Appliance Controlling Using IPAC

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Abstract— **Today, because of the advancements in the computer and electronic sciences everything is going to be automated. In fact, some devices or infrastructures are capable to change the behavior according to situations; these devices are called Smart Devices or Smart Infrastructures. This system is designed to meet the requirement of appliance control in automated or smart infrastructures which includes home, offices, industries or may be sophisticated vehicles like aero planes. Appliance control basically refers the process or technique of controlling a device (including complete machines, mechanical devices, electronic devices, electrical devices etc.) using some comfortable, luxurious and reliable means based on some automation methods.**

Even a number of standards have been defined for wired and wireless controlling and automation of home appliances including Bluetooth, UPnP, X10 etc, this field is still in developing state. In this document we have proposed an appliance controlling system, named as Internet and PC Based Appliance Control (IPAC), using concepts of parallel port programming.

IPAC is designed to control a device from PC and from Internet, and can be applied in any smart infrastructure to automate the device and can work with almost every type of automation method either it is wired (e.g. LAN) or wireless (e.g. Bluetooth). This system can be applied in designing smart homes, secure homes, centralized device controlling system, Bluetooth control system, WAP control system.

Index Terms— **Home Networking, Smart Homes, Secure Homes, UpnP Devices, X10 protocol, WAP Devices, IR Devices, Bluetooth Device**

I. Introduction

Why Home Networking is not so common?

There are several key problems associated with creation of home networked. Some of them are discussed below:

1. **Consumers are unaware of the benefits of the networked or smart home**

At this point in time, most home networks are used to connect PCs for tasks such as printing and shared Internet connectivity. Consumers still do not see the other potential benefits, such as on demand video, enhanced voice communications, and remote security control. Because of this lack of awareness, the demand for home networking products is still minimal

2. **Running additional wires through homes is costly and a hassle for consumers.**

In order to counteract this problem, the industry is developing wireless and other standards which will allow users to interconnect information devices without installation of new wires.

3. **Technology is too complex for most household users.**

Unlike other home electronics, the technology behind home networking is not intuitive and requires more technological expertise than the average household possesses.

4. **Lack of incentive for Internet providers to push networking technology.**

The home providers of broadband Internet (i.e., cable Internet providers and DSL providers) are currently surviving well enough on the strength of their connectivity service sales and do not need to push additional products. In addition, these communications carriers are too busy building network infrastructures and too swamped with customers demanding their high-speed access to spend time worrying about home networking.

5. **Potential privacy issues.**

Because the networked home would enable information to flow out of the home in ways that households are not accustomed to, privacy could be compromised. Additionally, the new technology behind information appliances and smart homes could introduce new security holes not before encountered.

6. **Interface issues.**

In smart home test beds, control interfaces have ranged from touch-screen devices to PDAs. Data on the effectiveness of the various interfaces seems scarce.

So, these were the some issues regarding the popularity of home networking. Now we shift our attention towards the home networking.

Imagine a completely networked home, in which every appliance can be remotely managed[14] from anywhere on the Internet with a simple Web browser[1][12][17][19]. The general goal of the automatic-home movement is to use networking technology to integrate the devices, appliances and

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services found in homes so that the entire domestic living space can be controlled centrally or remotely[16].
Following is a snap displaying a typical automated home. [2]

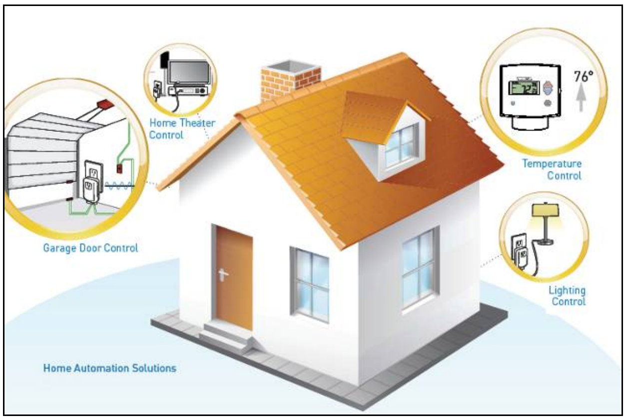

Fig 1 A typical Automated Home System [2]

Home wiring, the advance home developers are installing, typically adds several thousand dollars to the cost of a new home, and it is usually Ethernet or coaxial cable -- or some combination of both -- with other technologies in the mix. The network is being designed to make possible remote operation of appliances connected to the network.

