Abstract

The sensor networks had been used for various application areas and showed effectiveness under the prior application planning and right circumstances that includes cost, data handling and other resources. In order to generalize, it is required to reduce initial cost and use data effectively.

This paper proposes connecting a sensor network with the IMS that is the service platform of the NGN to solve these requirements.

This paper shows prototype implementation of proposed system for collecting electric power consumption.

1 Introduction

Sensor network is designed to collect data and use for many purposes. In an ordinary sensor network design, designer decides target application first. After that, he decides sensor device, data format, data distribution method and server. Such special or custom sensor network design for each application making is not cost effective approach. These vertical integrated systems use collected data exclusively. Then, the value of collected data is limited in the system.

On the contrary, if collected data is open, third party which has an idea even for without data collecting method can generate a new service like Web2.0 service. They have ability increase the value of collected data.

There is much discussion today on the Next Generation Network (NGN). The NGN is not only for high-speed network but also for service improvable network with the IP Multimedia Subsystem (IMS). The IMS provides many user related data, mobility support, QoS and so on.

In this paper, we propose to connect sensor network and IMS, which collects sensor data in order to provide a new service platform by sensor data, and standard IMS collected user context. We designed and implemented a system, which collects home electric power usage information as a prototype. In addition, as an example of system usage, we show an application that changes responsible payment in accordance with the intended use for electric power consumption.

2 Expected Application with NGN/IMS

The IMS is based on the IP architecture for multimedia and it was placed as a group of functional elements described to subsystem architecture and able to provide standardized and universal services for mobile users. The IMS based the NGN architecture presents as horizontal layers concept with independence of access and media transport from session control and applications. The IMS based application service relatively more cost effective developing than ordinal vertical integrated service architecture. Then the number of user and service-oriented service will increase.

From user’s point of view, the NGN/IMS become popular in tandem with the diffusion of the applications. In addition to current IP based services as the minimum, user expects more attractive applications that use capability of transport layer, QoS and subscribers’ profile. Especially, user wants context aware application.

We focus on the context in the IMS. E. Rukzio et al. summarize key characteristics for community (e.g. People, Places and Location, Devices, Services) [1]. Moreover, G.Chen divides context into four categories such as Computing context, User context, Physical context and Time context [2]. These contexts are stored in the IMS entities mainly in the Home Subscriber Server (HSS), XML Document Management Server (XDMS) and Application Server (AS). These entities obtain quite a lot of context information to make contextual service plan.
3 Sensor network on NGN/IMS

The IMS can provide attractive context aware service based on information from HSS and XDMS that covers human activity area by integrated communication methods. However, the IMS has neither detailed information like sensor data nor non-communication related information. In other words, sensor network is not designed with data compatibility, interoperability, service area and cost.

Thus, we propose to connect IMS that enable communication in almost all human activity area and sensor network in order to realize context aware service providing infrastructure for many people.

3.1 Reliability on the IMS

To keep sensor network system’s reliability, integrity of sensor data from each nodes and anti-interpolation at data transport are two of important issues.

Some sensor networks covers widely such as IrisNet[3] and Live E![4] use IP network to provide service. Regardless of IP network’s security and reliability concern, many sensor network use IP network with some effort for reliability on their own.

The most popular solution for these problems uses PKI and digital certification. However, this solution requires operating CA and distributing digital certification that is securely installed in each node. These are serious cost problems for each sensor network on IP network. Alternatively, sensor network connects the IMS is a realistic option.

When each node connects on the IMS, it requires sending SIP REGISTER message that is used by Call Session Control Function (CSCF) and HSS to check Public Service Identity and Private Service Identity.

3.2 Services provided by the IMS

When sensor network uses the IMS, sensor network has two usage options. One uses the IMS as data transfer purpose. The other uses the IMS for not only data transfer but also usable service enablers’ services.

The IMS data transfer provides seamless mobility for fix and mobile access network with security and reliability. In this case, required service server should be prepared by own.

To use the IMS standardized services, sensor network nodes should use the IMS protocols. The results are enable work with much kind of IMS service enabler and data. In addition, it enables to connect plural sensor networks. Then it integrates all information from sensor networks and the IMS to make service with lower cost.

3.3 Sensor node operation on the IMS

From the IMS point of view, at connecting sensor network and the IMS, each sensor node runs as User Equipment (UE) and network runs as one of the data transport network. From the other side of view, the IMS service enablers such as HSS and XDMS run in upper layer of sensor network. In addition, these service enablers have a responsibility to store data from sensor nodes and improve stored sensor data with IMS standardized data.

It exist two methods to collect sensor data from sensor nodes to database(DB). One is static pre-configured the other is dynamic configuration.

For these cases, sensor nodes should send SIP REGISTER message to CSCF in order to be authenticated by HSS.

