6th International Symposium on Advances in Science and Technology
SASTech
Malaysia | Kuala Lumpur
24 - 25 March, 2012
Scope of the Symposium
Organised by:
Khavaran Institute of Higher Education
Hosted by:
Geospatial Association of South East Asia

A Study on Crises Management System in Collaborative Smart Homes

Farhang Padidaran Moghaddam, Department of Industrial Computing, Faculty of Information Science and Technology, National University of Malaysia padidaran@ftsm.ukm.my

Riza Sulaiman, Department of Industrial Computing, Faculty of Information Science and Technology, National University of Malaysia rs@ftsm.ukm.my

Paper Reference Number: 6-11-24-166
Name of the Presenter: Farhang Padidaran Moghaddam

Abstract

The aim of this study is to introduce a system and infrastructure for facing out-of-control crisis in adjacent smart homes using ubiquitous computing aspects. The design of the smart home systems applies knowledge to generate a flexible, comfortable, healthy and efficient environment that enhances the quality of residents' life. In smart environments, management server is the entry point of access to each subsystem, acting as a residential middleware. In some critical events, standalone management system is not enough efficient for handling the anomalies like fire. This study proposes a coordinating system that deals with abnormal situations and community aspects of smart buildings in a ubiquitous computing environment. Coordinator system finds suitable surrounding parties for cooperation in solving the problem based on their profile, which includes location, list of facilities and working devices. Proposed system has three major processes, which are situation monitoring, reasoning and issuing a proper command. System architecture includes community mediator and reasoning as well as situation interpreting component. Message transmission and communication method are needed for the situation obtaining from smart home management servers. Java platform and web services are selected for this purpose. This study is able to extend the smart space's ability detect anomalies based on the contextual information gathered and interpreted. Thanks to director system, inhabitants are safer and more secure in the event of an emergency.

Key words: Crisis Management, Ubiquitous Computing, Smart Home, Collaboration.

1. Introduction

The Intelligent 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. We therefore define a “smart environment” as one that is able to acquire and apply knowledge about an environment and its inhabitants in order to improve their experience in that environment. As with other smart environments, smart homes are expected not to be invasive in the inhabitant’s daily life and provide him a natural and easy to use interface to his environment.

A smart environment is a small world where all kinds of smart devices are continuously working to make inhabitants’ lives more comfortable. A range of intelligent systems built for providing healthcare and wellness enables people to live at home with an improved overall quality of life (Cook, 2004).

Regarding to the Consumer Electronics Association (CEA), the smart home system involves five fundamental segments, home automation, security and access control, multimedia entertainment, remote communication, and networking protocols and regulations. These five elements can be integrated to work together. We aim at extending and empowering these advantages by providing a collaborative space between bordering smart homes. Cooperative spaces are more efficient to cope with critical situations such as intrusions, fires, emergency situations, gas leaks, medical emergencies and security issues.

According to new researches (Berg Inside, 2011), 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. Therefore, Detection of unusual events is an important issue in smart home research.

Benefits and functionalities of smart homes are quite well covered in the literature however interaction and correlations between adjacent smart homes, is not well defined nor well understood. Thus, our motivation is to cast light, especially, on this issue.

2. The System Concept and Objectives

There are some sub-systems that play a vital role for smart homes and provide wellbeing life to users by monitoring and controlling critical events in the home such as gas& smoke sensors, fire detectors, elderly health monitoring, surveillance and access control system (Fig. 1). The Home Management Server (HMS) is a central control system that centrally controls sub-systems of a building. The management server is the entry point of access to each subsystem, acting as a residential gateway, providing the required security and connectivity functionalities. The server will perform data retrieval and storage from underlying subsystems, through the database module for controlling operations of the respective subsystems.

Fig 1. Smart Home Sub-Systems and HMS

We can classify smart home events into 3 categories: 1- daily activities, 2- emergency events which are manageable by HMS and 3- out of control anomalies. In some critical events, standalone management system is not enough efficient for facing the problem. For example, in case of fire, the management system could not cope with, while the fire is out of control or communication lines are disconnected. Therefore, a ubiquitous crisis-management system is needed to deal with critical circumstances.

Crisis management is a challenging problem for homeland security and safety. This study proposes a supervisory system dealing with out of control critical situations and community aspects of smart homes on ubiquitous computing environment. The supervisory system could find suitable adjacent homes for cooperation in solving problems based on their profile, which includes location, list of facilities and working devices etc. In addition, the proposed system could inform neighbors in certain critical events to help others or save themselves. Interaction between two or more smart homes to achieve comfortable living more effective than a similar management system would do independently.

