The Raspberry Pi Platform Applied in Family House Control

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Abstract: - The Raspberry Pi and its support development tools are very attractive for educational experiments. This article presents an application example for smart household control system. That system is composed both from a set of simple wireless modules and sensors monitoring and controlling smart household technology and from a central unit processing collected data. According to results, pre-set actions are performed. The required actions variety and rules for a smart reaction on various situation can be created and configured by user via dedicated interface. That system can manage indoor and outdoor temperature measurement, the lighting control, RF transmitter, jalousie, motion sensor control etc. GIU for a PC and for a mobile phone extend versatility of that system even for a remote control.

Abstract: - Raspberry Pi, House Control, Smart Wiring, Internet of Things

1 Introduction

The term “Smart house” or “Smart household” is popular already since 1980s. The term “smart building” emerged in USA at the turn of the 80s and 90s decade. That term expressed an above-standard comfort building [1]. Since then, the technology development influences the meaning and the content of that interrelation “smart” and “building”. It is common that households are equipped with various electronic gadgets nowadays. Among many others, we can name desktop and mobile computers, smart TV sets being able to record TV broadcasts automatically, wireless garage gate control, and provide household both indoor and outdoor security. Those all are technologies taken for granted by majority of us contemporary that are forwarding the significance of smart building on.

Currently, we perceive that term, as fully automated household where individual devices control is doable via an uncomplicated user interface.

The household economic and ecological performance is taken for granted on the front burner. Following that, for example, heat leakage control, way of heating improvement, and water heating using solar panels. The smart building should be self-sufficient. Individual household appliances should be monitored. In case of any problem occurrence, the household resident should be warned and the problem solved as soon as possible.

The household appliances integrated in a smart system either via wireless technologies or via LAN are networked and controlled with a specialized system called “control unit”. That control unit collects data from connected devices, and based on its embedded logic, it is able to react on events occurring in the system. Individual activities are controlled and performed automatically without user intervention. In traditional smart-less household, all those activities need to be performed by the user.

A smart household example could be as follows. In homecoming, the entrance gate is automatically opened after resident´s identification by his mobile phone and GPS coordinates. The entrance door is automatically unlocked afterwards. On entering the entrance hall, lights go automatically on. Prepared comfortable temperature according to the season is a natural thing in case of a smart household. Thanks to the automatic temperature control, there is programmed temperature in all rooms according to our set requirements. Going to sleep, we can put the whole system in a standby mode via mobile phone command, what means that all lights go off, the entrance door is automatically locked, and other security elements are activated alternatively. We can be awaken with our favourite music, water for coffee is just boiling, and our car interior is warming up for a comfortable drive to work. Going to our garage, we can look at the actual weather forecast in our multifunctional mirror. On leaving our ground, the whole system is put into absence standby mode with all security elements activated. Of course, we should take such example naturally as a pinch of

salt. Nevertheless, that example could represent a goal system development is aiming at.

Although the particular technologies are not very new, it is not easy to network them in a coherent system controllable from one location. The individual household technologies have different communication channels and interfaces according to the manufacturer. Some of the do not have any communication channel and interface. Therefore, there is very complicated to install a smart system in an established household. The particular devices are not prepared and smart system compatible. For the purpose of such household automation, and to include in the smart system its existing devices, we have to create an active control of particular devices. We need also to realize modules able to communicate via various interfaces, or we need to procure brand new devices that are more advanced.

2 Effective Household Controlling

If we manage to interconnect as much as possible existing and newly installed devices, we obtain effortless access and controllability over the whole household. Thanks to unified access to all devices, we are able to create situation oriented modes and indoor environment according to user´s mood. One button touch sets the completely household particular complex setting.

Modes and situation examples:

a) Morning awakening - the morning awakening arrangement could start with jalousie slats opening, sun shine and music. All particular jalousie get open in between. On entering bathroom, lights are lit on and the favourite radio station is switched on.
b) Household locking - When leaving, all unnecessary appliances are automatically switched off, the jalousies get partially closed, air condition stops operation, all lights go out, and all security elements get active.
c) Household arrival – Before dweller arrival, system warms up or cools down the household to a required temperature, switches security elements off, according to the daytime, it closes jalousie, and it lights a main room.
d) Cinema – System switches the TV set on, it closes jalousie, and it dims lights.
e) Night mode – System is put in sleep mode, it switches all lights, and it activates outdoor security elements.

