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A Highly Flexible System for Smart Home Sensor Networks

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Abstract—With the rapidly growth of wireless sensor networks (WSN), more and more services provide people up-to-date information such as weather forecast, earthquake reports, fire alarm, even for the surveillance system, and so on. The raw data are usually hard to be understood by users. We had proposed an innovated sensor observation service with web-based and GIS-based architecture, which is named WSN Application Service Platform (WASP) [25]. WASP is a data management center, which designed with the concept of Services Oriented Application (SOA) as a Cloud Service. The raw data can be transferred into add-on valued data and shown on the web pages through WASP. Users can query and obtain the valuable information and realize the meanings of these data through web-based interfaces, which is defined in Sensor Web Enablement (SWE) by Open Geospatial Consortium (OGC). Based on WASP, we propose a flexible SWE-based Data Observation and Event Notification Framework on Social Networks for smart home applications. Data can be shown immediately on social networks (i.e. Facebook) via the framework. All sensors and devices provide their location information to data center and form a community. The proposed framework provides remote control functions for WSN to increase the data retrieval efficiency based on OGC SWE Sensor Observation Service (SOS), Sensor Planning Service (SPS), and Sensor Alert Service (SAS). The proposed system is helpful and efficient for user to enjoy the smart home applications.

Keywords: WSN, WASP, SOA, OGC, SWE, SOS, SPS, SAS

I. INTRODUCTION

More and more Internet services applied location information for supporting location-based applications. Therefore, location-based applications are tools that allow users to create interactive queries, analyze and show the spatial information on maps. On the other hand, Wireless Sensor Network (WSN) is widely used for environment monitoring and smart home applications. There are huge amount of data retrieved by sensors sent to the server for query by users. As a result, we are having more and more observations going on for providing people up-to-date information, for example, the indoor surveillance system. Those sensor networks keep providing its data, and the service provider aggregate and fusion those data to become useful and understandable information to users. However, with the rapidly growth of sensor networks, sensor information exchanging is an important issue. In traditional way, data are usually sent along with sensor ID, which is a serial number and hardly to be understood. If the location information of sensors can be included in these data and shown on the web pages, the user can obtain more useful and realizable information. On the other hand, the WSN application providers also need to develop interfaces or programs that offering data querying, accessing, and analyzing for different WSN applications. If there are no standards for data representation, data transmission, and query interface, and web services that is sufficient to various WSN applications. It will be the pain in the neck for service provider or system integration vendors to develop the framework over and over again. Moreover, the mashup among WSN applications cannot be done easily, and the scalability of services is low. Therefore, an open platform that integrates web2.0 mashup service, open sensor data exchange standard, and data cloud service is needed [3-6,11,12,21,23]. To develop publicly available geo-processing specifications for sensors, the Open Geospatial Consortium (OGC) defines Sensor Web Enablement (SWE), which is an open standard with a bunch of web service requests and replies for sensor information exchange. SWE described standard interfaces and encodings that provide sensor data exchangeability to web services. SWE is also a main component of OGC Web Services (OWS) [1]. All OWS [2] are with reference to Web Service Common Specification [20]. To implement the full capabilities of the SWE standards, four major services should be provided. The services are Sensor Observation Service (SOS) [16], Sensor Planning Service (SPS) [17], Web Notification Service (WNS) [18], and Sensor Alert Service (SAS) [19]. All sensor data should be described in XML format. Simple Object Access Protocol (SOAP) should be used by each service to provide communicability for each service.

In this paper, we developed a flexible system for smart home applications, which is a SWE-based Data Observation and Event Notification Framework. The proposed system specified the actions and message flows among the four major services of SWE. Furthermore, to provide an easy and straightforward mechanism of data presentation for users, we applied the WSN Application Service Platform (WASP) [25]. WASP is the combination of Internet/Web-based services and components, database systems, users, and WSN communities. The significant feature of the proposed

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system is that the event notification can be automatically sent to user's device or the corresponding social networks.

