International Journal of Broadband Cellular Communication
Vol. 1: Issue 1
www.journalspub.com

Home Automation Energy Efficient System

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Abstract

In automation systems, the use of wireless technologies offers attractive profits, although introducing a numeral of new technological challenges. The paper discusses these features for home and building automation applications. In this paper we study mobile home automation, a field that emerges from an integration of mobile application platforms and home automation technologies. Related standards are gauged. In this paper the KNX/EIB is extended through wireless technology over IEEE 802.15.4. The seamless extension is carried out by the design that follows the properties of the KNX/EIB wired medium via wireless communication. Besides, it is geared in the direction of zero-configuration and upkeeps the informal incorporation of protocol security.

***Keywords**: KNX/EIB, Zero Configuration, Automation System, IEEE, GSM*

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INTRODUCTION

The idea of smart home is an evolving concern to the recent technology reliant on society. Distant control technologies are broadly utilized for controlling household electronic appliances without going up to them. Computer Monitored household appliances can be proved a solution. Though, it cannot accomplish the present demand which is to regulate them from remote places. The benefits of cellular communications for example GSM technology is a impending key for such type of remote controlling activities[1]. For the enhancement of standard of living everywhere in the house, home automation systems is a result of attempt and were accomplished by the revolution in the region of integrated circuits and microprocessors. These systems provide the consumers with increased security and safety, economic benefit through energy control, and convenience by giving them control over every piece of domestic electrical equipment in the house[2]. Literature revels that the main objective for using GSM(Global System for Mobile Communication) network for the communication between the home and the users(and vice versa) is its wide spread coverage which makes the whole system online for almost all the time[3]. For convenience and safety of occupants home security system is needed. Along with this, it is obligatory design and application of a low cost, low power consumption, and GSM/GPRS (Global System for Mobile Communication /General Packet Radio Service) based wireless home security system.

The wireless home network comprises a GSM/GPRS gateway and three types of wireless security sensor nodes which are door security nodes, infrared security nodes and fire alarm nodes. The nodes are easy installing. The system can retort hastily to alarm incidents and has a user friendly interface containing a LCD (Liquid Crystal Display) and a capacitive sensor keyboard. The wireless communication protocol amid the gateway and the nodes is appropriate for other home appliances. Additionally, few more methods are engaged to certify the security of system information[4]. With state of the

art technology it is possible to achieve home automation with remote control and monitoring via GSM phones with low cost, less power consumption and good performance[5]. In this paper, we have considered and developed a typical and modest Home Automation System using (HAS). GSM technology is used to regulate electrical devices from a remote location at home by an easy mobile phone.

GLOBAL SYSTEM FOR MOBILE COMMUNICATIONS (GSM)

GSM

The most widespread standard for mobile phones is the Global System for Mobile Communications (GSM). The important benefits of GSM systems are advanced digital voice quality and low cost options for making calls such as text messaging. The advantage for network operators has been the ability to deploy equipment from different vendors because the open standard allows easy inter-operability. The architecture of the GSM network is briefly described below[6]. A GSM network is composed of several functional entities, whose functions and interfaces are specified. The layout of a generic GSM network is shown Figure 1. The GSM network is distributed into three broad categories. The subscriber carries the Mobile Station[7-8]. The Base Station Subsystem controls the radio link with the Mobile Station. The Network Subsystem, the main part of which is the Mobile Services Switching Centre (MSC), performs the switching of calls between the mobile users, and between mobile and fixed MSC also handles the mobility management operations. The Operations and Maintenance Centre, which supervises the correct operation and setup of the network is not shown. The Mobile Station and the Base Station Subsystem communicate across the Urn interface, also called as the air interface or radio link. The Base Station Subsystem communicates with the Mobile services Switching Centre across the A interface[9-10].The architecture of GSM is shown in Figure1

