New Approach to the Platform for the Application Development on the Internet of Things Environment

[*1] Yunhee Kang
[1]*Division of Information and Communication, Baekseok University, Cheonan, Korea 330-704, yhkang@bu.ac.kr*

Abstract

Internet of Things (IoT) is defined as the objects sharing information through the connection with the Internet, and IoT environment is rapidly being established with the supply of various sensors. Data processing in the IoT environment has three different properties which are variety, volume, and velocity. The ecosystem of the IoT environment requires processing of big data due to the data collected from various sensors and measuring devices. This paper introduces generic technology for designing reference architecture for the collection of sensing data and the applied processing of collected data. Due to the the property of the IoT environment, composition of a single architecture for supporting requirements of the use-case of users of various areas is not appropriate. The purpose of the designed architecture shall be the utilization of data for stream-based distributed processing. The architecture designed for the purpose shall solve the expandability and interoperability issue between events, messages, and applications required at IoT by utilizing messaging middleware.

***Keywords**: Sensors, Data processing, Architecture, Platform, IoT*

1. Introduction

Information distributes through the Internet are generated as the process of the data produced by human. However, the Internet environment is advancing so that the producer and the consumer of information made go together with all the objects with the connection of physical objects to the Internet by taking charge of sensing and actuation function, data processing and communication function. Internet of Things (IoT) is defined as the sharing of information through the connection of objects to the Internet, and the IoT environment is rapidly being established with the supply of various sensors [1-2]. Cisco expects 25 billion devices equipped with sensor will be connected to the Internet by 2015, and expects 50 billion devices equipped with sensor will be connected to the Internet by 2020. As the growth of IoT environments with the numbers and the types of sensors required for the collection of data, it is required for the processing of data collected from the sensors related with the objects by a sensing data collection system [3-4].

The data processing of IoT environment has three properties including variety, volume, and velocity of data. The ecosystem of IoT environment requires processing of big data due to the data collected from various sensors and measuring devices. Apache Hadoop is the key technology for the utilization of Big data based on the open source, settled as the de facto standard, and the utilization of Apache Storm for the real-time data processing is currently being applied.

The components of IoT system is physically distributed, and the effective management of the system, non-functional requirements including scalability and interoperability should be considered for the exchange of data between applications during the system designing process. In order to satisfy the requirements, it is required a common platform providing information on the application by collecting or by controlling various outside sensor information through the connection with various wire or wireless networks on IoT environment. In the design phase of IoT common platform, architecture for supporting application of objects and seamless interface is required.

This paper introduces the generic technology for the designing of referential architecture for the collection of sensing data and applied processing of collected data. As the composition of a single architecture for supporting the requirements of use-case of users of various areas is not adequate by the

* Corresponding Author
Received: Feb. 01, 2015, Revised Feb.25, Accepted: Apr. 02, 2015

nature of IoT environment, we needs to consider how to leverage the data for the stream-based distributed processing in the architecture designed in this paper. The purpose of the architecture designed shall be to solve the scalability and interoperability problem among event, message and application required on IoT environments by a messaging middleware.

The rest of paper is organized as follows: Section 2 depicts the background, characteristics and related researches of operating environment. In this section we describes the framework for WoT(Web of Things), approach for the web-based integration, and mobile environment. Section 3 describes IoT architecture design for the collection of sensing data. Lastly, section 4 depicts the conclusion.

2. Related Works

Auto-ID Lab is the research group of GS1/EPCglobal that is international standardization institution of RFID (Radio Frequency IDentification) and defined early IoT based on the objects with EPC (Electronic Product Code). This supported recognition of objects, global location tracing and tracking by storing and managing the information on the distributed system while reading the code in real-time through the RFID reader installed worldwide through attaching RFID tags distinguishable with EPC on objects. This enables management through real-time monitoring of information of objects, and operates various IoT services via standardized interface[1][3-4]. Current IoT has been expanded the definition of existing Internet and developed into paradigm of next generation Internet including object-to-object, human-to-object network where various surrounding objects participate on the Internet. Figure 1 shows the Internet environment based on the next-generation network where objects are connected to human.

