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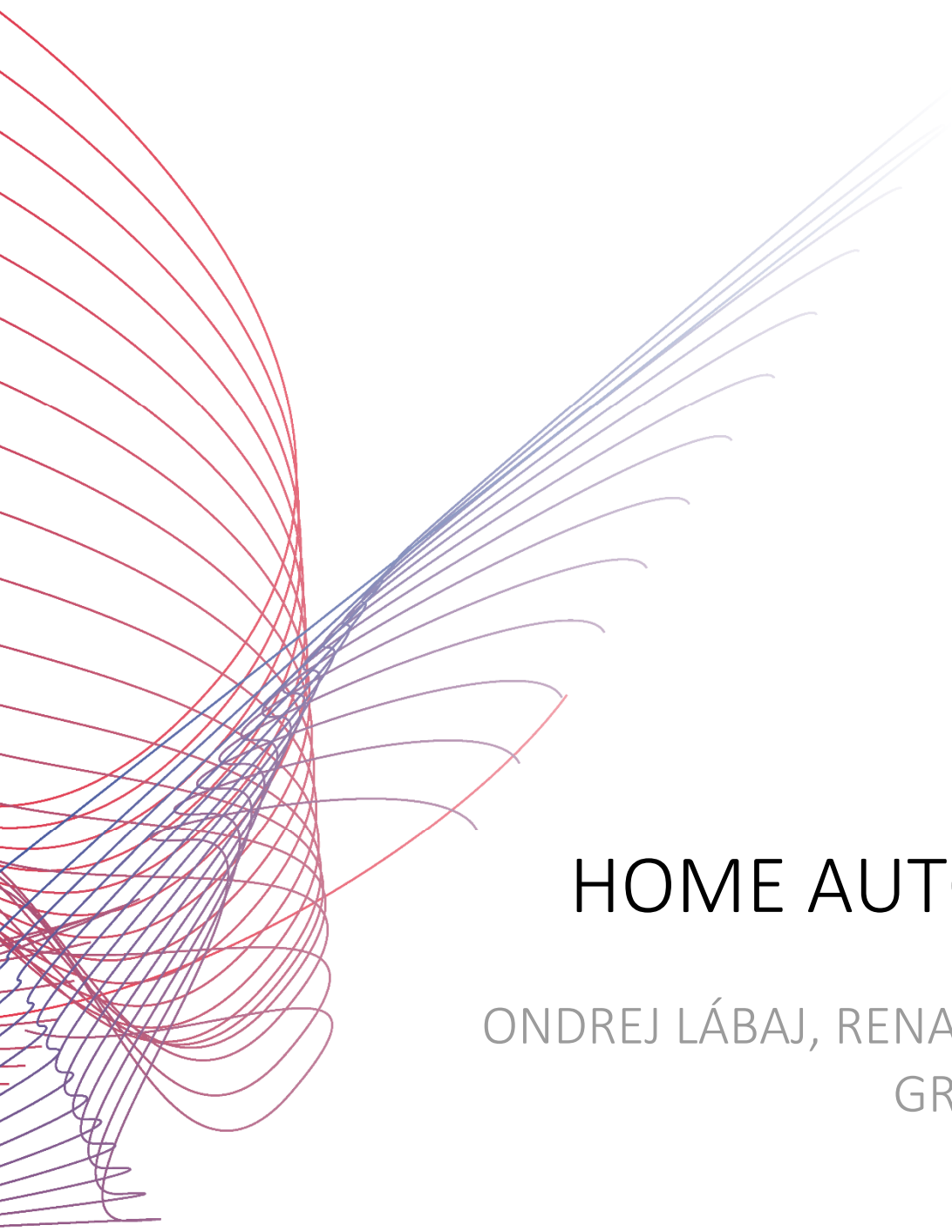

HOME AUTOMATION

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Explanatory Notes

	Definition
	Interesting
	Note
	Example
	Summary
	Advantage
	Disadvantage

ANNOTATION

Home automation is automation of a home, housework or household activity. Home automation may include centralized control of lighting, heating, air conditioning, home appliances, security devices such as locks of gates and doors, alarm etc. It also involves control of domestic activities, such as home entertainment systems, houseplant and yard watering or pet feeding, all to provide improved convenience, comfort, energy efficiency and security. Devices may be connected through a home network to allow control by a personal computer, and may allow remote access from the internet. They can also be controlled via applications installed in smartphones or tablets.