We occupy ourselves with devices and relevant control algorithms for smart building control development at our department.

The building lighting control via DALI bus is one of our implemented project [2]. To control the whole building with a programmable logic controller (PLC) is another variant of solution [3]. Although such solution is comprehensive, its high costs represent noticeable disadvantage. Those costs comprise also mostly a complete wiring replacement and completion what means sensors and actors interlinking.

As a cheaper alternative, there is a possibility to make use of a microcontroller or of a small cheap computer together with a higher number of wireless modules [4].

2.1 Systems on the market

There are many systems for smart household on the market nowadays. We aim at wireless communication possibility what means that PLC control does not fit in our project goals. PLC application is much more convenient for new buildings where the special wiring is indispensable.

2.1.1 Loxone

Loxone company offers both their flag ship PLC automation based on PLC Miniserver [5] and Miniserver GO [5] without the PLC link what is more advantageous for wireless communication with peripherals.

Other products are so called Loxone AIR. They serve for the networking of common household elements. Loxone company delivers also own system for all Loxone devices control – Loxone OS. The control is applicable via both web interface and via mobile Android or iOS devices.

2.1.2 Fibaro

Fibaro company offers an easy installation without necessity to cut chases in wall and to place hunred meters of cable [6].

Fibaro company´s products are based on miniature modules designed for easy installation without special demands on wiring.

Z-Wave protocol oriented control unit is one of Fibaro basic components for smart household. That control unit incorporates Fibaro System Home Center 2 for remote control over all connected devices. The control is executed via web interface as well as mode setting and composing rules for automation [6].

It is also possible to control the system from Android and iOS using specialized applications.

2.1.3 Control4

The core of Control4 system is a control unit offered in a few variants. Those variants differ in power, in number of ports and integrated devices like audio, and in range of controllable smart devices. Up to 50 devices can be connected to each control unit. Every unit is equipped with ZigBee communication interface.

Control4 system does not provide any own wireless sensors and modules. That shortage is substituted for Nyce company´s products represented with wireless modules communicating via ZigBee interface and protocol [7].

3 Main Ideas of Our Design

The designed system proceeds from these basic ideas [4].

3.1 Wireless modules application

Wireless approach can be regarded as a non-invasive form of household automation.

Many smart systems is based on PLC application what requires special wiring where a majority of devices and elements is interconnected with cable and relays or with other integrating technologies.

Those systems are advantageous in case of new building and flat construction or when we are refurbishing them including the new wiring installation.

However, if we plan to implement the smart building technology in an existing household, that system represents a costly alternative.

3.2 Open source products utilization

In pursuance of our project goals, there are employed products and applications developed as community projects so that they are freely accessible for use.

The big advantage of those projects is a numerous user base that the open discussion of problems or presentation of successful solution accompanied with detailed instructions is a standard way of improvement in.

3.3 Price

By employing open source projects and by modular solution of automation by our own, we are able not only modify the system exactly according to our needs, but we can also save money compared to commercial products employing. Nevertheless, a common user can install a smart system by himself only when he is at least basically knowledgeable in electrical engineering and in programming.

Provide that we would like to compare the particular solutions of our smart household project with commercial on shelf products; we would have to put value on our working time spent during our smart household model design and its following implementation. However, a simple evaluation method can be represented with central server price comparison while it is the focus of any smart household system. The control unit price comparison is collected in Table 2.3.

Table 2.3 Control unit price comparison

Product	Price in EUR VAT not included
Loxone	320
Fibaro	510
Control4	560 to 2250
Designed solution	45

3.5 Internet of Things -IoT

As the whole system is based on wireless communication, its functionality grows with number of devices interconnected in household network. Internet of Things notion represents a set of unequivocally identifiable devices performing in frames either of their own network or internet infrastructure. Devices are communicating without human intervention, and their main task is sharing sensors data via internet in order to be further processed. The Internet of Things term is still very new one, and we can see how far that technology proceeds in the future.

According to the expert estimation nowadays, roughly about 23 billions of devices communicate via internet throughout the world at present. That quantity is to be expected doubled up by the year 2020 (Fig. 1).

3.6 Remote access and household system securing

There is possible to control a smart household not merely from the household itself or its vicinity, but also from any place in the world where the link to our system is possible to establish. The remote access to our system is practicable via mobile phone technologies like GSM or via internet.