The proposed system extends smart spaces ability of communication with the outside environment to find more ambient knowledge. In order to achieve an efficient crisis management system, it is desirable for the proposed framework to take full advantage of those smart characteristics in a domestic control task in the attempt to create a situation-aware system that is oriented to build a smart space. This is the principal motivation of this study. By considering the natural advantages of the community, joining smart spaces in a collaborative environment is effective and noticeable.

3. System Method and Infrastructure

Our system is a situation-aware system. Situation awareness is the capability of monitoring and analyzing contexts, discovering situation changes, and matching system behavior based on situation changes. Additionally, the smartness of smart environments relies on situation awareness using ambient intelligence. Situation-aware system should have the following characteristics (Stephen, 2008):

- Understand the status of the living environment as well as various devices in a smart space.
- Understand the status and needs of the residences and environment.
- Proactively identify, configure, trigger and collaborate the actions of various devices in smart spaces to meet the emerging needs of the inhabitants.
- Automatically manage and optimize usage of various resources in smart spaces.

Besides, a situation-aware crisis management system should include the following functionalities:

- initiating a crisis based on critical situation reasoning system,
- processing a crisis by executing the missions defined by the coordinator system and then assigning and managing internal and/or external resources,
- wrapping-up and archiving crisis,
- Handling communication between coordinator/system and resources.

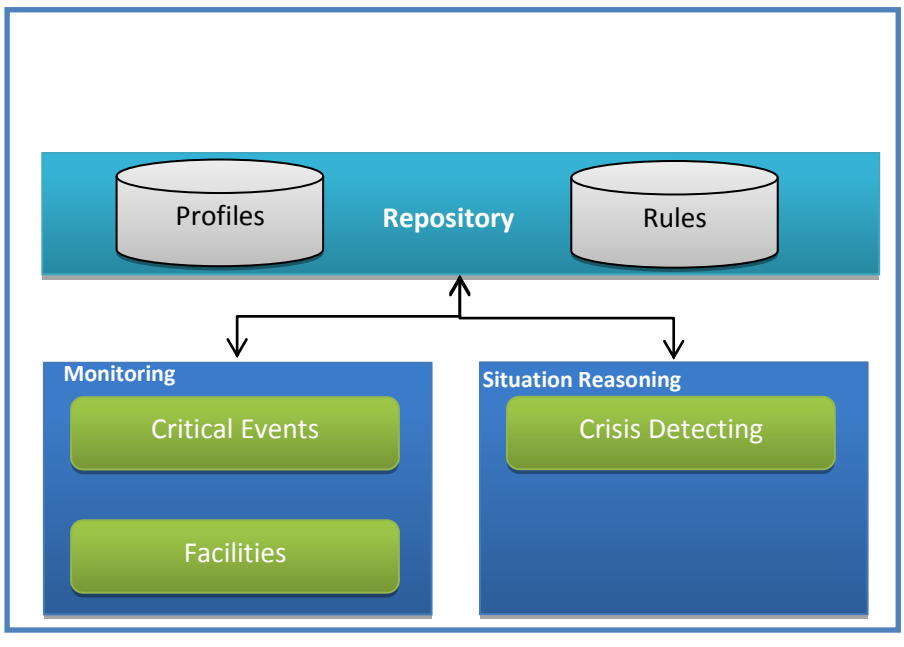
Situation Awareness contains data gathering, logic reasoning and responsive interaction to capture situations, which describe system states, from dynamic environments.

There are several technologies and languages that address the collaboration issue in a smart environment. These middleware technologies are built to cater the collaboration tiers suiting the smart spaces. The common selected approaches that drive collaboration in smart environment are Common Object Request Broker Architecture (CORBA) (Henning and Vinoski, 1999), Microsoft Component Object Model (COM) (Microsoft/com, 2011), .NET Framework (Msdn2, 2011), Sun's Java 2 Enterprise Edition (J2EE) (Oracle/java, 2011) and World Wide Web Consortium's (W3C) (Alonso *et al.*, 2004) extensible Markup Language (XML) based Web Services.

All of the Ubiquitous services are provided based on the situation around smart homes and situation-aware is the starting point of providing services. In the recent years, numerous studies have attempted to find and explore field of situation-aware and situation based services (Yau *et al.* , 2002),(Kim and Yau, 2004). To achieve this goal, the system should have or acquire a fair amount of rich information in the environment.

