not accept and return a complete SOAP request and response. They only return the request (or response) body.
>
> These functions are considered *deprecated*.

Figure 14-1 on page 457 shows the four UDFs.

In addition, DB2 Version 9 for z/OS has rich functionality to parse XML documents, to extract parts of an XML document and convert it to an SQL type, to convert XML data to tabular format, and to convert tabular format data to XML data.

In the following sections, we show a step-by-step example how to use these functions.

```
DB2XML.SOAPHTTPNV (
  ENDPOINT_URL VARCHAR(256),
  SOAP_ACTION  VARCHAR(256),
  SOAP_INPUT   VARCHAR(32672)
) RETURNS VARCHAR(32672)

DB2XML.SOAPHTTPNV (
  ENDPOINT_URL VARCHAR(256),
  SOAP_ACTION  VARCHAR(256),
  SOAP_INPUT   CLOB(1M)
) RETURNS VARCHAR(32672)

DB2XML.SOAPHTTPNC (
  ENDPOINT_URL VARCHAR(256),
  SOAP_ACTION  VARCHAR(256),
  SOAP_INPUT   VARCHAR(32672)
) RETURNS CLOB(1M)

DB2XML.SOAPHTTPNC (
  ENDPOINT_URL VARCHAR(256),
  SOAP_ACTION  VARCHAR(256),
  SOAP_INPUT   CLOB(1M)
) RETURNS CLOB(1M)
```

Figure 14-1 The DB2-supplied UDFs for outbound SOAP request support

> **Note:** If these UDFs seem to be missing in your DB2 installation, ask your DB2 administrator to run the relevant SQL statements in the DB2 installation job DSNTIJSG.

14.2 Introduction to the example

In this section, we are going to call the getDepartment Web service that we created and deployed in 7.2, “Using Data Web Services (DWS)” on page 160. Admittedly, this example might seem a bit contrived, because after all, the service accesses data that resides on the same DB2 system that calls the service.

The steps are:

1. Creating the SOAP request document
2. Creating the SQL to invoke the SOAP UDF
3. Parsing the SOAP response message
4. Creating a wrapper UDF

14.3 Creating the SOAP request document

First, we must build the SOAP request message in XML form. Now, rather than writing the XML document manually, we can use the Web Services Explorer tool to build a prototype request message and use this message as a starting point.

In fact, we have already done that in 7.2.7, “Testing the Web service” on page 169. Here is the SOAP request again (Example 14-1, slightly reformatted for better readability).

Example 14-1 SOAP request for calling the UDF (Version 1)

```
<?xml version="1.0" encoding="UTF-8" ?>
<soapenv:Envelope xmlns:q0="http://sg247669.itso.ibm.com/employee/"
                  xmlns:soapenv="http://schemas.xmlsoap.org/soap/envelope/"
                  xmlns:xsd="http://www.w3.org/2001/XMLSchema"
                  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
  <soapenv:Body>
    <q0:getDepartment>
      <DEPTNO>A00</DEPTNO>
    </q0:getDepartment>
  </soapenv:Body>
</soapenv:Envelope>
```

For easier readability and maintenance, we can improve and simplify the request document slightly (Example 14-2 on page 459).

Example 14-2 SOAP request for calling the UDF (Version 2)

```
<?xml version="1.0" encoding="UTF-8" ?>
<soapenv:Envelope xmlns:ews="http://sg247669.itso.ibm.com/employee/"          1
                  xmlns:soapenv="http://schemas.xmlsoap.org/soap/envelope/">  2
  <soapenv:Body>
    <ews:getDepartment>                                                       3
      <DEPTNO>A00</DEPTNO>
    </ews:getDepartment>
  </soapenv:Body>
</soapenv:Envelope>
```

Notes on Example 14-2 (these numbers correspond to the numbers on the right of the example):

1 Instead of sticking with the random `q0` namespace prefix, we changed it to `ews` (“Employee Web Service”).

2 Because the XML Schema and XML Schema-instance namespaces are not used in this document, we can simply omit the respective declarations.

3 Here, we use the `ews` prefix to refer to our application-specific elements.

14.4 Creating the SQL to invoke the SOAP UDF

Now, we are ready to create the SQL to invoke our Web service. It will call the `SOAPHTTPNV` UDF, because both the request and the response SOAP documents will easily fit into VARCHAR(32672) with plenty of room to spare.

Open the Data Perspective and create a new Data Development Project (or use the existing project that we created in 7.2, “Using Data Web Services (DWS)” on page 160).

Right-click **SQL Scripts** and select **New** → **SQL or XQuery Script**. Select **SQL Editor** as the tool for script creation. In the editor that opens, paste the following SQL statement (Example 14-3).

Example 14-3 SQL to call SOAPHTTPNV

```
SELECT DB2XML.SOAPHTTPNV(
    'http://wtscz1.itso.ibm.com:8128/EmployeeEmployeeWebserviceWeb/services/EmployeeW
ebservice'                                                                            1
  , ''                                                                                2
  , '<?xml version="1.0" encoding="UTF-8" ?>'                                         3
  ||'<soapenv:Envelope xmlns:ews="http://sg247669.itso.ibm.com/employee/"'
  ||'                  xmlns:soapenv="http://schemas.xmlsoap.org/soap/envelope/">'
  ||'  <soapenv:Body>'
  ||'    <ews:getDepartment>'
  ||'      <DEPTNO>A00</DEPTNO>'
  ||'    </ews:getDepartment>'
  ||'  </soapenv:Body>'
  ||'</soapenv:Envelope>'
) AS SOAP_RESPONSE                                                              4
  FROM SYSIBM.SYSDUMMY1
```

Notes on Example 14-3 on page 459:

1 The endpoint URL.

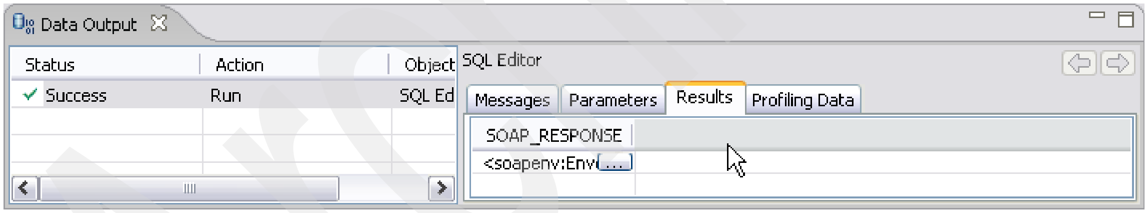
2 The SOAP action. We can leave this parameter blank (but not NULL) in our example.