A most simple way of remote communication between the user and his household is represented

with SMS or MMS. In case of an event, system can send SMS or MMS with the camera system picture after a strange movement detection to the user. User as well can send SMS to the system, as for example the adjusting message modifying in a particular way the system behaviour. As a general rule, those messages have exactly defined structure. However, there exists a risk that in case the mobile phone is lost or stolen, the control system services are disturbed. The household control via SMS is not very practical, and there is mostly a charge imposed on SMS services. That is either why the SMS application is efficient in case of selected events notification, or in case the other way of communication is impossible.

Other way of household control is the control via web interface from any device having access to the internet. In that case, we are connected directly to the central server, and we are able to control the whole household. Even in such case, the security aspect has the high priority. The internet environment is much more dangerous than GSM mobile networks. Moreover, there is an easier access to the system including security cameras browsing. That is why all communications between the user and the web interface are to be encrypted. The system login process should not be only based on login data, but also on one-time passwords and generators with SMS confirmation.

4 Project Main Goals

The following demands are placed on the solution of our smart household control project.

4.1 System remote management

- There is possible to address the system from any computer or mobile device in household concerned.
- To address the system outside that household is permitted exclusively with knowledge of security access data.
- It is possible to configure and monitor all connected devices.
- Possibility of rule creation for system automatic control (time and event controlled rules),
- System enables automatic notification sending at individual device state change (GSM, email and mobile application).

4.2 Temperature measurement

- The temperature measurement inside any room and outside the household.

4.3 Surroundings humidity measurement

- The humidity measurement inside any room and outside the household
- The indoor plant soil humidity measurement.

