Supporting Mobile and Sensing Solutions with IBM Intelligent Pervasive Platform

- Understand the Intelligent Pervasive Platform (IPP) and its architecture
- Learn how to handle sensing data with IPP Sensor Extender
- Interface IBM solutions with IPP and IPP Sensor Extender

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Redpaper

International Technical Support Organization

Supporting Mobile and Sensing Solutions with IBM Intelligent Pervasive Platform

July 2014

REDP-4866-01

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Second Edition (July 2014)

This edition applies to IBM Intelligent Pervasive Platform and IBM Intelligent Pervasive Platform Sensor Extender.

Contents

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Preface

This IBM® Redpaper™ publication describes the IBM Intelligent Pervasive Platform and IBM Intelligent Pervasive Platform Sensor Extender. Intelligent Pervasive Platform (IPP) enables you to create mobile applications that seamlessly deliver customized information and services to mobile users, based on their profile and location data. IPP Sensor Extender (based on IPP) supports the collection and standardization of sensing device data from sensor platforms that consist of sensing devices, packaging devices, and gateways. After standardization, the sensing device data can be forwarded to other applications that report, analyze, and display this data. IPP Sensor Extender supports the Internet of Things and machine-to-machine communication.

This paper provides the following information about IPP and IPP Sensor Extender:

- A description of each solution
- The high-level architecture for each solution, including key components
- Details of the data models for each solution, including examples of common data representations
- Integration with other IBM products
- Use in industry solutions

The paper is written for developers and others who are interested in using IPP and IPP Sensor Extender to create mobile and sensing applications.

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Thanks to the following people for their contributions to this project:

LindaMay Patterson
International Technical Support Organization, Rochester Center

Thanks to the authors of the previous edition of this paper, *Creating Mobile Applications Using the IBM Intelligent Pervasive Platform*, published in May 2012:

- Marc Yvon
- Frédéric Chanson
- Anthony Hervé
- Gary Yoong

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Summary of changes

This section describes the technical changes made in this edition of the paper and in previous editions. This edition might also include minor corrections and editorial changes that are not identified.

Summary of Changes
for Supporting Mobile and Sensing Solutions with IBM Intelligent Pervasive Platform
as created or updated on July 17, 2014.

July 2014, Second Edition

This revision describes the following new and changed information.

New information

- IBM Intelligent Pervasive Platform Sensor Extender
- Integration with various IBM products
- Various case studies

Changed information

- Updated information about IBM Intelligent Pervasive Platform (IPP)
- Removed IPP installation and product dependency information
- Removed XML representation of data

1

Introduction to IBM Intelligent Pervasive Platform

This chapter provides an overview of the IBM Intelligent Pervasive Platform (IPP). It also provides a high-level component diagram for IPP and, outlines key IPP services. The chapter covers the following topics:

- Overview of the IBM Intelligent Pervasive Platform
- Architecture of the IBM Intelligent Pervasive Platform including these topics:
  - IPP services
  - IPP data model
  - IPP data representation

1.1 Overview of the IBM Intelligent Pervasive Platform

More increasingly, mobile applications need to provide services and information to mobile users based on their mobility data (such as user profile and location data). The IBM Intelligent Pervasive Platform (IPP) is a comprehensive, open architecture framework aimed at the seamless delivery of relevant information and services to mobile users, based on profile and location data of users. IPP provides information and content delivery related specifically to points of interest and device user localization.

IPP enriches mobile applications with location-based services and is aimed at seamless delivery of the following capabilities:

- Relevant multilingual information, such as text, image, sound, and video
- Localization services that include guidance and *where am I?* detection
- Real-time information sent to a mobile application based on a user's profile and location

IPP can be used to seamlessly deliver pertinent information and services to mobile users, based on their profile and location data. That means a mobile application (based on IPP) can make use of user mobility data to provide beneficial information in a context that matters to that user. For example, an application can provide information that is relevant to the user's location, such as key points of interest or notable restaurants in the area.

This relevant information (from IPP data collection) can be used by mobile applications that support various areas, such as consulting, advising, alert creation, information customization, and social networking.

IPP is device independent. It orchestrates processes as they are requested by the application. This approach enables application developers to decide how to implement the user interface in phone-specific languages, such as these:

- Smartphone basic platforms, such as Apple iOS and Android operating system
- Web-based languages, such as HTML5 and WebKit
- Hybrid capabilities, such as Apache Cordova, and IBM Worklight®

IPP provides a representational state transfer (REST) web service application programming interface (API). This framework enables developers to provide various capabilities including the following examples:

- Position updates (*Where am I?*)
- User profile updates
- Information updates

New mobile devices, such as smartphones, are becoming more affordable. At the same time, networks can carry more information workload, making these new types of applications a great opportunity.

1.2 Architecture of Intelligent Pervasive Platform

IPP provides a mobile-based implementation so you can seamlessly enrich mobile applications with point of interest (POI) information. IPP can interface with mobile applications using either of these approaches:

- Supporting native mobile device environments (such as Android, Apple iPhone, and Microsoft Windows)
- Integrating web-based or hybrid applications such as IBM MobileFirst with IBM Worklight

A key feature of IPP (an IPP information service) is the ability to execute spatial computation. For example, it is possible to retrieve a list of point of interest instances based on a GPS location and a distance.

The user interacts with IPP by using a client application. This client application, typically a mobile application, manages the lifecycle of the user interactions. As the user navigates through the mobile application (including menus, lists, categories, and maps), the appropriate microflow of actions is invoked such as:

- Loading user profile information
- Loading categories list that may be of interest to the user
- Loading the point of interest instances of a category
- Rating a point of interest
- Saving the user profile

The IPP data model consists of a set of concept objects that are managed by IPP. These objects include point of interest and category objects, defined as follows:

- Point of interest (POI) objects contain a set of attributes, such as a POI title, a content description of the POI, and its spatial representation. This POI information is presented to the mobile user through a mobile application.
- Category objects provide classification of point of interest instances. A category contains a point of interest collection. Categories are organized into a hierarchy and can contain a sub-category list.

The data model details are described in 1.4, “Data model for the Intelligent Pervasive Platform” on page 5.

Figure 1-1 shows the high-level architecture of the IPP.

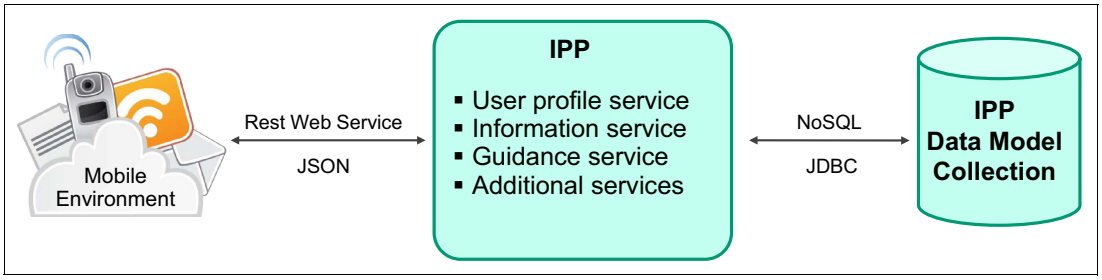

Figure 1-1 Intelligent Pervasive Platform architecture

As Figure 1-1 shows, IPP provides extensible REST APIs to query the various services and DB2 NoSQL storage capability for the IPP data model, represented in the JavaScript Object Notation (JSON) format.

1.3 About Intelligent Pervasive Platform services

As Figure 1-1 shows, IPP provides these key services:

- User profile service
- Information service
- Guidance service
- Additional services

1.3.1 User profile service

The user profile service manages mobile user information, such as preferred language, gender, age, and personal impairments. Based on the user profile, IPP provides the appropriate information and services to that user's mobile application. For example, the preferred language can be used by IPP to ensure that IPP returns the associated language-specific content to the mobile application.

1.3.2 Information services

The information service manages the IPP data model objects. With this service, creating, reading, updating, and deleting IPP data model objects (specifically, categories and point of interest instances) is possible.

This service manages the IPP information, whether it is geolocalized or not. It focuses on retrieving categories and point of interest instances from the IPP data model collection.

The main operations for categories are retrieving objects:

- All the category tree or a subset of the tree. A category classifies the point of interest instances into groups, such as hotels, restaurants, historic sites, and schools.
- A single category and its sub-categories

The main operations for point of interest is retrieving objects:

- A single point of interest.
- A list of point of interest instances that belong to a given category.
- A list of all point of interest instances, depending on a location coordinate and a distance around this location.

Optionally, point of interest objects can be filtered by a category. IPP also provides create, update, and delete operations for category and point of interest objects.

1.3.3 Guidance service

The guidance service can compute the appropriate path from a start point to an endpoint. These points might be the current user location, a POI location, or GPS coordinates. The appropriate path means that the service might consider several criteria for the calculation, such as the distance between each path step, the traffic constraints, and the user profile.

The path calculation uses a network graph representing the possible ways that can be crossed. This graph is composed of the following items:

- Nodes: Nodes are a localized point that represents outstanding elements of the graph, such as the POI location and the road crossing.
- Edges: Edges symbolize the link between two nodes. A payload is attached to the edge, defining the way the edge might be used, such as the edge distance, the edge orientation, and possible obstructions (for example, stairs and walls).

The guidance service returns a path made for a set of edges that represent the sequential elementary path from the start point to the endpoint.

The main operations, available with the guidance service, are retrieving the following paths:

- From the user location to a POI
- From a POI to another POI
- From one GPS coordinate to another GPS coordinate

In addition, the create, update, and delete operations are available for nodes and edges.

1.3.4 Additional services

IPP currently can support more than just mobile devices because of the addition of other services. Additional services are provided to support the Intelligent Pervasive Platform Sensor Extender which manages sensor platforms. IPP Sensor Extender is discussed in detail in Chapter 2 “Introduction to IBM Intelligent Pervasive Platform Sensor Extender” on page 11.

