07 - 10 September 2009

PROCEEDINGS

54. IWK

Internationales Wissenschaftliches Kolloquium
International Scientific Colloquium

Information Technology and Electrical Engineering - Devices and Systems, Materials and Technologies for the Future

Faculty of Electrical Engineering and Information Technology

Startseite / Index:
http://www.db-thueringen.de/servlets/DocumentServlet?id=14089

TECHNISCHE UNIVERSITÄT
ILMENAU

Impressum

Herausgeber: Der Rektor der Technischen Universität Ilmenau
Univ.-Prof. Dr. rer. nat. habil. Dr. h. c. Prof. h. c.
Peter Scharff

Redaktion: Referat Marketing
Andrea Schneider

Fakultät für Elektrotechnik und Informationstechnik
Univ.-Prof. Dr.-Ing. Frank Berger

Redaktionsschluss: 17. August 2009

Technische Realisierung (USB-Flash-Ausgabe):
Institut für Medientechnik an der TU Ilmenau
Dipl.-Ing. Christian Weigel
Dipl.-Ing. Helge Drumm

Technische Realisierung (Online-Ausgabe):
Universitätsbibliothek Ilmenau
ilmedia
Postfach 10 05 65
98684 Ilmenau

Verlag:
Verlag ISLE, Betriebsstätte des ISLE e.V.
Werner-von-Siemens-Str. 16
98693 Ilmenau

ISBN (USB-Flash-Ausgabe): 978-3-938843-45-1
ISBN (Druckausgabe der Kurzfassungen): 978-3-938843-44-4

Startseite / Index:
http://www.db-thueringen.de/servlets/DocumentServlet?id=14089

SENSORS NETWORK FOR HOME AUTOMATION

Pavol GALAJDA and Radovan BLICHA
Department of Electronics and Multimedia Communications, Faculty of Electrical Engineering and Informatics, Technical University of Košice, Letná 9, 042 00 Košice
e-mail: {Pavol.Galajda, Radovan.Blicha}@tuke.sk

ABSTRACT

Sensor networks for smart home are becoming a basis for a rapidly increasing range of applications. Home automation is interesting example of such applications. Individual applications have different requirements in terms of node functionalities, network size, complexity and cost. It is worthwhile time investment to design and implement a general purpose framework for sensor networks that would be adaptable to any monitoring application of interest with a minimum amount of effort. In this manuscript, we describe that accessible and useful services for elderly and disabled persons living at home based on wired and wireless sensor network technology can be delivered in mainstream systems and platforms.

Index Terms - Sensor networks, ZigBee, 1-wire

1. INTRODUCTION

Information and communication technologies play an increasing role in our lives, offering new opportunities and choice, improving public services and facilitating communication between people.
However, some of us are at risk of being excluded from these benefits. Two large and growing groups in this situation are elderly people, whose physical or mental functions may become reduced with age, and persons with permanent disabilities of all ages. They often find that Information Society services are complicated, expensive, poorly designed, do not address their preferences and requirements or require too much of a behavioural change on the part of the user.
The concept of a smart house, where devices could be controlled remotely, and would be automated for both comfort and energy efficiency was very appealing.
At the same time, costs for society for support to elderly and disabled persons are growing. With the demographic changes ahead, the societal demand for care of elderly and disabled persons will increase over the coming years. There is now a general trend in Europe to move away from institutionalised care of elderly persons and instead support living at home, e.g. with visiting personnel for home care and support.
There is also an increasing attention to the problems that may arise for elderly persons living longer in their home alone or with an elderly partner. Studies have identified some of the most important problems to be associated with accidents (e.g. falls, fires), anxiety and insecurity as well as an increased isolation from other persons and from community services [1].
The objective of the paper is to demonstrate that accessible, useful services for elderly and disabled persons living at home can be delivered in mainstream systems and platforms. This will be done in close cooperation with users and by involving key mainstream actors throughout the whole process. The technology platforms to deliver the different services are derived from standard technology. They integrate elements such as reliable self-organizing networks, user interaction technology, monitoring capability and service infrastructures that ensure quality of service, reliability and privacy. The services will be delivered on mainstream devices and services such as Home Automation (AH), Home Networking (HN), wired and wireless technologies and broadband Internet.
Our interest in automation and networking then grew out of a desire to set up a laboratory for testing these applications. Because of the growth in HA and HN, it seemed to make sense to set up the standard house as a laboratory for researching and educating about HA and HN. This has proved to be very successful.
Combination of wireless and 1-wire solutions for building an inclusive home environment is considered as acceptable solution, especially in new EU country as Slovakia is. We describe experimental solutions that are tested in our laboratory. The main goal is to achieve an accessible price and minimisation of adaptations.