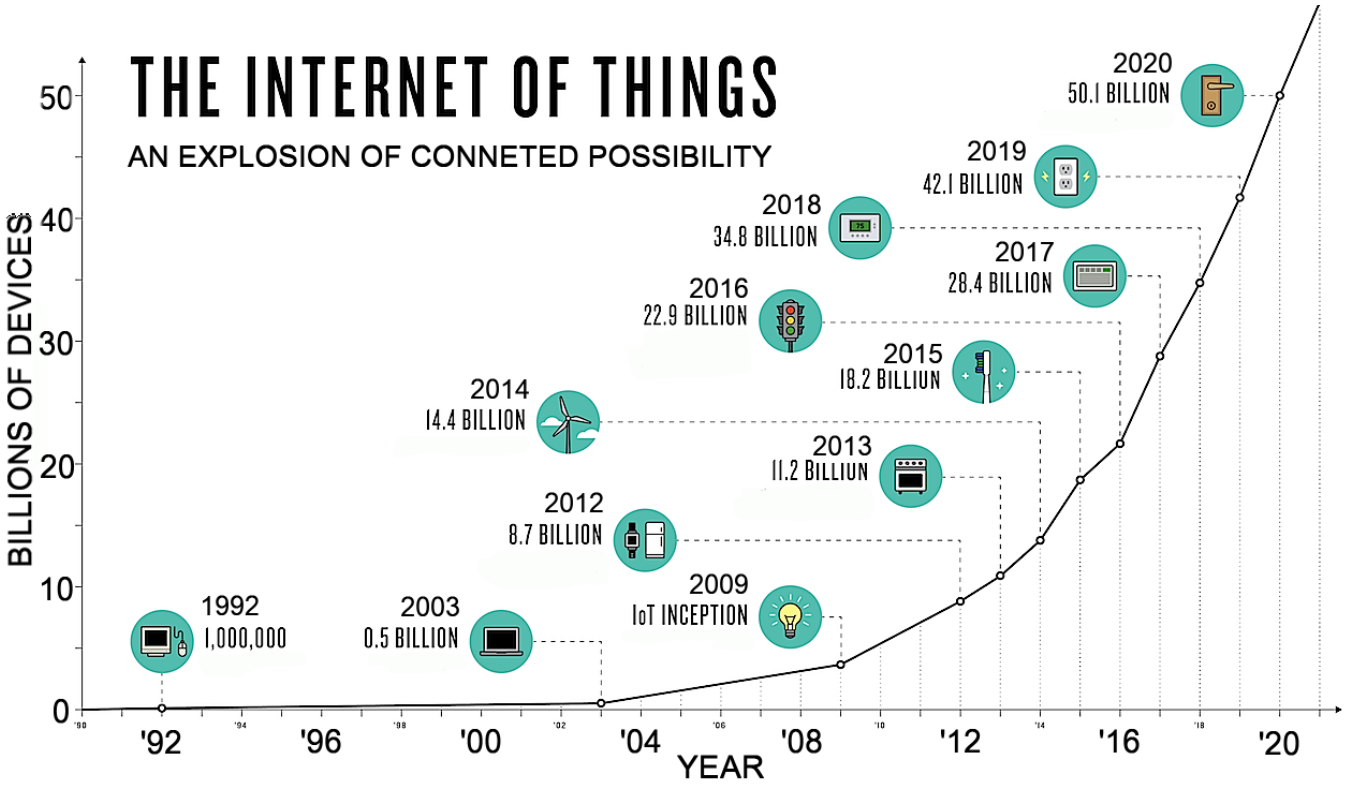

Fig. 1. Trend of IoT increase [23]

4.4 Movement detection
• People´s and animals´ movement is detected in selected rooms.

4.5 Illumination control
• The light go on/go out in any room is possible without user presence in that very room.
• The light intensity control in any room.

4.6 Jalousie control
• The indoor jalousie complete control comprising the full or partial opening/closing.

4.7 Security camera system
• Any household place monitoring with streaming and recording opposability.

4.8 Main entrance control unit
• The whole system controllability from a fixed place at main entrance.
• The "leaving" button to switch the whole system in the mode of "deserted" household.

5 The System Structure

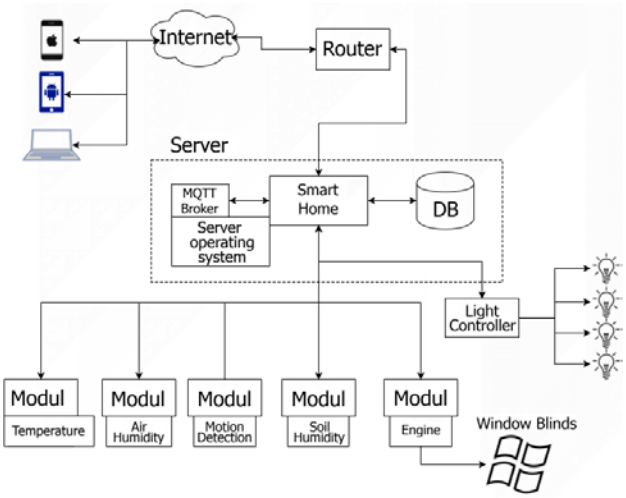

Fig. 2. Smart household architecture block diagram [4]

According to aforesaid requirements, the smart building system has been designed. The smart household, MQTT Broker, and database are carried on a server. Individual modules with connected sensors for temperature, air humidity, movement detection, indoor plant soil humidity measurement and the module for windows jalousie control are linked to the system. The light control module is also linked to the system.

5.1 Employed components

5.1.1 Raspberry Pi
Raspberry Pi is a fully-fledged miniature single-board microcomputer designed and developed by the British Raspberry Pi Foundation aimed at informatics education in high schools [8]. There is not possible to change the configuration of Raspberry Pi because all modules are soldered on one PCB. The GNU/LINUX operational system is employed, and it is possible to choose among a few distributions, like Debian, Ubuntu and others.
The Windows system does not support that device currently.

There is supplied a new model Raspberry Pi 2 in February 2015. That model is fitted out with a new SoC Broadcom BCM2836, and it includes a quadruple processor cores with clock rate of 900 MHz and a SIMD 1 GB memory to increase performance. The inbuilt graphic processor VideoCore IV supports OpenGL ES 2.0, 1080p30, MPEG-4 [8]. This model is used by the system as a central control unit for our smart household system concept.

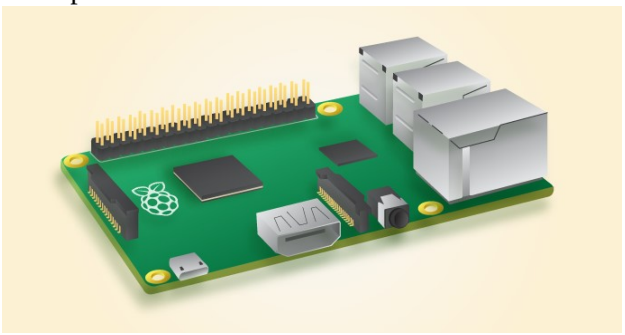

Fig. 3. Raspberry Pi 2[8]

5.1.2 GPIO
General Purpose Input Output – GPIO terminals serve to interconnection with any device with binary communicating interface.