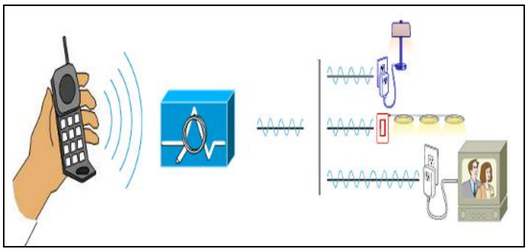

Fig 2 Already available extra wiring for device controlling in Smart Infrastructure

Other technology developers are generating buzz in this area as well. In June 2008, at the Bluetooth World Congress, vendors were touting the expansion of wireless networking technology into everything from air conditioners to cable television boxes."Bluetooth was originally developed as a wireless technology -- primarily for short-range exchange of data between laptops, PDAs and mobile phones," said Nick Hun, managing director at TDK Systems, whose Blu2i adapters are being used in such home applications. But, he noted, when early adapters were released to industrial engineers at the end of 2002 demand soon proved overwhelming.

Secure home
It is a highly cute smart home environment in which every device is automated with maintaining sufficient security. E.g. In the following figure home door is locked by software lock (by using a password) and can be opened only by software methods.

FIG 3 A SOFTWARE LOCK IN SECURE HOME ENVIRONMENT[2]

II. PRELIMINARIES

Summarized from [3][4][5][20][22] there are following technologies used to create a networking environment where home appliances work as a network nodes.

Direct Cable
In this devices are connected through serial, parallel or USB port. Generally desktop software is also supplied for making the device management a comfortable and easy task.

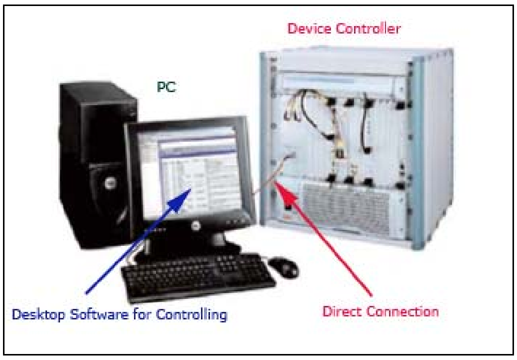

Fig 4 Direct Cable Connection Method of Home Networking[8]

Bluetooth
This is cross device wireless standard created for cell phones and PDAs, and can link up to eight devices.

Phone Line
Data shares the phone line frequency and requires phone jack every where a networked device is located. Also requires special cards and drivers.

Ethernet
Connections are made using hub system and network cards in each device. It requires driver installation and wiring. There are more expensive and chances of hardware conflicts are there.

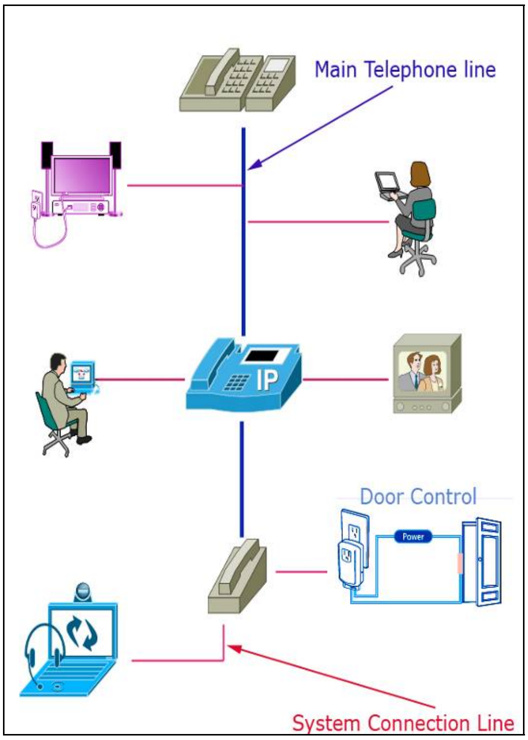

Fig 5 Use of telephone media for controlling home devices

Radio Free Network
Uses radio frequency waves to transmit data through walls and doors up to 800 feet, requires network card, can have some interference.

AC Network
Uses power lines and wiring already within home to connect parallel port to adapter in outlet. It is difficult to set up, slow networking, problems with interference from other devices and is also expensive [4].

Related Work
At 2Wire's R&D laboratory, researchers are currently developing [2009] wireless applications to control lighting and home security devices, Software and other IT companies are also not lagging behind in this advancement. Following figure shows a desktop PC Controlled automated home[2] from INSTEON.

Fig 6 Home controlling desktop software from INSTEON [2]

Related Technologies
UPnP(Universal Plug and Play Devices) UPnP technology is a distributed, open networking architecture that employs TCP/IP and other Internet technologies to enable seamless proximity networking, in addition to control and data transfer among networked devices in the home, office, and public spaces. Intel software for UPnP technology helps hardware designers and software developers build easy connectivity into common electronic devices [4] [6] [9].

