Proactive Architecture for Internet of Things (IoTs) Management in Smart Homes

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Abstract — *Smart homes are driven by heterogeneity in nature and consist of diverse components that promote user comfort and security. In recent times, tremendous growth of Internet of Things (IoTs) applications is seen in smart homes. The huge diversity of various IoTs applications generally leads to interoperability requirements that need to be fulfilled. Current IoTs management is achieved using physical platforms that lack intelligence on decision making. A proactive architecture that deploys Event-Condition-Action (ECA) method is proposed to resolve the management of heterogeneous IoTs in smart homes. The proactive architecture, developed with a core repository stores persistent data of IoTs schema, proved to be an ideal solution in solving interoperability in smart homes.*

I. Introduction

A smart home is a complex entity with diverse systems facilitating functions to occupants requirement based on the information acquired from computing appliances and occupants context[1]. Current development surfacing on diversified appliances and bespoke systems related with Internet of Things (IoTs) in smart homes commonly directed to interoperability difficulties in managing such systems. The Internet of Things (IoTs) are described as linking everyday objects like sensors, embedded devices to the Internet to enable seamless communication and message exchange [2]. On the other hand, interoperability is portrayed as the capability of multiple systems to use information in a federated manner. For smart homes, IoTs and interoperability are two major concerns for information dissemination among heterogeneous IoTs and also to perform interoperation in an agreeable manner. Figure 1 below depicts the elements of IoTs systems in smart home environment.

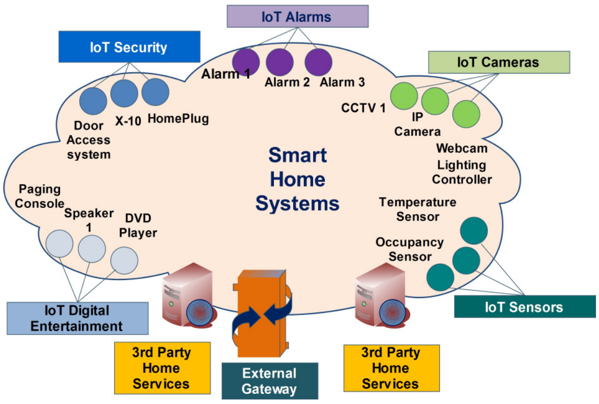

Figure 1: IoT systems in smart homes

Industrial association and special interest groups like OASIS and TAHI introduced open specification like Open Building Information Xchange with the aim of having unified architecture for information substitute and perception among heterogeneous IoTs in an interoperable setting. These consortiums projected that Web Services will evolve as primary channel in bringing interoperability for smart homes. Nevertheless, such interoperability schema should drive the possibility of decision making on home events to guarantee interoperation between heterogeneous IoTs could materialized in parallel without home dwellers intervention. Gradually, computing devices makes the formation of smart homes viable, however the bona fide challenge depends on sustaining the principal decision making mechanism among diversified systems. On the other hand, current practice on systems integration justifies that enabling variation in smart homes are complicated due to tight coupling between systems [3]. In addition, the heterogeneity of IoT systems is also another contributing factor that disables easy integration. To be specific, smart homes must not only emphasize the importance of bring together components of the systems but also on contextual behavior, often limited by the specific conditions. To solve the problem, we present a proactive architecture that offers interoperability via Web Services for heterogeneous systems. The architecture comprises of Event-Condition-Action (ECA) method succeeded from the field of artificial intelligence, guarantees to be an effectual means of managing heterogeneous IoTs. The outline of the paper is depicted as follow. Section 2 presents the proactive architecture and Section 3 details the implementation.

II. Proactive Architecture Development

The proactive architecture consists of several tiers that perform decision making for respective IoT systems. The

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core layer consists of Web Service based services that offers service coupling between a system and its service. The layer represents a set of IoT systems, home gateway and Web Services modules. The home gateway functionality is to enable access for external network. In smart homes, there exists limitation in introducing new IoT systems or services. To address such limitations, specific modules known as Device API and Device Stub is introduced to ensure new system's dependencies. Both modules consist of pre-defined SQL statements that communicate to the proactive architecture accordingly. In addition, the modules contains a set of application programming interface that refers to generic functions considered useful for application developers in constructing bespoke programs connecting and interoperating IoT systems. These modules required to generate those SQL statements that implements rules for IoT systems. For constructing application, developers would just need to call the preferred statements with minimal details of the architecture. A database is inclusive of the proactive architecture subjected to perform message queries pertaining to heterogeneous IoTs in smart home. The system implementation of the proactive architecture is illustrated in Figure 3 below:

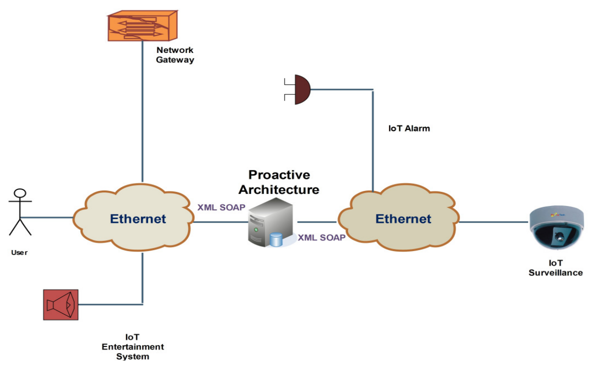

Figure 2: System Implementation

The IoT based proactive architecture was implemented with three IoT systems (IoT Surveillance Device, IoT Audio Device and IoT Alarm Device) to estimate their joint execution of tasks. The architecture would permit storing IoT systems data, permitting smart home users to define new functions, types of rooms, and predefined rules suiting the services. An application scenario on IoT based surveillance systems is depicted as shown in Figure 4 below:

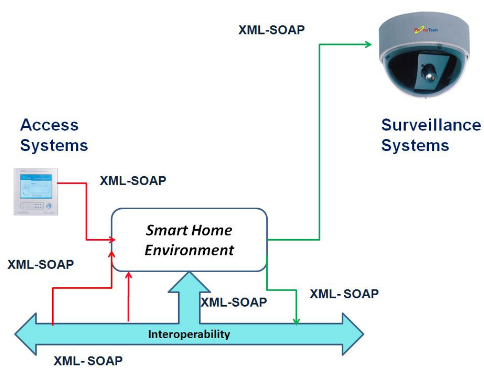

Figure 3: Application scenario with IoT based surveillance systems

Using the proactive architecture, IoT surveillance systems are configured and added as dependencies into ECA tiers in Service API. As different system vendors would have different platform for installation, the Service API here could proved benefecial by allowing easy addition of new dependencies. In this scenario, the surveillance systems using IoT cameras are configured with door access system. Once configured, the Service Stub tier in the proactive architecture will determine the appropriate rules based on ECA method for interoperation to take place. The surveillance system will jointly execute tasks based on the system status of all devices configured in smart home environment. The Service Stub component will proactively generates bespoke rules to trigger access systems based on the system response determined by surveillance system. The rules are channeled via XML SOAP messages in order to ensure interoperability among heterogeneous systems. It is worth highlighting that almost every systems and devices are able to excute in cross-event scenario except for fire-alarm. Fire alarms are categorized as universal responder and they are self-triggering components in IoT based smart home environment.

III. Conclusion

In this paper, a proactive architecture based on ECA rules proposed for IoTs interoperability in smart homes. The proactive architecture provides addition of dependencies each time an IoT system is configured without intervention. The architecture enables tasks interoperation among IoTs and compliments legacy system integration by allowing new dependencies each a new system is added.

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