Zigbee Home Light Controller implementation and verification on digital TV receiver

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***Abstract* — This paper presents a concept of a ZigBee home light control as an add-on to the digital TV receiver. Implemented software solution provides a lighting control by means of „smart outlets“ using digital TV device. The main goal was to implement software support that is easily portable on different platforms. Also, the graphical user interface (GUI) is implemented as a detached part of the software. The verification was conducted in real time and the system functionality is confirmed.**

***Keywords* — DTV, embedded system, graphical user interface, light control, ZigBee.**

I. Introduction

LIGHTING control presents a small part of home automation control systems. The main goal of home automation systems is to enable home devices to communicate with each other and to do some actions which are set by users. To make a home autonomous, it is necessary to obtain, mount and install different pieces of hardware, which often includes lot of wiring and non-uniform standards. In this paper, we presented the wireless home lighting control system that uses ZigBee protocol standard.

TV sets, set-top boxes, multimedia players etc. are all embedded systems controlled by built-in processors. Set-top boxes, for example, appear ideal for using as home automation controllers. Their embedded nature gives increased robustness and reliability. Availability of stand-by mode in these devices, allows non-stop operation for simple home control tasks.

We propose the embeddable light control solution based on highly portable Linux software. We will give an overview of software concepts, emphasizing on the event handling, behavior modeling and portable GUI (Graphical User Interface). Finally we will present a use case where the controller was implemented, and derive conclusions on its usability.

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II. Concept

To make the home controller really embeddable, its software must be highly portable and all interfaces used must be widespread in the consumer electronics industry.

Developed software is based on Linux, which consists two parts:

- Kernel – extended with drivers for the input-output subsystem, graphical system etc.
- User space – that run the applications.

TV platform used in this system is Micronas Pegasus 32bits with the 256MB of memory.

Smart outlets are remotely controlled outlets which are used to turn and dim the light on or off. User can access all information and control connected devices through the TV receiver. Smart outlets have DSP Texas Instruments chip CC2530 which communicates with the system via wireless protocol on 2.4 GHz. This is a true system-on-chip solution tailored for IEEE 802.15.4, ZigBee, ZigBee RF4CE and Smart Energy applications. [1]

ZigBee is a low-cost, low-power, wireless mesh networking standard, based on IEEE 802.15.4-2003 standard for wireless home area networks (WHANs), such as wireless light switches with lamps, electrical meters with in-home-displays, consumer electronics equipment via short-range radio. ZigBee is targeted as a radio-frequency (RF) application that requires a low data rate, long battery life and secure networking. [2]

TV platform communicate with smart outlets by using USB (Universal Serial Bus) dongle that has the same TI CC2530 chip as the smart outlet. Fig. 1. shows the Micronas Pegasus TV platform, used in this paper.

Fig. 2. shows front and back side of smart outlets and USB dongle plugged at the TV platform.

Fig. 1. Micronas Pegasus TV platform

Fig. 2. Smart outlet and USB dongle

ActionScript 2 is a scripting language developed by Adobe used to make Flash Graphical User Interface [3]. User can control smart outlets by using TV remote controller.

Flash application use TCP server to connect with the light control application at the TV receiver.

Fig. 3 shows software architecture (GUI, User Space, Kernel and Hardware as the lowest system layer).

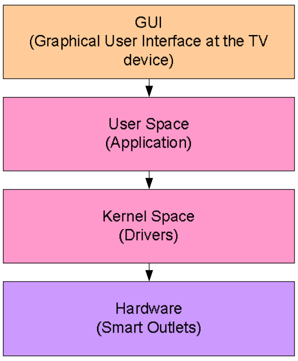

Fig. 3. Software Architecture

III. REALIZATION

Implemented software consists of the following modules which have certain functions for controlling and managing:

- Driver for communication control
- Device controller
- Macro controller
- Macro interpreter
- Communication protocol driver
- Database
- XML parser

Fig. 4. shows the software module organization.

