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Creating a Smart Home Environment with IOT Driven Home Appliances

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ABSTRACT

This paper aims at presenting the Smart Home concept. This paper describes in detail - a) The Smart Home concept b) Our concepts to model the Smart Home using smart devices c) Adaptive decision making using artificial intelligence and big data d) Large scale implementation of this concept to model a Smart Locality, Smart City up to the level of Smart country. Contrary to the other projects, this work is directed towards a sensors approach and an ontology modelling of the Smart Home. This work has the originality to take into account the real heterogeneity of information present in a habitat. This paper is a good overview to present what is a Smart Home and which are the necessary hardware and software components to make a Smart Home. Smart Home concept has been implemented using smart devices, adaptive decision making using artificial intelligence and big data. The work is directed towards a sensor approach and ontology modelling. This work focuses towards large scale implementation for smart systems.

Keywords: Internet of things (IOT), smart TV, smart devices – hand held devices, smart wearables, wireless sensor network.

I. INTRODUCTION

With the advancements in Internet technologies and Wireless Sensor Networks (WSN), a new trend in the era of ubiquity is being realized. Enormous increase in users of Internet and modifications on the internetworking technologies enable networking of everyday objects. “Internet of Things (IoT)” is all about physical items talking to each other, machine-to-machine communications and person-to-computer communications will be extended to “things”. Key technologies that will drive the future IoT will be related to Smart sensor technologies including WSN, Nanotechnology and Miniaturization. The automation of home settings to act according to the inhabitant requirements is termed as intelligent home automation system. [1, 4, 6]

Smart Homes, also known as automated homes, intelligent buildings, and integrated home systems are a recent design development. Smart homes incorporate common devices that control features of the home. Originally, smart home technology was used to control environmental systems such as lighting and heating, but recently the use of smart technology has developed so that almost any electrical component within the house can be included in the system. Moreover, smart home technology does not simply turn devices on and off; it can monitor the internal environment and the activities that are being undertaken whilst the house is occupied. The result of these modifications to the technology is that a smart home can now monitor the activities of the occupant of a home, independently operate devices in set predefined patterns or independently, as the user requires.

In general, an intelligent home automation system consists of clusters of sensors, collecting different types of data, regarding the residents and utility consumption at home. Systems with computing capabilities analyze the assimilated data to recognize the activities of inhabitants or events. These can automate the domestic

utilizations effectively and also can support the inhabitant by reducing the costs and improving the standard of living. In the recent past, several research activities were actively involved with IoT. Most of the research activities related to IoT are confined to management of resource constraint devices, and different mechanisms of interconnection. The future cyber-age networked infrastructures of household appliances in homes are likely to be reliant on sensors embedded in/on the infrastructure. Such technologies will act as a catalyst to the evolution of a new generation of services that will have a great impact on the social and technological eco-system. It can be envisaged that the next generation systems and services will encompass several domains such as e-Governance, Health Care, Transportation, Waste Management, Food Supply Chains, and Energy & Utilities.

New technologies and applications built on top of smart devices may fulfill the vision of Intelligent Infrastructure. To date, there has been no complete development of a monitoring smart home of commercial perspective, nor any investigation into how such a house is perceived by either the inhabitants or their careers. The smart homes designed so far are for different purposes such as information collection and decision support system for the wellbeing of the inhabitants, storing and retrieving of multimedia data and surveillance, where the data is captured from the environment and processed to obtain information that can help to raise alarms, in order to protect the home and the inhabitants from burglaries, theft and natural disasters. [2, 3, 5, 7]