1.4 Data model for the Intelligent Pervasive Platform

The IPP data model consists of a set of concept objects that are managed by IPP. These objects include point of interest (PointOfInterest) and category (Category) objects.

IPP has a generic data model, based on JSON representation, that allows it to describe all its data in the same way. An IPP object is made up of a list of simple attributes (key and JSON-value pairs) and a list of complex attributes (a key with one or more IPP objects).

The main IPP data model objects are as follows:

- Point of interest objects
- Category objects

1.4.1 Point of interest object

The point of interest (PointOfInterest) object defines the information that is intended to be presented to the mobile user. It contains a set of attributes such as a title, a content description, and its spatial representation.

A point of interest can be any useful or identifiable geolocalized object such as a restaurant, a museum, or a car. The point of interest can belong to a category.

Figure 1-2 shows a map of the city of Siracusa (on the left) with various point of interest instance locations and associated point of interest instances (places) by name (on the right).

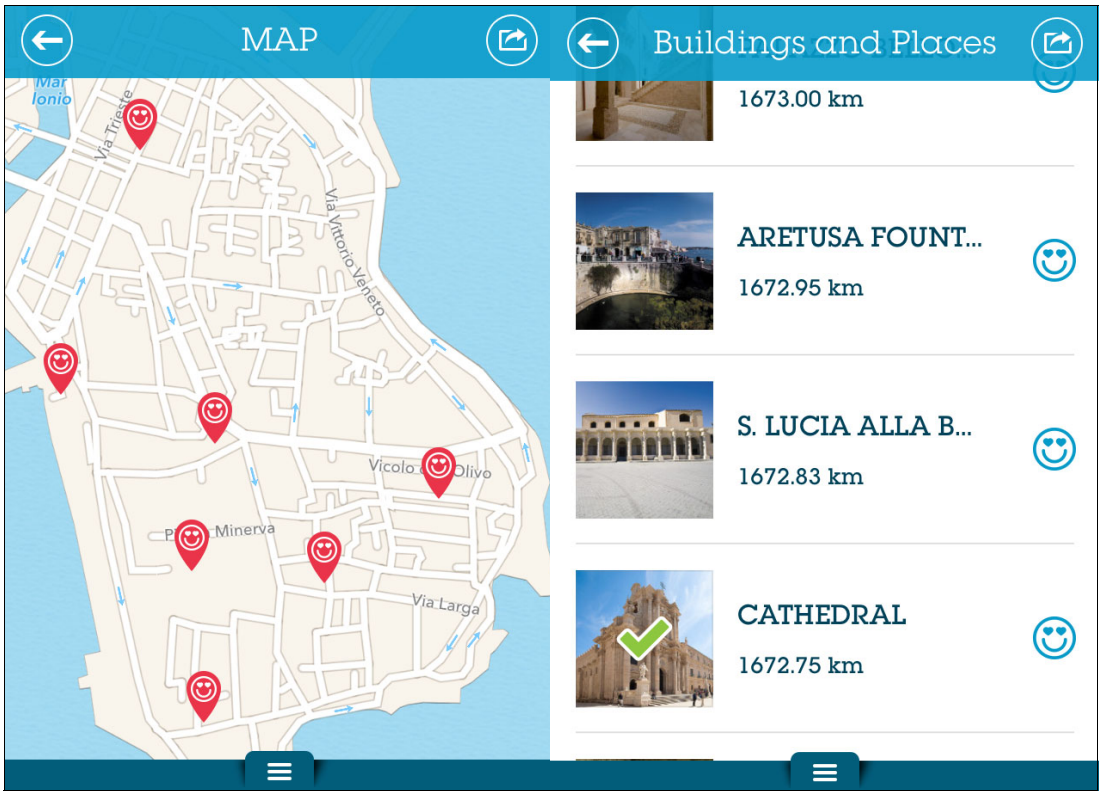

Figure 1-2 Point of interest map and list example

Figure 1-3 shows the detailed point of interest information (in English).

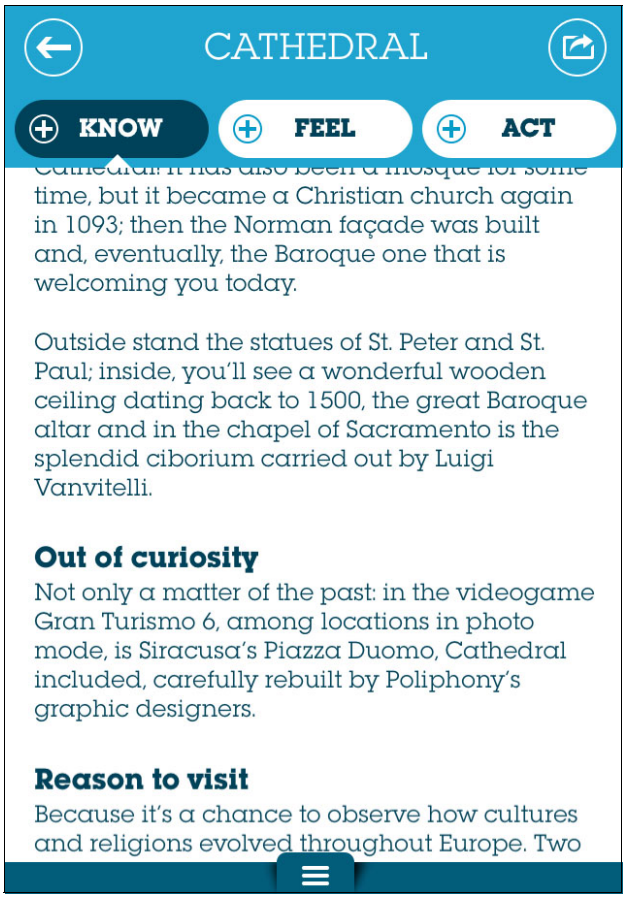

Figure 1-3 Point of interest detail

1.4.2 Category

Category objects provide classification for point of interest instances. A category contains a collection of point of interest instances. Storing various kinds of information is useful. Categories support a hierarchy that can contain sub-category lists. Based on a heritage capability (provided by IPP), each point of interest that is contained in a child category, also belongs to that child's parent categories.

Example 1-1 shows a tree of categories. In this example, point of interest instances are sorted based on their type. By heritage, a particular Chinese restaurant point of interest belongs to both the Chinese Restaurants category and (the parent) Restaurants category.

Example 1-1 Categories hierarchy

```
Museums
Restaurants
   Italian Restaurants
   Chinese Restaurants
   French Restaurants
Places
```

1.5 JSON representation of IPP data model

The IPP data model relies on a JavaScript Object Notation (JSON) representation.

JSON is an open standard format. JSON representation enables data exchanges between IPP and mobile applications. It is sufficiently generic to represent almost any type of data.

The JSON point of interest (POI) objects and category objects are stored in the IPP Data Model Collection shown in Figure 1-1 on page 3.

Many types of POI information can be represented in JSON. Some of the attributes on a JSON object are mandatory, specifically objname (defines the type of object) and code (a unique identifier). Each IPP object has a objname of either “poi” (for a point of interest) or “category” (for a category) and a unique code for that particular object (Example 1-2).

Example 1-2 Mandatory JSON object attributes

```
{
"objname": "poi",
"code": "Codename"
}
```

Point of interest objects define the information intended to be presented to the mobile user. These objects contain a set of attributes, such as a title, a content description and the object’s spatial representation. Additional information about a point of interest might include the category it is in, a questionnaire for the visitor, and a rating or feedback from visitors about that point of interest.

1.5.1 JSON representation of a point of interest title

Most point of interest objects have a title attribute. The title can be used by the mobile application to display the *title* (name) of the point of interest. Various attributes, such as title can be language-dependent. By appending a key (locale) the attribute can be identified to support a specific language. In this case, the title is represented as `"title_locale"` where locale specifies a particular language. Consider the Eiffel Tower locale as an example. In the `title_EN`, the EN means English and the value would be *The Eiffel Tower*; in French (`title_FR`) the title would be *La Tour Eiffel*.

If the point of interest title is available in several languages, then the JSON representation will have titles for each language defined by its locale (Example 1-3).

Example 1-3 POI object title attribute in multiple languages

```
{
"objname": "poi",
"code": "Codename"
"title_locale1": "The POI title in language 1"
"title_locale2": "The POI title in language 2"
}
```

1.5.2 JSON representation of a point of interest description

The point of interest object may have a set of documents to describe it in more detail. Each document contains a title, content, and is language-dependent. If the point of interest description is available in several languages, the JSON representation will have a key for each language, defined by its locale (Example 1-4).

Example 1-4 POI description supporting documents in multiple languages

```
{
"objname": "poi",
"code": "Codename",
"title_locale1": "The POI title in language 1",
"title_locale2": "The POI title in language 2",
"documents": [
   {
      "objname":"document",
      "title": {
         "locale1": "Title of the first POI description in language 1",
         "locale2": "Title of the first POI description in language 2"
   }
      "content": {
         "locale1": "The first POI description in language 1",
         "locale2": "The first POI description in language 2"
      }
},
   {
      "objname":"document",
      "title": {
         "locale1": "Title of the second  POI description in language 1",
         "locale2": "Title of the second  POI description in language 2"
      }
      "content": {
         "locale1": "The second POI description in language 1",
         "locale2": "The second POI description in language 2"
      }
   }
      ]
}
```

1.5.3 JSON representation of spatial data

If the point of Interest has spatial data, this data is described in the GeoJSON open format in the `"location"` attribute. GeoJSON is a format for encoding a variety of geographic data structures. It can represent different geometries such as a point, a line, or a polygon. For more details about GeoJSON, go to this web address:

http://geojson.org/

Example 1-5 shows a JSON representation of a point of interest as a point with coordinates; latitude, longitude, and altitude (altitude is optional).