Figure 1. Composition of IoT connecting human and objects

IoT environment starts from the efficient integration of Wireless Sensor Network and RFID, and by expanding the range of objects communicating in the integrated environment, the environment elements distributed to human, objects, and service interact in the form of sensing, networking, information processing and others while included in the Internet range. In the user perspective, smart devices are providing new applied services by utilization of embedded sensors, and the demands on the framework for this are increasing.

Various sensor convergence services for customization are based on the technology for the securement of interoperability between the opening of sensor resource and sensor network, and the design on the IoT framework is essential for the development of applied service as the core technology of distributed computing of IoT. Especially, interoperability on the multi-sensors and resources are provided, and standard data processing system enabling identical definition and interpretation on various sensing information, development, distribution, and operation of systematic service on the multi-tier users is required. The interpretation of definition can play a pivotal role for various devices to automatically function while the smart sensor collects required information transcending time and space along with network computing technology. Intellectualization of these sensors exceeds the utilization area of traditional sensors and expanding the utilization area of sensors to the establishment of highly-connected society connecting smart home system, remote-care system, smart building, intelligent automobile, healthcare and animals and plants and the creation of new future market.

Gartner defined low power networking, sensor data optimization and management technology, low power embedded OS technology, new electric power supply and storage technology and low-cost/low power processor technology as the essential technology of IoT in 2012. These main technological elements of Internet of Things include three technological elements including sensing technology, wire and wireless communication and network technology and service interface technology and may systemize as a software architecture.

Sensing technology is the core technology of IoT acquiring information of surrounding circumstance by attaching electronic tag on the required objects or places, and delivering information in real-time. Open-source platform is utilized for the development and operation of IoT device for sensing. Devices under the current IoT environment are classified and used in three sectors as follows.

Embedded 8-bit SoC (System-On-Chip) control device utilizes Arduino that is cheap open-source hardware platform. Arduino works on Microsoft Windows, Macintosh OSX and Linux as a multi-platform, and provides programming environment convenient for development. Especially, Arduino can be easily applied for the requirements of the user as the software and the hardware are all open-source. System based on Atheros and ARM is a restrictive 32-bit archtecture and can be utilized for the development of small-sized home router and various devices. The system uses Open WRT which is embedded Linux platform or exclusive embedded operating system, and recently, Arduino Zero or Arduino Yun are appearing as a platform. Figure 2 shows the Arduino Uno board.

Figure 2. Arduino Uno board

System of 32-bit or 64-bit architecture utilizing Raspberry Pi is a device with a size of a credit card which can be used on PC by connecting monitor, keyboard, and mouse, and including RCA (Radio corporation of America) and HDMI (High Definition Multimedia Interface) port for the output of video and LAN port for communication. SD card is obtained as a large number of GPIO and storage devices. Figure 3 shows the device based on the Raspberry Pi [6].

Figure 3. Raspberry Pi device

For communication between the device and the Internet, two ways of mode including direct method and communication method via gateway can be used. Wire or wireless communication and network technology used for this is the technology supporting connection of objects to the Internet and can be defined as efficient network management technology securing connectivity in the network environment

composed of wire-wireless network including NFC (Near Field Communication), UART, ZigBee, Bluetooth Low Energy, and WiFi.

With the development IT technology and the increasing demand on the open development environment induces increased attention on a simple applied development environment like the web. IoT environment is essential for the establishment of systematic integration system interoperable between the development systems required for the applicable connection with the physical devices [7-8]. The web enables the usage of standard HTTP protocol without considering the sub-network for the approach and operation of the devices related with objects. Actual objects are integrated into web environment, and these can be handled as a single service approachable through web.