X-10 Devices
X10 [7][21] is a communication language protocol that allows compatible products to talk to each other via existing 110 v electrical wiring in the home. Upto 256 different addresses are available and each device you can use usually requires a unique address.

Infra Red Device
IR data transmission is also employed in short-range communication among computer peripherals and personal assistance. Remote controls and IrDA devices use infrared light-emitting diodes (LEDS) to emit infrared radiation which is focused by a plastic lens into a narrow beam.

Bluetooth Devices [10][13]
It is a small form factor, low cost technology that provides low-power, short range (up to 10 m) links between mobile PCs, cell phones, printers or other devices arranged in ad hoc 'piconets' of up to 8 devices. For promoting interoperability between different Bluetooth devices Bluetooth Special Interest Group (SIG) has produced over 400 pages of profiles (published as volume 2 of the version 1.1 specifications). Bluetooth is a simpler technology than any other popular IEEE 802.1 1 standard for wireless local area networks. By 'simpler' is meant here fewer and/or less demanding RF semiconductor chips, fewer passive components and less complex digital base band chips.

III. Design of IPAC

Organization of IPAC

Figure[7] shows the complete organization structure of IPAC. In the figure only four devices are shown but using IPAC system we can control up to 128 devices (Why and How, This will be clear in the next section).

Functions of Different Units of IPAC

Web Interface (WI)
This is the interface available over the internet and appears on the browsers screen. Its function is to just provide an interface to user over the net through web browser so that user can access the appliance at the distant place (home or office).
User Interface (UI)

This is the WI counterpart for local users. This is the interface that is used by the users who own the server.

Fig. 7 Organization of IPAC

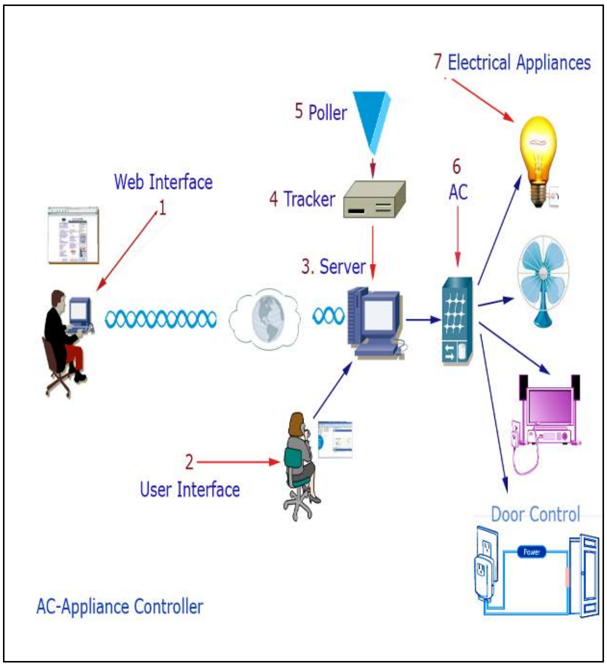

Fig. 7 Organization of IPAC

This is basically similar to INSTEON desktop[2] software and has aim of the device management a comfortable and easy task for user's point of view.

Server

This runs web-server so that the system can be accessed over the internet. Second important part of server is the database which stores the information about status of different devices.

Tracker

This system reads the status entries from database and generates proper control word to be PC port for generating proper signals. This is one of the most important parts of the system.

Control Word Format

For the proposed IPAC system an 8-bit control word will be used to control various home-appliances. Following figure shows the interpretation of different bits:

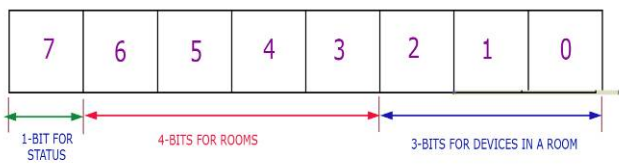

Fig.8 Control Word Format for proposed IPAC System

- 4-bits are used to address maximum of 16 rooms. (R-Field)
- 3-bits are used to address up to 8 devices within a single room. (D-Field)
- Single bit is used to set or reset (ON or OFF) the device selected by R-field and D-field bits. (SField)

In this structure we can address up to 128 devices because we are using 7-bits for addressing. All available 128 addresses (devices) are grouped into the 16 groups (rooms). Table1 shows these 16 groups and corresponding device address range.