3 The complete SOAP request document.

4 The correlation name is optional, but it improves readability.

Now, run the statement (by either right-clicking in the Data Projects Explorer view and selecting **Run SQL**, or by right-clicking in the editor and selecting Run SQL from there).

The result from running the query appears in the Data Output view (Figure 14-2).

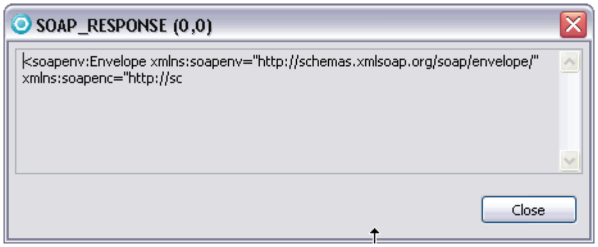


Status	Action	Object
✓ Success	Run	SQL Ed

SOAP_RESPONSE
<soapenv:Env ...

Figure 14-2 Output from running the query

To better inspect the output, click the ellipsis button ... next to the partial output in the SOAP_RESPONSE column. A pop-up window opens (Figure 14-3 on page 461).

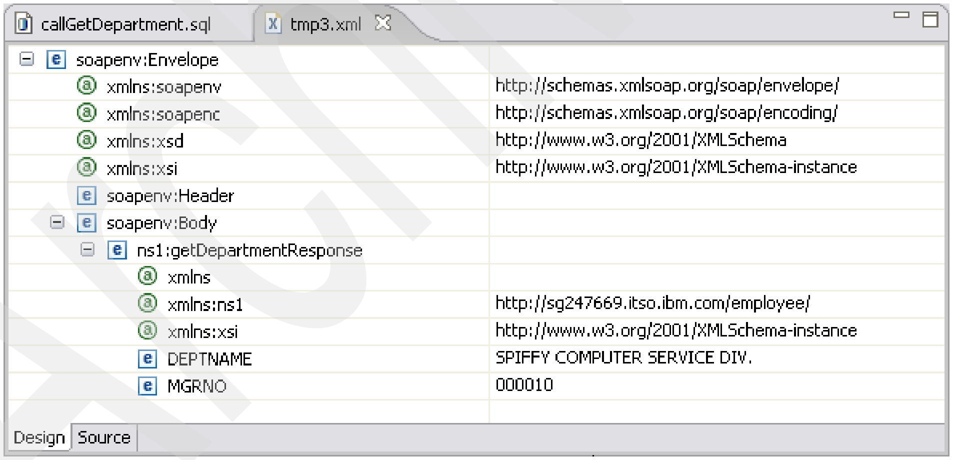


```
<soapenv:Envelope xmlns:soapenv="http://schemas.xmlsoap.org/soap/envelope/"
xmlns:soapenc="http://sc
```

Figure 14-3 Partial output from SOAPHTTPNV invocation

As you might have noticed, this output is not the complete output; it is not even a well-formed XML document, because Rational Application Developer by default limits the displayed size of character columns (and the maximum number of result rows to be fetched from a query).

So, in order to see the complete output, we have to modify the size limit. Select **Window** → **Preferences** → **Data** → **Output**. Set "Maximum bytes to retrieve for character or binary column" to a bigger value, for example, 1000. Run the query again and click the **...** detail button again. The output now is displayed in an editor window as an XML tree (Figure 14-4). You can switch to the Source pane to see the actual XML text.



```
⊟ e soapenv:Envelope
      a xmlns:soapenv                 http://schemas.xmlsoap.org/soap/envelope/
      a xmlns:soapenc                 http://schemas.xmlsoap.org/soap/encoding/
      a xmlns:xsd                     http://www.w3.org/2001/XMLSchema
      a xmlns:xsi                     http://www.w3.org/2001/XMLSchema-instance
      e soapenv:Header
  ⊟   e soapenv:Body
    ⊟   e ns1:getDepartmentResponse
            a xmlns
            a xmlns:ns1               http://sg247669.itso.ibm.com/employee/
            a xmlns:xsi               http://www.w3.org/2001/XMLSchema-instance
            e DEPTNAME                SPIFFY COMPUTER SERVICE DIV.
            e MGRNO                   000010
```

Figure 14-4 Complete output from SOAPHTTPNV invocation as XML tree

14.5 Parsing the SOAP response message

Now that we have successfully invoked the Web service from DB2, the next challenge is to parse the SOAP response. There are two possibilities:

- Parse the SOAP response XML document in your application program.

  This option is fairly easy to do in Java, but it is much harder in COBOL. IBM Enterprise COBOL does have an XML PARSE verb; however, this verb supports only the Simple API for XML (SAX) style (that is, event-driven style) of XML parsing, making it much harder to navigate the XML document than with tree-style XML parsing.

  > **Note:** Additionally, Enterprise COBOL V3.*x* did not have XML namespace support. This support was introduced with Enterprise COBOL V4.1.

- Use DB2 XML support to parse the SOAP response.

  DB2 comes with a rich set of functionality to create, validate, and parse XML documents. In this section, we use this functionality to parse the SOAP response message from the outbound Web service call, extracting only the parts in which we are interested. By using the DB2-provided XML support, we avoid having to parse the SOAP response in the application program itself.

  Refer to Example 14-4.

  > **Note:** A full explanation of the XQuery syntax is not in the scope of this book, but you can obtain more information in *DB2 Version 9.1 for z/OS XML Guide,* SC18-9858, and *DB2 Version 9.1 for z/OS SQL Reference,* SC18-9854.