Example 1-5 POI for a geoJSON location

```
{
"objname": "poi",
"code": Codename,
"location": [
   "geometry" : {
      "bbox" : [latitude, longitude, altitude, latitude, longitude, altitude],
      "centroid" : [latitude, longitude, altitude (optional)],
      "coordinate" : [latitude, longitude, altitude (optional)],
            "crs" : {
                        "properties": {"name": "urn:ogc:def:crs:OGC:1.3:CRS84"},
                         "type": "name"
                     }
      "type": "Point"
},
"objname": "temporal_location"
]
}
```

Bounding box (bbox) and centroid values are generated from the point of interest coordinates. The representation of this point of interest (Example 1-5) is a point, the lowest values, the highest values of the bbox and the coordinates of the centroid are the point coordinates.

The `"crs"` attribute indicates the coordinate reference system. In the GeoJSON format, it has the following values:

- *properties* contains a `"name"` member whose value is the reference system with the **“**`urn:ogc:def:crs:OGC:1.3:CRS84`**”** name.
- *type* is name

Point of interest geometry: A point of interest geometry can be more complex, for example representing a polygon such as a building.

2

Introduction to IBM Intelligent Pervasive Platform Sensor Extender

This chapter describes the IBM Intelligent Pervasive Platform Sensor Extender, also known as Intelligent Pervasive Platform (IPP) for sensor. This chapter covers the following topics:

- Overview of Intelligent Pervasive Platform Sensor Extender
- Architecture of Intelligent Pervasive Platform Sensor Extender including:
  - IPP Sensor Extender key components
  - IPP Sensor Extender data model

2.1 Overview of Intelligent Pervasive Platform Sensor Extender

The Intelligent Pervasive Platform (IPP) Sensor Extender enables the management of sensing devices and sensor platforms. A sensor platform supports data that is collected from various sensing devices, such as sensors, actuators, radio frequency identification (RFID) tags, switches, microphones, the Internet of Things, machine to machine (M2M) communication, and wearable computing devices. This extension to IPP is a dedicated service for sensor-based environments.

In a world that is more instrumented, and with the emergence of Internet of Things and M2M communication, IPP Sensor Extender provides the following unique solution capabilities:

- Integrating sensing device data

  This capability supports the representation of sensing device data (produced in various formats) into a common format. Each manufacturer of these sensing devices has its own format for the data that is generated by the devices; to make this data more usable, IPP Sensor Extender transforms the data into a common format.

- Collecting data

  This capability supports the collection of measurement data from a wide variety of sensing devices. For example, perhaps this capability can be used with sensing devices that collect data when testing prototype cars. The data collected might then be used to help determine if a malfunction exists with the car being tested.

- Controlling data quality

  This capability can collect metadata and help ensure quality factors (Q-Factor) are met. IPP Sensor Extender has established Q-Factor as the main criteria for this capability. It supports a sustainable solution over time and is the main element guaranteeing the data is trustworthy.

- Bridging between requesters and providers

  This capability provides a bridge between applications that consume sensing device data and data providers (sensing devices). For example, an application might consume the carbon dioxide (CO2) emissions data that is generated by sensing devices in a building to determine whether an issue exists with air quality.

With IPP Sensor Extender, you can implement an operational system, which has the following characteristics:

- Runs in an autonomous mode
- Collects different kinds of sensing device data simultaneously
- Is capable of being replicated in several different environments and scenarios

By using the IPP data model, IPP Sensor Extender has access to all the IPP capabilities (for example, the ability to do spatial queries or searches on sensing devices). The IPP data model and associated data storage capability are used for the sensing device data collected and for measurement restitution.

2.2 Architecture of Intelligent Pervasive Platform Sensor Extender

IPP Sensor Extender is an extension to the Intelligent Pervasive Platform. It provides support for collecting and formatting and standardizing sensing device data. This data can be used as input to various applications and by analytic tools that perform analysis of the data.

IPP Sensor Extender handles both descriptions of sensor platform devices (sensing devices, packaging devices, and gateways) and the sensing device measurement data. This source data is made available to other applications (Measurement Data Processing Applications) for reporting, display, and analysis.

Figure 2-1 shows a high-level architecture of Intelligent Pervasive Platform Sensor Extender.

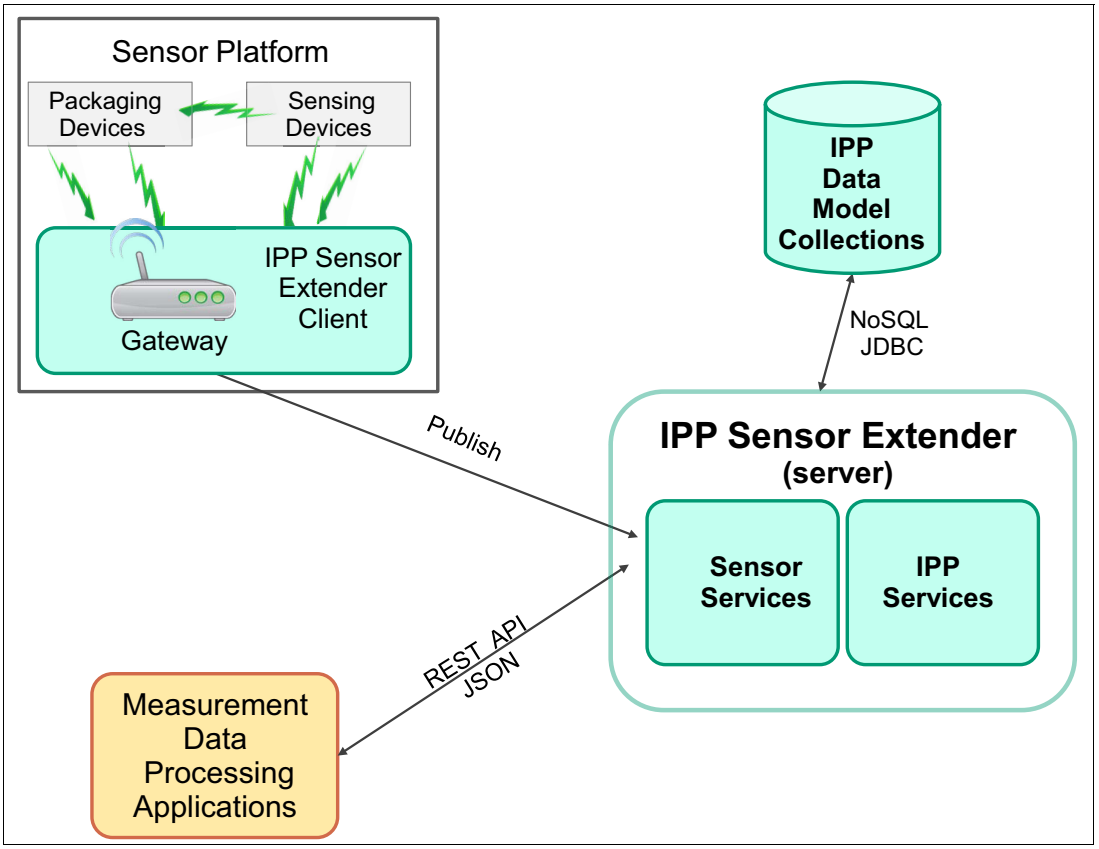

Figure 2-1 High level Intelligent Pervasive Platform Sensor Extender architecture

Before we describe components of the IPP Sensor Extender architecture, understanding how the data that is collected and maintained by the IPP Sensor Extender can be used is important. Figure 2-1 shows the Measurement Data Processing Applications. IPP Sensor Extender provides a set of REST APIs that enable these applications to process and derive relevant information and value from the sensing device measurement data. For example, IBM Analytics software (such as IBM Cognos® software and IBM SPPS software) can be used to analyze this data and represent the results in various ways, such as these:

- Display the data graphically in real-time to interested individuals.
- Perform average value computations for analysts.
- Produce reports with historical and current values to interested individuals.
- Generate recommendations and insights for decision makers.

2.3 IPP Sensor Extender components

Figure 2-1 on page 13 shows IPP Sensor Extender components that support collecting and handling of sensing device measurement data, the components are as follows:

- IPP Sensor Extender (Sensor service and Intelligent Pervasive Platform (IPP) services)
- IPP Data Model Collection
- IPP Sensor Extender Client

2.3.1 Sensor service and IPP services

The IPP Sensor Extender Sensor service manages the descriptions and details of sensor platform's devices and the sensing device measurement data. This service has capabilities that support the data model, the sensing devices registry, and the manipulation of measurement data. The Sensor service capabilities complement existing IPP services used by IPP Sensor Extender. The IPP services are described in 1.3, "About Intelligent Pervasive Platform services" on page 3.

The Sensor service (using a set of REST APIs) manages the following information:

- Sensor platform (physical structure) information
- Measurement data

Managing the sensor platform devices information

The detailed information about the sensor platform's devices is stored in the IPP data model collection. Each sensor platform device (packaging device, sensing device, and gateway) is managed as an IPP point of interest object. By using the existing IPP information service, the IPP Sensor Extender is able to update the various devices descriptions and perform actions such as these:

- Update the sensor platform's devices status
- Update a sensing device Q-Factor
- Change a device's location

Managing the sensing device measurement data

The following three types of IPP Sensor Extender services manage the sensing device measurement data:

- Collect

  The collect service receives the information coming from the gateways. The listener layer gets the raw sensing device measurement data from the gateway by using various network protocols (such as Message Queuing Telemetry Transport (MQTT), Transmission Control Protocol (TCP), and Hypertext Transfer Protocol (HTTP)). Next the unification layer transforms the raw data into the established common JavaScript Object Notation (JSON) format.

- Consolidate

  The consolidate service enhances the measurement data by adding related device description information. The consolidation layer appends relevant information to the sensing device measurement data by merging key sensing device description data (such as measurement unit, geolocation, time stamp, and manufacturer information). It also synchronizes the Sensor Platform information, updating the status or the geolocation if necessary. The results are stored in the IPP Data Model Collection.