OBJECTIVES

The main goal of the module is to introduce a student to the fundamental of home automation and its use in real life. The student is clearly acquainted with the overview and benefits of home automation, system architecture, control system, sensor types used in home automation, cost management and several use cases.

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1 Overview and benefits

Home Automation stands currently at a crossroads of rapidly emerging technologies such as internet, mobile communication and transformation of renewable energy. All these technologies have in recent years continually improved and become a standard in the households.

The development of these technologies is mainly related to the following aspects of smart home:

- current possibilities of home infrastructure (i.e. wireless coverage)
- usability and multifunctional of some types of equipment, mainly in the area of mobile devices
- motivation to invest into automation and control, i.e. to save energy or improve safety

Until now, home automation primarily concentrated on installing a remote power management for electrical outlets or lighting through install a wired or **IR** (*infrared*) control within the apartment. The used infrastructure has been slow, insecure and expensive. Also during the construction or reconstruction it was necessary to design a system in advance.

The rapid development in mobile communications meant for home automation creation of entirely new options, flexibility and prices. Wireless technologies such as 3G, 4G, WiFi and wireless communication interfaces such as Bluetooth, ZigBee, Z-Wave, Wifi moved this field forward significantly. Instead of simple controlling on/off status the new functionalities have opened up like data communication between controlled devices, intelligent networking in case of a power or signal loss during transmission.

A significant development was achieved in the graphical user interface (GUI). The time of smartphones and tablets finally brought universal control device. The revolution in operating systems and the deployment options of many applications knocked out stationary solutions dedicated control panels and control units. It's possible very easily to upgrade and update all applications. Application developers and companies involved in this field were given the opportunity to expand possibilities in the areas of power management, the security that is related not only to protection of property but also people moving in the area monitored by sensors (i.e. assisted living or elderly care).

Home automation or smart home system can be divided into following main areas:

- Smart Home Entertainment
- Smart Home Computing
- Smart Home Monitoring and Control

- Smart Home Health

Smart Home Entertainment includes control devices and applications for audio and video devices such as TV, set-top boxes, DVD players for multimedia content (DVD, BluRay), game consoles as well as digital cameras or home data storage.

Smart Home Computing includes mainly communication devices, such as smartphones, tablets and PCs, which enable within the home to share and stream data, the most common photo, music or video. These devices are applied also in the next field.

Smart Home Monitoring and Control is segment including in particular the smart metering and home automation systems, supervising and controlling the house lighting, heating or cooling and also safety. The most popular functionalities currently in use are from the safety area. It covers installing CCTV cameras, door lock control, together with lighting and control room temperature.

Smart Home Health covers mainly the area of assisted living, which addresses issues of patient care or the elderly, or children in domestic conditions, by monitoring vital functions, detection and ensuring of the comfortable communications with related parties in emergency or routine situations.

The evolution of the smart home with respect to each area is shown in the following figure (Fig. 1.1). The trend is to provide universal access point to the user that also can connect all devices and also play the role of controller [1].