2. THE APPLIED TECHNOLOGIES

Our research has focused on residential control as HA and smart and interoperable networks in services dedicated to help elderly people and people with limited mobility.
Future homes will utilize advanced wired and wireless networks for connectivity. Our objective is to demonstrate some of the underlying communication technologies that form the basis of such networks. Our recent development in 1-wire data transmission and low bit rate radio enable a whole new range of devices to effectively communicate. Typical

household devices (e.g., lights, doorbells, appliances, entertainment, security systems) are now on the verge of being seamlessly integrated into home networks by using both wired and wireless technologies. Essentially, the home network will consist of many low cost networked devices in addition to PC, broadband Internet connection and access point. This will allow homeowners a complete home network with the capability to control all aspects of their environment as well as introduce new applications for the home. Therefore the sensors are placed everywhere in the house and collect various physical data such as temperature, humidity, and light. The devices are then automatically activated if necessary.

One alternative to the aforementioned monitoring methods described in our paper is based upon wireless and wired networks composed of inexpensive sensor nodes. The size and expandability of these sensor nodes make them ideal candidates for detection and monitoring systems. One of the major obstacles confronted in the implementation of small wireless sensors is that the high energy consumption of the transmitter requires a huge battery for long operation lifetimes. For this reason wireless technologies having the performance characteristics that closely meet the requirements for reliability, low power and low cost become interesting. For such wireless applications, a standard IEEE 802.15 has been developed by the IEEE and the definition of the application profiles is organized by the ZigBee™ Alliance [2].

2.1. ZigBee Applications

HA offers manufacturers a proven standard approach to making devices reliable, affordable, easy to install and operate for the new construction and retrofit markets. HA provides standard interfaces for the remote control of lighting, Heating Ventilation and Air Conditioning (HVAC), power outlets, motorization, security, audio/video applications and devices (Fig. 1) should just plug into existing network [2].

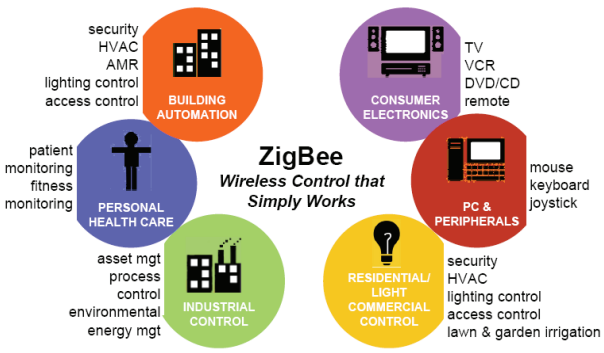

Figure 1 ZigBee applications

To interact with all these remotely controlled devices under a single standardized control interface, we'll need to put them into a network, specifically a home-area network (HAN). In this network ZigBee technology seems to be as a very emerging. HA also maximizes the numerous technical strengths of ZigBee including use of the globally available 2.4 GHz band and proven operational co-existence with Wi-Fi, Bluetooth and other systems.

ZigBee networks consist of multiple traffic types (Fig. 2) with their own unique characteristics, including periodic data, intermittent data, and repetitive low latency data. There are basically three types of network configurations that can be implemented under the 802.15.4 and ZigBee umbrella: point-to-multipoint (star) networks, tree networks and mesh (ad-hoc) networks. Point-to-multipoint networks are typically used for low cost gaming or entertainment centre control.