Some procedures and definitions are necessary for building a ubiquitous crises-aware smart space, this kind of space would collaborate with service management server of each single smart environment. Following components (Fig. 2) are needed for critical event awareness categorization in this study:

- Situation division: Situation division is used to establish a series of meanings of the values of situation variables. For discrete variables, the different values of situation often represent different meanings. But for continuous variables, we need to divide it into a number of seamless ranges. For example, day, week and month are three common division ways of time. Situation division can help us to define the crisis accurately.
- Reasoning rules definition: Situation reasoning is a way to find an implicit situation and relationships from the explicit situation and relationships. This finding process need to carry out with reasoning rules. The reasoning rules are the relationships between different situations.
- Critical Events Monitoring: Situation data acquisition reads situation data according to the predefined address and cycles, and sends the data to the reasoning component.
- Situation reasoning: According to the predefined rules, the reasoning machine reasons an implicit situation based on known situation. The crises detection division can be seen as a kind of simple reasoning. However, the division can be done directly from the value of situation variables, and the

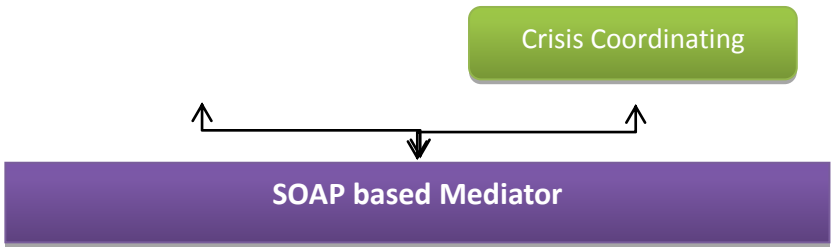


reasoning we discussed here is a more complicated situation which requires the support of reasoning rules.

Fig 2. Components of Proposed System/Middleware

State and command transmission, as well as, communication method in needed for the situation obtaining from smart home management servers. Java platform and web services are selected for this purpose.

Java Middleware technologies support interoperability by providing distributed protocols and APIs that can be used to create an interoperable system. In Java based platform, remote invocation or messaging is the key to achieve interoperability. Java middleware offers Remote Method Invocation (RMI) mechanism that is similar to The Common Object Request Broker Architecture (CORBA)-like object oriented middleware layer as distribution protocol. RMI enables objects to be called remotely



from other applications in a heterogeneous environment. This feature also extends for interoperation execution between systems and information exchange. One of the implementations of Java Middleware in smart home environments is the OSGi framework (OSGi Alliance, 2011). The OSGi Alliance introduced the Open Service Gateway Initiative (OSGI) specification defines a standardized, component oriented, computing environment for networked services.

Web Services are collected set of protocols and standards provides a common method for programmatic interaction among applications, services and devices (Miori *et al.* , 2006). It describes the standardized concept of function invocation relying on web protocols, independent of any platform (operating system, application server, programming language, database, and component model). Web Services consist of three entities:

- Service Provider – Create Web Services and publish to the external environment by registering through the Service Registry;
- Service Registry- Registers and categorizes published services;
- Service Requester - uses Service Registry to find a needed service and bind them accordingly to Service Provider.

XML and SOAP technology has been chosen as the enabler since both are prime candidates in playing their role as the lingua franca for interoperability. SOAP is very well suited for providing interoperability among heterogeneous smart home management systems due to the standard way of data representation and the format is extensible to deal with changing requirements. SOAP gets the desired data types without any complicated data transportation process.

During the SOAP message transaction it is interesting to note that message exchanging process are hidden from programmers as they are hidden inside the SOAP

middleware. Therefore facility managers can focus on situation reasoning towards data types to be received and the associated interoperation. Java is a considerable technology for implementing SOAP, and for building web services and applications that use SOAP as the "on the wire" data format (Fig. 3).