The rest of this paper is organized as follows. In Section 2, we give an overview of SWE and related works. In Section 3, we describe the proposed system. In Section 4, the functions of event notification with social networks are described. Finally, in Section 5, we conclude and discuss the future works.

II. RELATED WORK

A) SWE Environment

SWE is an open standard, which deal with a bunch of web service requests and replies for sensor information exchange. SWE includes several elements, such as XML, Web Services Description Language (WSDL) [8], Simple Object Access Protocol (SOAP), Universal Description, Discovery and Integration (UDDI). The formats of WSDL, SOAP, and UDDI are XML. All sensed data will be described in XML format [22, 25].

B) WSN Application Service Platform (WASP)

WASP is a Service Oriented Application (SOA)-based data management center including network software service, application elements, database system, WSN, and user communities [25]. The architecture of WASP can be divided into two major parts: WSN side and software service side. In a WSN, sensor nodes may communicate with other nodes hop-by-hop using Zigbee protocol. The raw sensing data transferred by a gateway (usually the sink node) to the partner local software services area or WASP cloud service area through the Internet using HTTPS protocol. A *Partner* means an organization or an institute that participate in WASP. On the other side, users can access the WASP cloud service area or the partner local software services area through the Internet, too. All the connections in Internet are using HTTPS protocol. The connections of the partner local software services area and WASP cloud service area may use HTTP protocol with SOAP or Representational State Transfer (REST) [24] to simplify the implementation. The major goal of WASP is providing different presentation schemes to show the data from WSN applications. WASP collects the data that sent by WASP Partners (WSN applications) periodically. SWE SOS and O&M specification can be used for this data observation. According to different objectives of WSN applications or services, the service components on WASP process the raw data from WSNs. Afterwards, high-level and value-added information or event are produced. Authorized users on WASP can access the add-on values data through many interfaces (e.g. web service via REST). Moreover, WASP provides functions for WSN events notification and remote control. Allowing users retrieve data conveniently and control the WSN remotely through OGC SWE SOS and SPS [25].

III. THE PROPOSED SYSTEM FOR SMART HOME

There are many devices and sensors applied for smart home applications. For example, as shown in figure 1, the functions of home surveillance are usually the smoke detector, CO detector, temperature monitor, etc. Each function contains many sensors. These sensors transmit sensing data to a central server through wireless communications. We use a digital photo frames to be a display of these sensing messages, and the gateway to the Internet. As shown in figure 2, a highly flexible system for smart home can handle the sensing information and communicates with other corresponding organizations, like fire brigades, security service firms, etc.

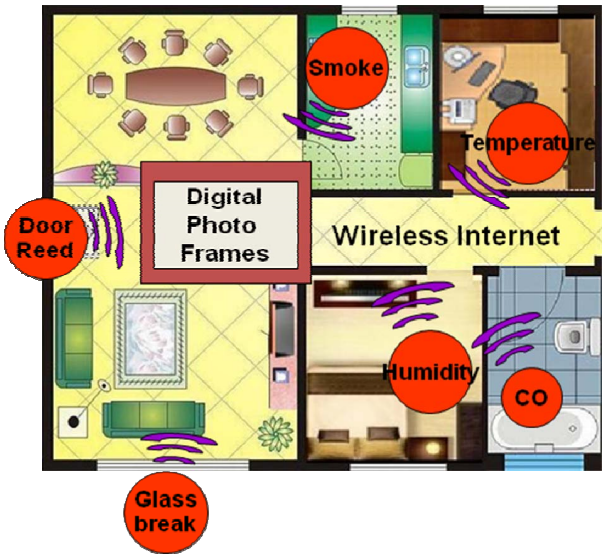

Figure 1. Smart home sensor network.