WoT (Web of Things) refers to distributed application and service approachable from all types of devices. At all foundation, web was suggested for the unification of all objects to the web for the enhancement of accessibility on the objects of IoT under the environment where the accessibility of informational resource is easy through Internet[9]. Standard development is currently being conducted at ITU.WoT that is the framework of WoT is being conducted at ITU-T SG14. In WoT, sensors, devices, and actuators are expressed as an objects based on the address system of web, and are registered through the smart gateway and ultimately searches, controls, and combines physical objects through web interface. Communication between these objects is based on REST, and supports up to physical mash-up. Conceptually WoT is an expansion of RFID used for the identification of existing objects, and composes address system for the Internet-based connection. The purpose of WoT is to support the communication of objects by using web. Figure 4 shows the integration of WoT-based devices, and in the perspective of application, each object is shown as the data of web or service, and enables approach and utilization. By enabling the approach by the operation of the web server, the device may only use HTTP protocol while not using specific protocol to the device at the web client.

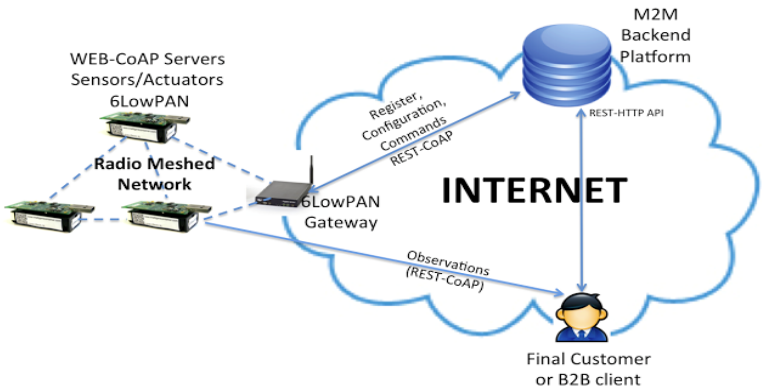

Figure 4. Integration on WoT-based devices

3. Designing Sensing Data Collection IoT Platform

3.1 IoT Service Platform : Functional Requirement

The software architecture of IoT service platform should support following service scenarios:

- IoT embeds functions like sensing on the objects, and the purpose of IoT is to create new value by recognition of user behavior and circumstance through conducting communication among the objects
- The application under IoT environment enables provision of useful information and convenience to the users by using various devices connected to the network.
- IoT device provides simple data, and provides various services on the applications through conversion.
- IoT application applies various IoT technologies including wire-wireless communication and sensors and establishes service-oriented environment.

For the service scenario operation, provision of useful information to the users should be accomplished through the collection, analysis and prediction of all the data occurring at the object, and the major required functions of the platform are as follows:

- Profile management for the IoT device registration
  - Conducting registration of platform for the approach to the object or device connected to the Internet
  - Supporting searching, addition, deletion, modification request on the registered devices.
- IoT user profile management
  - Conducting registration of information for the authentication of user and control of approach.
  - Supporting approach service through the application of web and smart devices which is the user client.
- IoT service and application profile management
  - Collection of data from the objects with sensors, management application and service information for the storage and processing.
  - All the data processing are conducted through the Internet, and supports cloud-based platform operation.

IoT service platform requires collection system expandable for the processing of data generated from various sensors. Messaging system under streaming-based data processing environment efficiently supports data delivery required for the application. Therefore, the sender in the application execution process operates in the method not waiting for the reception or processing of transmitted message by the receiver. Message is an independent information unit, and each message delivers the data and status required by the target task of application processing message.

3.2 IoT Concept Framework

IoT environment conducts interaction between object and human, and various services are supported during the process. Various services and contents are operated through interconnection, and the devices and objects of the user exchanges information through messaging service for the conduct of application composed of services. Figure 5 shows the designed IoT concept framework.