Raspberry Pi 2 board provides following I/O pins:
- 17 I/O pins
- SPI bus pin (Serial Peripheral Interface)
- I2C bus (Inter-Integrated Circuit)

Beside I/O pins, there are also pins for peripherals power supply:
- Two 5 Volts power supply pins
- Two 3.3 Volts power supply pins
- Eight common ground pins

The layout and pin location is displayed in Fig. 4.

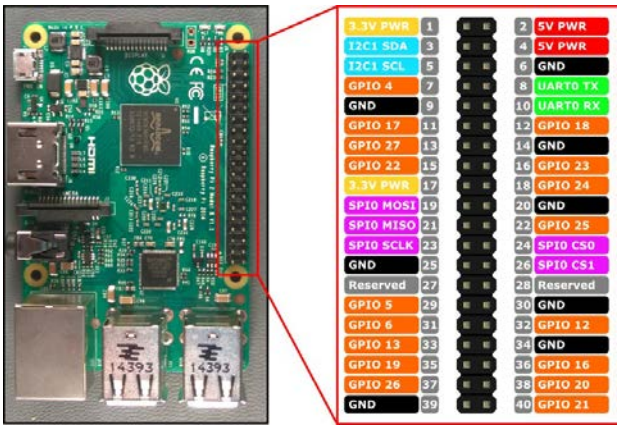

Fig. 4. GPIO [25]

5.1.3 Arduino

Arduino is an open platform with a graphic user interface development environment related to the Wiring environment (similar project like Arduino, i.e. a board with microcontroller and IDE) [9, 10].

The development hardware support is represented with Atmel 8 bit microcontroller boards in many varieties, as for instance ATMega8, ATMega168, ATMega328, ATMega1280 and ATMega2560.

Unlike Raspberry Pi, Arduino is not devised as a desktop so that it does not content any operational system.

As for that, the servicing programs need to be prepared on a different device, and to load it to Arduino afterwards.

The advantage of such solution is a lower energy consumption, and in contrast to Raspberry Pi, it is possible to power those modules from batteries.

5.1.4 Arduino Shields

The main aim of Arduino platform is the possibility to connect further modules called Shields that are plugged in via standardized sockets. A few modules interconnected in one unit constitute, for example, a subassembly accessable via LAN/WiFi which can switch on or off the lighting in aquarium. For realizing such subassembly we need following components :

1. Arduino Uno – a basic processing unit with running web server.
2. Ethernt shield – a board with RJ45 socket attached.
3. Sensor shield – the board for attached modules control (Relay module in our case).
4. Relay module – module realizing supplying current for connected device switching on/off (the light bulb power supply)

The interconnection of all shields is displayed in Fig. 5.

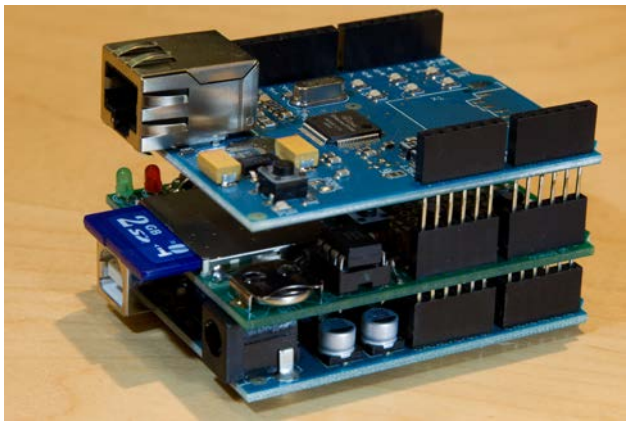

Fig. 5. Arduino Shields [24]

5.1.4 NodeMCU

NodeMCU is an open IoT platform that was developed from ESP8266 project by processing unit together with micro USB port (for power supply and communication) and with 10 I/O pins (6 digital pins, 3 analogue pins and one ADC pin) insertion in a common module. The first generation employs the ESP-12 processing unit with 20 KB SRAM and 4 MB flash memory. The incorporated Wi-Fi module supports 802.11b/g/n, devkit nodemcu v0.9 standard [11].

The second generation employs the new processor ESP-12E together with devkit nodemcu v1.0 [12].

5.1.5 GPIO

Like at Raspberry Pi or at Arduino, the NodeMCU includes I/O pins for peripherals communication. The pins sorting follows [13]:

- 6 digital
- 3 analogue
- 1 ADC
- Four 3.3 Volts power supply pins
- One 5 Volts power supply pin
- 4 common ground pins

5.2 Wireless modules

The majority of wireless modules uses the NodeMCU unit.