Example 14-4 Querying the SOAP response using XMLQUERY

```
SELECT
  XMLQUERY(                                                                1
   'declare namespace soapenv = "http://schemas.xmlsoap.org/soap/envelope/";    2
    declare namespace     ews = "http://sg247669.itso.ibm.com/employee/";       3
    soapenv:Envelope/soapenv:Body/ews:getDepartmentResponse/DEPTNAME/text()'    4
  PASSING XMLPARSE(DB2XML.SOAPHTTPNV(                                      5
    'http://wtscz1.itso.ibm.com:8128/EmployeeEmployeeWebserviceWeb/services/EmployeeW
ebservice'
  , ''
  , '<?xml version="1.0" encoding="UTF-8" ?>'
  ||'<soapenv:Envelope xmlns:ews="http://sg247669.itso.ibm.com/employee/"'
  ||'                  xmlns:soapenv="http://schemas.xmlsoap.org/soap/envelope/">'
  ||'  <soapenv:Body>'
  ||'    <ews:getDepartment>'
  ||'      <DEPTNO>A00</DEPTNO>'
  ||'    </ews:getDepartment>'
  ||'  </soapenv:Body>'
  ||'</soapenv:Envelope>'))
) AS DEPT_NAME                                                                        6
  FROM SYSIBM.SYSDUMMY1
```

Notes on Example 14-4 on page 462:

1 The first argument to XMLQUERY is the XQuery string, optionally preceded by namespace declarations.

> **Note:** The first argument to XMLQUERY must be a string literal. In the listing, we split that string literal into three lines for better readability; in the source code, however, it has to appear as one single line. Using CONCAT will not work, because CONCAT is a function, and again, it has to be a string literal.

2 As just mentioned, the XQuery string can be (and usually needs to be) preceded by namespace declarations of the form:

```
declare namespace prefix = "namespace_uri";
```

Using this syntax, we declare the namespaces for the SOAP envelope and for our own application-specific elements.

3 This expression is the proper XQuery expression. Reading from right to left, we see that it selects the text of the `DEPTNAME` element, of getDepartmentResponse, in the SOAP body, in the SOAP envelope.

4 The second argument to XMLQUERY is the document to be queried. We pass the result of the SOAPHTTPNV invocation as in Example 14-3 on page 459, converting it to a parsed XML document using the XMLPARSE function.

5 We give the result the correlation name of `DEPT_NAME`.

> **Tip:** In this example, the result of the XQuery expression was a string that was implicitly casted to a VARCHAR. It gets slightly more complicated if you want to process the result as a number. You can process the result as a number by using the XMLCAST function:
>
> `SELECT XMLCAST(XMLQUERY(...) AS DECIMAL(19, 4))`

14.6 Creating a wrapper UDF

At this point, the query that we have just developed can be included in an application program. However, for better readability and maintenance, it is much cleaner to hide the details of the SOAPHTTPNV call and the parsing of the SOAP response from the application. Therefore, we encapsulate the query using a wrapper UDF, as shown in Example 14-5.

Example 14-5 Creating the wrapper UDF

```
CREATE FUNCTION DEPARTMENT_NAME(DEPTNO VARCHAR(3))                              1
  RETURNS VARCHAR(40)                                                           2
  LANGUAGE SQL                                                                  3
  CONTAINS SQL
  EXTERNAL ACTION
  NOT DETERMINISTIC                                                             4
RETURN
  XMLCAST(                                                                      5
    XMLQUERY(
       'declare namespace soapenv = "http://schemas.xmlsoap.org/soap/envelope/";
        declare namespace ews = "http://sg247669.itso.ibm.com/employee/";
        soapenv:Envelope/soapenv:Body/ews:getDepartmentResponse/DEPTNAME/text()'
      PASSING XMLPARSE(DB2XML.SOAPHTTPNV(
        'http://wtscz1.itso.ibm.com:8128/EmployeeEmployeeWebserviceWeb/services/Employ
eeWebservice'
      , ''
      , '<?xml version="1.0" encoding="UTF-8" ?>'
      ||'<soapenv:Envelope xmlns:ews="http://sg247669.itso.ibm.com/employee/"'
      ||'                  xmlns:soapenv="http://schemas.xmlsoap.org/soap/envelope/">'
      ||'  <soapenv:Body>'
      ||'    <ews:getDepartment>'
      ||'      <DEPTNO>' || DEPTNO || '</DEPTNO>'                               6
      ||'    </ews:getDepartment>'
      ||'  </soapenv:Body>'
      ||'</soapenv:Envelope>')))
    AS VARCHAR(40)                                                              7
  )
```

Notes on Example 14-5:

1 The DEPARTMENT_NAME function takes a single argument of type VARCHAR(3).

2 It returns VARCHAR(40).

3 It is written in SQL, contains SQL, and takes an action outside of DB2 (namely, the SOAP call).

4 Alternatively, the UDF might have been declared as being DETERMINISTIC, because it returns the same result for the same input parameters (unless someone modifies the data in the underlying table, of course).

5 As just described, we have to use the XMLCAST function to change the result of XMLQUERY to our function's return type.

6 During the development of the SQL statement, we hard-coded the department number that we are querying. Of course, here we have to use the value that was passed as a parameter.

7 This part completes the XMLCAST function invocation.

14.6.1 Invoking the wrapper UDF

With all the bits and pieces in place, invoking our Web service via SQL is simple (Example 14-6):

Example 14-6 Invoking the wrapper UDF

```
SELECT DEPARTMENT_NAME('A00') AS DEPT_NAME
  FROM SYSIBM.SYSDUMMY1
```

In fact, an application that uses this UDF to retrieve the department name does not even know or care that under the covers, a Web service is called. And, even more importantly, the operation endpoint does not need to be hardcoded in the application program but is centrally maintained. Obviously, this approach results in better maintainability.

14.6.2 Retrieving multiple columns from the SOAP response

In the previous examples, we eventually returned only a single value from the call to SOAPHTTPNV. You might have a situation where you need to use several parts of the SOAP response; in our example, you might need both the department name and the manager's ID. It is not a good solution to create two UDFs, because the Web service will be invoked twice.

We present a solution in Example 14-7 on page 466. It uses the XMLTABLE function to convert an XML document (namely, the SOAP response) to tabular format.