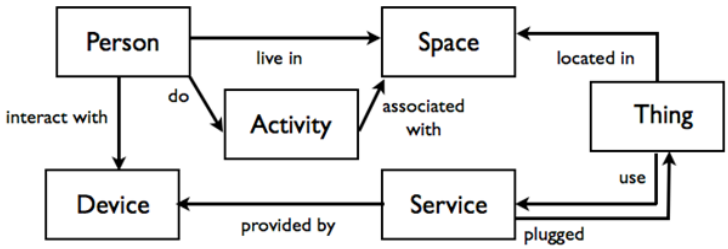

Figure 5. The designed IoT concept framework

IoT environment at designed IoT concept framework is composed at large number of Space, and unit Space operates context structure of IoT. Person participates on Activity, and various Activities are conducted at Space. Things with sensor locate at Space. The Person uses Device like smart phone, and uses service profile for the interface for the interaction with Thing. In IoT concept framework, service is the component providing specific function and is the basic component of software. In other words, service is the part of software commonly required at the application. The application can be called the software with wide range utilized only for specific domain.

Under IoT framework, message is generated by the environmental change outside the system including the notification by the sensor at the operating environment or notification by human. Messages are separated from primitive data of sensors and enable the hiding of specific details collected from the sensors. Primitive data expresses special data format and expression value in accordance with the type of sensors, and the message is coordinated to the value abstracting the primitive data. Message is composed to new message through the composition of numerous numbers of messages. Event is an incident requiring monitoring and expressed as an interpretation of received message. Action is a measure becoming a trigger by event, and used in the control of devices. Message is composed to new message through the composition of the numerous numbers of messages. Situation is expressed by multiple vents or actions and alters the status of service.

3.3 Composition of IoT Sensing Information Collection System

System where the interaction between the objects and human are conducted like IoT environment, and the system for the collection data collected based on the streaming required designing to support various services. The streaming-based data processing is operated through the interconnection with various services and contents, and the devices and objects of users exchanges information through messaging service for the application execution composed of services.

Messaging system provides two types of messaging models of publish-and-subscribe (pub/sub) and point-to-point queuing (P2P). Pub/sub model adequate for the realization of pipe-filter is utilized in the distribution of messages in the many-for-one type, and purpose of P2P model is for the one-on-one delivery of message[10-11]. The selection of these messaging models is determined in accordance with the messaging requirements of application. Especially, if the messages have to be distributed to various receivers, pub/sub model is adequate for messaging system. For component converting the data at pipe-filter pattern to deliver this to the remote component, make it utilize pub/sub-based middleware[12]. In pub/sub model, the message producer may transmit a single message to various consumers through virtual channel called Topic. The message producer operates without dependence on the consumer receiving the message. As this enables collection of occurred messages where the network connection is disconnected, it provides strength of collecting information in discontinuous network environment.

Designed IoT sensing information collection system is composed of 3 tiers of Things, Aggregator, and Application. Pipe-filter pattern is applied to the collector and connection between applications[13]. Things compose to messages after acquiring primitive sensing data from the sensing through the agent. This is expressed as a composition event that is the message of high level. Agent does not store acquired information on it's own storage device and delivers the information to the collector through wire-wireless network. At this moment, acquired information and alarm information are delivered to the application through the filter. Collector collects data from numbers of agents and stores the data by adding meta-data. The collector processes data by regularly conducting filtering on the collected data. For this, the filter uses asynchronous-based messaging base structure conducting the role of message bus.

The collector collects data from numbers of agents and stores the data by adding meta-data. The collector processes data by regularly conducting filtering on the collected data. For this work, the filter uses Apache Flume or Storm conducting the role of message bus. The Thing internally possesses sensors and delivers the acquired information to the collector through the wire-wireless network without saving the acquired information at the storage device. At this moment, the application operating at the cloud computing resource processes acquired information and alarm information, and the information required for the application are delivered through the filter. Between the collector and the application, producer-consumer relationship is made through the filter, and provides high expandability through loose-coupled connection. In addition, abnormal status and error information are delivered through the interpretation of subscribed message in application.