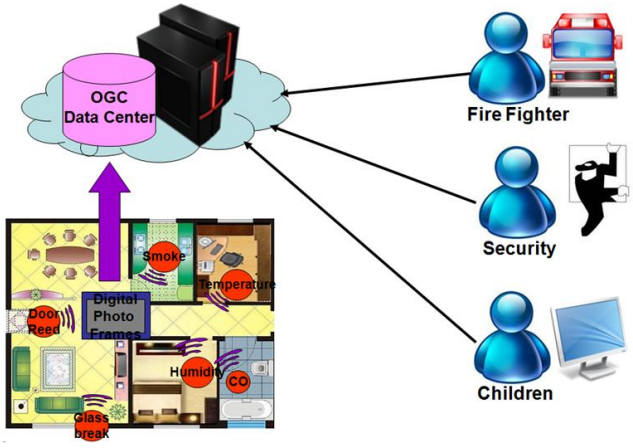

Figure 2. Highly flexible system for smart home.

From the scenario in Figure 2, in order to provide monitoring and alarm information about home surveillance, we applied many sensors to observe the indoor environment. Having the observation data, the user can get the alert when something happened, or get the observation data he

interested in. The architecture of the observation system is shown in Figure 3.

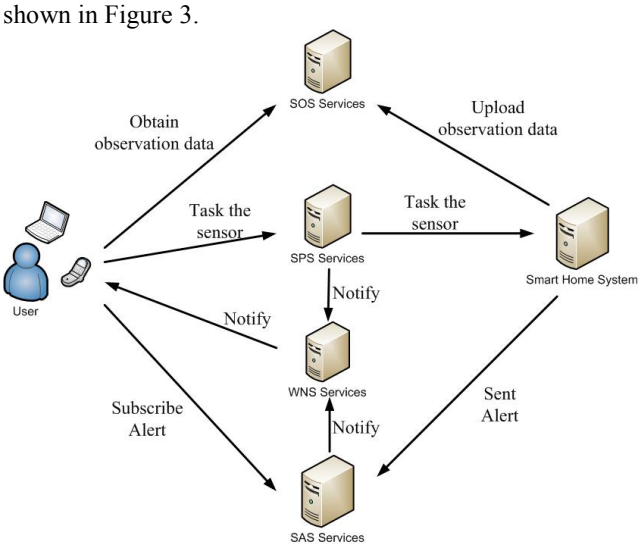

Figure 3. Architecture of observation system.

SWE provides several services to fulfill the monitoring and alert. These services are SPS, SOS, SAS, and WNS. The smart home system is response for managing the sensors that deployed in home. For each service, the system plays different roles as follows.

- SPS for controlling: According to the task that is submitted by SPS, the system will control the relevant sensors to do observing.
- SOS for data collecting: the system collects observation data from sensors and then uploads to SOS.
- SAS for decision: the system has domain knowledge to decide whether something will happen. If the answer is "Yes", it will send an alert to SAS.

The user uses SPS to task these sensors. In order to avoid that the user arbitrarily changes the parameters of sensors, this functionality is mainly used by Administrator. User can obtain the observation data by using SOS to get the observation data, or using SAS to subscribe the alert that he concerns about. And then, the user will get the alert sent by WNS when the event happens.

3.1 SPS for controlling

Figure 4 shows the scenario of SPS. The major work of SPS is tasking the sensors. The main procedures of tasking a sensor are:

i. The user sets the task parameters of the sensor, then submits the task to SPS.
ii. SPS transfers the task to Chiu-fen-er-shan station.
iii. The sensor which was tasked starts observing.
iv. Chiu-fen-er-shan station collects these observation data and uploads to SOS.
v. Chiu-fen-er-shan station sends notification to SPS when the task is finished.
vi. SPS notifies WNS to send notification to the user.
vii. The user receives the notification sent by WNS.

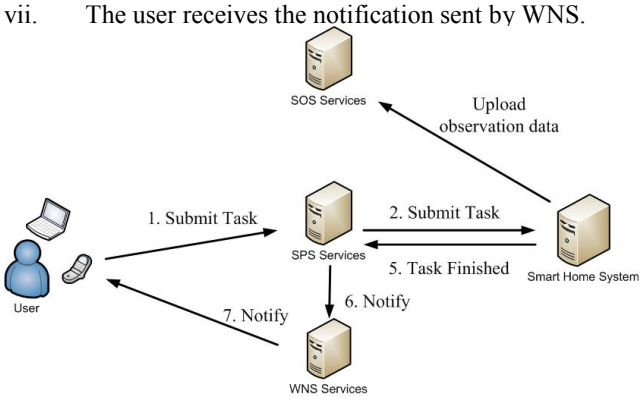

Figure 4. Scenario of SPS.