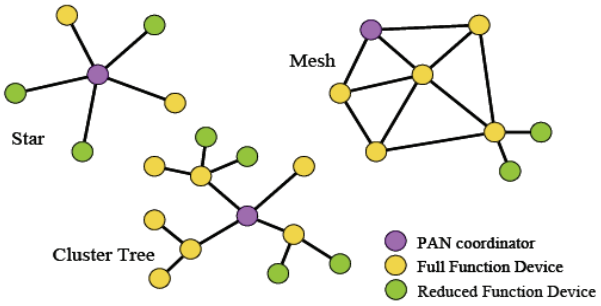

Figure 2 ZigBee Network Topologies

Zigbee network is distinguished by its identifier called PAN-ID and using just three general types of node at the network level: coordinator, router and end device. PAN-ID it is 16 bit value randomly assigned during creating of network. Every device is identified on MAC level by its MAC address and on network level by network address. The Zigbee standard has the capacity to address up to 65535 nodes in a single network.

An IEEE 802.15.4 WPAN is composed of one PAN coordinator and a set of devices. The PAN coordinator is the primary controller of the network and it is responsible for initiating the network operations. The standard defines a set of procedures implemented by the PAN coordinator to initiate a new WPAN and by other devices to join a WPAN. The PAN coordinator assigns a PAN ID (PAN identifier) to the network and selects a channel among those specified in the standard.

Network has attributes of automatic configuration, self-forming and self-healing. Characteristic sign of Zigbee network is multipath topology. When data can't be received by data terminal equipment through planned path, network dynamically redirects this data to the alternate path. Communication ability represents data capture and sensor nodes controlling, but also nodes are able to cooperate on complex tasks, as monitoring and evaluation of states individual automation systems. There is slight latency during

transfer of data between two nodes, but from sensor applications point of view, this latency is not so significant.
Zigbee uses basic security standards specified by IEEE (encrypting algorithm AES, CCM mode) and what is more, it defines types of security keys (Master key, Link key, Network key). Security is implemented using 3 layer encryption. Security model checks message integrity on application layer, authentication (so called freshness, or in other words, securing the system against repetitive attacks) and protection against interception. It protects access to devices against attacks from outside (outside the network, where device is active) and inside as well [3].

2.2. Wire Network and 1-Wire Devices

1-Wire® products provide combinations of memory, mixed signal, and secure authentication functions via a patented single contact serial interface (Fig. 3). With both power and communication delivered over the serial protocol, 1-Wire devices are unmatched in their ability to provide key functions to systems where interconnect must be minimized.

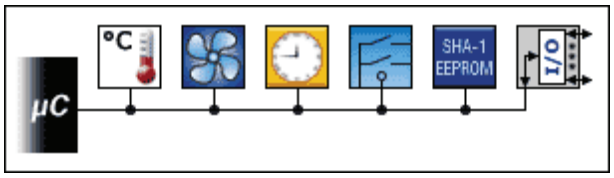

Figure 3 1-Wire Devices

The 1-Wire® Net, sometimes known as a MicroLAN is a low-cost network based on a PC or microcontroller communicating digitally over twisted-pair cable with 1-Wire components. A 1-Wire Net based system consists of three main elements: a bus master with controlling software, the wiring and associated connectors and 1- Wire devices. The 1-Wire net allows tight control because no node is allowed to speak unless requested by the master, and no communication is allowed between slaves, except through the master.
The 1-Wire® communication protocol can be generated with an IO pin on a microprocessor; however, care must be taken to provide the correct timing and proper slew rates to create a reliable 1-Wire network. Uncontrolled slew rates can severely limit the length of a network and create sporadic behaviour. If a serial communication UART is available, using a serial-to-1-Wire bridge (Fig. 5 illustrate simplified diagram of the DS2480B configuration) will eliminate these problems. The DS2480B is a serial bridge to the 1-Wire network protocol. This bridge allows any host with a very modest serial communication UART to generate properly timed and slew controlled 1-Wire waveforms [4].

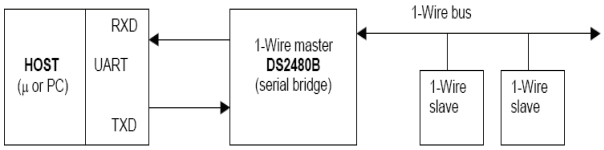

Figure 4 1-Wire Network based on a PC or microcontroller

3. IMPLEMENTATION AND RESULTS

The monitoring aims to get information about environment status and the activities of the monitored residence and person with the usage of the used sensor's data. Additionally the current common situation should be monitored to recognize and to avoid dangerous situations early.
The infrastructure and platforms that deliver the services have been developed in the project and use mainstream technology end architecture as shown in Fig. 5.