The notification layer can be called by the consolidation layer when communicating to an external process is necessary. This layer is used to manage various situations such as these examples:

- Send a Short Message Service (SMS) or email alert to a physical component manager if a defect status is detected and a repair is required.
- Call a third-party API to alert the system that a critical sensor value has been identified.
- Send a message to social media, based on defined triggers (such as a geolocation).

- Consume

  The consume service is responsible for returning the measurement data according to specific requirements as follows:

  - Filter: Filter is used to select a subset of the returned measurement instances according to some criteria. For example, a filter can get the measurements of a given sensing device by device ID for a particular date range.
  - Returned attributes: This capability limits the number of measurement attributes that are returned. For example, an application might need only a measurement's reading (value) and unit attributes.
  - Sort: Sort is used to organize the measurement instances in ascending or descending order by a given attribute. For example, instances can be organized in ascending order and by sensor type.
  - Restrict returned data: The number of returned measurement instances can be restricted, for example returning the last 50 records.

2.3.2 IPP Data Model Collection

The IPP Data Model Collection stores the sensor platform device descriptions and sensing device data. A NoSQL database is used to store the data. The NoSQL database leverages efficient storage for collections with highly flexible schema and allows horizontal scalability for efficient performance. Currently either IBM DB2 software that supports a NoSQL database or Cloudant (an IBM acquisition) software is used to store the data.

IPP Sensor Extender uses the IPP Data Model Collection to describe the devices in the sensor platform and sensing device measurement data. By using this approach, IPP Sensor Extender can take advantage of the standard IPP services and capabilities described in 1.3, "About Intelligent Pervasive Platform services" on page 3.

The IPP Data Model Collections represents the data in the JSON data interchange format.

2.3.3 IPP Sensor Extender Client

Figure 2-1 on page 13 also shows the IPP Sensor Extender Client software that is located on the gateway (or gateways) of the sensor platform. A *gateway* is a device or system that enables the communication of multiple sensing devices and "packaging" devices with an external system or environment. A packaging device receives sensing devices event data and then packages that data into a container before it is sent to the gateway. The IPP Sensor Extender Client software publishes the sensing device data and packets of sensing device data from the gateway to IPP Sensor Extender server.

IPP Sensor Extender Client may be developed or customized by the enterprise that implements an IPP Sensor Extender solution. This client software can provide its own data format with information generated by the sensing devices.

2.4 IPP Sensor Extender data model

The IPP Sensor Extender data model consists of the following data formats:

- Sensing device description
- Packaging device description
- Gateway description
- Sensing device measurements

2.4.1 Sensing device description

A sensing device detects an event (a measurement) and transforms the measurement data from its physical form to a digital format. This data is sent either to a packaging device and then on to a gateway or directly to a gateway.

Having a well-formed description of the sensing devices that describes the device's characteristics is necessary. The sensing device attributes are as follows:

- Identifier
- Name
- Sensing device type (for example, CO2 and HUM)
- Measurement unit (such as temperature in either Fahrenheit and Celsius (centigrade))
- Maximum value (for example the maximum temperature)
- Minimum value (for example the minimum temperature)
- Q-factor (optional)
- Degree of precision (optional)
- Limitations (optional)

More sensing device attributes can be as needed.

2.4.2 Packaging device description

The packaging devices put one or several sensing devices event (measurement) data into packets before that data is forwarded to the gateway. These devices can be mobile or stationary. They can have several states, such as activated, de-activated, and turned on or off. The packaging device attributes are as follows:

- Identifier
- Name
- Status
- Timestamp status (last time status changed)
- Geolocation information/spatial information
- List of (one or more) sensing devices associated with the packaging device

More attributes can be added if needed.

2.4.3 Gateway description

A gateway enables data from packaging devices and sensing devices to be sent outside of the sensor platform. The list of connected devices is flexible because a packaging/sensing device can be associated with different gateways at different times. A gateway can have different states.

The gateway attributes are as follows:

- Identifier
- Name
- Status
- Timestamp status (last time status changed)
- List of associated packaging devices

More attributes can be added if needed.

2.4.4 Sensing device measurements

A measurement consists of the details of a physical event that is generated by a sensing device. Each measurement has an event-specific value (such as a temperature or device reading) that can be geolocated. As with the sensor platform devices, measurements are represented in JSON. The measurement attributes are as follows:

- Identifier of the transmitting device
- Identifier of the sensing device
- Timestamp
- Geolocation
- Reading (measurement value)
- Unit (measurement unit)

More attributes can be added if needed.

2.4.5 JSON representation

IPP and IPP Sensor Extender use JSON to represent data. JSON is sufficiently generic to represent almost any kind of data. The JSON representation enables data exchanges between IPP Sensor Extender and the applications (using the data). Example 2-1 shows a typical JSON representation of a sensing device's measurement data collected by IPP Sensor Extender.

Example 2-1 JSON representation

```
{ “sensor":"sensor type (such as, CO2, Temp, or hum)",
   device":"device identification",
   timestamp":time,
   geometry":
   {
      "type": "Point",
      "coordinates":[ latitude, longitude, altitude (optional)]
   },
   "reading": value
}
```

The geometry (geolocation) attribute (included in the measurement instance) is described in the GeoJSON open format. *GeoJSON* is a format for encoding a variety of geographic data structures.

3

Exploring IBM Intelligent Pervasive Platform potential solutions

Intelligent Pervasive Platform (IPP) and IPP Sensor Extender can integrate with a wide variety of IBM software, creating robust solutions. These solutions can be applicable to many industries and industry sectors. This chapter describes key IBM software that IPP can integrate with to create solutions and offers example solutions in various industries.

3.1 IPP integration with various software and technologies

This section describes ways that IPP can integrate with various IBM software solutions and fits with the IBM strategic areas of cloud computing, big data and analytics, mobile computing, social business, and security. The software solutions described here are as follows:

- Mobile
- Visualization
- Social networks
- Analytics
- Internet of Things (IoT) and machine to machine (M2M) communication
- Rules management

3.1.1 Mobile

IBM Worklight helps extend business applications to mobile devices. IBM Worklight provides an open, comprehensive platform to build, run, and manage HTML5, and hybrid and native mobile applications. IPP can interface with IBM Worklight and mobile applications created for Worklight. By including IPP in the overall mobile solution, developers can use the IPP REST APIs to retrieve point of interest instances by their associated categorization. For example, a mobile application can request information (point of interest instances) stored in IPP based on mobile user profile and on geolocation criteria.

For more information about IBM Worklight, go to this web page:

`http://www.ibm.com/software/products/en/worklight`

Also, in various situations, the mobile device can be used as a gateway for sensing solutions based on IPP Sensor Extender. In these cases, IPP Sensor Extender capabilities are used to collect and standardize the sensing device data and forward that data to other applications for display, reporting, and analysis.

3.1.2 Visualization

IBM visualization technology can display data that is collected by IPP and IPP Sensor Extender. Visualization software allows business application developers to create customizable, interactive displays, such as diagrams, charts, and maps. These visualization products include professional tools, customizable components, and libraries which can help to reduce both development time and risk. The generated graphical interfaces help end users gain a visual and timelier understanding of their data, enabling them to respond to changes more quickly.

IBM Rapidly Adaptive Visualization Engine

With IBM Rapidly Adaptive Visualization Engine (RAVE), you can describe how the visualizations that are being created should look. RAVE is an engine that can be used to visualize data that is collected by IPP and IPP Sensor Extender. RAVE can be used to display the collected data with a set of layouts that can easily be integrated into applications that are used by various groups, such as decision makers, administrators, and analysts.

Figure 3-1 shows an example visualization of noise-sensing data that is collected and standardized by IPP Sensor Extender. In this case, the RAVE-based solution uses IPP REST APIs to access the data that is stored in the IPP Data Model Collection.

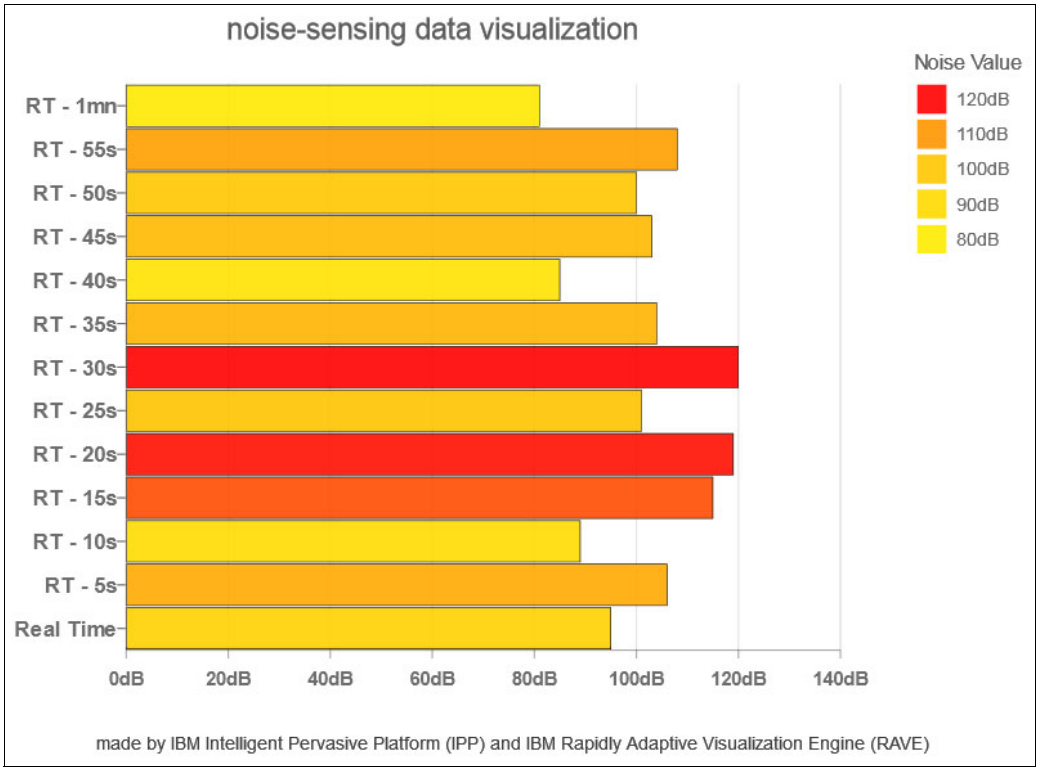

Figure 3-1 Dashboard with RAVE visualization

For more information about IBM RAVE, go to this web address:

http://www.ibm.com/software/analytics/many-eyes/

IBM Intelligent Operations Center

IBM Intelligent Operations Center provides an executive dashboard to help city leaders gain insight into various aspects of city management. The executive dashboard spans agencies and provides a view into underlying agencies, such as emergency management, public safety, social services, transportation, and water management. IBM Intelligent Operations Center helps in the management of large complex environments and in improving communications.

