IDEA GROUP PUBLISHING
701 E. Chocolate Avenue, Suite 200, Hershey PA 17033-1240, USA
Tel: 717/533-8845; Fax 717/533-8661; URL-http://www.idea-group.com
ITB12804

This paper appears in the book, *Emerging Trends and Challenges in Information Technology Management, Volume 1 and Volume 2* edited by Mehdi Khosrow-Pour © 2006, Idea Group Inc.

A Practical X10 Protocol Implementation Over a Cellular Network Using SMS

Joffre Pesantez, Escuela Superior Politécnica del Litoral, Km 30.5 Av. Perimetral, Ecuador

Hernán Córdova, Vrije Universiteit Brussel (Dept ELEC/TW), Pleinlaan 2, B-1050 Brussels, Belgium, & Escuela Superior Politécnica del Litoral, Km 30.5 Av. Perimetral, Ecuador, hcordova@vub.ac.be, hcordova@espol.edu.ec

ABSTRACT

This document presents the results of an X10 protocol implementation using the Short Messaging System (SMS) and shows how can they work together in order to provide a home system control for remote controlling electric home devices. The protocol X10 and the architecture of a SMS system are discussed yielding to a practical implementation for a home system control using the Nokia SDK Beta 3.0 development kit. Results gathered from the experiment are shown and conclusions are delivered emphasizing the advantages and drawbacks from the proposed implementation. Further, it is shown that the application runs independently of the cellular technology used on the network.

I. INTRODUCTION

Multimedia applications are becoming more popular. However, there are still applications that can be performed by using low data rate systems.

The monophasic power supply that feeds the breaker box is distributed among the different supplies that, at the same time, feed the light switches, current supplies and other devices. Therefore, the structured home cabling that physically interconnect the different electrical devices like lights, lamps, electro domestics, becomes a lesser home network. Making use of this network, it is possible to send control signals in order to obtain some control level over the home devices.

On the market, there already are modules that allow the control of electrical devices through the electric cabling and even more, to make use of a computer for controlling and supervising. However, there is still no a system that integrates an additional control component: the text messages through a cellular phone without taking care of the technology employed by the cellular network (and operator using a specific technology like CDMA or GSM).

The overall objective is to deploy a system that will allow the user to interact with its electrical home devices allowing to remotely turning on or off a specific device using any cellular phone that supports Short Messaging System (SMS). In order to achieve this goal, a software interface will be created and the Nokia SDK Beta 3.0 development kit will be employed.

In section II We start discussing how the short text message travels from the mobile that generates the message until the destination and which are the elements involved in between. Then, in section III, we go through the theory of transmission of X10 and how the elements of a home control system based on CM17A or CM11A can work together. In section IV, we continue explaining the necessary elements for connecting the local mobile to the personal computer: DLR-3P cable and the Nokia Connection Manager Software. In section V, in order to integrate the functionality of a mobile cellular phone and SMS, we use de Software Development Kit Beta 3.0 de Nokia that allow us developing our SMS-Control application putting these two technologies together.

Finally, section VI considers the advantages and drawbacks of X10, showing how it may affect our home control system, and the way that future developments can join WAP technology with X10 letting the home having on-line access for control or the interaction of a teleworker with his intranet.

II. SMS: CONCEPTS AND ARCHITECTURE

A. Short Messaging System (SMS).

This is a wireless service globally accepted that allows the send and reception of alphanumeric messages between 2 users of a cellular mobile network. Further, It is also possible to send emails, paging, et cetera. Typically, this message can not be greater than 160 alphanumeric characters excluding images and any sort of graphics. The SMS messages are supported by the GSM, TDMA, and CDMA networks. Since its acceptance into the GSM standard, it has also been included in other standards like the Nordic Mobile Telephone (NMT), Code Division Multiple Access (CDMA) and Personal Digital Cellular (PCD), the latter being used in Japan.