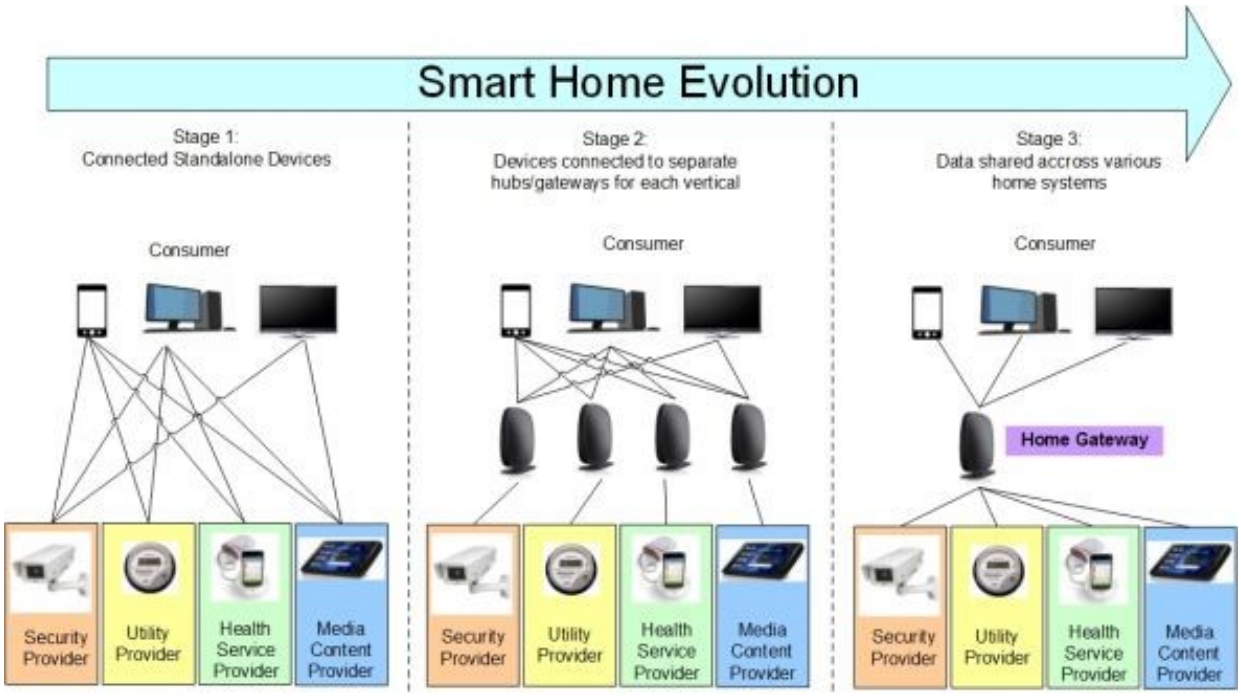

Fig. 1.1 – The evolution of the smart home

2 Smart home control system architecture

From the architecture point of view home automation contain five following parts:

- equipment or devices under control, or devices which are controlled
- sensor/sensors, including an element executing an action (i.e. switching circuit, closures, etc.).
- communication network
- the control system (controller)
- end devices of remote control

2.1 Devices under control

This refers to all components, such as home appliances and all electronic devices, which are connected and managed through home automation system. Producers of these devices increasingly support wireless connectivity, especially through WiFi, Bluetooth, Z-Wave interface, enabling direct connection to the control network.

Appliances, which are not have wireless interface, is possible to control through the appropriate adapters. The use of adapters allows the management of older appliances. On the other hand, control is mostly limited to basic functionality such as turn on/off or dimming (for lights).

2.2 Sensors and actuators

The sensors are basically the eyes and ears of the home network. There are various sensors:

- temperature measurement
- measurement of light intensity or UV radiation
- level measurement of liquid or its presence
- gas detection
- movement detection
- noise detection

Actuators are enforcement of actions. Depending on the type of required interaction can be divided into mechanical (pump), electrical (motor) or electronic (dimmer, relay).

2.3 Communication network

Communications network provides connectivity between devices under control, sensors and actuators on the one side and controllers, including remote control on the other side. Currently, the networks can be divided into three main categories, according to the transmission medium in the process:

- communication through the supply network
- communication via wired network
- communication via wireless network

Communication through the supply network

It is based on the principle of using electrical installation of a flat. The signal transmission is at the level of 20 kHz to 100 MHz. Standard, which until recently dominated in this area was X.10, later replaced by HomePlug. HomePlug entered into force in 2010 (IEEE 1901). His recent version - AV2 - help to achieve data transfer rates up to 500MB/s.

The great advantage of this type of communication is the possibility of using the existing electricity grid in the apartment.

The disadvantage can be the actual phase separation and the presence of the electrometer in the electrical system, which prevents transmission of data signals.

Communication via wired network

In this area two open standards are known - KNX and LON. KNX is a European (EN50090, 2003) and international (ISO / IEC 14543-3, 2006) standard for home automation and building automation. This is an abbreviation from the name Konnex. This standard replaces the older European standards **EIB** (*European Installation Bus*), Batibus (used primarily in France) and **EHS** (*European Home Systems*).