Example 14-7 Converting the SOAPHTTPNV output to tabular format

```
WITH RESPONSE AS (                                                                  1
  SELECT DB2XML.SOAPHTTPNV(
     'http://wtscz1.itso.ibm.com:8128/EmployeeService/services/EmployeeWebservice'
   , '',
     '<?xml version="1.0" encoding="UTF-8" ?> '
  || '<soapenv:Envelope xmlns:ews="http://employee.sg247669.itso.ibm.com"'
  || '                  xmlns:soapenv="http://schemas.xmlsoap.org/soap/envelope/">'
  || '  <soapenv:Body>'
  || '    <ews:getDepartment>'
  || '      <DEPTNO>A00</DEPTNO> '
  || '    </ews:getDepartment>'
  || '  </soapenv:Body>'
  || '</soapenv:Envelope>'
  ) AS SOAP
  FROM SYSIBM.SYSDUMMY1
)
SELECT T.*                                                                          2
FROM RESPONSE, XMLTABLE(                                                            3
  XMLNAMESPACES('http://employee.sg247669.itso.ibm.com'     AS "ews",
                'http://schemas.xmlsoap.org/soap/envelope/' AS "soapenv"),
  '$resp/soapenv:Envelope/soapenv:Body/ews:getDepartmentResponse'                   4
  PASSING XMLPARSE(DOCUMENT SOAP) AS "resp"
  COLUMNS "DEPT_NAME" VARCHAR(255) PATH 'DEPTNAME'                                  5
        , "MGR_NO"    VARCHAR(255) PATH 'MGRNO'                                     6
) AS T                                                                              7
```

Notes on Example 14-7:

1 We use a common table expression to capture the SOAP response.

2 Return all columns from the result table that is returned by the XMLTABLE function.

3 The XMLTABLE function does the work. It expects a namespace declaration, an XQuery expression to select the list of elements that corresponds to the result rows, and a COLUMNS expression that declares the columns to be returned.

4 The XQuery expression selects the element list to be turned into rows.

5 Data from DEPT_NAME column comes from the DEPTNAME child element of each row.

6 Likewise for the MGR_NO column.

7 The correlation name used in 2.

Note: Unfortunately, as of DB2 Version 9 for z/OS, there is no way to wrap this SQL as a UDF as easily as in the previous section; currently, SQL functions can be scalar functions only. You have to create a simple external table UDF in COBOL or another supported language.

15

Using an external Web service in batch applications

In this chapter, we explore two possibilities for consuming Web services in batch applications, specifically:

- Using DB2 outbound Web services
- Calling a Java client from Enterprise COBOL

Because we have already explained DB2 outbound Web services in detail in Chapter 14, “Using DB2 as a Web service requester” on page 455, we only discuss this scenario briefly in this chapter. Our focus in this chapter is on the option to use Enterprise COBOL.

15.1 Introduction

So far, we have only discussed calling Web services from a managed environment, that is, from an application server, such as WebSphere Application Server or CICS Transaction Server. You might be in a situation where you have to invoke an existing Web service from a stand-alone environment, such as a batch application.

Unfortunately, at the time of writing, there is no predefined solution to call a Web service using only pure COBOL.

Therefore, there are really three options:

- Use DB2 outbound Web services, which we briefly described in “Using DB2 outbound Web services” on page 470 and explained in more detail in Chapter 14, “Using DB2 as a Web service requester” on page 455.
- Use WebSphere MQ, with or without an enterprise service bus (ESB). We do not discuss this scenario in this book, because this scenario basically comes down to inserting a message on an MQ queue from a batch job, converting this messages to a SOAP request in an ESB, subsequently converting the SOAP response message back to a plain MQ message, and handing it over again to the batch program. This method is quite a round-trip, and in most batch environments, there is only enough of a window of available time to perform such a round-trip once or twice, but not much more.
- Call Java from COBOL. We focus on this solution in this chapter, because we have not discussed this solution before in any other book. In this solution, we invoke a Java class from the COBOL batch program, and we let this Java class take care of sending and receiving SOAP requests. We discuss this approach in “Calling a Java client from Enterprise COBOL” on page 471.

15.2 Using DB2 outbound Web services

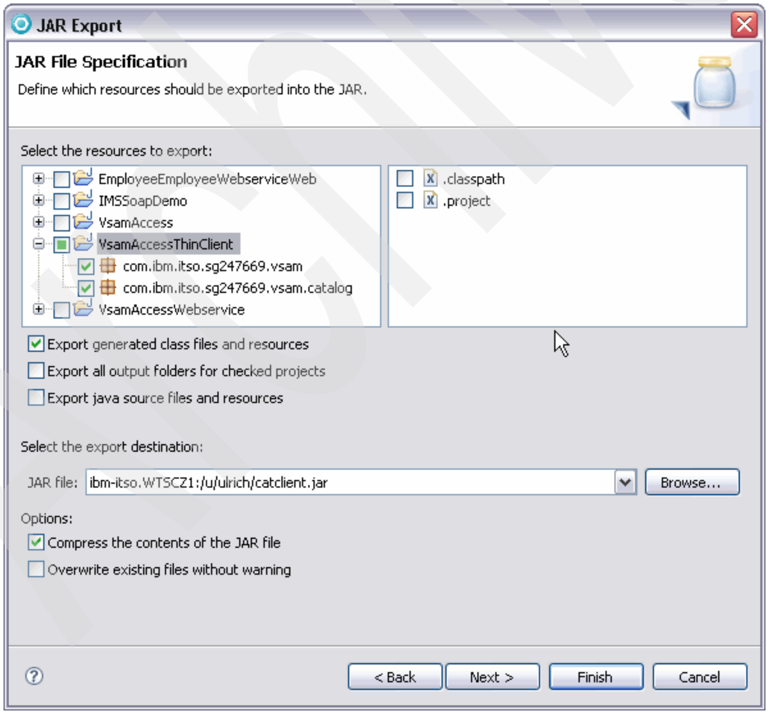
Probably the easiest way to call a Web service from a COBOL (or PL/I) batch application is to use DB2 outbound Web services support, which we discuss in Chapter 14, “Using DB2 as a Web service requester” on page 455. We do not even provide an example here, because to an application program, the Web service invocation is just a regular embedded SQL statement. Specifically, if the SOAP UDF invocation is “wrapped” as a custom user-defined function (as we recommend in 14.6, “Creating a wrapper UDF” on page 464), the Web service call is virtually indistinguishable from calling a scalar function.