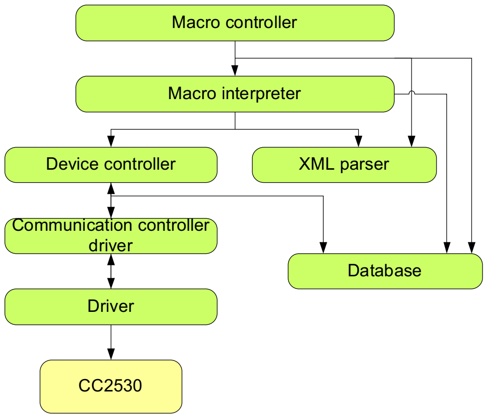

Fig. 4. Software module organization.

Driver for communication control sends the command to destination module which is used by controller and also gets the state of this module, gets the list of modules, searches for modules etc. This module is in charge of initialization and de-initialization and also should know about existent driver controller.

Device controller sends commands, gets the state of the specific device and uses functions with the time control.

Macro controller enables control of textual macros written in XML. This specifies how to control light.

Macro interpreter is used to parse textual macros and to call appropriate control functions.

XML parser is used to parse XML documents.

Database provides functions for saving, erasing, modifying, searching of the room, devices and macros. Database also provides:

- Add/Erase room
- Add/Erase device at the room
- Add/Erase scenarios or macros

Each room has unique identification number (ID), name, size and the number of the devices in this room.

Each device has unique identification number, ID for the driver controller that manages this device, module name and description, room ID, position in the room. Also there is an information about current status of the device (active/passive).

Macro or scenario has unique ID, state (active/passive/pause), name and buffer with the macro code.

Macros are the essence of the system for light control and also for home automation systems. They provide dependence of the different home devices. Macros can send commands directly to some devices and also it is possible to run and stop macro that controls few different devices. For example, we can make different scenarios: party (turn on and off different devices) or sleep (dim to the lowest level), etc.

Fig. 5. shows the example of macro that dims in three bulbs at the same time.

```
<macro>
    <driver type=\"time\" moduleid=\"3\" repetition=\"relative\" time=\"1\">
    <var name=\"dimlevel\" type=\"number\" val=\"0\" />
    <for loop=\"20\">
        <var name=\"dimlevel\" val=\"++\" />
        <instruct ack=\"0\" moduleid=\"1\" function=\"dimm\"
intensity=\"dimlevel\"/>
        <instruct ack=\"0\" moduleid=\"2\" function=\"dimm\"
intensity=\"dimlevel\"/>
        <instruct ack=\"0\" moduleid=\"3\" function=\"dimm\"
intensity=\"dimlevel\"/>
    </for>
    </driver>
</macro>
```

Fig. 5. XML example for light control

In this system, it is possible to run more than one macros at the same time. In this case, some device can execute commands from different macros.

User can create scenarios via graphical user interface. In this case, created scenarios are sent via TCP server in XML format and saved in database. This scenario can be run, stopped or erased.

Also, it si possible to pospone the running or to run periodically. Postponed running provides scenario that can be run after specific time. Periodic running provide that the same scenario can be run more than once automatically. User can stop scenario in the same way as he run it.

Smart Outlets provide that light source can have the following actions:

- Turn on
- Turn off
- Set the light level at the specific value (dim in/dim out)

IV. VERIFICATION

The light control system was verified in a few different ways:

- Verification of each part of the system
- Verification of communication with the CC2530 smart outlets
- Verification of communication between CC2530 smart outlets and devices
- Verification with the graphical user interface

At first phase of the verification, we used console terminal to confirm the correct system functionality.

We used packet sniff application to see all the packet data sent between CC2530 smart outlet and devices.

Afterwards, we use graphical user interface to verify system functionality. User sends commands via remote controller and controls each light source apart or make some scenario for all of devices.

Fig. 6. shows the environment during the verification. Application works on digital TV receiver and the “play scenario” window is shown.

Fig. 6. Verification environment

Fig. 7. shows the graphical user interface, main menu and each of the submenu directly from flash application (edit home, add device, create scenario and play scenario).

Fig. 7. Graphical User Interface

Console verification, as well as verification on the digital TV device with graphical user interface confirmed the system functionality.

V. CONCLUSION

This paper provides ideas and concepts that might branch researches of solutions for home automation towards easy integration and more reuse in an average household. We presented the implementation of the home light controller with user interface for the digital TV receiver that was proven both exciting and efficient for end users.

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