RESTful Integration of Cooperative Smart Homes to Create a Crises Coordinating System

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ABSTRACT: *In smart spaces, crisis management is a challenging problem for inhabitant safety and security. In some critical events, standalone home management system is not enough efficient for handling the anomalies like out-of-control fire. The rise of REST architectural style as a lightweight and simple interaction model has motivated us to study the feasibility of emerging REST principles to design and integrate commonwealth smart homes to create a cooperative environment. In this paper, we introduce the state-of-the-art in applying REST concepts to develop Web services for creating synergistic smart space platform. Our study proposes a crisis coordinating framework which enables efficient emergency management in ubiquitous intelligent environments using REST architectural style.*

Keywords: Smart Home, Crisis Coordination, REST, Anomaly

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1. Introduction

The smart space concept is an important step towards achieving enhanced the quality of people's lives in a real world environment. The smart environments link computers to everyday settings and commonplace tasks. A definition of "*smart*" or "*intelligent*" is "*the ability to acquire and apply knowledge*", while "*environment*" refers to our surroundings [1]. Smart spaces intend to create safer, more efficient and more convenient environment for users, so particular services should be developed.

As depicted in this figure 1, a smart home is a small world where all kinds of smart devices are continuously working to make dwellers' lives more comfortable. The essence of Home Management Systems and smart homes is in the control technologies, which allow integration, automation, and optimization of all the services and equipment that provide services and manages the environment of the building concerned. A range of intelligent systems built for providing healthcare and wellness enables people to live at home with an improved overall quality of life [2].

According to new researches [3], the number of new smart home installations worldwide was 0.44 million in 2010. Growing at a compound annual growth rate (CAGR) of 65 percent, this number is expected to reach 5.38 million by 2015. Smart homes and connected home technologies have been around for decades, but up until recently, this has been a niche segment either for the very affluent or extreme technophiles. There is an increasing shift in smart home technology adoption from custom and luxury

residences to mainstream and production homes. Consequently, we would see condominiums of smart homes and also several smart spaces, in near future. In smart spaces, crisis management is a challenging problem for inhabitant safety and security. Therefore, Detection of unusual events is an important issue in smart home research.

Figure 1. Smart home, sub-systems and HMS

Cooperative Smart Homes (CSH) comprise set of smart homes (figure 2) which are adjacent or commonwealth. CSH aims at joining the isolated smart spaces, enabling for dynamic grouping of helpers and corresponding information exchange and cooperation. In case of emergency, extending the concept of smart space, CSH utilize capabilities of smart environments to cope with abnormal situations.

2. An Anomaly Coordination Scenario

In this section, an imaginary scenario is explained. The scenario reflects system functionality and system major challenges in case of out of control fire. This is an emergency coordination scenario to clarify the motivations of our work. The location of our scenario is a condominium which includes several smart homes. Each smart home equipped with a management system (HMS) which can monitor sensors, control actuators and report current state and abnormal events to the central coordination system (CCS). A smart home generally refers to a house environment equipped with several types of computing entities, such as sensors, which collect physical information (temperature, movement detection, noise level, light, etc.), and actuators, which change the state of the environment (figure 1). In this scenario, we consider a smart home equipped with occupancy, smoke detection, and temperature sensors. These devices have the ability to collect context information and to interact with management system in each smart home, in order to identify the context situation of the environment. If management system detects an abnormal situation then try to cope with it. In case of crisis controlling failure, the management system needs to ask help from central coordinator system. Following scenario describes such situation:

2.1 Situation

The sensors detect smoke and notify the Smart Home Management System (SHMS), which in turn uses the occupancy sensor and realizes that an elderly lies down. The SHMS therefore verifies situation by a picture of the room captured using the surveillance camera. The SHMS decides to trigger the sprinklers and to alert the fire department about the problem, as well as, decides to alert outside inhabitants.The emergency situation turns to crisis when the SHMS detects that sprinklers and communication line are out of service. Adjacent homes could be helpful to cope with crisis. They could alerts the fire department, as well as, could ask help to survive elderly who lied down because of smoke.