15.3 Calling a Java client from Enterprise COBOL

The solution to invoke a Web service from a batch program that we discuss in this section is to use the COBOL/Java integration features that are in IBM Enterprise COBOL. They provide seamless interoperability between those languages, allowing Java objects to be created and used in COBOL without the need to cope with the intricacies of using the *Java Native Interface (JNI™)* functions. Almost all the details of Java Virtual Machine (JVM) creation, method invocation, and so on are automatically handled by the COBOL compiler and run time, and you need to use JNI only for special tasks, such as array manipulation and string conversion.

In this section, we use the Java proxy classes that we generated for the VSAM catalog access Web service (6.7, “Creating a Java client for the VsamAccess service” on page 144 and 6.8, “Creating a wrapper service” on page 150).

We exported the generated Java proxy to a Jar file in the z/OS UNIX file system, using the “Export to remote JAR” wizard (**File** → **Export** → **Other** → **Remote JAR File**). Refer to Figure 15-1.


JAR Export

JAR File Specification

Define which resources should be exported into the JAR.

Select the resources to export:

- □ EmployeeEmployeeWebserviceWeb
- □ IMSSoapDemo
- □ VsamAccess
- ■ VsamAccessThinClient
  - ☑ com.ibm.itso.sg247669.vsam
  - ☑ com.ibm.itso.sg247669.vsam.catalog
- □ VsamAccessWebservice

□ .classpath
□ .project

☑ Export generated class files and resources
□ Export all output folders for checked projects
□ Export java source files and resources

Select the export destination:

JAR file: ibm-itso.WTSCZ1:/u/ulrich/catclient.jar

Options:

☑ Compress the contents of the JAR file
□ Overwrite existing files without warning

Figure 15-1 Exporting the Java client to a remote JAR file

We use the classes in that JAR file from a COBOL program (Example 15-1).

Example 15-1 COBOL program invoking a Java Web service client

```
Process pgmname(longmixed),lib,thread,dll
******************************************************************
 Identification Division.
 Program-id. "CallWS" is recursive.
 Author. Ulrich Seelbach.
******************************************************************
 Environment Division.
 Configuration Section.
 Source-Computer. IBM-System-z with debugging mode.
 Repository.                                                                        1
     Class CatalogAccessSrvLocator
        is
        "com.ibm.itso.sg247669.vsam.catalog.CatalogAccessServiceLo
-       "cator"
     Class CatalogAccess
        is "com.ibm.itso.sg247669.vsam.catalog.CatalogAccess"
     Class CatalogItem
        is "com.ibm.itso.sg247669.vsam.catalog.CatalogItem"
     Class CatalogItemArray
        is "jobjectArray:com.ibm.itso.sg247669.vsam.catalog.Catalo
-          "gItem"
     Class JavaException
        is "java.lang.Exception"
     Class jstring
        is "java.lang.String"
     .
******************************************************************
 Data Division.
 Working-Storage Section.
 01 serviceLocator Usage object reference CatalogAccessSrvLocator.                  2
 01 catalogService Usage object reference CatalogAccess.
 01 listResult     Usage object reference CatalogItemArray.
 01 item           Usage object reference CatalogItem.
 01 exc            Usage object reference JavaException.
 01 jstr           Usage object reference jstring.
 01 listResultLength       Pic S9(9) comp-5.
 01 Item-Data.
     10 Ref-ID             Pic S9(9) comp-5.
     10 Description        Pic X(40).
 01 listIdx                Pic S9(9) comp-5.
 Linkage Section.
 Copy JNI suppress.

*******************************************************************
 Procedure Division.
 Mainline Section.
     Perform Init-JNI                                                     3
D    Display "Getting service locator"
     Invoke CatalogAccessSrvLocator new                                   4
            returning serviceLocator
     Perform Exception-check                                              5
D    Display "Getting service endpoint".
     Invoke serviceLocator 'getCatalogAccess'                             6
            returning catalogService
     Perform Exception-check
D    Display "Invoking list operation on service"
     Invoke catalogService 'list'                                         7
            using by value 0
                           0
            returning listResult
     Perform Exception-check
D    Display "Getting result length"
     Call GetArrayLength                                                  8
          using by value JNIEnvPtr
                         listResult
          returning listResultLength
     Perform Exception-check
     Display listResultLength " record(s) returned."
     Display "---------------------------------------------------"
     Perform Display-all-items
     Move 0 to Return-Code
     Stop run
     .
 Init-JNI Section.
D    Display "Initializing JNI"
     Set Address of JNIEnv to JNIEnvPtr
     Set Address of JNINativeInterface to JNIEnv
     .
 Display-all-items Section.
     Perform varying listIdx from 0 by 1                                  9
             until listIdx = listResultLength
       Call GetObjectArrayElement                                        10
            using by value JNIEnvPtr
                           listResult
                           listIdx
            returning item
```

```
      Perform Exception-check
      Perform Display-item
    End-perform
    .
Display-item Section.
    Invoke Item 'getWsItemRef'                                  11
      returning Ref-ID
    Invoke Item 'getWsDescription'                              12
      returning jstr
    Call 'GetStringPlatform'                                    13
         using by value JNIEnvPtr
                        jstr
                        address of Description
                        length of Description
                        0
    Perform Exception-check
    Display Ref-ID ": " Description                             14
    .
Exception-check Section.
    Call ExceptionOccurred                                      15
         using by value JNIEnvPtr
         returning exc
    If exc not equal to null then                               16
      Call ExceptionClear
           using by value JNIEnvPtr
      Display "Java exception caught"
      Invoke exc 'printStackTrace'
      Move 16 to Return-Code
      Stop run
    End-if
    .
```

Notes on Example 15-1 on page 472:

1 The “Repository” paragraph identifies all classes that are going to be used in the program and defines the association between the external class name (that is, the fully qualified Java class name in this case) and the name that is used in the program.

2 Declare references to instances of various classes.

3 Initialize the JVM environment special registers.

4 Create a new instance of class CatalogAccessSrvLocator and assign a reference to that instance to serviceLocator, which is equivalent to the following Java statement:

```
serviceLocator = new CatalogAccessServiceLocator();
```

5 Check for exceptions thrown from the previous statement.

6 Invoke method `getCatalogAccess` on serviceLocator and assign the result to catalogService, which is equivalent to:

```
catalogService = serviceLocator.getCatalogAccess()
```

7 This call is the actual Web service call. It invokes the `list` method with two parameters and assigns the result to listResult, which is equivalent to the following Java statement:

```
listResult = catalogService.list(0, 0)
```

8 The result from the list invocation is a Java array. To find out the length of that array, we call the respective JNI method.