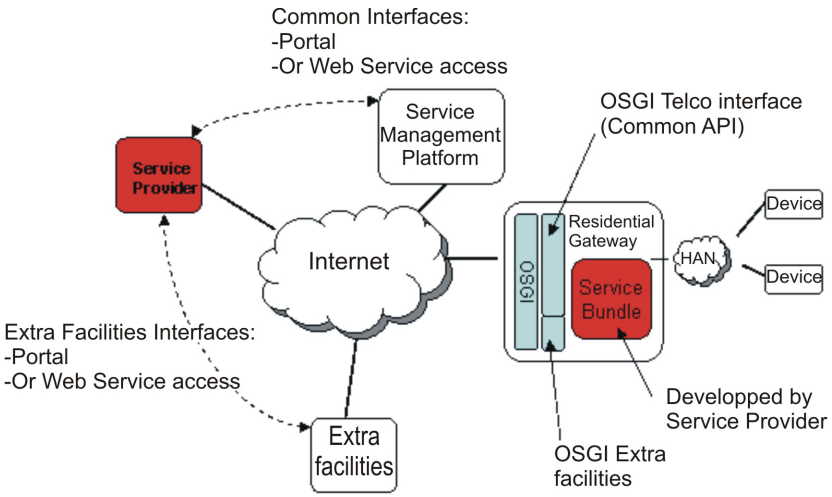

Figure 5 MonAMI General Architecture

The architecture is centralized on the Residential Gateway (RG). The first role of the Gateway is to centralize the MonAMI Services in one central point. This centralization enables services to share the same resources and to create extended services for example for different technology (ZigBee and 1-wire in our solution).
This architecture consists of:

- A Remote Interaction Framework which enables the RG to interact with the Telco Service Platform provided by FT and TID respectively.
- A Premise Equipment Interaction Framework which enables to interact with sensors and actuators.
- A Monitoring Framework which enables to detect application event and allow application monitoring
- An Accessible Framework which enables the management of User Interfaces (UI).

The RG is therefore used to execute services (mainly Java code in our solution). The Feasibility and Usability (FU) centre services uses a set of software associated to each framework above to create the links and interfaces with the External Elements (sensors, actuators, service platform, UI, etc see Fig.6).

```
   BundleEvent RESOLVED
OWDriverOsgi4AMI bundle starting ...
OW Driver is starting...
onewire.adapter.default set to: {DS9490}
onewire.port.default set to: USB1
Connecting default adapter ...
Adding monitor for adapter {DS9490} ...
OW Driver started.
OWDriverOsgi4AMI bundle started.
BundleEvent STARTED
Arrived 6 devices.
ServiceEvent REGISTERED
ADD: 1900000009C82A20 - the OW Light Sensor
ServiceEvent REGISTERED
ADD: B800000009BB9D20 - the OW Light Sensor
ServiceEvent REGISTERED
7F0008015095F910  Lower treshold set to: -55.0
7F0008015095F910  Upper treshold set to: 100.0
ADD: 7F0008015095F910 - the OW Temperature Sensor
ServiceEvent REGISTERED
ADD: 8100000094CE5826 - the OW Temperature Sensor
ServiceEvent REGISTERED
ADD: 8100000094CE5826 - the OW Humidity Sensor
ADD: 8400000E7EFF7801 - Not defined type of device
ServiceEvent REGISTERED
ADD: 96000000037D7F29 - the OW Motion Sensor
ServiceEvent REGISTERED
ADD: 96000000037D7F29 - the OW Smoke Sensor
There are 7 devices connected.
96000000037D7F29  Movement: not detected
B800000009BB9D20  Light level: 66,40 %
96000000037D7F29  Movement: not detected
7F0008015095F910  Temperature : 26,50 C
8100000094CE5826  Temperature : 27,50 C
96000000037D7F29  Movement: not detected
B800000009BB9D20  Light level: 66,40 %
8100000094CE5826  Humidity : 27,77 %
B800000009BB9D20  Light level: 66,40 %
96000000037D7F29  Movement: not detected
7F0008015095F910  Temperature : 26,50 C
8100000094CE5826  Temperature : 27,59 C
B800000009BB9D20  Light level: 66,40 %
96000000037D7F29  Movement: not detected
8100000094CE5826  Humidity : 27,77 %
96000000037D7F29  Movement: not detected
96000000037D7F29  Smoke: not detected
96000000037D7F29  Movement: not detected
1900000009C82A20  Light level: 25,20 %
B800000009BB9D20  Light level: 66,40 %
```

