An Automatic Registration Procedure for Sensor Web Plug and Play

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ABSTRACT:

Sensor Web is a network connecting different types of sensors that are distributed around the world. These sensors can continuously monitor the environment information and generate observations. In recent years, with the advance of micro-controller and sensor technologies, the cost of constructing sensing systems has been lowered. Government agencies, scientists, and developers can deploy large-scale sensor monitoring network with a cost lower than before. However, the deployment of large-scale sensor network is still time-intensive and labor-intensive. To reduce the labor costs, automatic deployment of new sensors is the main focus of this research. However, different manufacturers produce sensors with different proprietary protocols. This heterogeneity issue causes difficulties in proposing an automatic deployment procedure. To address this issue, an ideal solution is to design a uniform way for sensors to be self-contained and to connect with web services automatically. In general, we propose a solution, Sensor Web Plug and Play, to achieve automatic deployment of sensor networks. This research first proposes a description file that can describe the sensor capabilities, and then designs an automatic registration procedure allowing sensors to automatically advertise their capabilities to a sensor web service (e.g., the Open Geospatial Consortium SensorThings API). Accordingly, the web service can create virtual identities for the sensors. Once the virtual identities are established, the sensors can continuously upload their observations to the service. To prove the concept, an agriculture monitoring application is designed and developed to monitor in-filed environmental data.

1. Introduction

The concept of sensor web was proposed by the NASA Jet Propulsion Laboratory (JPL) in 1997 (Delin, 2005). Sensor web is a network connecting various types of sensors distributed around the world via the Internet. These sensors can continuously monitor their surrounding environment information and generate observations for monitoring applications (Nittel, 2009).

In recent years, with the advance of microcontroller and sensor technologies, the cost of constructing sensing systems has been lowered. Government agencies, scientists, and developers can deploy large-scale sensor monitoring network with lower cost than before. However, the deployment of a large-scale sensor network is still time-intensive and labor-intensive. Each node of sensor web requires time for manually installation and configuration.

To reduce the time and labor costs, automatic deployment of new sensors is a possible solution. Sensors should automatically join into the sensor web by communicating with other sensor nodes through M2M (machine to machine) communication. This type of automatic register procedure is called Plug and Play (Bröring et al., 2011).

However, manufacturers produce sensors with different proprietary protocols. Devices created by different manufacturers cannot communicate and interoperate with each other. And users cannot connect with different devices with a single communication protocol. This heterogeneity issue has created sensor web silos and caused difficulties in proposing an automatic deployment procedure. The Plug and Play concept can only be realized when all the parties involved in the ecosystem conform to a uniform rule (Stirbu, 2008). Therefore, an ideal solution is to design a uniform way for sensors to be self-describable so that the other machines can realize how to interact with new joining sensors.

In addition, sensor devices may have some severe hardware constraints, such as power, memory, processing resources etc. Sensor devices can be classified into 3 classes by comparing their resource availability (Bormann et al., 2012). While Class-0 devices' RAM and FLASH are very small, Class-0 devices can hardly connect to the Internet. Class-1 devices are slightly better than Class-0 devices, but it is still difficult to directly connect to the Internet

without a gateway. Class-2 devices have enough resource to execute any task and can connect to the Internet directly without help from other aid hardware. At present, most of the sensor devices belong to Class-1. Hence, gateways will play an important role in sensor web (Broering et al., 2010) to help the sensor devices connect to the Internet and communicate with sensor web service (e.g., the Open Geospatial Consortium SensorThings API[1]).

To sum up, the objective of this research is to design a Sensor Web Plug and Play standard for developers to follow. With the proposed Sensor Web Plug and Play, the costs of labor and time can be reduced when deploying large-scale sensor systems. Overall, this standard includes the following three parts:

1. An automatic registration procedure for sensor Plug and Play.
2. A description document, which contains the information that sensor Plug and Play required, and sensing capability of devices.
3. A smart gateway that supports different kinds of wireless communication, such as Bluetooth, ZigBee, LoRa etc. This smart gateway can help Class-1 devices connect to the Internet and communicate with sensor web services.

2. Methodology

2.1 Sensor Web architecture

Generally, sensor web architecture contains three layers (Atzori et al., 2010) (Figure 1). The lowest layer is device layer, and the second layer is service layer. The sensor devices can send observations to web service through the Internet. Some devices are not able to connect to the Internet directly. In some systems, a gateway is required to be a communication bridge between the device layer and the service layer. The third layer is application layer, developers can design various kinds of environment monitoring applications.