2.2 Major Challenges

The critical situations described above allow us to identify several key challenges in terms of:

2.2.1 Creating an interactive and ubiquitous space

As described, a cooperative environment among commonwealth smart homes could be helpful and efficient in case of an out-out-control emergency. A smart space criticality coordinator needs to be able to observe its environment continually and to take corrective measures in case of environmental changes which can cause the system to enter an abnormal state. Once a critical event has been detected, the system should take instantaneous action to control its effects. In order to create such environment, a steady communications and interactions are required. The key challenge is choosing a communication protocol which provides loose coupling, as well as, provides interaction among different SHMS platforms.

2.2.2 Information processing and interpreting

In order to detect uncontrollable crisis, it is necessary to identify the situations in which the adaptation is required. A lot of information that is generated by the different devices in each smart home. So, we need to define which part of this information is useful to send to central crisis coordinator system. Therefore, the coordinator system need to interpret relevant situations and react accordingly.

Figure 2. Cooperative Smart Homes Infrastructure

3. Providing RESTful Mediator Solution

Accessibility of information and effective communication is of extreme importance. Efficient coordination is essential to save time and lives of inhabitants as well. Actions should be taken immediately after the detection of emergency situation. Proposed crisis coordination manager supports abnormal situation-aware application that adjust their behavior by reasoning dynamically over each smart home situational information. This contextual information generally comes from diverse and heterogeneous smart home platforms, which designed in different software styles and architectures.

The heterogeneity of platforms in terms of technology capabilities and communication protocols, and the identification of adaptation situations make this integration difficult. Thus, this challenge requires a flexible solution in terms of communication support and context processing to leverage context-aware applications on the integration of heterogeneous situation reports.

In order to exploit the situational information provided by these home management system platforms, a mediator solution is required to collect and distribute the situational information efficiently. Particularly, a resolution dealing with context information and coordinate critical situations must be able to connect with various smart space management platforms.

In this study, we propose out-of-control emergency coordination framework which includes a simple but efficient resource-oriented mediator solution to facilitate situation awareness in smart homes.

In just a few years, the number of Internet-connected "*things*" (home appliances, smart energy meters, health monitors, and sensors) is predicted to be orders of magnitude larger than the number of users and traditional computers. The Web of Things

is a vision where everyday objects are seamlessly integrated into the World Wide Web (WWW) using well-known standards and blueprints (e.g. URIs, HTTP and REST) [4]. Lightweight Web Services have been motivated by the concept of the Internet of Things – a technological revolution to connect daily objects and devices to large databases and networks, and therefore to the Internet.

Proposed framework enables the integration of heterogeneous management system platforms based on the REST (REpresentational State Transfer) principles [5], standard discovery and communication protocols, and resource representation formats.

In his dissertation Fielding [5] describes how the Web's architecture as a spread hypermedia system evolved in its primary stages. In particular, the thesis discusses how the Representational State Transfer, or REST, architectural style was used to guide the development. Given that REST identifies the architectural constraints that have made the Web a success, it has been argued that also the web services should be architected in a similar fashion [6]. These so-called RESTful services would then embrace the way applications on the Web are intended to function.

The major principles of REST, likes the use of resources and the hypertext as an engine of application state in the sense of [5], are widely agreed upon, there looks to be conceptual confusion concerning how they do manifest and how they should manifest themselves in actual RESTful services.

In our view, the REST concepts of simplicity (in terms of interaction protocols) and flexibility (regarding the supported representation formats) make it an appropriate architecture style for making synergistic smart homes.

In this model, Web services standards are used as mediator among smart homes and central coordinator system. Web services are tailored at each management systems where the Profile for Web Services (PSW) is used to enable communicating, discovery, and eventing with central coordinator system.

4. The Proposed Platform

The interaction, Information processing and interpreting issues enforce several requirements for the development of CSH. To deal with these issues, we propose an inclusive and simple solution, which leverages on the integration of events and context information as well as the dynamic interactions by using the REST architectural style.