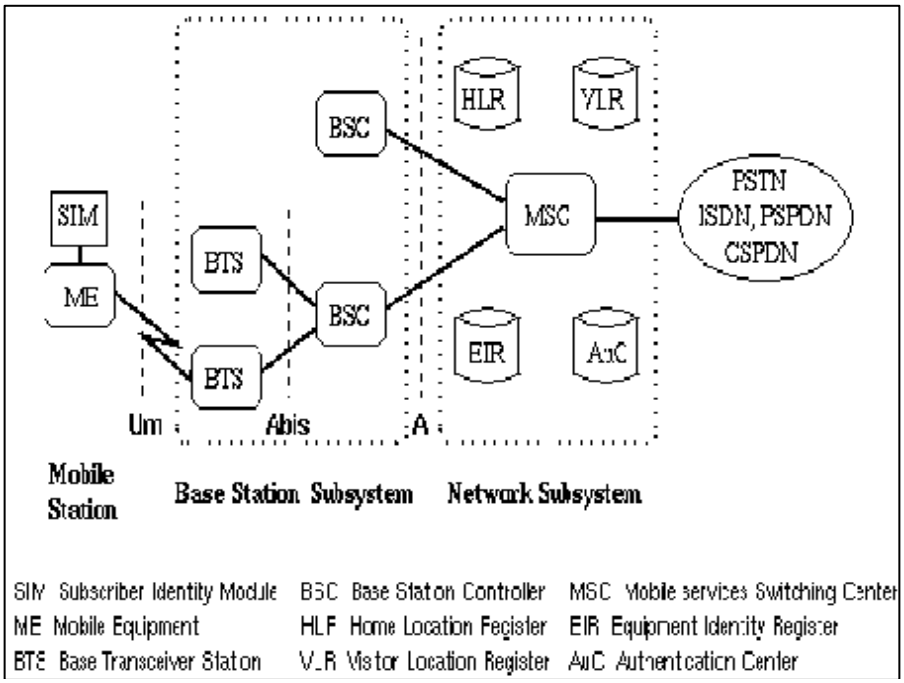

Fig. 1: *Architecture of GSM*

For operation of the mobile part, an communicating software has been established in J2ME[11,12] platform as shown in Figure 2. Any mobile phone that supports Java can use this software through this user can co-operate with the house easily by choosing the right

commands from the menus. An example is demonstrated in Figure 2.

Fig .2: *Step By Step Usage of the Mobile Control Program.*

The details of the "Lock the Door" command are as follows:

1. An SMS message is created which has a content of "Lock the Door" command in an encrypted way.
2. This message is sent to the GSM modem which is connected to the server.
3. The main control program running on the server decrypts reads and interprets the message content.
4. An appropriate command is sent to the door lock system via the transceiver node and the door is locked.
5. A feedback SMS message (e.g. "The Main Door is Locked at 04.07.2006 at 11:58.") is sent back to the user.

Internet

In order to accomplish communication with the home automation network remotely, another option is use of the Internet. To realise this, a web server is constructed to take requirements from remote clients. The clients can send requests to the home appliances and the home appliances can send their status to be displayed for the remote client through the server.

Speech

A speech recognition program is on paper to regulate the house through a human voice. In our system, we found that the Dynamic Time Warping (DTW) algorithm[13-17] to be utmost appropriate for our application. The benefits of using DTW are its high performance, simplicity, and adaptability to our system and it is used broadly in speech recognition. To use DTW in speech recognition, first, the input data (user command word) has to be converted into a template. Then, this input template is compared with the speech templates stored in the database by the use of DTW. The DTW algorithm outputs distances between the input and each of the database templates. The template which gives the lowest distance is the recognized word[18].

HOME AUTOMATION USING THE GSM (PROTO-TYPE DESIGN)

The design of the Home Automation proto-type using GSM is shown in Figure 3. The aim is to control electrical devices at home, from a remote location by a simple mobile phone. This is achieved by sending an SMS to a receiver present at home which is in turn connected to a hardware kit.

The SMS then received by the receiver is transmitted to the microcontroller (present in the kit) using a serial port. The microcontroller then reads the message received and controls the appropriate device. To achieve this, Microcontroller (AT90S8515) is coded with a program (written in assembly language).

This program is stored in the flash memory which is in-built into the micro controller. The microcontroller also has I/O ports which are used to control the state of the output devices. The devices are connected to the microcontroller through relay circuits so that the mother board is

protected from strong reverse currents in case high voltage appliances are used. The following components constitute the hardware kit used for home automation. A G.S.M. cell phone, a G.S.M. modem (transmitter/receiver), AT90S8515 microcontroller, Relay Circuits, Reset Circuit, Power Circuit, Max 232 Chip, Serial port and a Serial Bus. The Microcontroller AT90S8515: The AT90S8515 is a low-power CMOS 8-bit microcontroller based on the A VR RISC architecture. By executing powerful instructions in a single clock cycle, the A T90S8515 achieves throughputs approaching 1 MIPS per MHz, allowing the system designed to optimize power consumption versus processing speed. User commands are transported to the home automation server (which is done by a PC) through one of these three substitutes. In the home automation server the incoming commands are handled, then digitized and sent to the appropriate unit to be processed. In each unit there are separate low-cost microcontrollers to receive the commands from the transceiver and apply these to the appliances they are attached to.