5.2.1 The NodeMCU supporting scripts implementation

There are a repeating set of steps in creating and programming individual modules. These steps are as follows:

1. Module activation from sleep mode.
2. Module connection to Wi-Fi.
3. The particular module task execution.
4. Communication with the central node.
5. Putting a module in the sleep mode for a set time period.

It is necessary to implement servicing LUA script for a particular function execution.

5.2.2 Module initialization

The module initialization begins with loaded firmware starting (we use basic firmware with LUA language), and with seeking out the initialization script „init.lua". If script is accessible, it starts automatically.

In case of automatic launching, the script refers to another script "wifi.lua" which connects module to preset Wi-Fi. There is reference to module function specific script „specific.lua"in further step. Script „sleep.lua" brings module in sleep mode finally.

5.2.3 Module link to the local Wi-Fi network

Module tries repeatedly to connect to Wi-Fi network specified in „wifi.config"file which SSID and password are also in. If connection to Wi-Fi fails, or if DHCP server does not assigned IP address, module repeats that attempt in 10 seconds interval. In case that connection fails even after that set of attempts, module is put to sleep mode for 10 minutes. After module activation, the „init.lua"script is launched again.

5.2.4 Communication with the central node

A simple HTTPrest API serves for communication between a notification module and central node. We specify module ID and data to be transferred, and data are sent to central server with the POST utility. Central server processes data, it sends response HTTP 200 to that module, and server stores data in database or it launches other predefined action according to the implemented procedure. Providing the central application is not able to accept that message, it sends the error code HTTP 400 and saves the information about unsuccessful transaction in logs [4].

The script implementation is very simple in this case. There exist servicing utilities for HTTP communication in ULA language. The only items to be defined are destination address and message content. The message reception has to be checked afterwards.

5.2.5 Putting module to sleep for a set time period

In order to serve their purpose, there is necessary to consider the power supply concept of individual modules, and how to minimize energy consumption. There are two groups of modules. First group is characterized by uninterrupted operation.

This group includes sensors and modules waiting all the time for launching event, like movement sensor, jalousie control, camera system etc.

The second group includes so called notification sensors that are measuring physical quantities in regular intervals. In between, those sensors can enter the sleep mode that they are consuming minimum energy in until they are activated to perform their task.

There exists „dsleep()" procedure for NodeMCU module. It is a core function either sending reseting signal from PIN32 (RST) to PIN8 (GPIO16 marked D0 on the board) or trying to read that signal. The interconnection of pins RST and D0 is prerequisite for the correct function of procedure.

5.2.6 Temperature measurement module

There exist both simple sensors measuring only temperature and advanced sensors measuring also air humidity. The air humidity could be interesting for case of keeping constant household humidity by automatic humidifiers.

Recommended household air humidity should vary from 40% to 60% depending on particular room. A higher humidity prevails in bathroom, in kitchen, or in sleeping room. The higher humidity is undesirable for food and where clothes are stored. That objects are threaten with moulds. The humidity measurement either can help in moulds formation prevention or in warning about insufficient humidity leading to health problems like sore eyes or sore throat may arise.

Nevertheless, same rooms are not interesting for humidity control so that only temperature measurement is sufficient. In that case, we can use a cheaper sensor. DS18B20 sensor has been selected for our project. When also humidity level is of our interest, we can choose DHT11 sensor or a more expensive but more accurate sensor DHT22.

For a created module fulfils its function of temperature measurement and data passing to server, it is necessary to implement ULA language script. The function of that script is as follows:

1. Module activation from sleep mode („init.lua").
2. Module connection to Wi-Fi („wifi.lua").

3. Temperature value reading from sensor („temp ds18b20.lua“).
4. Temperature forwarding to server („data send.lua“).
5. Putting module in sleep mode for a specified time period („sleep.lua“).

The sleep mode after task execution saves the connected battery energy.

5.2.7 Humidity measurement module

There exist many sensors for the soil humidity measurement. The budget-wise sensor Produino LM393 has been selected for our project.

That sensor is one of the cheapest on the market (1.7 EUR). That sensor enables humidity evaluation both in digital and in analogue form (relative humidity percentage in the range of 0 – 100. Nevertheless, the digital form is very inaccurate, and it indicates only exceeding of pre-set humidity limit.