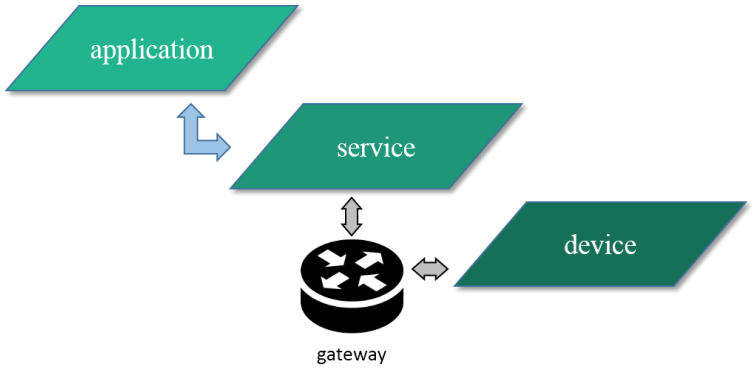

Figure 1: Sensor Web architecture

2.2 Automatic registration procedure

The automatic registration procedure designed in this research can be divided into three steps:

1. New sensor device sends its unique id and description file to the gateway.
2. Gateway checks its lookup table that records the registered sensor devices. If the unique id of the new sensor device does not exist in the lookup table, this device has not been registered yet. The gateway will help the device register a virtual identity in the web service and store the virtual id and unique id for the device into the lookup table.
3. The sensor device can now continuously generate observations and uploads observations to the gateway. The gateway will help sensor device upload its observations to the corresponding web service according to the lookup table.

2.3 Description file

Since various kinds of sensor devices produced by different manufacturers use different proprietary protocols, a description file is necessary to make sensor devices self-describable and self-contained. In this research, the web service is the SensorThings API, which is an Open Geospatial Consortium (OGC) open standard for Internet of Things web services. Hence, we design the description file according to the data model of the SensorThings API (Figure 3). Once the sensor device sends the description file to the gateway, the gateway can register device a virtual identity on the web service according to the description file. The description file also contains the sensing capability

[1] https://github.com/opengeospatial/sensorthingst

of the sensor device, which helps the gateway upload observations collected by the device to the web service.

2.4 Smart gateway

While many sensor devices cannot connect to the Internet directly, sensor web requires a smart gateway be the communication bridge between devices and web services. As there are various kinds of wireless communication method for sensor devices, such as Bluetooth, ZigBee, LoRa etc., the gateway should support these wireless communication methods to help Class-1 sensor devices connect to the Internet.

For devices and the smart gateway to communicate with each other, specific settings for different wireless protocols are required. This research takes ZigBee as an example and proposes a Sensor Web Plug and Play ZigBee profile by defining the standard configuration of ZigBee communication modules. As long as a device's ZigBee communication module follows the ZigBee profile setting, the device can directly connect to the smart gateway.

3. Result

This research proposed a Sensor Web Plug and Play solution for reducing the time and labor cost of sensor deployment. Overall, the result includes three parts:

a、 An automatically registration procedure for sensor web that can help device register itself on the web service. When the sensor device is new to the gateway and the web service. The gateway finds the device's unique id doesn't exist in the lookup table, where stored all the registered devices in. The gateway will help device register to the web service and store the virtual id with unique id into the lookup table.

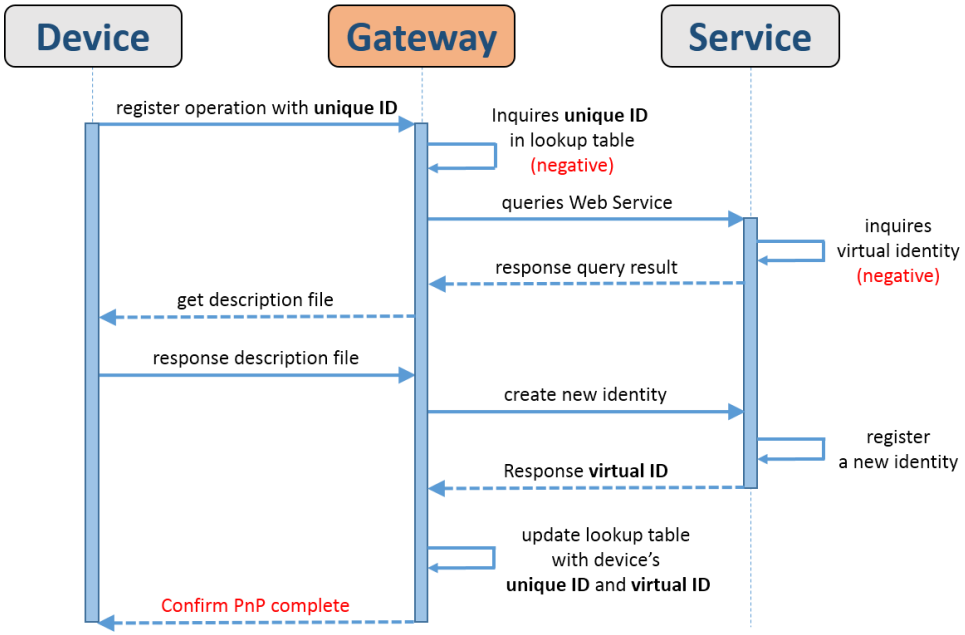

Figure 2: Automatically registration procedure

b、 A smart gateway that supports ZigBee and follows the Plug and Play ZigBee profile. Table 1 is the proposed setting, which defines the necessary information for smart gateways and devices to automatically connect with each other.