These devices have also the capability of sending their status back to the transceiver node which is connected to the home automation server thus they can be monitored in real-time. After receiving the feedbacks from the appliance nodes, the home automation server interprets them and performs the necessary tasks.

BACK-END ARCHITECTURE AND CONCEPTS

Figure 4 shows an overview of the overall architecture of the proposed service, including a mobile client 1, a back-end installed in the user's house 2-5, and various options to integrate telephony or network service providers 6. Based on this architecture we identified three scenarios. In the end, the type of realization largely depends on the prevailing conditions and the requirements of the users. If there is no home server or residential gateway, the provider has to find other channels to access and control the devices installed in the customer's house. For many telephony installations this is straight forward as they can often be configured directly by the telephone operator.

Other devices come with a built-in network interface including a minimal web-server or other interfaces such as a GSM module. With increasing complexity of features offered by the appliances, it makes sense to leave the installation and configuration to a specialist.

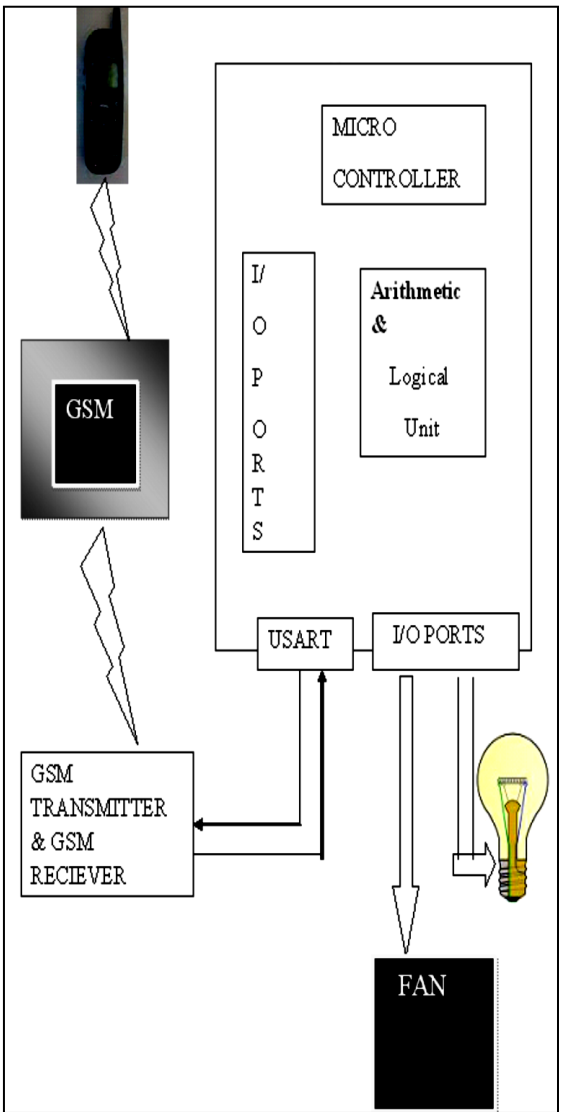

Fig. 3: *Block Diagram of Home Automation.*

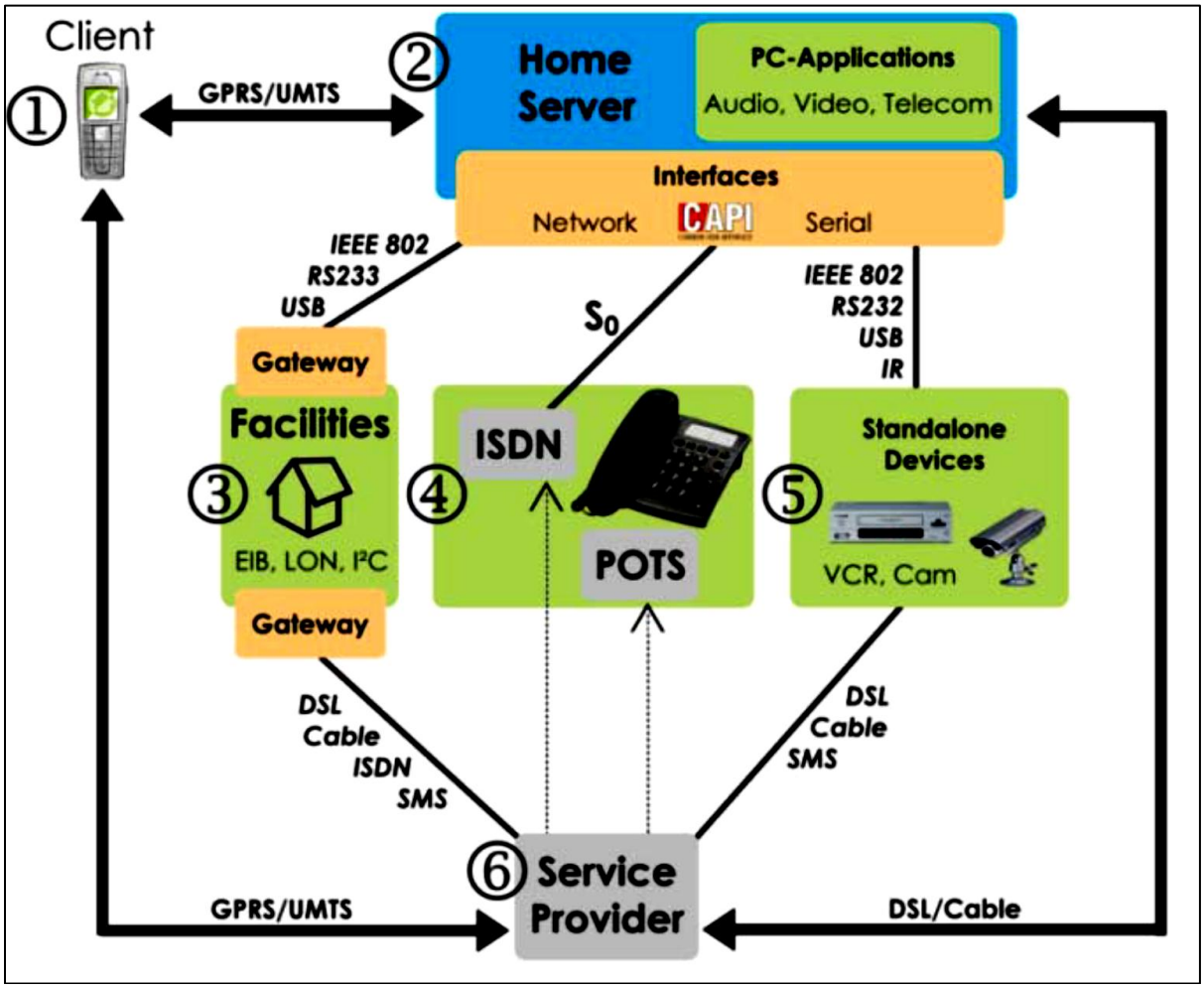

Fig. 4: *Integration of Back-End Systems.*

Similar to the communication scenarios shown in, there are different locations within the architecture where w**e** can implement intelligent control, such as the processing of automation rules. For instance, such control logic could be placed in the home server, in the systems of a service provider, implemented in the controlled devices themselves or distributed over the whole system.

THE PROTOTYPE FROM THE USERS

Perspective

The mobile application which provides the UI for our proposed service was developed according to the MIDP (Mobile Information Device Profile), which is the most widespread open software platform for mobile devices. When using the high-level API of MIDP, the form of presentation of interaction elements, such as menus and commands, is largely left to the device and its operating system. This means our custom-developed application is consistent with the native interface experience the user is accustomed to from applications which come built-in or preinstalled with the device. In addition, using the high-level API makes the application independent of particular devices[19-21].

When the user navigates to a leaf of the tree hierarchy, then each menu item represents a device module. The UI of a device module consists of selection and input fields and, hence, is clearly distinguishable from the navigation screens. A device module fulfils two

functions. Firstly, it displays the current state of a device, showing for instance the current position of the window blinds in the living room. Secondly, it allows the specification of a desired target state, for example by entering that the blinds should be half closed. For our prototype we developed some device modules for different tasks as shown in Table 1 which we will discuss in the following sections.

