論文の内容の要旨

論文題目　The Research of IoT Architecture for Open Services in Smart Buildings

(スマートビルにおけるオープンサービスのためのIoTアーキテクチャーの研究)

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In recent years, massive advancement in information and communication technologies have led to a new paradigm, The Internet of Things (IoT), in which every device are connected to the Internet, provide great benefits to control and monitor the physical world in real time. The deployment of IoT technologies in buildings becomes a solution to realize smart buildings. The realization of smart buildings is expected to reduce energy consumption and provide comfortable space for occupants. Currently, building systems are managed closely and can only be managed in one direction from administrator to occupants. The concept of open services has been introduced as the next paradigm in delivering services in the era of IoT. Open services have been successful in mobile phone domain to utilize various sensors and functionalities of mobile phones to provide diverse services to users. By adopting the concept of open services into smart buildings, we can encourage the third developers to bring their innovation and create new services to occupants.

However, adopting open services into smart building area is challenging because of the natural differences between the environment of smartphones and smart buildings. In a smartphone, the hardware is managed by one platform such as iOS, android or windows phone. In contrast, a smart building consists of heterogeneous devices that may use different platforms. Since a smartphone is managed by one platform, it has a standard Application Program Interface (API) to access and utilize their functionalities, whereas a smart building has a variety of devices produced by the different manufacturer without a standard API. In addition, a smartphone contains fixed elements, which mean no elements will be added or removed after the smartphone is

manufactured. By contrast, a smart building contains dynamic devices, which mean devices may be dynamically attached and removed at any time according to necessity. Moreover, how to restrict an access to elements of a smartphone is managed by operating systems, while how to implement access control in buildings is challenging because it may consist of heterogeneous devices including those with limited resources. Furthermore, a smartphone is used by one user, while a smart building is occupied by many users. Therefore, services in smart buildings are more complex compared to smartphones.

In this thesis, we propose architecture to provide open services in smart buildings by utilizing IoT devices. To deal with the heterogeneous devices, we propose a de-facto standard for API design, which adopts device abstraction and uID architecture. We also provide functionality description to allow developers create application more easily. To control access to heterogeneous devices including resource-constrained device, we propose an access control framework in which security manager is deployed as a trusted third party, and split into authentication manager and access control manager. Lastly, we investigate what services are needed in buildings and show how to realize an idea into a service. As a concrete example, we show the development of service for automatically predicting collective user preference in smart buildings.

To evaluate the proposed architecture, we implemented Smart Building API with access control framework in the real building environment and developed a service for predicting collective user preferences. A de-facto standard API design is evaluated by comparing it with the development process of application by using traditional RESTful style. The results showed that the proposed API design succeeds in reducing the development cost and supporting the developers to create application more easily. An access control framework is evaluated by conducting several scenarios of the experiment to measure the performance. The average of response time is less than 0.1 seconds, which indicates that the proposed framework is feasible to be practically used in a real smart building. Lastly, a service for predicting collective user preference is evaluated by conducting the experiment in a real smart building. The result showed that the proposed services reduced a manual intervention by 64.2 %, which indicates a service is feasible to optimize comfort level in smart buildings.