In designed infrastructure, we follow the REST principles [5] to reduce the coupling among SHMSs by concentrating on data exchange interactions, which can have multiple representations (e.g., XML and JSON).

In addition, the coordinator system contains the functionalities required for event collecting, event processing, and deciding. These are needed to detect and to coordinate the crisis caused .The designed infrastructure uses a Complex Event Processing (CEP) engine for event processing and detects anomalies. We need a decision-making engine that can process them and create relations to identify uncontrollable critical circumstances, using predefined rules. When a critical situation is detected, coordinator system ask commonwealth smart homes to activate their actuator to cope with the crisis caused.

Figure 3 depicts the general architecture of the designed infrastructure.

4.1 Intermediary Infrastructure

REST enables Web Intermediaries (WBI) to achieve the requests exchanged by the members in the communication process. WBI are computational entities that are positioned between interacting entities on a network to tailor, customize, personalize, or enhance data as they flow along the stream [7]. Therefore, we can benefit from this possibility to improve the performance of proposed system.

RESTful systems are loosely-coupled systems which follow these principles to exchange application states as resource representations. This kind of stateless interactions enhances the resources consumption and the scalability of the system. Furthermore, there is no need for service discovery and interpretation on the client's part, merely the IP address or network names for the Portal server it wishes to contact. Once the REST client is pointed at a coordinator server, it sends an HTTP command to a specific URL in that server's domain which relates the exact resource which should be operated on.

This framework presents an IP-based network where each SHMS can directly communicate to coordinator system through RESTful Web services.