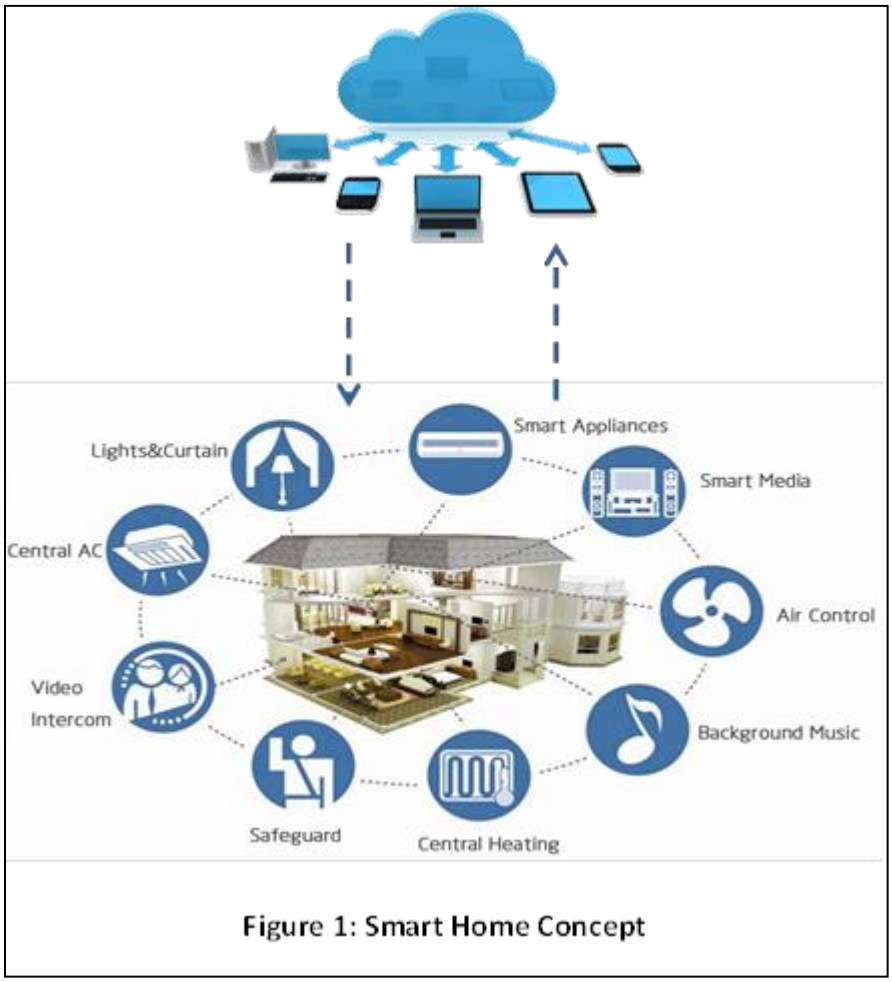

Figure 1: Smart Home Concept

II. DESIGN AND DESCRIPTION OF SMART HOME SYSTEM WITH INTELLIGENT DECISION MAKING AGENT

In a schematic way, a smart home can be described by a house which is equipped with smart objects, a home network make it possible to transport information between objects and a residential gateway to connect the smart home to the outside Internet world. Smart objects make it possible to interact with inhabitants or to observe them. Those smart objects can be just a light that we can control or ask it about it state, a refrigerator which knows its state and is able to supply in line by itself, telephony, security systems, and videos on demand. Those entire objects will be connected on the home network to give their states or receive instructions. Home networking allows the home to become fully connected, controlled externally as well as internally. The residential gateway offers an extern access by the way of Ethernet or Internet network. This gateway makes it possible to the house to connect new services and to download them. The service provider is in charge of the new services for inhabitants and their accessibility. 'Figure 1' depicts the smart home. A smart home is composed of appliances like washing machine, refrigerator, sensors, and motors, some user interfaces like voice, visual or graphical. There is a residential gateway which connects to the internet.

In our Smart home concept, the following use cases are described:

1. Indoor environment: 'Figure 2' depicts a local network of smart devices communicating with each other performing sensing, monitoring and controlling functions. The Smart TV will act as the central monitoring unit for all devices as well as a gateway for man machine interface. Smart devices such as smart refrigerator, smart door, smart washing machine etc. will push a notification message on the Smart TV screen in case of any activity status update. The smart devices will also send a push notification if any decision is required from the inhabitants. Consider the below given scenario for better understanding of the above mentioned use case. The user is at home. There is someone at his main door and the doorbell rings. A camera unit installed at the main door will sense the ringing of doorbell and capture the image of the visitor at the door. This captured image will be sent to the Smart TV via the wireless local network and a message will pop up on the TV screen, along with the image, asking whether the door is to be opened. If the user now selects 'Yes' on his Smart TV, a control signal is sent to the actuators and rotors installed on the main door. These rotors automatically open the door and allow the visitor to enter.