B. SMS Network Architecture

Basically, SMS architecture is conformed by the following elements:

- ESME (External Short Messaging Entities)
- SMSC (Short Message System Center)
- STP (Signal Transfer Point)
- HLR (Home Locator Register)
- VLR (Visitor Locator Register)
- MSC (Mobile Switching Center)
- Air Interface
- BS (Base Stations)

Figure 1. Basic Architecture of a SMS System

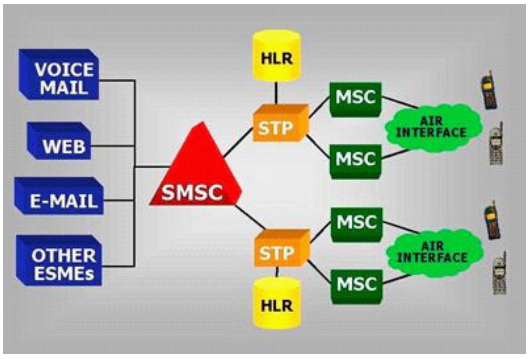


Figure 2. X10 Transmission Scheme

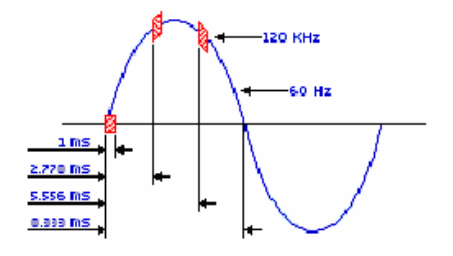
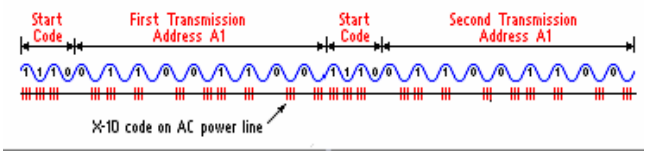


Figure 3. Complementary Bit Transmisión



III. PROTOCOL X10: CONCEPTS AND HOME CONTROL SYSTEM

A. X10 Protocol and Home Control Systems

X10 is a protocol that works over the electrical home network already installed, without the need of modifying the infrastructure of the electrical installation. The X10 transmitter devices send a low voltage level signal, previously encoded, that is superposed to the alternate power electrical signal (120 volts, 220 volts). Any X10 receptor device, connected to any power supply, will detect that signal.

However, only the receptor with the right identification, that is, with the same address going into the signal, will reply. This communication system can address up to 256 codes, configuring the code on each receiver or emitter such that the device may reply to it, for example, A-1 where A is the home code and 1 is the unity number. If, for instance, it is required that a set of lights reply to the same code, then, the same code has to be configured in all those receivers.

As it is shown in figure 2, each of the bits of the control word is sent 3 times during the power-signal half cycle. A logic ´1´ is represented by the presence of a sine-wave signal at frequency of 120 KHz; a logic ´0´ is represented by the absence of that signal. When the cross-zero detection of the power-supply signal is performed, the bit is sent, accordingly, which is superposed to the AC signal at 60 Hz.

In figure 3, the bit transmission is complementarily performed, that is, after sending a logic ‘1‘, a logic ‘0‘ is sent and vice versa, becoming in an useful technique to handle and identify errors in the frames.

B. Elements of a home control system based on X10

This kind of system is mainly conformed for the home electric network, a controller, a transceiver and the X10 receiver modules. The X10 protocol has 2 variants: CM17A and CM11A. The CM17A alternative is used for sending control words through the RF devices to the transceivers, which is a variant of the NEC IR protocol that is used when driving infrared controls. The CM11A is the commercial implementation of the X10 protocol itself, used for sending control words straight to the power line. In Annex A.1, there are the diagrams of these variants.

In both configurations we encounter the computer and the system controller besides the others X10 receiver devices. The different home devices are connected to the power supply lines through the X10 receivers. The main difference between these 2 configurations lies on the transceivers used by each.

In the CM17A, the computer sends the control words through the serial interfaces to the RF call firecracker, and these are received via wireless to the TM751 transceiver, which transforms the RF signals and put them into the electric power supply system. CM17A only allows X10 codes (sending), so that, the communication is unidirectional.

In the CM11A, a special transceiver is directly connected to the computer and adapts the codes sent by the computer directly to the power system without sending the signal to any other device. The CM11A transceivers do listen X10 signals that are on the system and they transfer them to the computer, that is, the communication is bidirectional.