9 Iterate over all elements of the result array.

10 Get the element at position listIdx, using a JNI function.

11 To display an item's data, we need to invoke the respective getter method. Method `getWsItemRef` returns a Java int, which maps to a COBOL PIC9(5) item (with a USAGE clause specifying BINARY or one of its variants) without any special conversion.

12 Method `getWsDescription`, however, returns a Java string.

13 We need to convert the Java string to EBCDIC using a JNI function.

14 Display the current item.

15 Check whether the last Java method call (or JNI call) caused an exception.

16 If so, print the stacktrace and terminate the program.

To compile the program, we used the following shell script (Example 15-2 on page 476). It copies the source code from the MVS source library to a z/OS UNIX file, and then, it invokes the COBOL compiler and the binder from z/OS UNIX via the **`cob2`** command.

> **Note:** In order to compile the program in the traditional way, from MVS batch, you have to copy the `JNI.cpy` copybook from the z/OS UNIX filesystem to an MVS data set. The COBOL compiler cannot process z/OS UNIX files when invoked from MVS batch.

Example 15-2 Shell script to compile the COBOL program

```
#! /bin/sh
IGY_HOME=/usr/lpp/cobol
JAVA_HOME=/usr/lpp/java/J5.0

cp "//'ulrich.source.cobol(callws)'" ./callws.cbl

$IGY_HOME/bin/cob2 -g \
   -o "//'ulrich.load.lib(callws)'" \
   -I$IGY_HOME/include \
   callws.cbl \
   $JAVA_HOME/bin/j9vm/libjvm.x \
   $IGY_HOME/lib/igzcjava.x
```

To run the program, we used the following JCL, as shown in Example 15-3.

Example 15-3 JCL to invoke the COBOL/Java sample program

```
//COBWS   JOB 'COBOL -> Java -> Web service',SEELBACH,
//        NOTIFY=&SYSUID,MSGLEVEL=(1,1),REGION=0M
//CALLWS  EXEC PGM=CALLWS,
// PARM='/ENVAR("_CEE_ENVFILE=/u/ulrich/cobenv"),POSIX(ON),XPLINK(ON)'      1
//STEPLIB DD DISP=SHR,DSN=ULRICH.LOAD.LIB                                    2
//        DD DISP=SHR,DSN=CEE.SCEERUN
//        DD DISP=SHR,DSN=CEE.SCEERUN2
//        DD DISP=SHR,DSN=BBO61Z1.SBBOLD2
//        DD DISP=SHR,DSN=BBO61Z1.SBBOLOAD
//        DD DISP=SHR,DSN=BBO61Z1.SBBGLOAD
//JAVAOUT DD PATH='/tmp/ulrich.javaout',                                     3
//           PATHOPTS=(OWRONLY,OCREAT,OTRUNC),PATHMODE=(SIRUSR,SIWUSR)
//JAVAERR DD PATH='/tmp/ulrich.javaerr',                                     4
//           PATHOPTS=(OWRONLY,OCREAT,OTRUNC),PATHMODE=(SIRUSR,SIWUSR)
```

Notes on Example 15-3:

1 Specify the Language Environment (LE) parameters for the program. `_CEE_ENVFILE` points to a z/OS UNIX file containing environment variable settings. `POSIX(ON)` and `XPLINK(ON)` are mandatory for COBOL main programs calling Java.

For more information, refer to *Enterprise COBOL for z/OS Programming Guide,* SC23-8529.

2 In addition to our own load library, we need the Language Environment run time and several WebSphere native libraries in the STEPLIB concatenation. The native libraries are used by the WebSphere thin client library.

3 Set up z/OS UNIX files for Java `System.out` output.

4 Set up z/OS UNIX files for Java `System.err` output.

The following example (Example 15-4) shows the LE environment file referenced by the previous JCL. Note that this file is not a shell script but more like a properties file, so you cannot use the familiar `LIBPATH=$LIBPATH:/`*`what`*`/`*`ever`* idiom. Also, each environment setting must be on one unbroken line with no internal blanks.

The most important setting in the LE environment file is the CLASSPATH for the Java Virtual Machine, referencing the Web service client JAR file that we created and exported to the host earlier (refer to page 471) and the Web Services thin client run time.

Using the `COBJVMINITOPTIONS` variable, you can pass options to the JVM that is started by the COBOL run time. In this case, we specify a Java system property pointing to the SSL configuration file, similar to what we did in 6.7, “Creating a Java client for the VsamAccess service” on page 144 on page 149. a Java system property pointing to the SSL configuration file is needed for opening connections to the HTTPS endpoint.

Example 15-4 LE environment file for running the COBOL/Java sample program

```
LIBPATH=/lib:/usr/lib:/usr/lpp/java/J5.0/bin/j9vm:/usr/lpp/java/J5.0/bin:/WebSphereZ1
2/V6R1/AppServer/lib
CLASSPATH=/u/ulrich/catclient.jar:/WebSphereZ12/V6R1/AppServer/runtimes/com.ibm.ws.we
bservices.thinclient_6.1.0.jar
COBJVMINITOPTIONS=-Dcom.ibm.SSL.ConfigURL=file:/WebSphereZ12/V6R1/AppServer/profiles/
default/properties/ssl.client.props
```

Note: Actually, we cheated a little bit. We were unable to successfully connect to the Secure Sockets Layer (SSL) endpoint, apparently due to SSL configuration problems, so we changed the default endpoint to HTTP before exporting the Jar file (by modifying the value of `catalogAccess_address` in class `CatalogAccessServiceLocator`).

However, without the `com.ibm.SSL.ConfigURL` setting, the connection attempt failed at an earlier stage, exactly as it did in 6.7, “Creating a Java client for the VsamAccess service” on page 144 on page 149.

The program produced the following output, on SYSOUT (Example 15-5 on page 478), and therefore, was a success.