Sensing devices can be used in various ways within a city environment, such as sensing air and water quality, weather changes, and traffic congestion. The data from sensing devices can be collected and standardized by IPP Sensor Extender. The resulting data can be input to the Intelligent Operations Center, which analyzes and visualizes relevant data on the executive dashboard used by city leaders.

For more information about the IBM Intelligent Operations Center, go to this web address:

http://www.ibm.com/software/products/en/intelligent-operations-center

3.1.3 Social networks

Social networks have become one of the most efficient ways for sharing information. They are powerful means for accessing almost real-time information by a particular group of participants. IPP can be used to broadcast pertinent data according to predetermined settings. For example information that is collected and managed by IPP can be automatically shared with social media accounts.

A social network solution that uses IPP might support the following activities:

- Social network administrators define accounts that are related to spatial areas.
- Mobile users follow their favorite accounts.
- IPP complements the collected and localized data with specific tagging, making it possible to search the data.
- IPP sends data to the corresponding geo-fenced social network accounts.
- Mobile users consume the targeted information as it arrives on their mobile device.

One of the key strengths of IPP integrated with the social media is to seamlessly broadcast data according to the interests of mobile users. IPP can be applied to various industries as a channel of communication at a low cost because accessing this data with a simple user interface is possible.

3.1.4 Analytics

Analytics can help an organization make better decisions by providing new insights from the volume and variety of data available today. IPP solutions work in conjunction with these analytic solutions in the following ways:

- IPP can be a source for data as mobile users move from location to location and can provide results to mobile device users that is derived from analytics.
- IPP Sensor Extender has capabilities to collect and standardize data from sensing devices provides a great source of input to analytic solutions.

IPP APIs provide the means to access data that IPP solutions have collected. This data can feed an operational data store that is input to further analytics, such as to identify trends and to improve business performance in a particular area.

IBM InfoSphere® Streams is an advanced analytic platform that allows applications to quickly ingest, analyze, and correlate information as it arrives from thousands of real-time sources. IPP solutions could be a source of stream data enabling real-time analytic processing of data in motion.

Data collected by IPP solutions can also feed very large file systems optimized by IBM InfoSphere BigInsight in combinations with the Hadoop Distributed File System (HDFS) and the IBM General Parallel File System (GPFS™).

IPP data can also provide inputs for predictive tools, such as IBM SPSS® software, to identify patterns over a certain period time. Also, solutions could use applied learning over a set of IPP collected information to generate representative patterns.

Every day, a massive volume of data is collected, allowing new insights to be discovered. Some data will be filtered and not processed and some data will be key information for gaining business differentiators.

For more information about IBM InfoSphere Streams, go to this web address:

http://www.ibm.com/software/products/en/infosphere-streams

For more information about IBM InfoSphere BigInsight product family, go to this web address:

http://www.ibm.com/software/products/en/subcategory/SWP12

3.1.5 Internet of Things and machine-to-machine communication

We now live in a world where many objects are connected to the Internet and are communicating data in an unprecedented order of magnitude. Billions of these objects can sense, communicate, and share information from almost anywhere (this is known as the *Internet of Things*). These objects can be embedded in complex systems including networks of objects, machines, and mobile devices, such as smartphones.

IPP solutions can play a key role in this new environment by becoming a broker for this data. IPP can be incorporated into applications that interact with mobile devices. While IPP Sensor Extender can be used to collect and standardize data from sensor platforms, this data can be used for analysis and as input to other applications.

With the Internet of Things being deployed at this scale, organizations and individuals can make better decisions in real time about their daily life. For example, IPP solutions could be part of an application to generate the best route to follow or identify a particular location to avoid based on an event, such as an accident or a pollution alert. The scope of possibilities is endless.

Also, many organizations want to analyze this data to create business insights or obtain valuable information. This interest in the (IPP and IPP Sensor Extender) data applies to many different industries, such as healthcare, automotive, travel and transportation, and retail.

IPP solutions also integrate with several products and solutions that address machine-to-machine (M2M) communication trends. For example, IPP can be integrated with applications built with Codename: IBM Bluemix™. Bluemix is a *platform as a service* offering based on the Cloud Foundry open source project. Bluemix delivers robust features and services that are easy to integrate into cloud applications.

IPP Sensor Extender can collect and standardize sensing device data and any M2M information while Bluemix provides the overall platform for managing and manipulating this data.

For more information about Bluemix, go to these web addresses:

- http://www-01.ibm.com/software/ebusiness/jstart/bluemix/
- https://www.ibmdw.net/bluemix/
- http://www.ibm.com/cloud-computing/us/en/paas.html

3.1.6 Rules management

IPP can easily interact with rules defined at the client device or in the server environment. IPP has been used in various Proofs of Concepts (PoC) with IBM Operational Decision Manager (ODM). The basic flow of interaction is as follows:

1. IPP collects the data from the mobile devices.
2. IPP forwards the data to IBM ODM through a Web service.
3. IPP obtains the results from IBM ODM and returns the data to the mobile device.

IBM Operational Decision Manager provides the means to define, maintain, and execute rules. The results of this rules processing (such as an alert message) can easily be returned to IPP, which then forwards it to the mobile device for display.

For more details about IBM Operational Decision Manager, go to this web address:

http://www.ibm.com/software/products/en/odm

3.2 IPP and IPP Sensor Extender in various industries

Diverse industries and industry sectors are taking advantage of advances in technology. IPP and IPP Sensor Extender have a role to play in many industries. This section provides examples of how IPP solutions have been used. These examples are only a starting point for the possibilities of using IPP solutions in various industries such as these examples:

- Health (healthcare)
- Environment
- Public
- Retail
- Transportation
- Travel and Tourism

To view the various case studies that use IPP solutions, go to the following web address:

http://www.ibm.com/able/europe/CaseStudies.html

3.2.1 Health

The health (healthcare) industry has made many advances, thanks in part to new technology. IPP solutions can play an important role in health care by providing mobile users access to vital information and by collecting key sensing device data that is used by applications. For example, IPP Sensor Extender might provide vital information to a doctor or hospital staff about the ongoing condition of a patient in their care.

Connecting homes for aging adults

Many aging adults want to continue to live in their own homes as long as possible. Today, various sensing devices exist that can monitor living conditions, provide remote support, and help ensure security of the residents. These devices, incorporated into an overall solution (including IPP Sensor Extender), can help improve quality of life and ensure independence.

The homes of aging adults can be equipped with various air quality sensing devices and security devices. These air quality sensing devices can detect conditions, such as smoke, carbon monoxide (CO), carbon dioxide (CO2), methane gas, and changes to temperature and humidity. When necessary, personal monitoring devices can also be used to monitor personal health conditions, such as blood pressure and heart rate.

This sensing platform sends the data to the IPP Sensor Extender. The IPP Sensor Extender receives the data and transforms it from the various manufacturer-specific formats to the IPP generic format. IPP Sensor Extender can process the data and sends alerts when needed.

The IPP Sensor Extender server has a Sensors Registry that contains information about the sensing devices, such as their characteristics and their hierarchical dependencies with physical containers. This information is essential to providing the correct data to applications, maintaining the operational system, and creating alerts whenever appropriated to interested parties such as a, nurses, doctors, assistants, social workers, and relatives.

Bolzano Italy solution

Bolzano, Italy wanted to innovate their social services through the use of technology and to establish new economic sustainable models. The idea was to coach and assist remotely a group of senior individuals while in their homes or during daily activities. A network of assistants (including relatives) used a solution that included IPP Sensor Extender to collect data from the sensing devices and share it with other applications, such as displaying key information on a dashboard. IPP was used to provide information to the seniors and the assistants.

For more information about this project, go to the following web address:

http://www-03.ibm.com/able/europe/Health/AbitareSicuri.html

Also see the video at the following web address:

https://www.youtube.com/watch?v=kDvW8R4BLOI

3.2.2 Environmental sector

Everyone is becoming increasingly aware of changes to our environment. Many of these changes are attributed to gases in our atmosphere. A key way to better understand these effects is to use sensing devices to monitor and measure the levels of various gases, such as nitrogen dioxide, carbon dioxide, and carbon monoxide. Analysis of these measurements is helping analysts and scientists track the changing levels of these chemicals. IPP and IPP Sensor Extender can play a key role in collecting and processing this information.

Environmental Sensing hub

Sensing devices are being used extensively to monitor environmental conditions, such as air quality. In many cases these sensing devices are stationary but they can also be attached to vehicles. The sensing data collected could be forwarded by a model device with Bluetooth and use a telecommunications network to forward the data to IPP Sensor Extender. Included with this sensing device data is the GPS location of the mobile device at the time of the transmission. The sensing devices could monitor for pollutants, such as nitrogen dioxide, carbon dioxide, carbon monoxide in the air and weather related conditions, such as temperature and humidity.