Room Number	**Device Address Range**
1	0-7
2	8-15
3	16-23
4	24-31
5	32-39
6	40-47
7	48-55
8	56-63
9	64-71
10	72-79
11	80-87
12	88-95
13	96-103
14	104-111
15	112-119
16	120-127

Table:1 Grouping of 128 addresses into 16 different groups

Encoding

When converting the status record from database into control word we will first find the binary equivalent of room and device separately. From the control word structure it is clear that we have to left shift the room bits by three position to place them at the correct position. Then we can OR the 'room bits' and 'device bits' to determine the absolute address. .Similarly we have to 'OR' the absolute address with $(10000000)_2$ for making the status field '1' if the device is ON. Otherwise if the device is OFF there is no need to change the MSB because by default it is '0'. Moreover, one thing to be noted here is that the address of first room is '0000' but we say it 'Room 1" just to keep the room number in natural domain. Similar is the case with device address. So while decoding we will decrease the room number and device number by 1 prior to converting to binary equivalent. This is shown in the flow chart given below. While implementing the system in HLL it is important that in place of decreasing room-no by 1 then covering to binary and then shifting the room bits by 3-bits is just equivalent to multiplying room no by 8 after decreasing by 1. Similarly ORing with $(10000000)_2$ is equivalent to adding with 128 in decimal number system (only in this particular case).

Example

If room number is 5, device number is 8 and we want to set this device in ON state.

Binary Method

$(5-1)_{10}=(4)_{10}=(00000100)_2$ (room bits)
$(8-1)_{10}=(7)_{10}=(00000111)_2$ (device bits)
Status =1
Shifting room bit left by 3-position we get $(00100000)_2$
After ORing with device bits we get $(00100111)_2$
Since the status is ON so we have to OR with $(10000000)_2$
After ORing we get $(10100111)_2$ which is the required control word.

Denary Method

$(5-1)_{10}=(4)_{10}$ (corrected room no)
$(8-1)_{10}=(7)_{10}$ (corrected device no)
Status =1
Multiplying corrected room no by 8 we get 4X8=32
Adding with corrected device number we get 32+7=39
Since the status is ON so we have to add 128
After adding 128 we get $(167)_{10}$ which is the required control word.

Since binary equivalent of $(167)_{10}$ is $(10100111)_2$ we are at the right track. Following figure the complete process flowchart

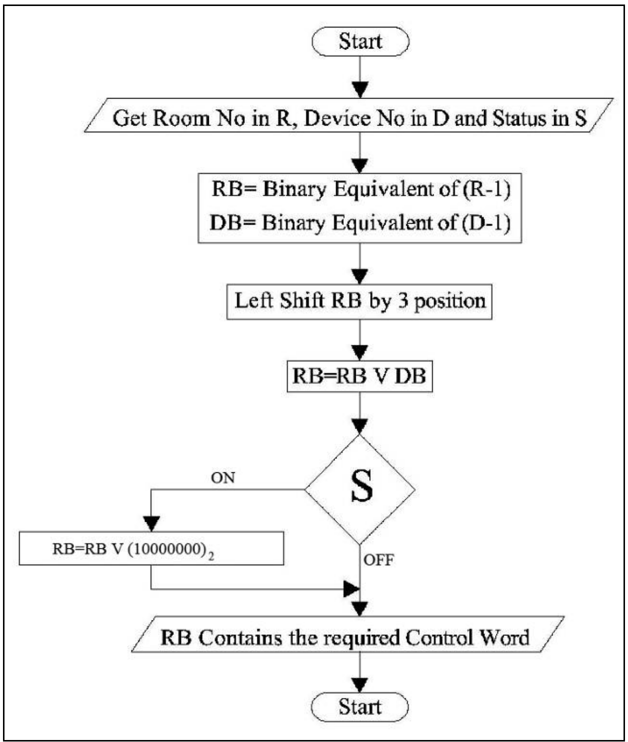

Fig 9: Flowchart for Encoding the room number, device number and their associated status into corresponding control word.

Poller

This part of IPAC remains in running state as long as your system (server) is ON (if you do not want to exit the IPAC service). This system, after a periodical time, executes the tracker so that if any changed had been made in the device status it should be propagate to corresponding device. Its function is to watch (poll) the database continuously so it is designated as Poller.

Appliance Controller (AC)

This part of IPAC, which is in the form of hardware, is responsible for interfacing the controlling PC (Server) with electrical devices. This part comprises of a 7X128 line decode that is used to address one out of 128 devices (7 input bits are taken from the 7 LSBs of parallel port). The MSB from the parallel port represents the data (status i.e. ON or OFF). With the addition of a relay of proper rating we can connect any device. The relay passes the AC signal as long as the device-status associated with this is ON. For maintaining the device continuously (even in power failure condition) we have to attach a memory element for storing the device status (We have used flip-flop) for that.