LON stands for *Local Operating Network*, originally introduced in 1990 and later in 2008 as ISO/IEC 14908 as a solution for automation in industrial buildings, airports, stadiums and street lighting.

Compared KNX and LON, Local Operating Network architecture uses decentralized management. For large installations, the management and can avoid

a central control point, which is important particularly for public installations with high demands on availability.

Communication via wireless network

Today there are more technologies that allow wireless transmission for both the home automation and building automation.

Transmission speeds, frequency and modulations used for each technology are different. An important distinguishing criterion can be the way how to power sensors, or battery life supplying independent sensor. The table below summarizes the wireless technology used in home automation [2].

Wireless technologies used in home automation

	EnOcean	**Z-Wave or KNX-RF**	**ZigBee (802.15.4)**	**ZigBee (802.15.4)**	**Bluetooth (802.15.1)**	**WLAN (802.11)**
Frequency	868	868	868	2400	2400	2400
Data rate (kbit/s)	125	30	20	250	720	11000-54000-100000
Range (indoor/outdoor in meters)	30/300	9.6/20	30/500	30/500	10/100	20/50
Energy needed	extremely low	low	low	low	medium	high
Risk of data colison	very low	medium	medium	low	very low	high

In the building management was the use of wireless sensors always the second option, particularly in existing buildings. But the existence of new standards using very low power consumption of power supply gradually changes this situation.

Wireless interfaces such as Z-Wave, ZigBee, **BLE** (*Bluetooth Low Energy*) and **RFID** (*Radio-frequency identification)* is now being progressively integrated into power outlets, lighting controls, and household appliances. The same goes for audio and video electronics, where the WLAN (WiFi) module is part of the device, ready to stream multimedia content directly from the Internet, with possibility to be fully controlled via smartphones. A new generation of wireless technology is the standard EnOcean, able to communicate on a wireless line through energy from light or temperature changes in the environment or through energy recovery from mechanical switching lighting controls.

The control system (controller)

Under the controller is meant a control device that acts as a "brain" in the whole home automation system. Into this unit are directed information collected by sensors and vice versa sensor receives control commands. Under orders for sensors is meant for example setting the level at which the sensor send messages, etc.

Mostly, the sensor is unit that unidirectional sends collected information to the control unit where are evaluated. Based on predefined rules, control unit sends a command to the appropriate actuator that performs the desired action. The role of this component in the whole architecture is also texting, e-mailing or sending notification directly to the control unit (via the application in the smartphone/tablet).

These units already have the standard *Operating System* (**OS**) such as Linux/Windows/OS-X, which are specially adapted for these units.

If necessary, the control units supplied Uninterruptable Power Supplies (**UPS** - *Uninterruptable Power Supplies*) or contain a battery that some time can provide independence from the main power source during a power failure.

The remote control

One of the main reasons for the growing popularity of home automation systems in the residential segment is the ability to control the entire system via smartphone or tablet, more precisely said through the applications installed on the endpoint device. Over the past few years and also nowadays the great development of new applications for households is taking place.

The terminal equipment is via WLAN (WiFi), 3G/4G (via the Internet) connected to the home system. The control setting is possible not only of the areas of the house, but also at a distance. In the past, such a remote control was realized as the connection of control unit to the telephone line.

Comparison of wireless technologies

ZigBee

ZigBee is a networking standard operating in the so called routed mode, developed by members of the ZigBee Alliance [3]. His current name was established in the 90s, the original was called "HomeRF" protocol. Ratified standard was publicly released in June 2005, as "ZigBee radio standard". This standard also defines the network security as an additional layer to the existing IEEE 802.15.4 standard [4].

ZigBee has been proposed for use in a wide range of different types of applications, starting with home automation which uses mainly battery-powered sources and ending with industrial use in the management of large objects.

IEEE 802.15.4 standard was finalized in 2003 as a *Low-Rate Wireless Personal Area Network* (**WPAN**), which includes several layers. In particular it is the so-called Direct Sequence Spread Spectrum (**DSSS** - *Direct Sequence Spread Spectrum*), *Physical Radio* layer (**PHY**) and software layer *Media Access Control* (**MAC**).