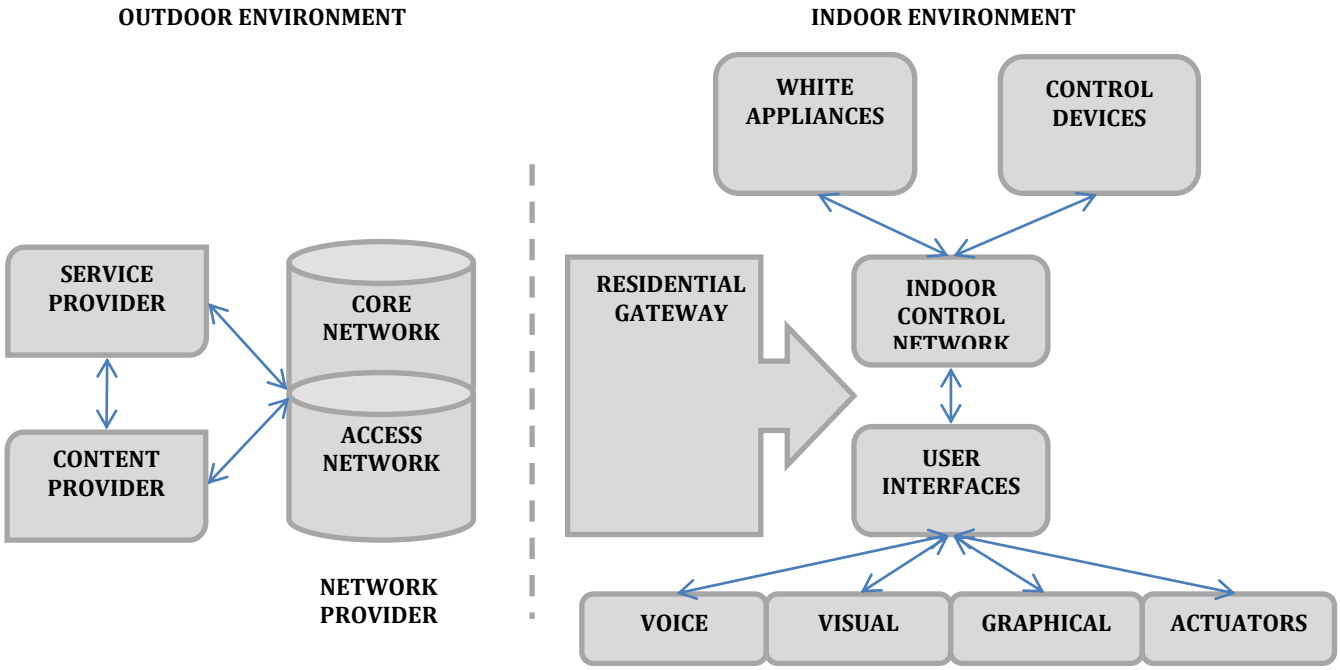

FIGURE 2: SMART HOME AUTOMATION SYSTEM MODELLING

Conversely, if the inhabitant chooses not to open the door he will select 'No' on the Smart TV screen and the door will remain closed. Additionally a default message will be displayed on the LCD screen mounted on the main door informing the visitor to come again later. This message may also be customized to suit the requirements of the inhabitants.

2. Outdoor environment: This scenario depicts a global network of smart devices communicating with each other performing sensing, monitoring and controlling functions. The portable smart devices such as smart phone, tablet or smart wearables will act as the central monitoring unit for all devices as well as a gateway for man-machine interface.

Consider the below given scenario for better understanding of the above mentioned use case.

The user is away from home. He has already set up an activity for the washing machine at his home to wash clothes at 10 am. At 10 am a notification message is sent to user's portable smart device through the global internet network that the washing machine has started. As programmed, the washing machine starts to fill water. Before the water level could reach the predefined set level for washing clothes, the pipes run dry due to water shortage. The washing machine keeps attempting to fill the water for nearly ten to fifteen minutes but the task could not be completed successfully. A notification message is sent to user's portable smart device that the water could not be filled up to optimum level for washing clothes. Do you still want to wash clothes in the available water? The user will send a decision 'Yes' or 'No' and the washing machine will either continue or stop depending upon the decision received.