Example 15-5 Output from running the COBOL/Java Web service client

```
Initializing JNI
Getting service locator
Getting service endpoint
Invoking list operation on service
Getting result length
0000000020 record(s) returned.
---------------------------------------------------
0000000020: Ball Pens Blue 24pk
0000000030: Ball Pens Red 24pk
0000000040: Ball Pens Green 24pk
0000000050: Pencil with eraser 12pk
[... omitted ...]
0000000210: Clear sticky tape 5pk
```

Part 3

Appendixes

A

Defining data used in samples

In this appendix, we show the JCL for creating and loading the catalog VSAM file and the Data Definition Language (DDL) to create the DEPT sample table.

JCL for creating and loading the catalog VSAM file

Example A-1 is the JCL to create and load the catalog VSAM file that we use in several examples in this book. To run the JCL, edit the jobcard and change the `@dsindex@` placeholder to a valid high-level qualifier for the dataset.

Example: A-1 JCL to create and load the catalog VSAM file

```
//DFH$ECAT JOB ,NOTIFY=&SYSUID
//*********************************************************************
//*                                                                   *
//* JCL NAME = DFH$ECAT                                               *
//*                                                                   *
//* DESCRIPTIVE NAME = Web Services example application               *
//*                                                                   *
//* FUNCTION =                                                        *
//*    This is sample JCL to build the catalog data file required     *
//*    by the base application of the web services example            *
//*    application                                                    *
//*                                                                   *
//*********************************************************************
//DEFKSDS EXEC PGM=IDCAMS,REGION=64M,COND=(0,LT)
//SYSPRINT DD SYSOUT=*
//AMSDUMP  DD SYSOUT=*
//SYSIN DD *
   DELETE @dsindex@.EXMPLAPP.EXMPCAT PURGE CLUSTER
   SET MAXCC=0
   DEFINE CLUSTER (NAME(@dsindex@.EXMPLAPP.EXMPCAT)-
          TRK(1 1) -
          KEYS(4 0) -
          RECORDSIZE(80,80) -
          SHAREOPTIONS(2 3) -
          INDEXED -
          ) -
          DATA (NAME(@dsindex@.EXMPLAPP.EXMPCAT.DATA) -
          ) -
          INDEX (NAME(@dsindex@.EXMPLAPP.EXMPCAT.INDEX) -
          )
//*
//CPYKSDS  EXEC PGM=IDCAMS,REGION=64M,COND=(0,LT)
//SYSPRINT DD SYSOUT=*
//AMSDUMP  DD SYSOUT=*
//SYSIN DD *
 REPRO INFILE(INFILE) OUTFILE(OUTFILE)
//OUTFILE  DD DSN=@dsindex@.EXMPLAPP.EXMPCAT,DISP=SHR
```

```
//INFILE   DD *
0010Ball Pens Black 24pk                    010002.900135000
0020Ball Pens Blue 24pk                     010002.900006050
0030Ball Pens Red 24pk                      010002.900106000
0040Ball Pens Green 24pk                    010002.900080000
0050Pencil with eraser 12pk                 010001.780083000
0060Highlighters Assorted 5pk               010003.890013040
0070Laser Paper 28-lb 108 Bright 500/ream   010007.440102020
0080Laser Paper 28-lb 108 Bright 2500/case  010033.540025000
0090Blue Laser Paper 20lb 500/ream          010005.350022000
0100Green Laser Paper 20lb 500/ream         010005.350003020
0110IBM Network Printer 24 - Toner cart     010169.560012000
0120Standard Diary: Week to view 8 1/4x5 3/4010025.990007000
0130Wall Planner: Eraseable 36x24           010018.850003000
014070 Sheet Hard Back wire bound notepad   010005.890084000
0150Sticky Notes 3x3 Assorted Colors 5pk    010005.350036045
0160Sticky Notes 3x3 Assorted Colors 10pk   010009.750067030
0170Sticky Notes 3x6 Assorted Colors 5pk    010007.550064030
0180Highlighters Yellow 5pk                 010003.490088010
0190Highlighters Blue 5pk                   010003.490076020
020012 inch clear rule 5pk                  010002.120014010
0210Clear sticky tape 5pk                   010004.270073000
//
```

DDL to create the DEPT sample table

Example A-2 is a trimmed-down version of the DDL to generate the DEPT sample table. We removed foreign key constraints to other tables in the DB2 sample database to make it self-contained. Be sure to verify the BUFFERPOOL and STOGROUP settings.

Example: A-2   Simplified DDL to create the DEPT sample table

```
CREATE TABLE DEPT (
      DEPTNO CHAR(3) NOT NULL,
      DEPTNAME VARCHAR(36) NOT NULL,
      MGRNO CHAR(6) WITH DEFAULT NULL,
      ADMRDEPT CHAR(3) NOT NULL,
      LOCATION CHAR(16) WITH DEFAULT NULL
   )
   AUDIT NONE
   DATA CAPTURE NONE
   CCSID EBCDIC;
```

```
CREATE UNIQUE INDEX XDEPT1 ON DEPT (DEPTNO ASC)
   NOT CLUSTER
   NOT PADDED
   USING STOGROUP SYSDEFLT
     PRIQTY 12
     SECQTY -1
   PCTFREE 10
   BUFFERPOOL BP0
   DEFER NO
   COPY NO
   PIECESIZE 2097152 K;

ALTER TABLE DEPT ADD CONSTRAINT DEPTNO PRIMARY KEY (DEPTNO);
```

B

Additional material

This book refers to additional material that can be downloaded from the Internet as described next.

Locating the Web material

The Web material associated with this book is available in softcopy on the Internet from the IBM Redbooks publications Web server. Point your Web browser at:

`ftp://www.redbooks.ibm.com/redbooks/SG27669`

Alternatively, you can go to the IBM Redbooks publications Web site at:

`ibm.com/redbooks`

Select the **Additional materials** and open the directory that corresponds with the IBM Redbooks form number, SG247669.

System requirements for downloading the Web material

There are no specific requirements to download and store the material on your workstation. To be able to use, however, the materials in your workstation tools, such as Rational Developer for System z, you need to meet the minimum system requirements for the specific tool that you plan to use.

