

## Mobile IP-Based Architecture for Smart Homes

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### **Abstract**

*Smart Home technology is the integration of technology and services through home networking for a better quality of living. This paper provides a review of the recent developments in technologies for Smart Home Automation and Mobile IP and its potential application and integration to Smart Home systems. The principles of MIPv6 are adopted for providing mobility on the design of the architecture for MIP-Based Smart Home.*

**Keywords:** *mobile MIPv6, Smart Home, home automation, MIP-Based Smart Home*

### **1. Introduction**

The emerging developments in information technology have changed the way people deal with their daily living chores. The era of ubiquitous computing were brought by these developments wherein all the works are left for these machines. The advent of Smart Homes was influenced by trends within the society and with the idea of helping and supporting the elderly and disabled persons. Improving the quality of life for disabled and elderly people is becoming everyone's concern. By making the home environment comfortable could be helpful to improve the quality of life.

Smart Home is the integration of technology and services through home networking for a better quality of living. All the devices and appliances in home are connected so they can communicate with each other and with the residents. The home devices and equipments can be controlled using the latest state-of-the-art Smartphones or PDAs. Some of the different applications supported by a home network are house lightings, home security, entertainments systems, ventilation systems, etc. Smart homes offer a number of benefits that a conventional home could not offer. For example, in a conventional home, you need to have chains and padlocks to keep intruders from entering your home premises. In a smart home security system, the residents may even know and talk to persons that wish to visit without moving an inch.

This paper provides a review of Smart Home systems, technologies for mobile IP, and their potential applications in Smart Homes Security and Automation. The qualities of an ideal Smart Home application system are also identified and serve as the basis for the design of a ubiquitous architecture for IP-Based Smart Home system utilizing the current state of the art

technologies primarily on wireless sensor networks and mobile IP. The principles of MIPv6 for moving nodes are adopted for a more refined mobility solution.

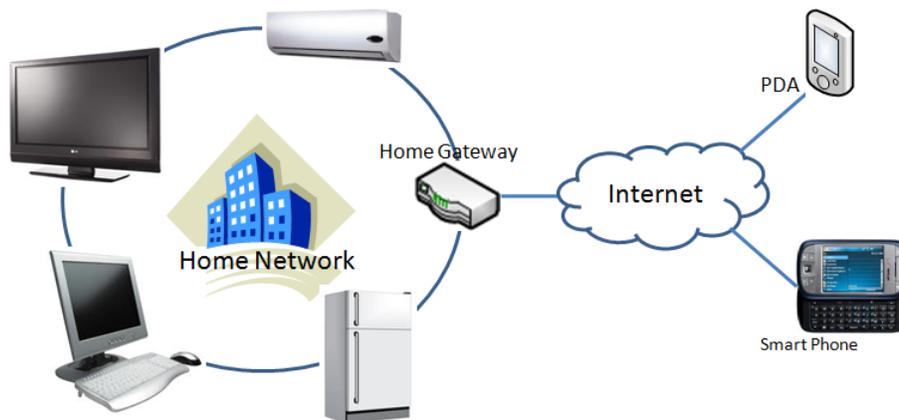
The rest of this paper is organized as follows: Section 2 illustrate how Smart Home works; the proposed architecture for Mobile IP-Based Smart Home is outlined in Section 3; and the concluding remarks in Section 4.

## 2. Smart Home Systems

A smart home is defined as a home or building equipped with specially structured wiring to enable occupants to remotely control or program an array of automated home electronic devices by entering a single command. For example, a homeowner on vacation can use a Touchtone phone to arm a home security system, control temperature gauges, switch appliances on or off, control lighting, program a home theater or entertainment system, and perform many other tasks [1], [9].

The field of home automation is expanding rapidly as electronic technologies converge. The home network encompasses communications, entertainment, security, convenience, and information systems [1].

Generally, in traditional smart home architectures, all components in a home network are controlled by a home gateway, which acts as service provider for users [2]. From this server, all other appliances and components are controlled by the users. All protocols for operating the home equipments are defined in this server. Figure 1 outlines a traditional setup for a smart home architecture wherein the home gateway controls other home appliances and also connects with other user devices through the Internet.



**Figure 1. Architecture of a Traditional Smart Home System**

Some equipments and appliances can work with a peer-to-peer network setup, but is on applicable to home equipments that uses same protocols. Thus, a home gateway is enabled as the service gateway, translating between different protocols for appliances.

The different technologies that could provide for smart home communication are X10, Insteon, Zigbee and Z-Wave. X10, developed in 1975 by Pico Electronics of Glenrothes, Scotland, allows compatible products to talk to each other remotely over the already existing electrical wires of a home. It is an international and open industry standard for communication among electronic devices used for home automation also known as domotics. It primarily uses power line wiring for signaling and control, where the signals involve radio frequency bursts representing digital information [3].

Some systems use radio waves to communicate between home equipments, such as Zigbee and Z-Wave. These two are the most prominent radio networks and uses mesh network topologies. Z-Wave is a proprietary wireless communications protocol designed for home automation, specifically to remotely control applications in residential and light commercial environments. The technology uses a low-power RF radio embedded or retrofitted into home electronics devices and systems, such as lighting, home access control, entertainment systems and household appliances [4].