Table 1: *Overview of Device Modules.*

Function	Application Sample	Device Name
Switching (on/off)	Lighting, windows, doors, alarms, profiles	SwitchDevice
Range	Dimmer, window blinds	AnalogDevice, BlindDevice
Telephone	ISDN	ISDNDevice
Imaging	Security camera	ImageDevice

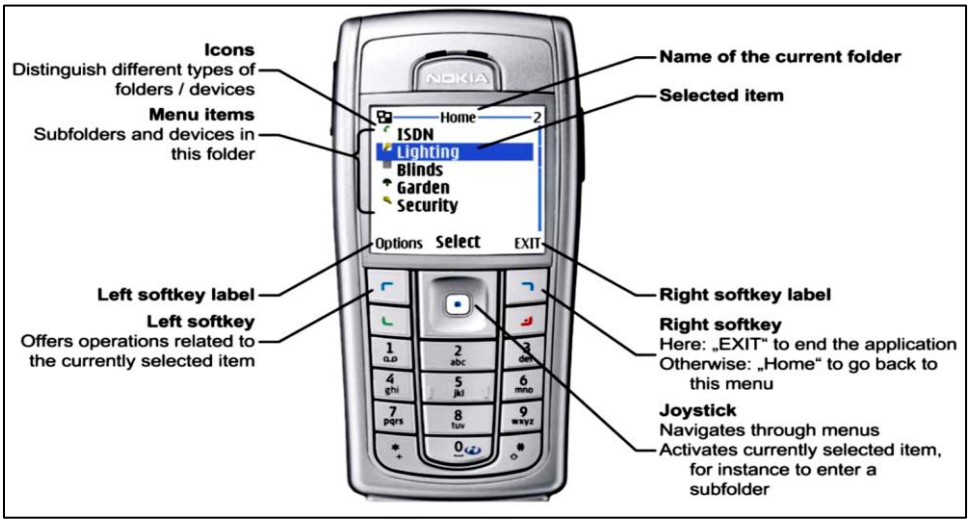

Fig. 5: *The User Interface Showing the Main Menu.*

Coding

The algorithm for Home Automation using G.S.M (Programming the Hardware Kit) is given below:

Step 1: The Pins of port c are defined as the I/O ports. As only

3 devices are being used in our case just the pins 0, 1, 2 are cleared.

Step 2: The USART is initialized to work in both transmission and reception modes. This is done by Moving $86 in UCSRC and setting the baud rate at customary value of 12 ($OC) and Setting the bits TXEN and RXEN of UCSRB. Also baud rate is doubled for better performance. (By setting the bit U2X of UCSRA)

Step 3: The stack pointer is set to the end of SRAM locations, just in case it is required.

Step 4: The AT Commands are written into the flash memory which are to be retrieved later.

Step 5: The first AT command (AT+CMGF=I) is retrieved from flash memory and transmitted to the G.S.M. modem. This code enables the microcontroller to detect the G.S.M. modem.

Step 6: The Microcontroller Awaits for a confirmation code (OK) to proceed further. If an error code (OR) is received, Start over from Step 1
Step 7: The second AT command (AT+CNMI=2, 2, 0, 0, 0) is
Retrieved from flash memory and transmitted to the G.S.M. modem. This code enables the microcontroller to set the baud rate of the G.S.M. modem.
Step 8: The Microcontroller Awaits for a confirmation code
(OK) to proceed further. If an error code (OR) is received, Start over from Step 1
Step 9: The third AT command (AT+CMGR=I) is retrieved from flash memory and transmitted to the G.S.M. modem. This code enables the microcontroller to continuously interact with the G.S.M. modem.
Step 10: Retrieve Data from the Modem.
Step 11: If a confirmation code (+CMT) is received by it (which signifies a sms received by the modem), the micro controller can receive the SMS from the Modem. Else go to
Step 12: Read the next Byte of the message.
Step 13: If this byte is equal to $13 (ASCII value of ENTER key) then proceed to next step Else go to Step 12.
Step 14: Initialize SRAM. i.e. set the X pair registers to $0100 (which is an address Location in SRAM.
Step 15: Read the next byte from the SMS message and write it into next byte SRAM.
Step 16: Check if this byte is equal to $13 (ASCII value of ENTER key)
Step 17: If it is equal go to Step 18 ELSE go to step I5
Step 18: The SRAM pointer (X pair register) is set back to its original value
Step 19: The first byte is stored in a register named dvc, which signifies the code of the device to be controlled.
Step 20: The second byte is stored in a register named status, which signifies whether the specified device is to be turned on (1) or off (O). And the SRAM pointer is reset again
Step 21: If dvc not equal to '1' (or ASCII $31) Go to Step 25
Step 22: If Status equals '1' (or ASCII $31) Set pin 0 of port C, go to Step 12.
Step 23: If Status equals '0' (or ASCII $30) Clear pin 0 of port
C, go to Step 12.
Step 24: Go to Step 10
Step 25: If dvc not equal to '2' (or ASCII $32) Go to Step 29
Step 26: If Status equals '1' (or ASCII $31) Set pin 1 of port C, go to Step 12
Step 27: If Status equals '0' (or ASCII $30) Clear pin 1 of port C, go to Step 12
Step 28: Go to Step 10
Step 29: If dvc not equal to '3' (or ASCII $33) Go to Step 33
Step 30: If Status equals '1 ' (or ASCII $31) Set pin 2 of port C, go to Step 12
Step 31: If Status equals '0' (or ASCII $30) Clear pin 2 of port C, go to Step 12
Step 32: Go to Step 10
Step 33: If dvc not equal to '4 ' (or ASCII $32) Go to Step 10
Step 34: If Status equals ' 1 ' (or ASCII $31) Set pins 0, 1, 2 of
Port C, go to Step l2
Step 35: If Status equals '0' (or ASCII $30) Clear pins 0, 1, 2 of
Port C, go to Step 12
Step 36: Go to Step 10
Step 37: End process.