The IPP Sensor Extender server can collect, standardize, and store the sensing device data that is sent from the mobile devices. This data can be forwarded to various applications and solutions, such as the IBM Intelligent Operations Center. The IBM Intelligent Operations Center can analyze and display the location and the associated sensing device data to city officials.

Figure 3-2 shows the selection of a particular car location on the map with the detail sensing device data at that location.

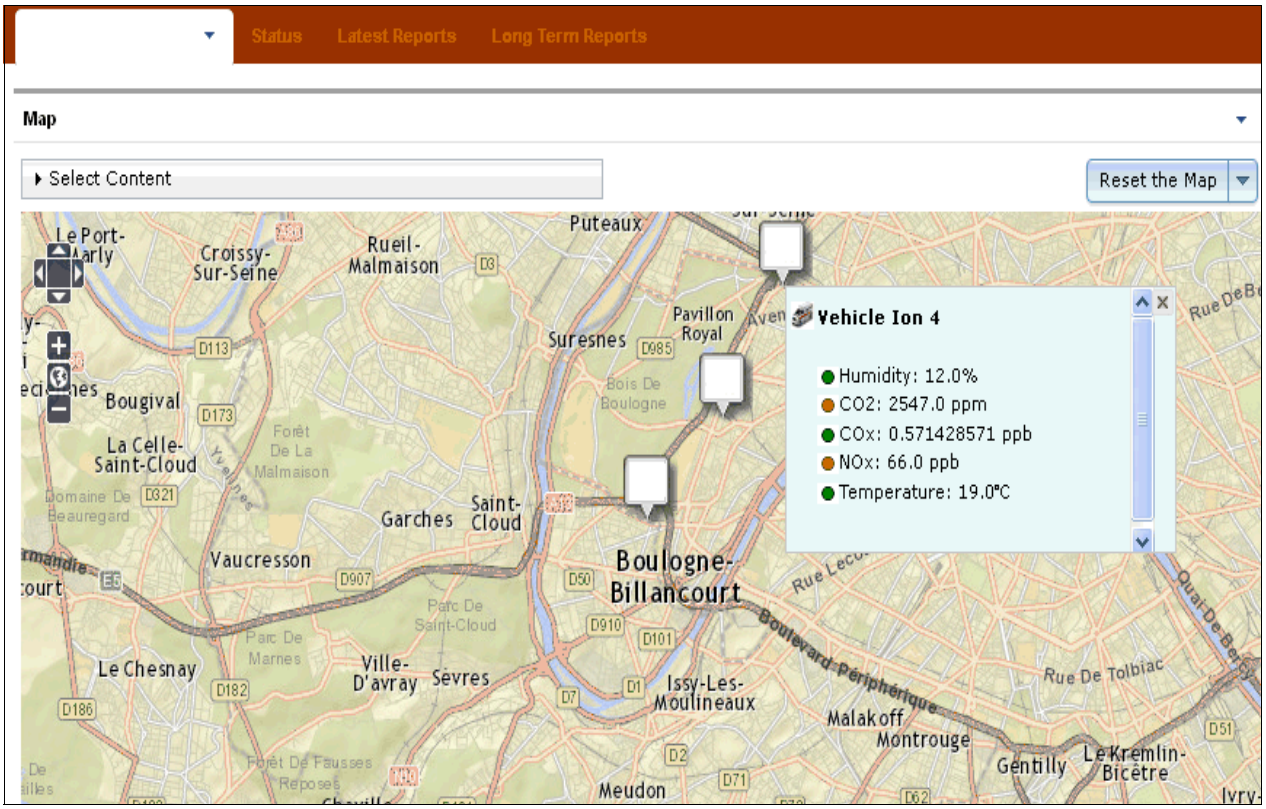

Figure 3-2 Last sensor data from car 4

Figure 3-3 is a graph of the CO2 emission (from the sensing device) over time. Data from the other sensing devices can be displayed graphically too.

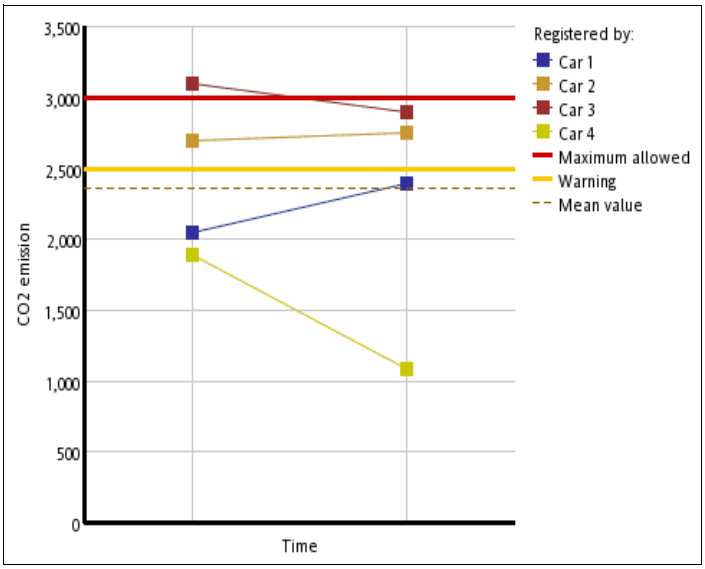

Figure 3-3 Evolution of CO2 emission data for each car over time

Specific sensing device measurement data (from the cars) can be sent via IPP to social media.

Figure 3-4 shows tweets that are generated for car2 (by IPP) at a particular location. The tweets state the temperature and air quality ratings.

Figure 3-4 Tweets from car 2

Using the IPP Sensor Extender, it was possible to extract the GPS location of each car and to build Keyhole Markup Language (KML) files. The start and end locations, the path, and the time stamp were displayed on a map.

Figure 3-5 shows the high-level architecture of an environmental sensing hub.

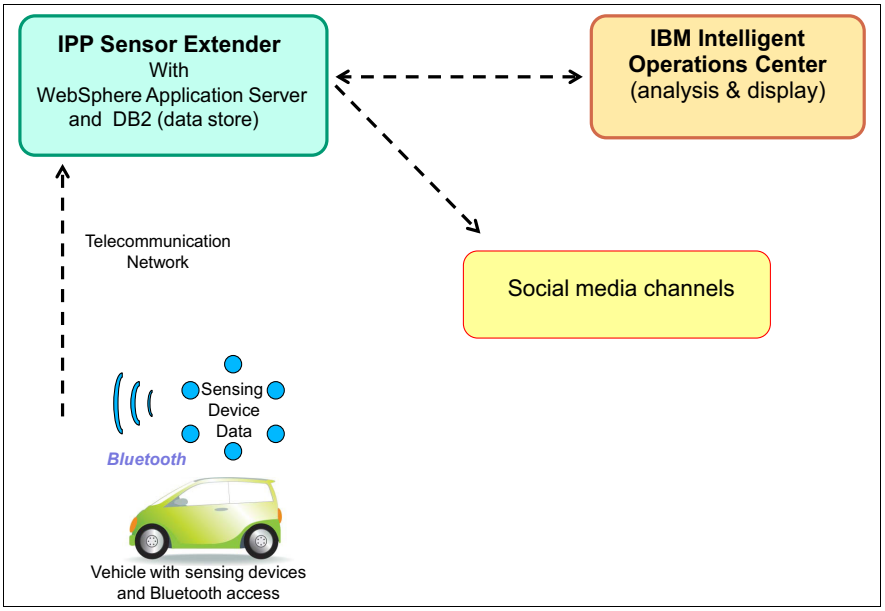

Figure 3-5 Environmental sensing hub architecture

Connected cars

IBM in partnership with Peugeot equipped four electric cars with sensing devices that collected environmental data (such as nitrogen dioxide, carbon dioxide, carbon monoxide, temperature, and humidity). IPP Sensor Extender collected and standardized this data. The data was forwarded to a server for additional processing and display on a dashboard.

For more details about this case study, go to this web address:

http://www-03.ibm.com/able/europe/Environment/ConnectedCars.html

To view a video about this solution, go to this web address:

http://www.youtube.com/watch?v=oAhQO6jPqiA

3.2.3 Public sector: Everyone can contribute to make the planet smarter

On 20 July 2010, the VisLab Intercontinental Autonomous Challenge (VIAC) started from Parma, Italy and traveled to Shanghai, China (28 October 2010). The challenge proved the possibility of moving between two continents by using non-polluting vehicles that were powered by green energy and with virtually no human intervention.

Related to VIAC, the IBM Human Centric Solution Center wanted to show how people and citizens can contribute key information (such as tracking air quality) to organizations (such as city and regional governments). The project demonstrated “green behavior” by equipping these VIAC vehicles with CO2 sensors for their journey. Existing technology, including sensing devices and a smartphone, were used. The CO2 results were transmitted from the smartphone (used as a gateway) through the Internet to a Twitter channel, which provided access to a live stream of data. This information was available to anyone who wanted to view the data.

Figure 3-6 shows the key components that were used to send sensing device data from the vehicle (with sensing devices on the roof) to the live blog.