IV. MOBILE INTERCONNECTION TO THE PC

A. PC and the Nokia Software Development Kit

The mobile interconnection occurs on 2 levels: Physic and Logic. The physical interconnection is performed through the DLR-3P Cable of Nokia, which is a proprietary cable that allows connecting some Nokia models to a computer. The communication between the mobile and the PC is based on the proprietary protocol of Nokia that allows the communication in full-duplex mode. However, the Nokia Connection Manager (NCM) has to be used in order to achieve a logic communication between two devices. This NCM allows the computer to send the FBUS codes.

B. The Nokia Software Development Kit (SDK) Beta 3.0

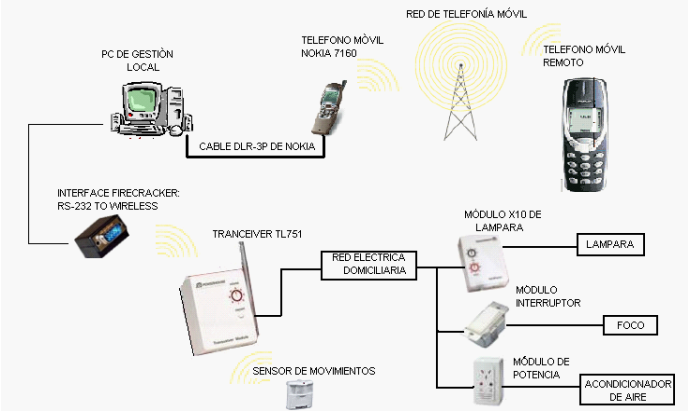
This is a set of tools that allows integrating the functions of the mobile device and the interaction with the computer with the program implementation developed in different languages. The SDK consists of a set of libraries, each having specific tasks related to the functionality of the mobile. All the libraries are implemented like Component Object Libraries) COM libraries, being this the name that Microsoft provides to its standard for the integration between the software components. A client application exploits these libraries through objects, also called type libraries in some contexts. A library of objects can be considered like a binary description of the library of components. Many environments can support these libraries, such as Visual Basic, Visual C++, Delphi, Visual J++, among others.

Each library in the Nokia SDK contains one or more functional entities called components. These software components can be reused and present their functionality through a set of interfaces well-defined. A client application creates an instance of the component, configure a reference to the desired interface and have access to the methods through this reference. An interface contains a set of features, methods and functions related to a specific functionality, grouped under only one denomination. The interfaces are divided into 2 categories, according to the place where the methods are requested.

The methods of the interfaces at the input are implemented in the object components and receive the calls from the external clients. The object performs the service requested and returns the result to the client. Most of the interfaces into these libraries are input interfaces, which are requested by the client application. The methods or events of the output interfaces are implemented on the sink of the client and they receive the call from the object. The object defines the interface that will be used and the client deploys it, thus, the output interfaces let the object reply to the client. The output interfaces are often used to notify the client when something important is happening or to inform the customer when an asynchronous operation has been completed. The output interfaces are also called connection points, event interfaces, notification interfaces or source interfaces.

In the development of this Project, the NokiaCLMessaging library was used (see Annex B.1), using extensively the IShortMessageItem interface (see Annex B.2). Through these methods it is possible to read the received messages by the mobile phone and to send messages by itself.

Figure 4. Network Schematic



III. SOFTWARE DEVELOPMENT KIT INTEGRATION

A. X10 Convergence: The X10 Home Control System and the SMS Control Application

Figure 4 clearly shows the interaction between the elements of the home control system. The control words are sent as written messages generated in the remote mobile, then received by the local mobile and transferred to computer through the DLR-3P cable and the Nokia Connection Manager.

In this computer, after having deployed a software interface in Visual Basic, useful for the SMSControl application, it is possible to pick the received message and send the word control through the interface/transceiver, according to the alternative X10 used (that is, CM17A or CM11A), to the X10 receiver devices which executes the order allowing or not the turning on of the power supply line to the electric home user-device. Therefore, on that way, it is possible to have the remote control of the switched on and off by means of the written messages. On the bidirectional configuration, the CM11A, the X10 commands that are fired by the alarms –generated by the movement sensors, for instance- are gathered, transferred to the computer and lately performs an emergency call to the remote mobile(s).