Figure 6 MonAMI Report of Executable Services in Residential Gateway

The technology platforms to deliver the services will be derived from standard technology. They will integrate elements such as reliable self-organizing networks, wearable devices, user interaction technology, monitoring capability and service infrastructures that ensure quality of service, reliability and privacy. The services will be delivered on mainstream devices and services such as ZigBee and 1-wire.
For example, the monitoring activities of persons it is necessary to equip the person or the environment, in which the persons stay, with different sensors. Depending on the sensor types, different information about the current activities of a person can be reached. To make life with sensors more acceptable for persons, it is important to fix sensors to environment or to persons in such a way, that persons will not be handicapped or impaired in daily life.
In the following several different sensors are listed, which are suitable for indoor monitoring. Depending on the used sensors, different information about the current activities of the monitored person can be derived from one sensor or from the combination of several sensors, which can be used to locate persons, to recognize their mode of locomotion and to recognize their current actions as well.
One of the most important information for recognizing and preventing dangerous situations is the information of a person's position. Just imagine the following situation: A person switches on the oven and after that the person leaves the flat. In order to avoid a fire, the system has to recognize that the oven is on and the person is not in the flat. So to localize a person is a very important task. Whereas outdoor location is easy to accomplish using commercial GPS devices, locating a person in an indoor environment is in general an open research problem. GPS does not work indoors. Therefore a different approach must be used for calculating the position of a person within a room. We introduce some types of sensors, which can be used for solving as well as identification of dangerous situations. Each sensor type will be shortly introduced (Fig. 7):

- **1-wire USB Dongle:** is required to connect the 1-wire network with the RG
- **1-wire light level sensor:** the natural lighting control involves controlling electric window shades and draperies according to the level of ambient luminosity.
- **1-wire temperature sensor:** central heating- solutions include measure of temperature and control of valve. These units can be used to monitor environmental conditions, both indoors and out. The device may be installed in multiple indoor locations, to monitor conditions throughout the home (e.g. bathroom, kitchen, living areas).