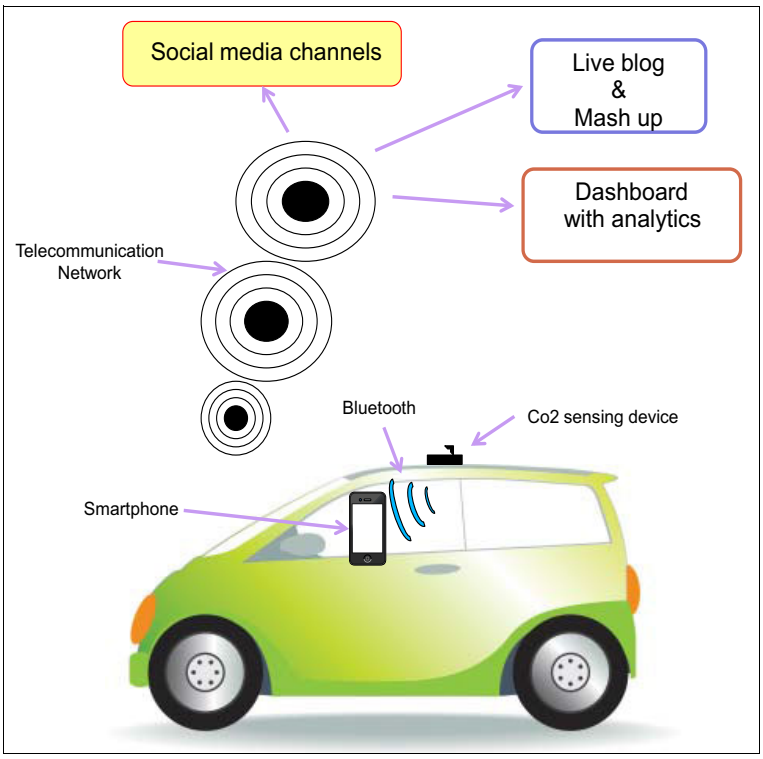

Figure 3-6 High level flow from vehicle-based sensing devices to the data consumers

Figure 3-7 shows the 13,000 kilometers route the car took during the three month VIAC journey.

Figure 3-7 Map of vehicle route

The architecture of this IPP Sensor Extender solution is shown in Figure 3-8.

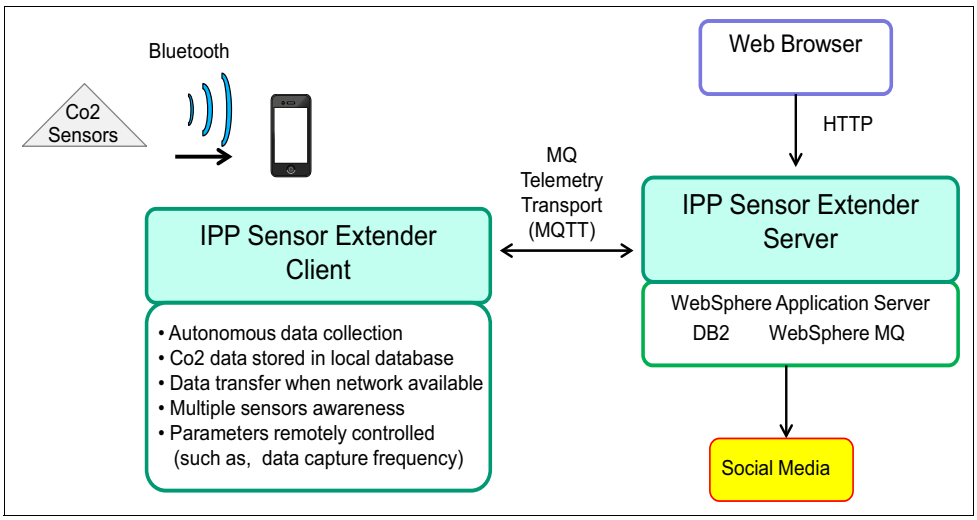

Figure 3-8 Architecture of air quality sensing solution

The environmental information was collected in real time and shared with the community. Analytics were applied to better understand predictions and parameter correlations. This solution demonstrated that individuals (themselves or using their means of transportation) can become sensing devices and share this data using their own mobile devices to give

feedback to a central entity. This approach helps the central entity make faster and better decisions through intelligent analysis of the incoming data.

To learn more about this project, go to this web address:

http://www-03.ibm.com/able/europe/Environment/Greenhaviour.html

To view the video about this project, go to this web address:

http://www.youtube.com/watch?v=9cgrkZEZ6kg

3.2.4 Retail industry

The retail industry has made great strides in communicating with its customers through the use of mobile device applications and the Internet. IPP and IPP Sensor Extender have a strong role to play in the retail environment. For example, IPP might be used to give mobile users information about various types of stores, and eating and drinking establishments close to their location. IPP Sensor Extender can collect and standardize sensing device data that can be input to applications that are designed to understand and affect customer behavior.

Noise sensing at events and locations

Noise at an event or at a particular location can change an individual's behavior either positively and negatively. Noise levels can also indicate increased customer traffic and activity levels at a particular location or fan excitement at a sporting event. This information can be valuable to retailers and food and beverage businesses.

IPP Sensor Extender can be used to collect data from noise sensing devices that monitor crowd noise levels. This data can be displayed on a dashboard for interested parties to view.

Figure 3-9 shows the overall architecture with IPP Sensor Extender as part of the solution.

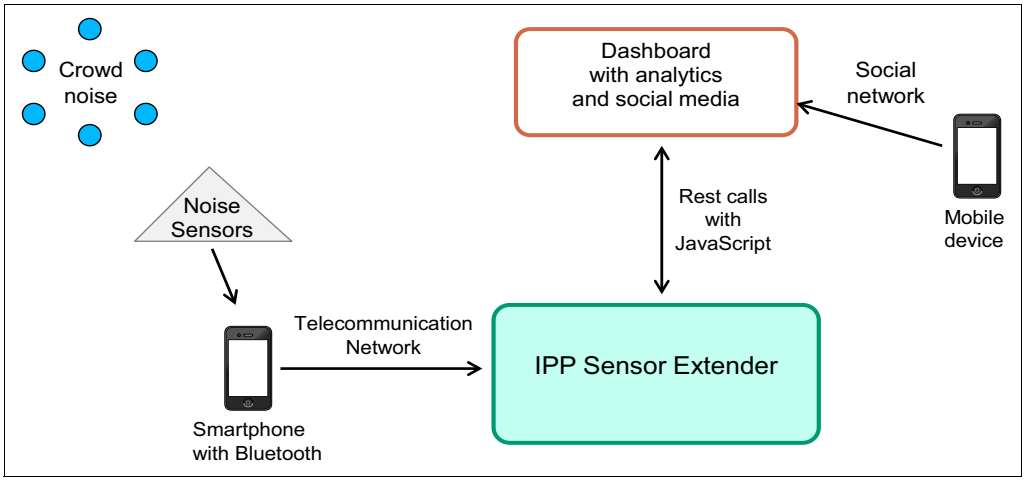

Figure 3-9 Noise sensing solution architecture

In this architecture, noise-sensing devices communicate with a smartphone using Bluetooth. The data is sent to an IPP Sensor Extender server using a telecommunications (3G) network. The sensing data from IPP Sensor Extender can be graphically displayed at specific intervals using a visualization tool such as IBM RAVE. For social activity around an event, social media can be used to share information.

Noise sensing at Via della Spiga

The objective of this project was to track crowd noise through noise-sensing devices and display the data in real time on a dashboard. IPP Sensor Extender was used to collect the data and make it available for display on a dashboard. For this project, IBM Italy had a booth on the Via della Spiga (Milan, Italy) at the Milan Fashion Week (MFW).

To learn more about this project, go to this web address:

http://www-03.ibm.com/able/europe/Retail/MFWNoiseSensing.html

To view the video about this project, go to this web address:

http://www.youtube.com/watch?v=1aUjipmxaKc

3.2.5 Travel and Transportation

The Travel and Transportation industry has made great strides in the use of technology to better support and serve its customers. This section provides examples of how IPP can be used to improve the mobile device users experience while traveling.

Find accessible places for everyone

For people with disabilities, difficulty exists in finding public and private services that have the accessibility that meets their individual needs. Individuals might ask these questions:

- Is it possible to enter the city hall with a wheelchair?
- Does the museum offer a service for blind people?

To give the relevant information to people with disabilities (and for the general public), a mobile application can be created by using IPP. The IPP-based application via the IPP Data Model Collection would provide both the mobile users profile (including any disability) and the point of interest instances with relevant information.

The mobile device might display points of interest according to some criteria, such as nearness, category, and the user's disability profile. Another approach might be for the user to request a particular service close to the user's current location. The IPP-based application uses the mobile device location and user profile to provide the nearest requested service that fits a person's particular needs. The application might include a comment feature allowing the user to give feedback.

Any Where Any Device Any One (AWADAO) project

The AWADAO project mission provides information about public and private places to disabled persons, through their mobile devices. The places are defined in IPP as point of interest instances where each place includes accessibility information. Information about the places are added or changed as needed. Each user is kept anonymous but can provide a disability profile to the search in order to find appropriate locations. Every individual can give feedback on their experience by rating the location.

To learn more about this solution, go to this web address:

http://www-03.ibm.com/able/europe/Transportation/Awadao.html

To view the video about this solution, go to this web address (in French and some English):

http://www.youtube.com/watch?v=4FgwWOcGiJE

To try the AWADAO application, go to this web address and click **Map view** or **List view**:

http://www.awadao.fr/en/awadao/service

3.2.6 Tourism sector

Many people travel to places recommended by other travelers. They like to learn details about points of interest that they should be sure to see while they are at or near a particular location. Learning about less traveled points of interest can appeal to the more adventurous traveler. Having information about a point of interest or proximity from a point of interest can be helpful.

How visitors experience city points of interest

Helpful to city administration is to understand how the city's attractions are viewed by visitors. A mobile application can enable visitors to access point of interest information (such as location, history, and other review comments). The application might also provide feedback about the impressions and experience of visitors. This feedback can be reported back to city administration, so administration can plan improvements to the attractions or identify actions that need to be taken.

IPP can be the heart of a mobile device-based point of interest application. IPP can both maintain point of interest information and provide point of interest information to mobile applications. It can also provide data to the city administration, based on feedback of visitors.

Figure 3-10 shows a mobile device with point of interest instances, displayed on a map.