Electrical Appliances

These are home appliances which we are going to control. We will control the electrical device using this system but inclusion of transducer we can also control mechanical or electromechanical devices.

IV. Simulation

In Section-I, Section-II and Section-III we have laid out, designed our proposed system IPAC. In this section we will discuss a particular simulation of IPAC to analyze the results.

Simulation Requirements

Following table gives the detail requirements needed for running the simulation of IPAC :

Platform (Technology)	Purpose
Visual Basic 6.0	User Interface
HTML	Web Interface
ASP	For Controlling from Internet
Access 2000	Database Mappings
D-25 Type Parallel Port	Sending Control Signal to Appliance Controller
PC74HC154P	For Decoding Control Word
HD74LS04P	For Inverting Active Low Output of Decoder
12 LEDs	To display the Control Signals

Table.2 Simulation Requirements

Simulation Screen Shots

Following are some snaps taken from the simulation:

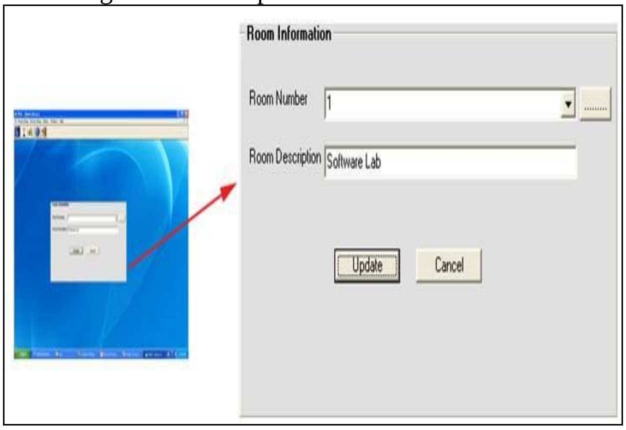

Fig 10 Status Changing by user interface

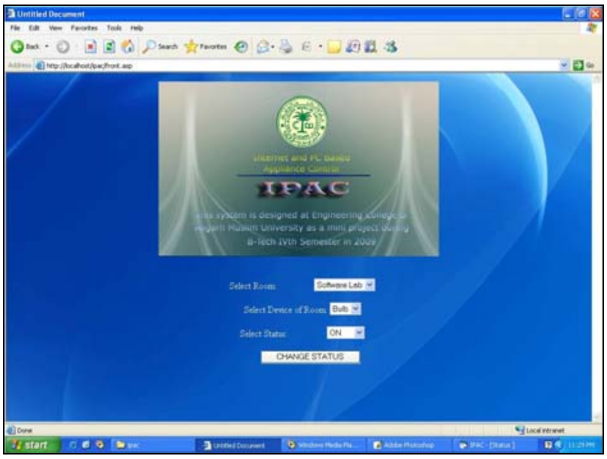

Fig 11 Status Changing by Web Interface

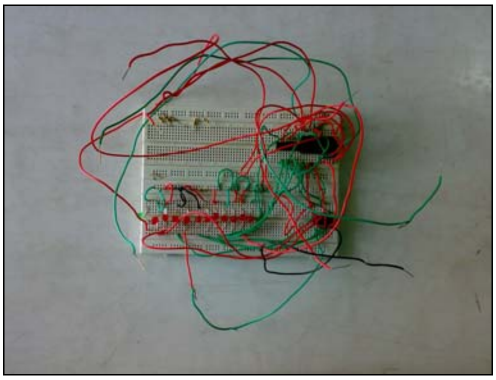

Fig 12 Appliance Controller for simulating controlling the LEDs

V. RESULT AND CONCLUSION

We have designed this system for controlling electrical devices but the design can be extended to control mechanical devices. We have simulated the system for controlling the LEDs and this is working properly. At last we will finish our system design discussion by concluding that using the *parallel programming concept of PC* is also a good tool for controlling home appliances.

The major benefit is the cost. Since here the major cost factor is the PC which is generally present in every intermediate level family. Other major cost distribution factor is the cost of the software but this is a very long time asset. The hardware part (i.e. Appliance Controller) is just a decoder and a set of flip-flops so it is hardly of app. $10 USD. The remaining is the relays and the cost of the relay depends on the rating which depends on the device to be control. Except relays all the cost-distribution factors are one-time and fixed investment and does not depends on the number of devices we are going to control.

VI. ACKNOWLEDGEMENT

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BIBLIOGRAPHY

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