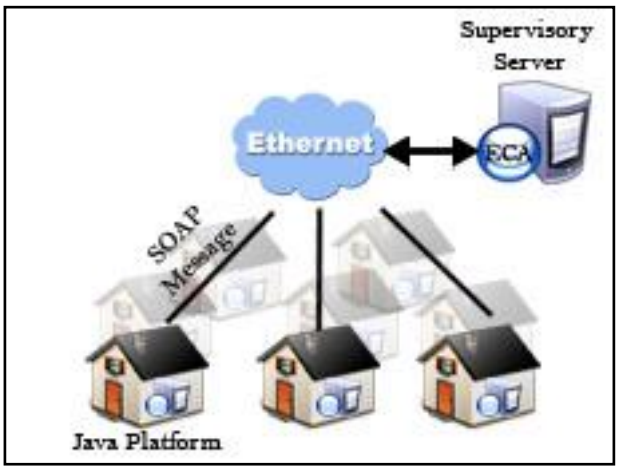


Fig 3. The System Overview

As stated earlier, Situation reasoning is one of the system processes. Situation reasoning engine analyzes the environmental context and generate an appropriate service. Reasoning Engine loads the rules and contexts for selecting the contexts of the adaptive services. It matches and transmits the service control data exploiting the contexts of the Reasoning System Manager, Policy Manager. Reasoning System Manager manages the Reasoning Agent and controls the state of reasoning process. Our system uses rule-based reasoning and Event Condition Action (ECA) is selected for interpreting the critical and out of control events among smart homes.

ECA rules are considered useful in smart environments because: I) Devices and subsystems need to react towards occurrence of some set or series of events; II) the behavior of particular subsystem is subject to some conditions other than standard occurrences of the event; III) Service logic should be separated from execution of procedures in smart space. Due to the constant interaction between subsystems and changes in times, ECA rule looks practical in providing event-driven process for smart home management. An example of rule for subsystem interoperation is depicted below:

- On <Fire_Alarm_TRIGGER>
- If <still triggered after 10 min>
- Do<Alert Adjacent Homes Inhabitants>

ECA rules take the form “on” some event “if” some condition then some actions. Here, events are defined as a happening of interest at a particular point of time. If conditions pertaining to the events are evaluated as true, then one or more actions are taken. Once an occurrence of the event described in the ON clause takes place, if the condition represented in the IF clause is true, the action as stated in the DO clause is executed by the system. The rule is said to be triggered when the ON clause is satisfied by the rule and the IF clause is satisfied. Events in the intelligent building can be

classified into two categories; internal events and external events. Internal events are events that require a triggering condition by a single event.

4. Conclusions

The research proposes a coordinator system and infrastructure that deals with critical situations and community aspects of smart spaces in a ubiquitous computing environment. In this system, the situation of smart parties and environmental information around them will be efficiently handled to provide watching services.

Collectively, the approach could help assist in defining type and scale of the abnormal situation and subsequently plan appropriate actions.

This study aims to extend smart space's ability of communication with the outside environment to cope with out of control crisis. By considering the natural advantages of the community, joining a smart space to a collaborative environment is effective and noticeable.

Employing situation awareness and ECA reasoning mechanism, coordinator system is able to find the best party to help in uncontrollable crisis. This system can provide solution for inhabitants to help other victims or save themselves.

This study is a sight into the wider view of smart environments security and safety. Thanks to this system, residences are safer and more secure in the event of a crisis.

References

Alonso G., Casati F., Kuno H. and Machiraju V. (2004), Web Services: Concepts, Architectures and Applications, Springer-Verlag Berlin Heidelberg.

Berg Insight AB . (2011) . *Smart Homes and Home Automation*, MarkertReaserch report.

Component Object Model, *http://www.microsoft.com/com/default.mspx*

Cook D. and Das S. (2004). Smart Environments: Technology, Protocols and Applications. *Wiley Series on Parallel and Distributed Computing*. Wiley-Inter science.

Henning M. and Vinoski S. (1999), *Advanced CORBA Programming with C++*, Addison-Wesley.

Java 2 Enterprise Edition, *http://java.oracle.com/*

Kim, C. and Yau, S. (2004), An Adaptive Qos Management Model for Aware Middleware. In: Yang, L.T., Guo, M., Gao, G.R., Jha, N.K. (eds.) EUC 2004. LNCS, vol. 3207, 972–981.

Miori V., Tarrini L., Manca M., and Tolomei G. A. T. G.,(2006), An open standard solution for domestic interoperability, Consumer Electronics, IEEE Transactions on, vol. 52, 97-103.

NETFramework2.0, *http://msdn2.microsoft.com en-us/netframework/aa731542.aspx*

OSGi Alliance, *http://www.osgi.org*

Stephen S. (2008). Situation Awareness in Smart Home Environments, SmartHome Workshop.

Yau, S., Karim, F., Wang, Y., Wang, B., Gupta, S.(2002), Reconfigurable Context-Sensitive Middleware for Pervasive Computing, IEEE Pervasive Computing 1 (3), 33–40.