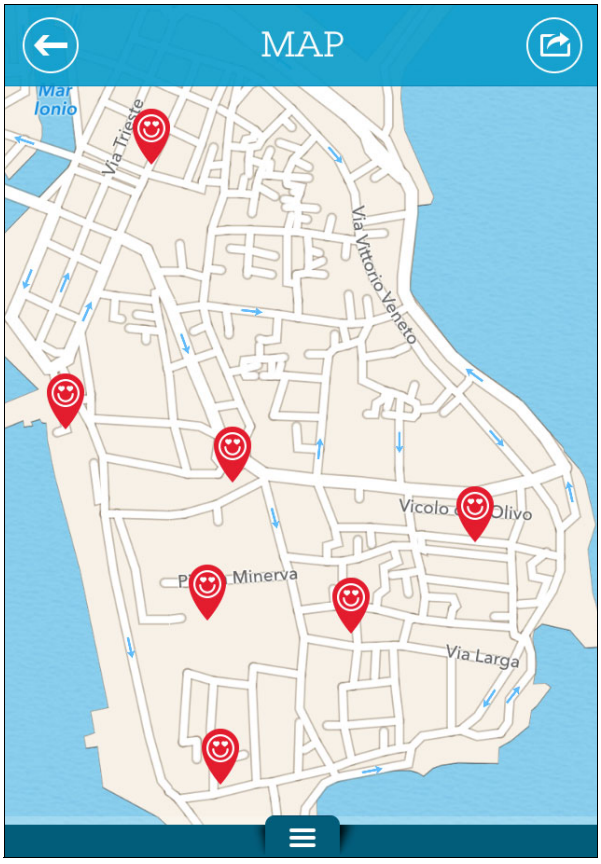

Figure 3-10 Point of interest instances on a map

Figure 3-11 shows the KNOW page, which lists detail information about a point of interest.

Figure 3-11 KNOW page

Figure 3-12 shows the FEEL page, which asks the user to select the emoticon that best matches the user's feelings about that particular point of interest.

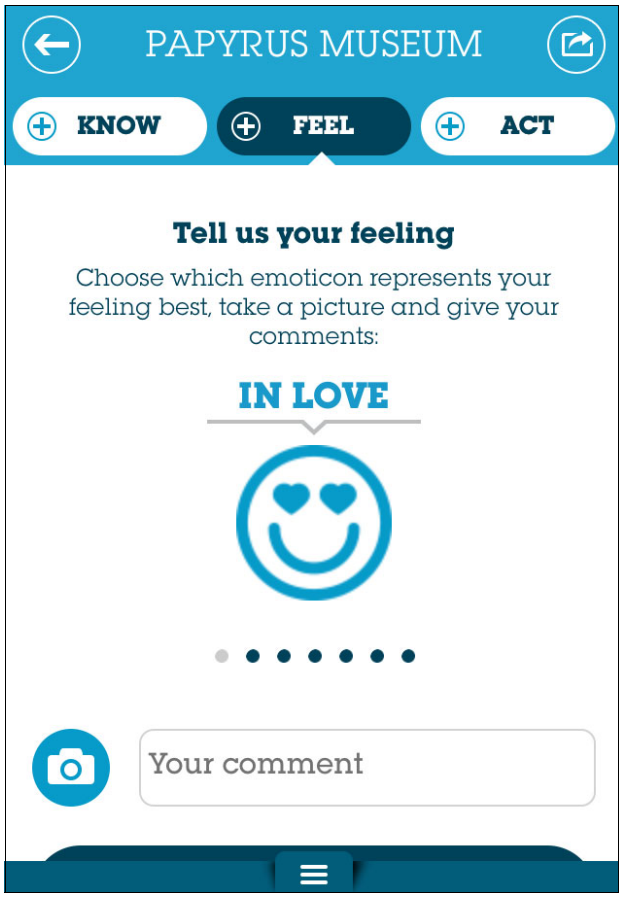

Figure 3-12 FEEL page

Figure 3-13 shows the ACT page, where the user can answer questions about the user's particular experience at that point of interest.

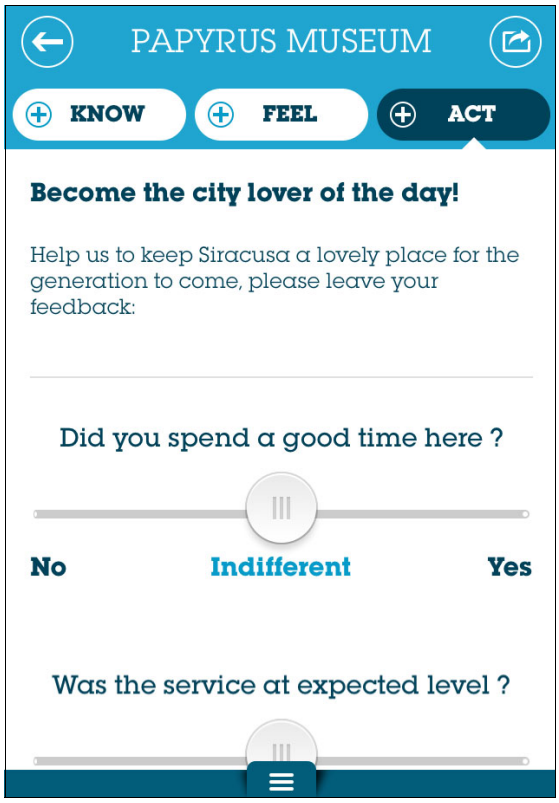

Figure 3-13 ACT page

The visitor feedback data can be reported, analyzed, and displayed graphically on a dashboard for the city administration to view. For example, the dashboard shows the rating of each point of interest and the statistics about the user responses. This information can also be shared with social media sites that provide point of interest information to visitors.

Figure 3-14 shows the overall architecture of the solution.

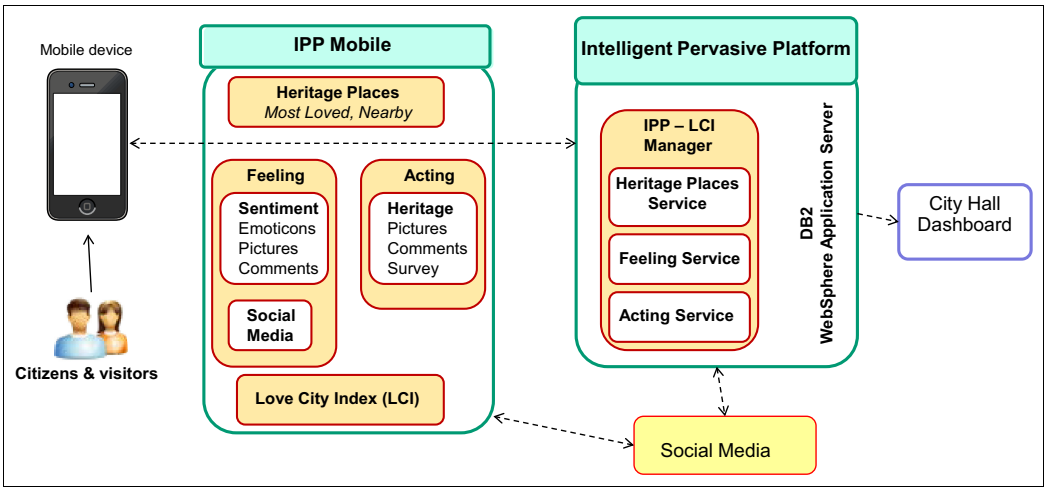

Figure 3-14 Point of interest application architecture

Related publications

The publications listed in this section are considered particularly suitable for a more detailed discussion of the topics covered in this paper.

IBM Redbooks

The following IBM Redbooks publications provide more information about the topic in this document. Some publications referenced in this list might be available in softcopy only.

- *Enabling Mobile Apps with IBM Worklight Application Center*, REDP-5005
- *Extending Your Business to Mobile Devices with IBM Worklight,* SG24-8117
- *IBM ILOG ODM Enterprise and Data Integration*, REDP-4740
- *IBM InfoSphere Streams: Accelerating Deployments with Analytic Accelerators*, SG24-8139
- *IBM Intelligent Operations Center for Smarter Cities Administration Guide*, SG24-8061
- *IBM Intelligent Operations Center V1.6.01: Unleashing the Programming Model to Extend the Base Solution*, TIPS1161

You can search for, view, download or order these documents and other Redbooks, Redpapers, Web Docs, draft and additional materials, at the following website:

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These websites are also relevant as further information sources:

- Human Centric Solutions: Technical Overview

  http://www-03.ibm.com/able/europe/TechnicalOverview.html
- Human Centric Solutions: Case studies

  http://www-03.ibm.com/able/europe/CaseStudies.html

Help from IBM

IBM Support and downloads

ibm.com/support

IBM Global Services

ibm.com/services

Supporting Mobile and Sensing Solutions with IBM Intelligent Pervasive Platform

Understand the Intelligent Pervasive Platform (IPP) and its architecture

Learn how to handle sensing data with IPP Sensor Extender

Interface IBM solutions with IPP and IPP Sensor Extender

This IBM Redpaper publication describes the IBM Intelligent Pervasive Platform and IBM Intelligent Pervasive Platform Sensor Extender. Intelligent Pervasive Platform (IPP) enables you to create mobile applications that seamlessly deliver customized information and services to mobile users, based on their profile and location data. IPP Sensor Extender (based on IPP) supports the collection and standardization of sensing device data from sensor platforms that consist of sensing devices, packaging devices, and gateways. After standardization, the sensing device data can be forwarded to other applications that report, analyze, and display this data. IPP Sensor Extender supports the Internet of Things and machine-to-machine communication.

This paper provides the following information about IPP and IPP Sensor Extender:

- A description of each solution
- The high-level architecture for each solution, including key components
- Details of the data models for each solution, including examples of common data representations
- Integration with other IBM products
- Use in industry solutions

The paper is written for developers and others who are interested in using IPP and IPP Sensor Extender to create mobile and sensing applications.

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