A digital potentiometer adjustable with cross-point screwdriver on the sensor board serves for limit setting.

Pin A0 serves for sensor data reading in the value range 0 to 1024. That range scale is subsequently mapped to the actual soil humidity. “Moisture” type data is sent back again with „data send.lua“ script.

The houseplants soil humidity is unlike the temperature changing not so frequently, so that there is not necessary to awake module every 10 minutes. It is sufficient to set sleep mode for an interval of about 60 minutes (the maximum value is about 71 minutes). The module with batteries operational time can be remarkably extended.

5.2.8 Movement detection module

One of the most frequently used sensors are the movement sensors installed in buildings and in households. Those sensors are most often used for entrance automatic lights, toilet lights and in other windowless rooms.

Sensor function principle is based on pyroelectric effect expressing relation between pyro-sensitive material deformation and temperature change. The pyroelectric materials represent a subset of piezoelectric materials. Temperature change causes material deformation and subsequently a surface electric charge occurrence. The optical system projects surroundings picture on pyroelectric sensor surface. Any thermal change in surroundings caused for example by a person walking by deforms certain sensor surface area, and it is possible to detect induced charge [26].

The movement detection module has been realised with commercial models NodeMCU and HC-SR501. HC-SR501 module can identify movement in angle of 120° and distance of 7 meters (price 1 EUR) [14, 15].

The sensor data is read via digital pin D4 which is set to mode „gpio.INT“, and with the help of „gpio.trig()“ function, we put pin D4 in automatic detection mode. In that mode, pin D4 waits for event (call-back), and in case of logic 1 reception, module calls the preset function. There takes place a notification of central node about movement detection with the script „data send.lua“ and „Motion“ data type in our case.

5.2.9 Household lighting control module

The household lighting control requires not only module creation with wireless communication addressing ability to a mobile device, but also a wireless control of lighting itself. All foregoing modules are exclusively collecting physical quantities data, but they do not communicate with their environment. Providing that we need to control remotely, we need to deal with a problem what to communicate at lights with. Common house light is connected to the mains voltage of 230 volts, and it is controlled with a touch switch is located at the wall or it may be located at the power supply cable.

The further requirement concerns light intensity control, so called dimming possibility [16].

The design could be related to following alternatives:

1. Light source socket equipped with wireless communication possibility.
2. A new generation of wireless bulbs.

Light source socket with wireless communication

It is about a very simple and efficient way how to control the household lighting. Such solution is also very cheap what could be illustrated with price of 18 EUR for a set of 4 sockets with wireless RF controller. The serious disadvantage of that system is a very poor integration in smart system. We can control sockets not only with included controller but also with any other RF controller. Sockets are matched with a particular controller. Despite of fact that such solution is one of cheapest, its implementation is very demanding and it requires an expert knowledge in radio technology field.

New generation of wireless bulbs

There is emerging also a Wi-Fi application for house lights remote control besides the radio-controlled sockets in couple of recent years. Unlike a simple controlling element insertion between bulb and socket, there are modified light bulbs containing embodied radio receiver. Nevertheless, that system comprises another component called Wi-Fi Hub that receives simple UDP packets initiating the radio signal for individual bulbs control. Such arrangement is easy to implement and to control via any device communicating via a Wi-Fi link. The higher costs of such solution are compensated for much easier incorporation in our smart household system [17].

5.2.10 Window jalousie adjustment module

The last module for smart household system design is an automatic jalousie controller. There exist many jalousie system concepts. In our project, we are concentrated on the current broadly used system of indoor horizontal jalousies supplied for common plastic window design. That system is handled by means of bead pull-chain driving the shaft of window blind.

Most simple way how to handle window blinds is a direct shaft rotation handling. That way of handling has a drawback in module mounting on pull-chain end what means a higher pull force for pulling the blind up. That is why we need 12 volts motor and adaptor power supply.

One of few stepping motors with operational voltage of 12 volts is 28BYJ-48 motor. Stepping motors are well applicable for jalousie handling because of stepwise controlled rotation in accurate number of steps. There is 64 steps needed for one turn of the motor shaft.

Step motor is attached to the module via 4 pins - D1, D2, D3 and D4. These pins constitute and interface between step motor and ULN2003A processing unit. That chip transforms impulses received from NodeMCU module to signal for step motor shaft rotation.