3.2 SOS for data collecting

Figure 5. Scenario of SOS.

Figure 5 shows the scenario of SOS. The major work of SOS is to obtain observation data. The user can get observation data that the user wants to retrieve from SOS.

3.3 SAS for decision

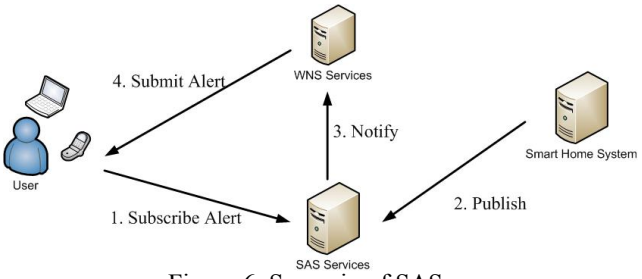

Figure 6. Scenario of SAS.

Figure 6 shows the scenario of SAS. The major work of SAS is to process the alert or notification subscriptions. The main procedures of alert notification are:

i. The user submits the subscription.
ii. Smart home system publishes notification while alert was invoked.
iii. SAS notifies WNS to send notification to the user.
iv. The user receives the alert sent by WNS.

IV. EVENT NOTIFICATION WITH SOCIAL NETWORKS

How to notify the user efficiently when there are events occurred? We notice that there are two major ways can reach users. One is the network and the other is the phone systems. To avoid complicated setting and user interface, we chose the popular social networks (like facebook, plurk, twitter, etc.) as the network platforms to display the notification messages. On the other hand, our system can automatically make phone calls to users via voice notification. If user didn't pick up the phone, our system will inform his/her friends or families to spread out the notification. Vice versa, user can subscribe or query the information which sensed by sensors through network or phone system. They can follow the sequences which are shown in Figure 8, and the architecture of the event notification is shown in Figure 7.

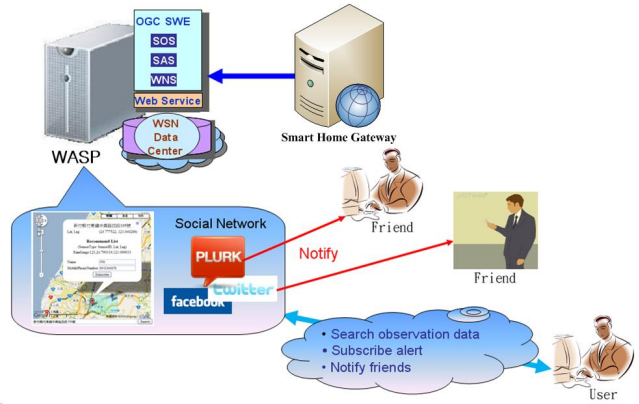

Figure 7. Event notification with social networks

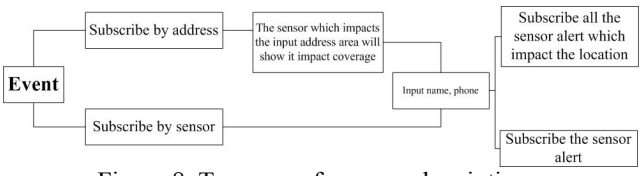

Figure 8. Two ways for user subscriptions.

V. CONCLUSION

In this paper, we proposed a flexible SWE-based Data Observation and Event Notification Framework. SWEDOEN specified the actions and message flows among the four major services of SWE. Furthermore, to provide an easy and straightforward mechanism of data presentation for users, we applied the WASP [25]. We demonstrated the smart home system uses the SWE standard, will change the way of providing the debris flow information data. Moreover, the event notification is combined with the social networks and phone system. The proposed framework is helpful and efficient for users to enjoy the sensor observation service.

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