1. Adaptive decision making using artificial intelligence and big data:

This scenario depicts an artificial intelligence based agent that will make the decisions for the user depending upon the collected history database.

a. In the above mentioned use case I, the intelligent agent will create a history database as shown in Table 1.

This database is created for future reference. The visitor's image, data and time stamp and decision made by the user are saved in the database. Additionally, the user can feed data in the system regarding the identity of the visitor in case of regular visitors such as family members etc. The intelligent agent will study this database and by using various decision making algorithms, it will save the preferred decision for each visitor.

TABLE1: VISITOR HISTORY AND DECISION DATABASE

Visitor's image	Visitor's identity	Date and time	Decision made	Preferred decision
	Sister - Anjali	05.05.2016	Yes	Yes
		19.04.2016	Yes	
		24.02.2016	Yes	
		01.02.2016	Yes	
	Unnamed	17.05.2016	Yes	No
		04.03.2016	No	
		03.02.2016	No	
		12.01.2016	No	
	Colleague - Rahul	16.04.2016	No	Null
		14.03.2016	Yes	
		09.01.2016	No	
		29.11.2015	Yes	

In future, if 'Sister – Anjali' comes at the door, depending upon the past decision database and preferred decision, the intelligent agent will automatically open the door and a notification will pop up on the smart TV that 'Sister – Anjali' is at door and the door has been opened, along with her image captured by camera at the door.

In case of equally probable decisions of 'Yes' and 'No' for a particular visitor, like Colleague – Rahul' the intelligent agent will save the preferred decision as 'Null' and ask the inhabitant for a decision each time.

Likewise for any new visitors and unidentified visitors, the decision has to be made by the inhabitant as explained above.

Since opening of main door for visitors is also a case of safety and security, the inhabitants may choose to disable the intelligent adaptive decision making system and personally give the decision each time.

b. In the above mentioned use case II, the intelligent agent will create a history database as shown in Table 2.

This database is created for future reference. The message/ error, its details, remarks, the decision required and the decision made by the user are saved in the database. The intelligent agent will study this database

TABLE 2: WASHING MACHINE HISTORY AND DECISION DATABASE					
Message / Error	**Details**	**Remark**	**Decision**	**Decision made**	**Preferred decision**
Insufficient water	Water level - 1 lts.	Less than minimum threshold	Continue washing?	No	Continue washing when water level is 4 lts. Minimum
Insufficient water	Water level - 2 lts.	Less than optimum threshold	Continue washing?	No	
Insufficient water	Water level - 4 lts.	Less than optimum threshold	Continue washing?	Yes	
Insufficient water	Water level - 5 lts.	Less than optimum threshold	Continue washing?	Yes	
Fluctuating voltage	Low voltage	Lower than minimum threshold	Switch to inverter?	Yes	Switch to inverter when voltage is lower than minimum threshold and higher than maximum threshold
Fluctuating voltage	Low voltage	Lower than optimum threshold	Switch to inverter?	No	
Fluctuating voltage	High voltage	Higher than optimum threshold	Switch to inverter?	No	
Fluctuating voltage	High voltage	Higher than maximum threshold	Switch to inverter?	Yes	

and by using various decision making algorithms, it will generate a condition based preferred decision for each message/error case.

In future, if the water level is found to higher than 4 lts., the intelligent agent will decide to continue washing and a notification will be sent to the user's smart device regarding the error and the decision made. The user may still choose to stop washing and send his decision through his smart device. However, the system will not wait for the user's decision and the decision made by the intelligent agent will be deemed final unless interrupted by the user. Similarly if the voltage level is found to be higher than maximum, the intelligent agent will automatically decide to stop washing based on past decisions' history. The user may still choose to continue washing and send this decision through his smart device. However, the system will not wait for the user's decision and the decision made by the intelligent agent will be deemed final unless interrupted by the user.

Mentioned above are a few examples of adaptive decision making by intelligent agent, based on big data stored in cloud, depicting past user behaviour for various use cases. All the smart devices send this user based decisions to the cloud on day to day basis to create a reference database of big data for future decisions by the adaptive intelligent agent. This means that the smart home system will learn the behaviour of its inhabitants and it will also behave accordingly as the time progresses. The behaviour of smart home system of two different homes will not be the same after a few years even if it was the same system that was set up initially.