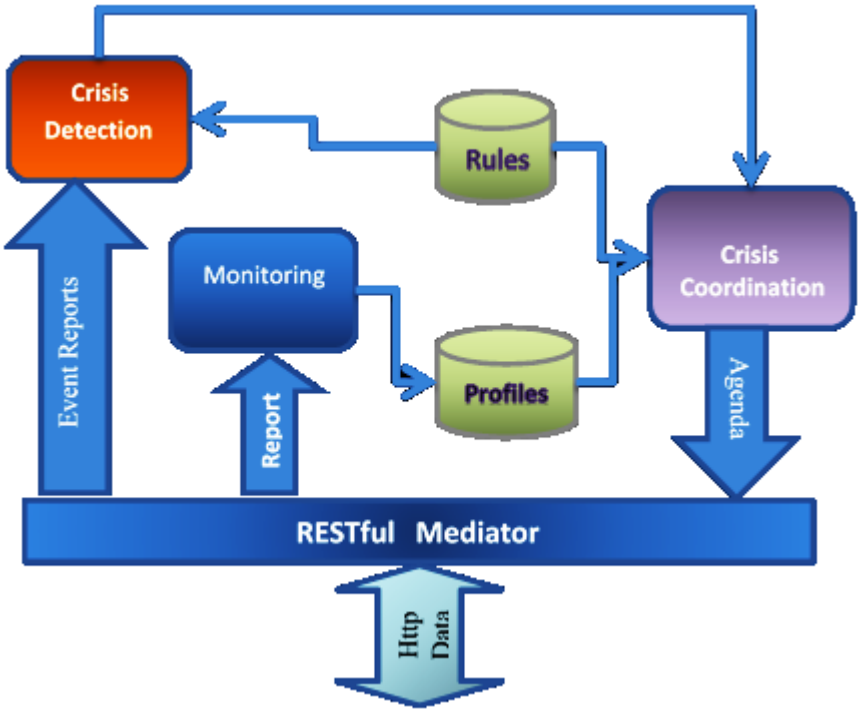

Figure 3. Depicts the general architecture of the designed infrastructure

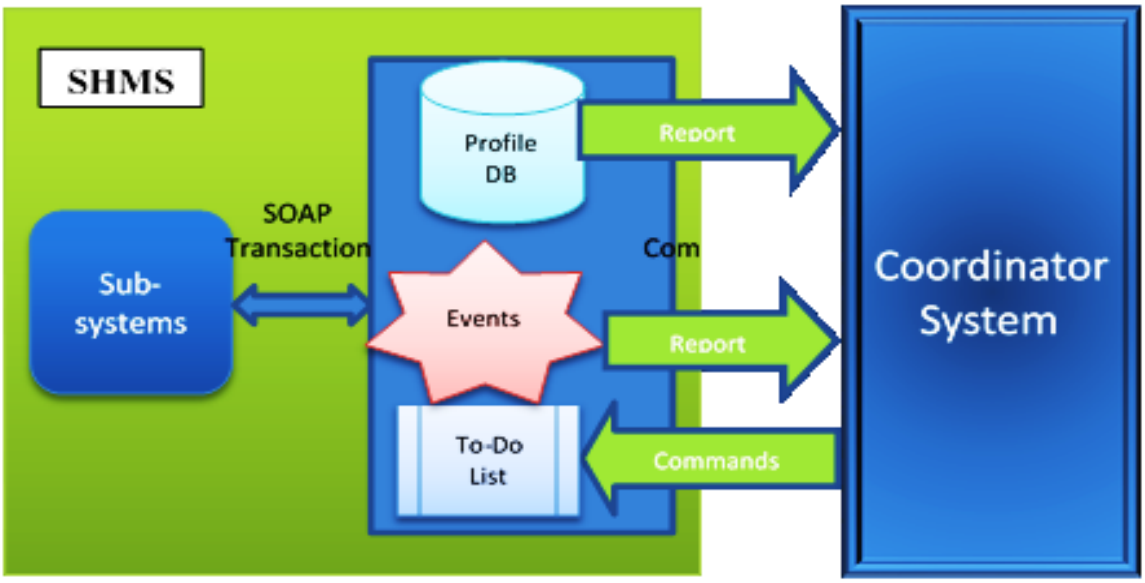

Figure 4. System Correlation

The RESTful mediator consists of HTTP Server, REST Engine and XML parser. It is an intermediate module for handling the REST requests received from a Web client (refer to SHMS) or sent from the crisis coordinator system through RESTful Web services.

HTTP server (refer to Coordinator) is a server to handle the incoming and outgoing HTTP requests. It provides interface to perform certain HTTP related tasks such as accessing request details (headers, entity body and URL path), constructing an HTTP response, etc. The REST framework also includes a XML parser to parse requests in XML format.

As depicted in figure 4, SHMS collects events and facilities in its repository. In same way, SHMS reports abnormal events and

its facilities to the coordinator system. In addition, the coordinator system needs to issue proper commands to helpful SHMSs. The coordinator system and the SHMS state are synchronized using an Web-based event-driven system.

In designed framework, there is specific URI for each facility (e.g. /SMHS-1/sprinkler) and event in SMHS-side and coordinator-side, as a web resource. By deploying REST principles, coordinator-side is updated during interval timing.

We utilize the simple REST interfaces (i.e., PUT, POST, DELETE and GET) and unique identifiers (i.e., URLs). In particular, the smart spaces subscribe and unsubscribe via the POST and DELETE interfaces, respectively. The subscription request includes the URI that is used for sending the events. The PUT operation is used in event notification.in this way, the system supports environment dynamism.

5. Related Works

Related studies show that an IP-based approach for home automation can offer equivalent performance with related traditional home automation standards, while concepts from the Web bring convenience to developers and users [8, 9]. In addition, in [10] the design, architecture and development of a Web-based application framework for smart homes was presented, aiming to address the issue of heterogeneity in platform architectures.

6. Conclusions

A RESTful mediator for a Web-based crises harmonizing framework was described, which may organize a cooperative smart space. The REST architectural style is followed in order to address heterogeneity of SHMS platforms. Moreover, the simplicity, lightness, reusability, extensibility, and flexibility properties that characterize REST as suitable option for interactive space among SHMSs and coordinator system. Collectively, the approach could help assist in defining type and scale of the abnormal situation and subsequently plan appropriate actions. By considering the natural advantages of the community, joining a smart space to a cooperative environment is effective and noticeable. . Thanks to this system, inhabitants are safer and more secure in the event of a crisis.

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