For our sample development, we ran all tools inside a VMWare image. If you plan to do the same thing, we recommend 3 GB of RAM or more. Allocate about 50% of RAM to your VMWare image, and leave the other 50% for your primary Windows systems. Note that a VMWare image can grow in size considerably. You have to expect a minimum size of about 7 GB of disk space for a very small image with one tool up to more than 30 GB for an image with a complex development environment.

Using the Web material

The additional Web material that accompanies this book is explained in the following sections. The material is supplied per chapter/scenario.

Exposing VSAM data as Web Services

The additional material for this scenario is packaged in a zip file. It includes z/OS components, such as JCL, a Java jar file needed for JZOS, and a workspace that can be used in a shared development environment with both the Data Studio Developer Version 1.2 Toolkit and Rational Developer for System z.

The name of the zip file is:

```
Exposing VSAM and DB2 as a Web service.zip
```

Exposing data as a service by using IBM WebSphere Message Broker

The additional material for this scenario is supplied as a single file, namely, a workspace file for the WebSphere Message Broker Toolkit Version 6.1.03. This workspace file, when loaded, includes the entire solution.

The name of the workspace file is:

```
Exposing data as a Web service using WMB.zip
```

Exposing DB2 data as a service

The additional material for this scenario is packaged in one zip file. It includes z/OS components, such as JCL, a Java jar file needed for JZOS, and a workspace that can be used in a shared development environment with both the Data Studio Developer Version 1.2 Toolkit and Rational Developer for System z.

The name of the zip file is:

```
Exposing VSAM and DB2 as a Web service.zip
```

Exposing IMS data as a service

All components referred to in the chapter are included in a zip file. This zip file includes both z/OS components, such as the database descriptor (DBD) and the program specification block (PSB), and workstation components, such as workspace file for RDz.

The name of the zip file is:

```
Exposing IMS data as a Web service.zip
```

Exposing an IMS application as a Web service

All components referred to in the chapter are included in a zip file. This zip file includes both z/OS components and workstation components, such as a workspace file for RDz.

The name of the zip file is:

```
Exposing an IMS application as a Web service.zip
```

Integrating an external Web service with a CICS application

The material for this scenario includes:

File name	Description
README.txt	Instructions to set up sample
External WebService CICS source.zip	Source code of the application that needs to be integrated
ExternalWebService CICS_RDz Workspace.zip	Workspace containing RDz-generated artifacts

Integrating an external Web service into an IMS application

The material for this scenario includes:

File name	Description
README.txt	Instructions to set up sample
External WebService IMS source.zip	Source code of the IMS components
External WebService IMS RDz Workspace.zip	Workspace containing RDz-generated artifacts

Using DB2 as a Web service requester

The additional material for this scenario is packaged in one zip file. It includes z/OS components, such as JCL, a Java jar file needed for JZOS, and a workspace that can be used in a shared development environment with both the Data Studio Developer Version 1.2 Toolkit and Rational Developer for System z.

The name of the zip file is:

```
Exposing VSAM and DB2 as a Web service.zip
```

Using an external Web service in batch applications

The additional material for this scenario is packaged in the same zip file as the data-related scenarios. The name of the zip file is:

```
Exposing VSAM and DB2 as a Web service.zip
```

Related publications

The publications listed in this section are considered particularly suitable for a more detailed discussion of the topics covered in this book.

IBM Redbooks publications

For information about ordering these publications, refer to “How to get IBM Redbooks publications” on page 490. Note that several of the documents referenced here might be available in softcopy only:

- *Application Development for CICS Web Services,* SG24-7126
- *Implementing CICS Web Services,* SG24-7206
- *Securing Access to CICS Within an SOA*, SG24-5756
- *DB2 for z/OS and OS/390: Ready for Java*, SG24-6435
- *WebSphere Service Registry and Repository Handbook*, SG24-7386
- *Patterns: SOA Design Using WebSphere Message Broker and WebSphere ESB,* SG24-7369
- *Implementing an ESB using IBM WebSphere Message Broker V6 and WebSphere ESB V6 on z/OS,* SG24-7335
- *WebSphere for z/OS V6 Connectivity Handbook,* SG24-7064
- *WebSphere Business Integration Message Broker Basics,* SG24-7090
- *Distributed Functions of DB2 for z/OS and OS/390*, SG24-6952

Other publications

These publications are also relevant as further information sources:

- *The Value of IBM System z and z/OS in Service-Oriented Architecture*, REDP-4152
- *C/C++ Run-Time Library Reference,* SA22-7821
- *C/C++ Programming Guide,* SC09-4765
- *JZOS Batch Launcher and Toolkit Installation and User’s Guide,* SA23-2245
- *Enterprise COBOL for z/OS Language Reference,* SC23-8528

- *Enterprise COBOL for z/OS Programming Guide,* SC23-8529
- *DB2 Version 9.1 for z/OS SQL Reference,* SC18-9854
- *DB2 Version 9.1 for z/OS XML Guide,* SC18-9858
- *IMS Version 10 System Definition Reference*, GC18-9966
- *IMS SOAP Gateway User's Guide and Reference,* SC19-1290
- *IMS Version 10 Communications and Connection Guide*, SC18-9703
- *IMS Version 10 Application Programing Guide*, SC18-9698
- *IMS Version 10 Application Programing API Reference*, SC18-9699
- *IMS Version 10 System Programming API Reference*, SC18-9967-00
- *IMS TM Resource Adapter User's Guide and Reference Version 9, Version 10*, SC19-1211
- "Building an Enterprise Service Bus using WebSphere ESB, Part 4" by Rachel Reinitz and Andre Tost, 28 February 2006:

  http://www.ibm.com/developerworks/websphere/techjournal/0702_reinitz/0702_reinitz.html

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Enabling z/OS Applications for SOA

Learn how to use patterns to help you modernize your applications

Use our samples of a selection of patterns to get started

Understand integration and modernization

The objective of this IBM Redbooks publication is to demonstrate ways of enabling existing applications and data on z/OS for integration into a service-oriented architecture (SOA). The focus is on solutions using Web Services as the underlying technology for this integration.

This book describes a variety of patterns that can be applied to enabling z/OS applications for service-oriented architecture. Many of these patterns are explained by means of a sample. Each sample is included in the additional material of this book.

This book is intended for readers who are interested in extending the function of their existing applications in order to benefit from SOA.

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