So that, behind the hardware employed, there is the SMSControl application that allows the convergence between the SMS system and the X10 devices. Two versions of the SMSControl Application were developed based on the CM17A and on the CM11A.

Both applications were performed using Visual Basic using a simple template scheme. The main difference is that in the case of CM17A, the control words that are sent to the DB9-RF interface are based on the CM17A itself while in the case of CM11A, the own Visual Basic libraries were used.

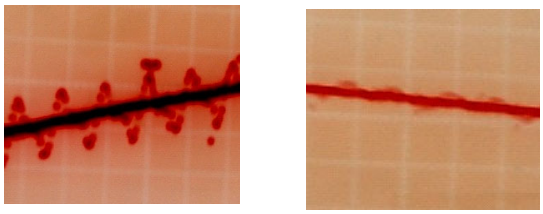
In a general sense, the templates that these applications have are found on Annex C.1.

B. Running the System: An Analysis on the performance

Most of the functions of the Nokia SDK don´t work properly with the local mobile, a Nokia 6320, especially the function sendSMS, which is supposed to allow sending a text message at the time the movement sensor fires an alarm. The message was sent seven minutes later of the firing alarm. Due to this, an emergency call had to be used at the firing time and the sending of DTMF through that call.

The inherent X10 problems related to collisions, because when having several transceivers and the sending of some control words simultaneously in a shared medium, the income of unknown signals generated by X10 adjacent systems configured with the same home code. Finally, due to the attenuation of X10 signals when passing through the electrical home devices connected to the closest power supply lines where are connected the transceivers as well as the receivers. The sources of these electric home devices do not mostly filter the signals greater than 60 Hz.

Figure 6. a) X10 signal, b) X10 Attenuated Signal



(a) *(b)*

I. CONCLUSIONS

We can conclude that X10 Systems present the following advantages:

- They do not need any additional cabling in order to deploy the network of devices.
- Depending upon the sort of the system controller, the X10 systems may not be complex to deploy because they do not require that an operator holds a big electronics experience and knowledge. Instead, there are plug-and-play devices that allow the immediate installation of a control system,
- The X10 devices, transmitters as well as receivers and transceivers are on the market, thus, they are easy to be acquired in electronic stores or markets. X10 is a relatively mature protocol, being already deployed since a few years ago.
- It is very easy to modify the X10 modules due to the easy development of its software routines. This makes X10 attractive and flexible for control solutions, as this work can demonstrate that.

However, X10 also presents some drawbacks that can be summarized as follows:

- X10 is not scalable. It was not designed for a complex system such as data transmission on the end-devices. Further, X10 was not thought for industries branches or hostile environments, where noise sources exist. In this sense, X10 is not a direct competitor of PLC based-solutions, which are focus on complex and robust designs.
- X10 devices, as it was discussed and analyzed are sensitive to an erroneous behavior either when the X10 signal is transmitted on noisy environments or when the transmitters are close to any power supply that is not able to filter signals in the order of 120 KHz, as it is the case of some old televisions.

Our recommendation is that the developments of new control components for X10 based-systems will be using WAP and Cellular supporting this technology. In a very short period of time, the written messages will be suitable for very simple tasks. Instead, a more stable bidirectional control will be achieved using TCP/IP through WAP, such that the computer, that is the X10 system controller, can be on-line by means of a public IP address (generated by its ISP) and can be accessed in real-time including more complex tasks (bidirectional) like the record of events during the working period, triggered alarms record and even for industry applications, things like access to databases by an remote user, so forth.

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ANNEX A

A.1 CM17A Configuration (Firecracker) and CM11A Configuration

Figure A.1 and A.2 shows these 2 alternatives configurations of the home control system.