6 Camera Supervising System

One of the main security elements for household security is without doubt camera-supervising system. It guards the household both against intrusion from outside and also monitors various parts of household, like child´s rooms and animals without personal presence necessity. The majority of camera systems is also detecting movement, and in case of such event, camera system can notify user, send the event documenting picture, or it can start event recording.

There exists a huge amount of various camera systems for household security provision. The most important attributes of a quality camera is its functionality, placement variety, and also its ability to communicate with other systems. The outdoor camera required attributes set will naturally differ from the indoor camera one.

Fig. 6. Raspberry Pi Camera module [18].

We have employed the Raspberry Pi camera for our project. Its integration in system is easy, and its performance in household projects is excellent.

6.1 Camera installation in Raspberry Pi

The Raspberry Pi camera module is capable of taking full HD 1080p photo and video and can be controlled programmatically.

If we want to use camera also during the night, it is recommended to accomplish it with two infrared light generating LEDs. Those LEDs are to be fixed with screws on the camera PCB, one LED on each side.

Without those auxiliary lighting, camera would not be able to record picture with corresponding quality in the dark.

The camera installation in Raspberry Pi system is very simple. The only requirement is to connect camera data cable to terminals ready for that purpose.

The further step is Raspberry Pi starting and camera making accessible. We activate „sudo raspi-config“ command on user terminal and subsequently, we find „Enable camera“ item.

That camera enables also streaming services. The access to video stream is possible via a PC or via mobile application „IP Cam Viewer Lite“. That application is available for both mobile platforms Android and iOS as well.

7 OpenHAB Server Implementation

OpenHAB (Open Home Automation Bus) is a server Java application designated for home automation. It offers both a server backend running on all common operational system versions (Windows, Linux, and OS X) and also frontend in the form of web environment plus mobile applications for Android and iOS. It is an open code project what means that application is free of charge under the EPL licence. That is why OpenHab is becoming an excellent candidate for household automation and smart household creation starting projects.

7.1 Architecture

Backend is a very undemanding application running also on less performing devices (Raspberry Pi or Arduino, for instance).

The system is modular, and it is possible to extend it with add-ons serving as interface for peripherals. Among those extensions, we can find also binding to Milight system for light bulb control, binding to MQTT broker in both modes publish/subscribe, email client, blue tooth and others.

7.1.1 Event bus

Event bus is a main service of OpenHAB application. It enables communication among architecture individual devices. Any device can make use of bus for updating or for state change announcement. Commands ensuring state change or starting connected device activity represent other events. All bindings are communicating directly with bus. That loose link enables dynamic character.

7.1.2 Data repository

The other part represents a data repository, which stores states of all connected elements. It takes care for synchronization among all connected packages. All obtained data can be stored in a database, in a hard disk or in cloud systems to ensure durability even after system restart.

7.1.3 Logic of automation

The basic prerequisite for smart household is to react automatically on current state of integrated devices. According to the predefined automation rules, it is possible to control all those devices. As for example, the reaction on received state change from a movement sensor. In case of movement detection and time period condition (between 20:00 o´clock and 7:00 o´clock) fulfilment, the lighting is activated by sending command for the Milight bulb.

Fig. 4. OpenHAB adding items – bedroom [4].

Fig. 5. OpenHAB map creation – rooms [4].

7.1.4 States logging

OpenHab Log serves for data storage in log files or in databases. The RRD4J (Round Robin Database

for Java) is a default database serving mostly for diagram generation in user environment [21].

The other possibility is a link to SQL database or to another one. Providing we store data in files, we find them in OpenHAB home/logs directory [22].

7.2 Graphic User Interface - GUI

OpenHab makes possible to answer individual queries directed to the databases, and to present response in predefined graphic windows. Those windows are to be displayed on a computer s, mobile phone or tablet screen with any operational system.

The windows creation description is beyond the scope of this article. Nevertheless, the following figures illustrate resulting windows example.

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Conclusion

Our project has fulfilled initially formulated task aimed at. The smart household automation simple illustrative model realised with easy applicable development tools like Raspberry Pi and wireless modules has been realized. System is fully functional and documents that it is realizable with relatively small costs and without necessity to cut chases in walls for its installation.

In spite of the fact that the smart household model is simplified only to room lighting and shading, humidity sensing, it is very illustrative in sense of further extension possibility with more complex controllable devices. That is why it has also educational dimension for our students to experiment with smart house elements control.

Our modular smart household model solution does not hamper further model modification and extension for sake of household control optimization.

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