'Figure 3' depicts the large scale implementation of smart automation concept to engulf various smart homes, offices, localities, cities, states etc. As shown in figure various smart homes create a smart locality. Many such smart localities along with smart offices, smart schools, smart shopping malls, smart hospitals, smart airports, smart amusement parks, smart restaurants etc. connected in large scale local area network form a smart city. Many such smart cities connected through a complex web of wide area network create a smart state and all such smart states connected to a common cloud server on a global scale web based network create a smart country.

The day to day data from the various smart devices used in smart homes, smart offices etc. are maintained in a huge cloud. All this big data collected over time creates a well-managed easy to access reference database at home level, locality level, city level, state level and country level.

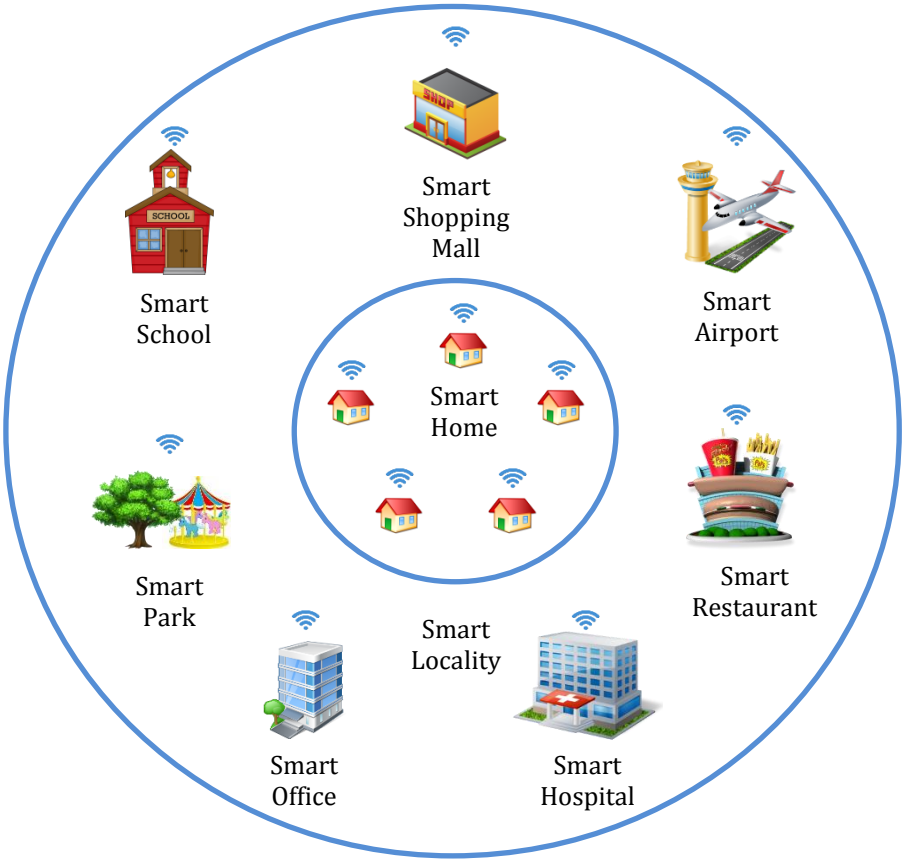

Figure 3 : Smart City

III. CONCLUSION

This paper, presents what a Smart Home is, which components are necessary to make a Smart Home. Firstly, a concept regarding indoor environment and smart home automation using Smart TV as the central monitoring and man to in presented machine interface unit. Second, the outdoor environment and functioning of smart home system when the user is outdoors is described. In this, the hand held smart devices such as smart phones, tablets, smart wearables etc. act as the central monitoring interface for monitoring and control of smart home appliances. Next, this paper illustrates the idea of artificial intelligence based decision making system which decides the controlling actions for various smart home appliances. These decisions are based on extensive study of past behavior of inhabitants which are stored in a cloud to form a reference database. This big data is applied to various decision making algorithms and the decisions thereby made by the intelligent agent are used proactively by the smart systems, thereby eliminating the need for user interface. Lastly, the concept of smart home to encompass a smart locality, smart city, smart state and thereby a smart nation at large is elaborated.

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