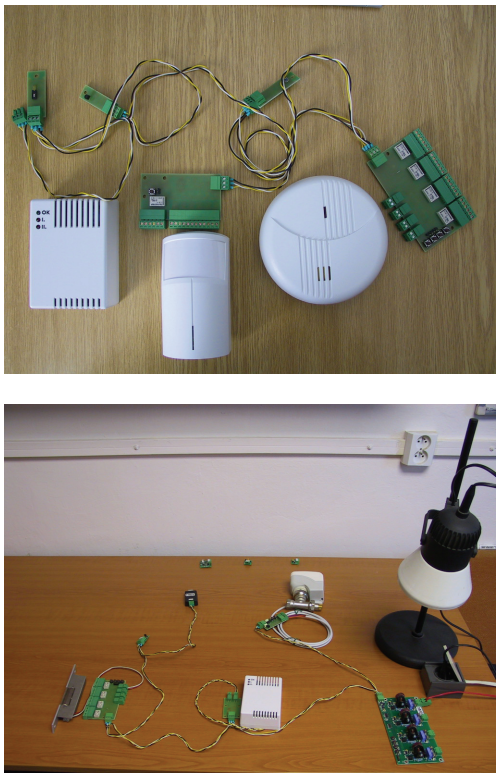

Figure 7 Types of sensors for different MonAMI services

- **1-wire ambient humidity sensor:** central heating- solutions include humidity monitoring and control of valve. These units can be used to monitor environmental conditions, both indoors and out. The device may be installed in multiple indoor locations, to monitor conditions throughout the home (e.g. bathroom, kitchen, living areas). As a part of a total home automation system, humidity can be a trigger for events such as turning on fans, or controlling zone heating and cooling.
- **1-wire valve controller:** central heating-solutions include humidity monitoring, measure of temperature and control of valve. The device may be installed in multiple indoor locations as a part of a total home automation system to controlling central zone heating.
- **1-wire PIR sensor**: the motion detector will sense motion with a range of approximately a few meters. This motion sensor can be used as a part of a comprehensive home automation system or, with the appropriate software, to simply turn on a single light when someone walks by.
- **1-wire gas alarm:** the gas detector will provide 1-wire output and can be used as a part of house alarm system. If gas is detected, the detectors make a warning sound and its 1-wire output will be triggered. There is an optional alarm memory function. The detectors make regular auto testing and report their condition with its LED indicator.
- **1-wire fire alarm:** the smoke detector will provide 1-wire output and can be used as a part of house alarm system. If smoke is detected, the detectors make a warning sound and its 1-wire output will be triggered. There is an optional alarm memory function. The detectors make regular auto testing and report their condition with its LED indicator.
- **1-wire electric door opener:** the remote control of the motor of swinging door together with electric door opener will open or close any swinging door automatically.
- **1-wire power point (230V/50Hz) controller:** connect/disconnect every apparatus from the mains, which allows controlling remotely single devices such as lamps, fans or heaters.

Feedback from the testing of FU centers in six countries: France, Spain, Sweden, UK, Slovakia and Germany will be used to improve and enhance the services and infrastructure/platforms as well as to identify those services that are most suitable from user, community and market perspectives.

3.1. 1-Wire Bus on RG Serial Port

Using the RG serial port for communication with the 1- Wire bus implies converting the EIA voltage levels of the serial port to the TTL levels. For interfacing the RG serial port to the 1-Wire bus five port lines can be used: RTS and CTS lines can be used for supplying voltage to the DS18S20 sensors; DTR and DSR can be used for reading/writing to the data line of the sensors; the fifth line is the GND line of the port.
Dallas Semiconductors provides a chip (DS2480B) that converts both the voltage levels and the protocol of the RS232 serial port to the 1-Wire values and reverse (Fig. 4) [5]. By using this chip, both the software problem of timing and the hardware problem of voltage levels are elegantly solved.

4. CONCLUSION

An experimental 1-wire and ZigBee based home automation system was built and tested. Results described hardware and software solutions based on an OSGi platform and Java are presented. The automation of houses for seniors may have different solutions. The combination of 1-wire and ZigBee modules provide a chance to find optimal solutions regarding complexity of adaptations, price, user acceptance and quality of service. This paper presents the Slovak plans and contributions to the testing of services using the MonAMI technological platform. By automating and centralizing control of all home systems from virtually everywhere, HA increases

comfort and security, and most importantly, becomes more efficient at reducing our need of energy, as well. We do believe there is a market for home automation, but the products must be easy to install in new and old homes and have to make a significant impact to our quality of life.

5. REFERENCES

[1] MonAMI News FU FOCUS: Slovakia & United Kingdom, Mainstreaming on Ambient Intelligence Newsletter from The MonAMI project 1, 2009, http://www.hi.se/Global/pdf/2009/MonAMI/MonAMINews1.pdf.

[2] Homepage of ZigBee™ Alliance, http://www.zigbee.org/.

[3] E. H. Callaway and Jr. E. H. Callaway, "Wireless Sensor Networks: Architectures and Protocols," CRC Press, August 2003, pp. 352.

[4] Homepage of 1-Wire MAXIM, http://www.maxim-ic.com/.

[5] Application Note 192: Using the DS2480B Serial 1-Wire Line Driver, http://pdfserv.maxim-ic.com/en/an/AN192.pdf.

ACKNOWLEDGMENTS

This work has been funded by VEGA 1/4088/07: Rekonfigurovateľné platformy pre široko pásmové bezdrôtové telekomunikačné siete and MonAMI: Mainstreaming on Ambient Intelligence.