Figure A.1. CM17A Configuration (Firecracker)

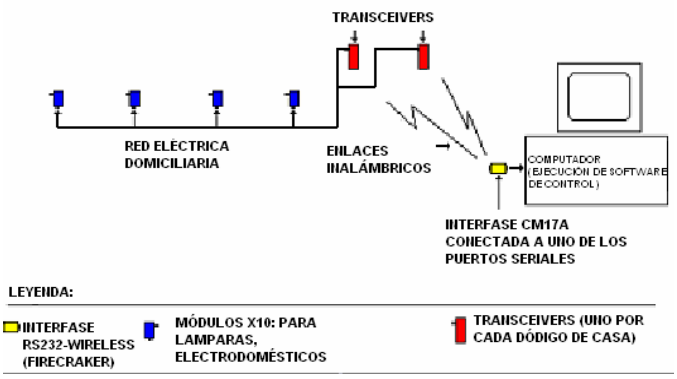
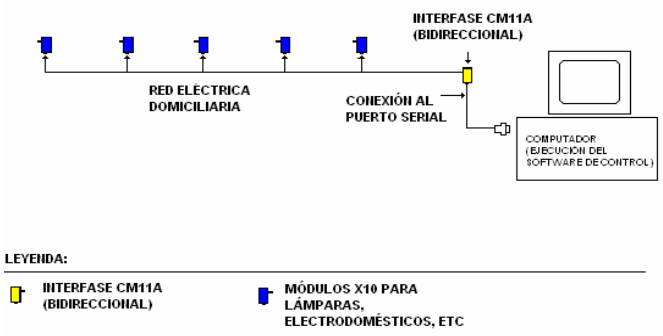
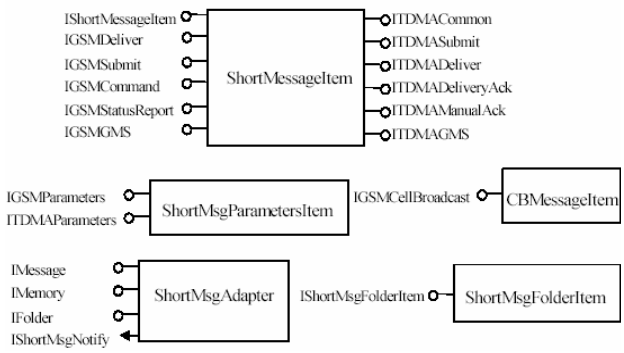


Figure A.2. CM11A Configuration



ANNEX B

B.1 NokiaCLMessaging Library Components



B.2 IShortMessageItem Interface Methods

Table B-1. IShortMessageItem Interface Methods

METHOD	DESCRIPTION
SendSMS	Send SMS message
ReadSMS	Read SMS message
SaveSMS	Save SMS message
RequestCB	Enable or disable the cell-broadcast messages monitoring
EnableNotifications	Enable the SMS events monitoring
DisableNotifications	Disable the SMS events monitoring

ANNEX C

C.1 Templates

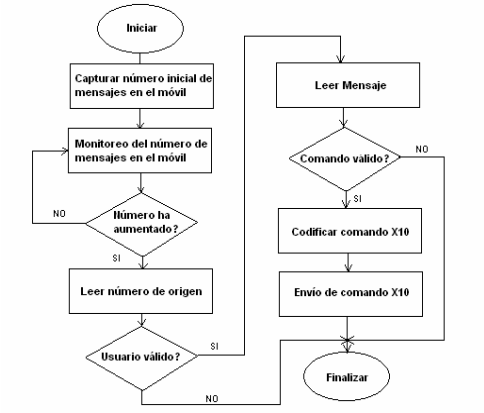
FrmAddUser: This receives all the users of the system. These will be identified using the number of the cellular phone, that is, a list with all the numbers that will use the system has to be done.

FrmAddDevice: This one allows adding the devices to be controlled. These are placed in a list with the describing features like the name, the home code and the device code, that is, its ID.

FrmConfigSMSControl: This is the core template of the application because the most important tasks are planned here, such as:

- Serial Port to be used.
- Total Activation of the system
- Monitor of the written messages sent by the remote mobile
- Reading of these messages from the memory of the local mobile
- Validation of the telephone number from which the message is sent, comparing the elements from the users list on the FrmAddUser.
- Validation of the received command in the message sent by the remote mobile, comparing with the elements from the device list on the FrmAddDevice
- Use of the protocol to encode the control word.
- Send bit per bit of the X10 command according to the CM17A or CM11A alternative mode.

Figure 5. *Logic Control in the frmConfigSMSControl scheme*



FrmConfigAlarm: This is an additional feature that is present only in the SMSControl Application, based on the CM11A interface. This template allows the user scheduling tasks of switching on and off the X10 devices, besides the fact of sending a state report to the devices and enable the emergency calls and DTMF digits.