ZigBee is a specification for a suite of high level communication protocols using small, low-power digital radios based on an IEEE 802 standard for personal area networks. Applications include wireless light switches, electrical meters with in-home-displays, and other consumer and industrial equipment that require short-range wireless transfer of data at relatively low rates. The technology defined by the ZigBee specification is intended to be simpler and less expensive than other WPANs, such as Bluetooth. ZigBee is targeted at radio-frequent (RF) applications that require a low data rate, long battery life, and secure networking. ZigBee has a defined rate of 250 kbps best suited for periodic or intermittent data or a single signal transmission from a sensor or input device [5].

The INSTEON is a system for connecting lighting switches and loads with extra wiring. It is an integrated dual-mesh network that combines wireless radio frequency (RF) with the home's existing electrical wiring intended to improve reliability by providing backup system in case of wireless interference. It is a home automation networking technology designed by SmartLabs, Inc. It is designed to enable devices such as switches, thermostats, motion sensors, etc. to be networked together using the power line, radio frequency (RF), or both. All INSTEON devices are peers, meaning each device can transmit, receive, and repeat any message of the INSTEON protocol, without requiring a master controller or routing software and do not require network supervision [6].

Here are some examples of smart home products and their functions [7].

- Cameras will track your home's exterior even if it's pitch-black outside.
- Plug your tabletop lamp into a dimmer instead of the wall socket, and you can brighten and dim at the push of a button.
- A video door phone provides more than a doorbell -- you get a picture of who's at the door.
- Motion sensors will send an alert when there's motion around your house, and they can even tell the difference between pets and burglars.

- Door handles can open with scanned fingerprints or a four-digit code, eliminating the need to fumble for house keys.
- Audio systems distribute the music from your stereo to any room with connected speakers.
- Channel modulators take any video signal -- from a security camera to your favorite television station -- and make it viewable on every television in the house.
- Remote controls, keypads and tabletop controllers are the means of activating the smart home applications. Devices also come with built-in web servers that allow you to access their information online.

All the appliances and devices connected to the home network are receivers, and the means of controlling the system, such as remote controls or keypads, are transmitters. Smart homes obviously have the ability to make life easier and more convenient. Home networking can also provide peace of mind. Whether you're at work or on vacation, the smart home will alert you to what's going on, and security systems can be built to provide an immense amount of help in an emergency. For example, not only would a resident be woken with notification of a fire alarm, the smart home would also unlock doors, dial the fire department and light the path to safety [7], [9].



**Figure 2. Smart Home Applications [10]**

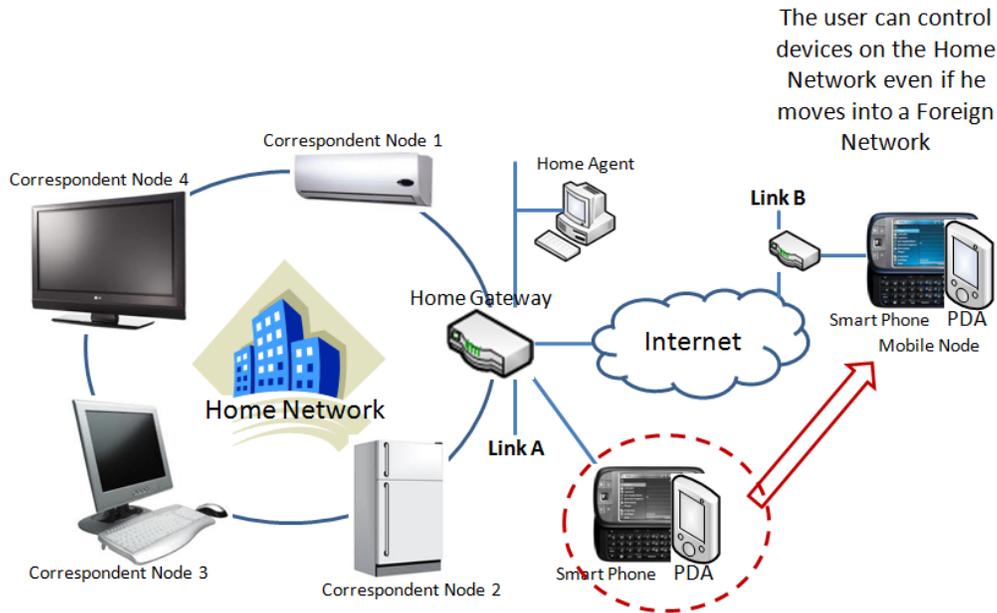
Smart homes also provide some energy efficiency savings. Because systems like Z-Wave and ZigBee put some devices at a reduced level of functionality, they can go to "sleep" and wake up when commands are given. Electric bills go down when lights are automatically turned off when a person leaves the room, and rooms can be heated or cooled based on who's there at any given moment. One smart homeowner boasted her heating bill was about 1/3 less than a same-sized normal home. Some devices can track how much energy each appliance is using and command it to use less [7].