3.3.1 Static pre-configured node

For sensor nodes, data protocol is not a matter. However, XDMS is an only the IMS standardized service enabler to store sensor data. XDMS stores XML format data that adapts registered XML Schema format by XCAP[5] protocol which bases HTTP protocol. However, general XML format for sensor data is not standardized. Fortunately, almost all sensor nodes use XML format or easy to convert to XML format such as UPnP, ECHONET and Diameter AVP format. For this method, each node requires resource to deal with XML data and HTTP protocol.

3.3.2 Dynamic configurable node

SIP SUBSCRIBE[6] or SIP REFER[7] is suitable method to order each node to sent URL for sensor data. Of course, these SIP methods can use other purposes. To receive SIP message, dynamic configurable node requires more resource than static pre-configured node. Furthermore, it is possible to waste resource by received message description. To avoid it, dynamic configurable node is designed carefully.

Figure1 shows a sequence that XDMS send SIP SUBSCRIBE to sensor node and IMS gateway in order to collect sensing data.

3.3.3 Sensor node and IMS gateway

In order to collect sensor data to XDMS, each sensor node not have to connect IMS directory. Sensor nodes can connect to IMS via gateway.

Using gateway is good option for both sensor nodes does not have enough resource to connect the IMS directory and sensor node is not touchable for some reasons.

Using gateway, at first, each node has to find, connect and register to gateway in local network according to local protocol such as ZigBee, DLNA, ECHONET and so on. At
second, each node sends own data to gateway. In the end, gateway sends sensor data to XDMS.

3.4 Utilize sensor data

Collected sensor data in XDMS can work with other data in XDMS and user related data in HSS. These collected data can use in near real-time or after event.

SIP event package is used for near real-time data usage. To receive the notification when information from a specific sensor node was updated, SIP SUBSCRIBE has to be done to corresponding URI on XDMS. Then, when information is updated, SIP NOTIFY can be received. It is possible to combine with presence information on the user in HSS.

For using data after event, service provider shows, edits and deletes by XCAP protocol. In this case, service provider can send SIP SUBSCRIBE message that describes require information in "Event" header’s "document" entity. Then, when information is updated, SIP NOTIFY can be received.

4 Prototype: electric power consumption collecting system with IMS

We designed and implemented the sensor network that used the IMS to collect personal electric power consumption data. This system is composed for sensor nodes, gateway node, XDMS, third party’s application server and HSS/CSCF by OpenIMSCore[8].

4.1 Sensor node

This system targeted equipments that are PC, light and air conditioner. Electrical power consumption metered for each of equipments by external power meter. Then, metered data is sent to gateway by data logger PC.

Each of data logger PCs finds SIP URI of gateway in DHCP message. Data logger PC sends sensor data every 1 second to SIP URI of gateway by SIP PUBLISH message that is consisted by monitored current power consumption data and device description in XML data.

4.2 Gateway

Gateway collects temporary each of electric power consumption data by sensor node. Then, gateway sends them to XDMS as IMS UE. Because written in 3.3.1, each of nodes has not enough resource to connect independent IMS UE. In addition, gateway is needed when adding it to existing sensor network to connect the IMS.

Collected electric power data in gateway sends every 5 seconds to XDMS by SIP PUBLISH or XCAP PUT as XML message that is consisted of XML data from dangled sensor nodes.

Sensor node and gateway implementation use UCT IMS Client[9] which we modified to use SIP event package and SIP PUBLISH.

4.3 XDMS

XDMS has the function to receive the sensor data transmitted from the gateway, to save the data, and to output, and to work with the third party service. This XDMS is modified previously work[10] to support XPath.

5 Example usage for electric power consumption collecting system with the IMS

We made a prototype usage scenario (see Figure3) for electric power consumption collecting system with the IMS.

In this scenario, XDMS and corporate authentication server work together in order to pay employee’s electric power expense during "tele working" from company account.

The time of beginning and at the time of the end of the "tele working" are detected by authentication process at corporate authentication server.

When the "tele working" is begun, employee PC discovers the gateway in a local network by using DHCP, and acquires the device list of an electric equipment and address information on XDMS.

After the session to a corporate authentication server is established, an electric equipment lists (for instance, air conditioner, light, and PC, etc.) that sum up the amount of the electric power is exchanged between employee’s PC and corporate authentication server. The corporate authentication server sends the SUBSCRIBE message specifying the event package corresponding to the device list for user PC, user PC replies to a corporate authentication server the NOTIFY message to store the electric equipment list used in the body.

When the corporate authentication server receives the device list in NOTIFY message, the server checks list and returns a reply (success case: ’200 OK’).

Only user knows URI of XDMS that stores user’s private electric consumption data. User should tell this URI to corporate server. Then, user PC sends a request (3rd party call control message) to invoke team working between XDMS and the corporate authentication server. When "tele working" is finish, this session is terminated.

6 Conclusion

In this paper, we described the design and implementation of sensor network on the IMS which collecting electric power consumption data of each device. Additionally, we described an application scenario which sensor data works with user context in the IMS.

References