4. CONCLUSION

IoT is a distributed computing environment where the sensor and the object with control function are seamlessly connected with the user, and the interoperability support is essential for the data exchange between the services and applications. Service interface technology plays the role of connecting the IoT components with the Service and Applications. Service interface conducts systematic management of application and service, and IoT platform design for the operation of application and service is required. In the IoT application development, service platform connects various objects and applications. Through the reference architecture proposed in this paper, reduction of development expense and time of IoT sensor, terminal, and service can be accomplished. Systematic sensing data collection system facilitates the creation of new service ecosystem by providing various information on the Internet by smart of objects.

The framework for WoT is the approach for the web-based integration, and mobile environment. The study has also designed concept framework for IoT system by using messaging system having interoperability and expandability of IoT application. The study has used messaging system having high expandability and low combination for the improvement of interoperability of IoT application, and for the designed IoT concept framework, IoT application for the monitoring of objects of IoT environment will be applied to the operational framework.

References

[1] Luigi Atzori, Antonio Iera, and Giacomo Morabito, “The Internet of Things: A survey,” Computer Networks: The International Journal of Computer and Telecommunications Networking, vol. 54, no. 15 pp. 2787-2805, 2010.
[2] Jayavardhana Gubbi, Rajkumar Buyya, Slaven Marusic, and Marimuthu Palaniswami, "Internet of Things (IoT): A vision, architectural elements, and future directions," Future Generation Computer Systems, vol. 29, no. 7, pp 1645-1660, 2013.
[3] Sun, Enji, Xingkai Zhang, and Zhongxue Li, "The internet of things (IOT) and cloud computing (CC) based tailings dam monitoring and pre-alarm system in mines," Safety science, vol. 50, no. 4, pp. 811-815, 2012.
[4] Antonio Iera, Christian Floerkemeier, Jin Mitsugi, and Giacomo Morabito, "Guest editorial: The Internet of Things," IEEE Wireless Communications, vol. 17, no. 6, pp. 8-9, 2010.
[5] Massimo Banzi. 2008. Getting Started with Arduino (Ill ed.). Make Books, Sebastopol, CA.
[6] Vladimir Vujović and Mirjana Maksimović. 2015. Raspberry Pi as a Sensor Web node for home automation. Comput. Electr. Eng. 44, C (May 2015), 153-171.
[7] Felix Xiaozhu Lin, Zhen Wang, Robert LiKamWa, and Lin Zhong, “Reflex: using low-power processors in smartphones without knowing them,”. SIGPLAN Not., vol. 47, no. 4, pp. 13-24, 2012.
[8] Rohit Chaudhri, Waylon Brunette, Mayank Goel, Rita Sodt, Jaylen VanOrden, Michael Falcone, and Gaetano Borriello, “ Open data kit sensors: mobile data collection with wired and wireless sensors”, in Proceedings of the 10th international conference on Mobile systems, applications, and services, Low Wood Bay, Lake District, UK. 2012, p. 351-364.
[9] Benoit Christophe, Mathieu Boussard, Monique Lu, Alain Pastor, and Vincent Toubiana, "The web of things vision: Things as a service and interaction patterns." Bell Labs Technical Journal, vol. 16, no. 1, pp. 55-61, 2011.
[10] Sun, Java Message Service, http://java.sun.com/ products/jms/, 2001.
[11] S. Pallickara and G. Fox, "NaradaBrokering: a distributed middleware framework and architecture for enabling durable peer-to-peer grids", in Proceedings of the ACM/IFIP/USENIX 2003 International Conference on Middleware, Brazil, 2003.
[12] Pietzuch, P. R., Shand, and B., Bacon, J., "Composite Event Detection as a Generic Middleware Extension, " IEEE Network, vol. 18, pp. 44-55, 2004.
[13] François, A.R.J., Software Architecture for Computer Vision: Beyond Pipes and Filters, Prentice Hall, 2003.