Parameter	Standard setup
Channel	1000
PAN ID	14647
Address	Coordinator (smart gateway): DH (Destination Address High) – 0 DL (Destination Address Low) – FFFF
	Router/End device (device): DH (Destination Address High) – 0 DL (Destination Address Low) – 0

Table 1: ZigBee profile

c、 A description file follows the data model of the OGC SensorThings API (Figure 3) to describe device's capability. The description file contains necessary information for the smart gateway to register device and its observations to the web service.

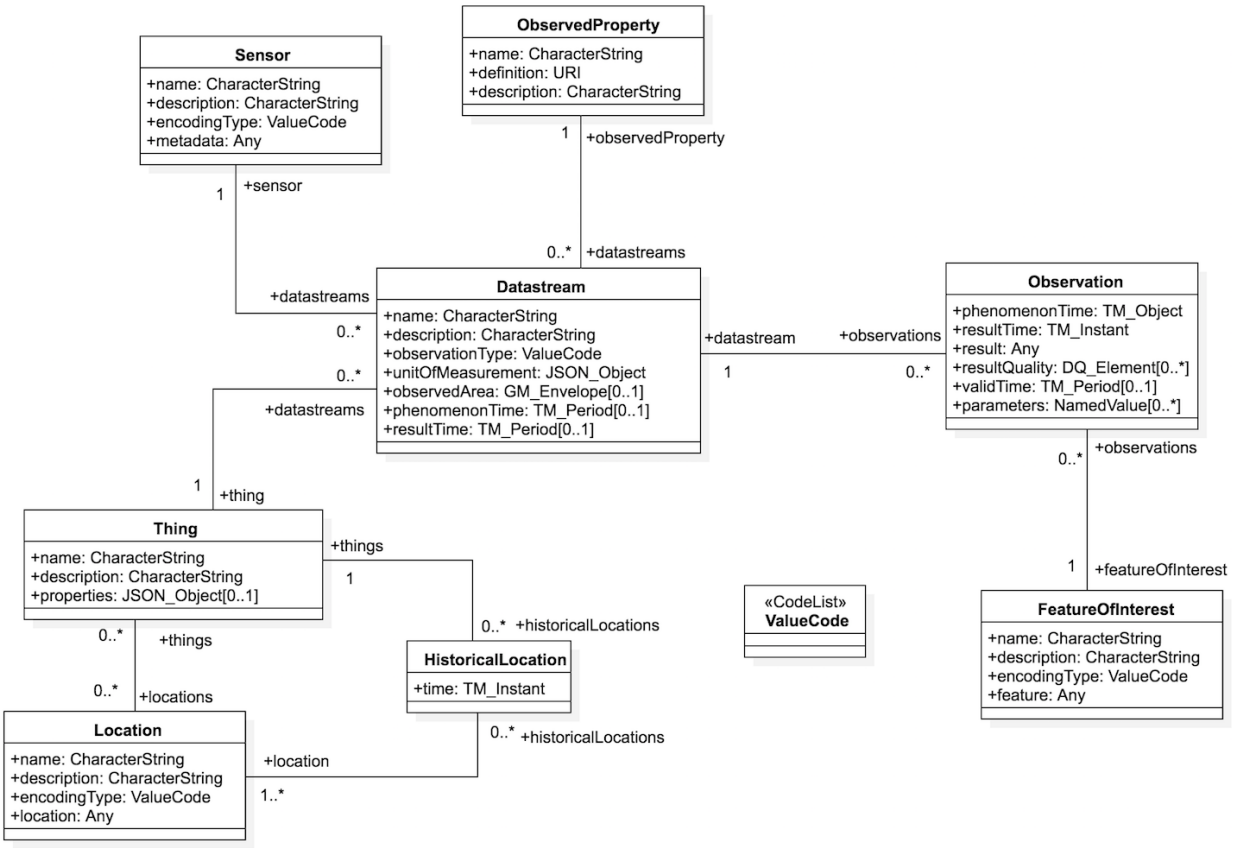

Figure 3: OGC SensorThings API data model

4. Conclusions and Future work

This research proposed a Sensor Web Plug and Play solution, includes an automatically registration procedure for Plug and Play, a description file for sensors and a ZigBee profile for gateway wireless communication.

Recently, a new communication protocol, LoRa, becomes popular in the Internet of Things field. LoRa is more energy efficient, has longer transmission distance, and has better signal penetration ability. In the future, this research will take LoRa into account to define a Sensor Web Plug and Play LoRa profile for a large-scale sensor system deployment.

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