Smart home technology promises tremendous benefits for an elderly person living alone. Smart homes could notify the resident when it was time to take medicine, alert the hospital if the resident fell and track how much the resident was eating. If the elderly person was a little forgetful, the smart home would perform tasks such as shutting off the water before a tub overflowed or turning off the oven if the cook had wandered away. It also allows adult children who might live elsewhere to participate in the care of their aging parent. Easy to control automated systems would provide similar benefits to those with disabilities or a limited range of movement [7]. Another example is that if an elderly person has a medical condition that could be of concern, the vital signs can be routinely sent to the appropriate medical facility. The smart home equipped with artificial intelligence will learn to distinguish dangerous readings and alert medical personnel immediately. Figure 2 outlines some of the applications that a smart home can offer. This project was a Mobile Phone Project by Nokia [10].

### **3. Proposed Architecture for Smart Homes**

Based on the discussed related technologies and smart home systems, a smart home technology is the integration of technology and services through home networking for a provision of a better quality of living. Smart home technology is shifted from being purely concerned with the integration of electrical equipment within the home to also include ICT functionalities. It becomes a home environment in terms of different networks for work & productivity, entertainment, communication and information and home automation that are merging and connected to the outside world by a home gateway. Its value does not depend on one single system alone but with the interconnection with the different systems and how they integrate and interact to each other.

The proposed architecture for Smart Homes is based on the integration of the emerging technologies of Wireless Sensor Networks and Mobile IP. The traditional setup for Smart Homes is enhanced by providing mobility utilizing the current state-of-the-art principles of MIPv6. The scenario is shown on Figure 3, wherein the user can still control the home appliances or equipments connected to a home network even if he moves into a foreign network. When the user is away from the home network and enters a foreign network, the user's mobile phone or PDA is associated with a care-of-address which identifies his current location.



**Figure 3. Design Overview of a MIPv6-Based Smart Home Architecture**

Mobile IPv6 is a version of Mobile IP that allows users with mobile devices whose IP addresses are associated with one network to stay connected when moving to a network with a different IP address. When a user leaves the network with which his device is associated (home network) and enters the domain of a foreign network, the foreign network uses the Mobile IP protocol to inform the home network of a care-of address to which all packets for the user's device should be sent [8]. Each mobile node is identified by its home address disregarding its current location in home network. While away from its home network, a mobile node is associated with a care-of address which identifies its current location and its home address is associated with the local endpoint of a tunnel to its home agent. Mobile IP is most often found in wireless WAN environments where users need to carry their mobile devices across multiple LANs with different IP addresses.

The use of the standard mobile IPv6 message formats will be utilized for communication among nodes (home appliances) and exchange of home information within the smart home system. The communication signals from the user will undergo authentication procedures as for the standard MIPv6 handover scheme to ensure that the home networked is controlled and managed by the exact resident and home owner.

The services that can be offered by the MIPv6-Based Smart Home system are bound with the following:

- *Security and Safety.* Most elderly people's priority in home consideration is to live safely and securely in their own homes. Some example of such services are
  - Entrance monitoring, wherein people inside the house would know who is on the front doors before they could open the door. Could be accessed thru remote controls via phones, or monitor displays.

- Intrusion alarms.
- Smoke detectors are installed in all areas of the house that when triggered does not only sounds the alarms and opens the immediate fire sprinklers, but also gives a signal or call to a nearest fire station, with indicators of the presence of a real fire. The devices include sensors that are able to recognize the danger of a fire and send an emergency call automatically
- Automatic light switching could be helpful for the elderly people.
- If the residents leave the house, the electronic cookers and other electrical appliances are automatically switched off.
- *Entertainment systems and Multimedia.* The provision of automated entertainment systems powered by remotes and speech recognitions.
  - Integration of remote learning or bringing an educational system at home for the children. A classroom setup could be installed and embedded on the children's rooms or study areas.
  - Multiple monitors for televisions that you don't have to install separate television sets on kitchens or comfort areas.
- *Comfort and ease of use.* The installed home automation does not distract the daily chores of the residents and it must be easy to use.
- *Medical Emergencies.* There is an integration of tele-monitoring or personal health monitoring for the residents health needs using medical devices at home. This includes continuous measurement of physiological parameters. Different sensors are embedded in different places or objects at home, or utilizing wearable medical sensors to achieve advanced multi-parametric health monitoring.
- *Communications.* The integration of an intercom system is an added mobility for residents.

The above are just a few services and benefits offered by Smart Homes.

#### **4. Conclusion**

The utilization of Mobile IPv6 with the Smart Home Systems is optimized to provide mobility and enhanced communications and interconnection for home networking that could lead to efficient, reliable, and emergent services a home networking could offer. The proposed architecture could provide a seamless convergence for communicating between the users and the home devices and equipments as he leaves his residence. The user can have autonomous control of the home devices and equipments even if he changes location or network provider since the system is installed with IP addresses recognized with proper authentications.

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