Testing the code

We have so far discussed the basic design and working of the proposed Home Automation System using GSM. But any project is not complete without exhaustive testing and debugging, and ours is not any different. The input here in our project, is the SMS that is received by the GSM modem (which was sent by a remote user using a cell phone). The SMS, that is received, is then stored in the SRAM via USART. This is done by the calling a sub-routine "read-msg". Assuming that the SMS sent has only two characters, the first

one are stored in a register called 'dvc' and the second one in another register called 'status'. If the SMS sent has more than 2 bytes of data, then only the last two bytes are taken into consideration while implementing the code. Now depending on the SMS sent, the microcontroller controls the appropriate device by reading the values present in dvc and status registers, if the dvc register is 1, the first device is controlled if the dvc register is 2, the second device is controlled if the dvc register is 3, the third device is controlled if the dvc register is 4, the all the devices are controlled Irrespective of the device, if the status register is 0, the device/devices is/are made to turn OFF. And turn on if the status register is 1.Hence in this way, an SMS that is sent, is stored in intermediate memory locations (registers) and in turn are used to control the actual devices. The practical implementation is shown in Figure 3. The table in the following page depicts the I/O States for various inputs that are given and a result that is achieved. If we would switch to local usage (or offer it as an additional mode), i.e. controlling devices from within the house, we would clearly have to consider scenarios with visual contact between the user and the controlled physical device; for example, it could make sense to remove the additional step necessary to execute a command (as the status is then obvious). Hence, future versions of the mobile front-end should be context sensitive and take the current situation and location of the user into account and adapt accordingly. For a manufacturer who wants to sell his devices and home appliances, having (local or mobile) controllability could be the decisive difference to the competitor. Interestingly a lot of appliances already come with some interface which enables remote control. The main challenge is the technical integration and design of a consistent and usable interface across all devices.

Table 2: *Testing the Code Home Automation System Using GSM.*

Input Value (SMS Sent)	**Intermediate Values**		**Output Values**		
	Device register (dvc)	**Status Register (status)**	**Device1**	**Device2**	**Device3**
10	1	0	Off	NC	NC
11	1	1	On	NC	NC
20	2	0	NC	Off	NC
21	2	1	NC	On	NC
30	3	0	NC	NC	Off
31	3	1	NC	NC	On
40	4	0	Off	Off	Off
41	4	1	On	On	On
00	0	0	NC	NC	NC
110	1	0	Off	NC	NC
011	1	1	On	NC	NC
1011	1	1	On	NC	NC
1110	1	0	Off	NC	NC

CONCLUSION

Wireless sensor and actuator networks are becoming a more and more attractive alternative to wired solutions in the HBA domain. A number of technologies that fulfil the specific requirements of this class of wireless networks have reached commercial status, with none of them clearly in the lead. In this paper, we presented the requirements of home automation systems and evaluated how current Internet technology compares to the capabilities of traditional standards. In the present work, we have operated the designed home automation system to control electrical devices using an embedded circuit located remotely, via an SMS. This however is only a prototype

into the technology that has far reaching consequences. Further the format for SMS record and its relevant fields are to be well defined. In future we would like to extend this work for more additional and minute control features of the home appliances by including the new evolving technologies. Integrating with newer technologies would enable us to have far greater improvements in control and automation technology than what we possess now.

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