Several manufacturers of chips offer 802.15.4 as part of one integrated board with a microprocessor and 128 kilobytes of memory for ZigBee applications.

The main objectives of the ZigBee standard are:

- wireless networking for industry management, connecting medical equipment and home automation
- Mesh network with its own organization, without the need for a control unit, for example in the case of a failure of communication on the road. The role so called "data forwarder" from remote sensor takes over the closest sensor nearby
- low data demands
- low energy consumption, at least one year without battery requires recharging or replacement

ZigBee defines several types of entities or devices:

- network coordinators - one in a network that is the root of the network tree
- **FFD** device (*full-function device*), fulfilling the role of routers
- **RFD** devices (*reduced-function device*), which cannot be a router

Only the FFD devices can control the routing in the mesh network. ZigBee for this purpose defines the star-structure containing RFD at the edges of the network but also the hybrid network, called cluster tree.

ZigBee 802.15.4 radio uses the 2.4 GHz frequency, in the USA it is 915 MHz and in Europe 868 MHz. The last two lower frequencies did not receive support from manufacturers operating on the market for end consumers.

Manufacturers of end devices must be members of the ZigBee Alliance.

Z-Wave

Z-Wave is just as ZigBee networking standard operating in the routed mode. The owner of the patent for this protocol is the company Sigma Design [4], which bought the patent from its creator, company ZenSys of Denmark, in 2008 [4].

This wireless communication protocol is focused primarily on applications for home automation where the main objectives are:

- low cost solutions for standard households
- very long battery life of powering sensors
- easy installation which can be handled also by regular user
- possibility to easy connect sensor to the network
- interoperability between network devices from different manufacturers

The communication protocol of the Z-Wave technology routes messages using *Source Routing Algorithm* (**SRA**). Source routing algorithm requires from the initiator of the report (under initiator is meant device/sensor) knowledge about the layout of other sensors/devices in the network. Based on this knowledge the messages are routed always via the shortest route. Maintaining the current database and forwarding the network topology of active devices in the network is a task of complicated software device, which is also responsible for other devices that may be mobile in the area, i.e. they may change their position.

Z-Wave (Fig. 2.1) defines a different categorization of equipment because the mentioned logic can cause the price of device/sensor will be too high. Thus Z-Wave defines so called slaves (subordinate devices). Slave device cannot monitor conditions mentioned above like moving, and is therefore statically programmed to communicate with a specific device in the network. Described logic is the most important functionality of this protocol.

Fig. 2.1 – Z-Wave technology

Z-Wave radio networking is designed for limited quantities so called nodes, which may be up to the 232 in the network. However, producers recommend a maximum number of nodes 30 to 50, where each one communicates in an interval of 5-15 minutes.

Z-Wave reports are of variable length. Just for information, message body may have an average of 4 to 6 bytes; the latency must not exceed 200 milliseconds.

Also in case of Z-Wave the manufacturers of equipment supporting this communication protocol have to be members of the Z-Wave Alliance.

Wifi

In recent years, WiFi (IEEE 802.11) has become the standard for broadband wireless networking at homes or corporate LANs. Increasing popularity therefore addressed the home automation especially in the field of streaming media content between devices at home.

IEEE 802.11 is a standard that currently comes with several versions *a*, *b*, *g* and *n*. 802.11*a* is licensed for 5GHz band and is unused in facilities for ordinary households. In the sector of ordinary users are used 802.11*b*, *g* and *n*. Version *b* has communication speed 11Mb/s (megabits per second), used since 1999. The next version is *g* with speed 54 Mb/s, launched in 2002. Version *n* with speed of 100Mb/s and higher began to use in 2006. WiFi network is typically implemented in a star network topology. This is not a mesh that means, it is always a point-to-point communications.

Wifi with its transmission speeds is on the top of all wireless technologies used at home.

The big disadvantage is the high energy consumption and a complex process configuration.

In case of star topology it is important to think about the reach limits what is usually 50 to 100 m in free area. Central access point is usually controller or router to which the controller is generally connected through an Ethernet connection.

The big advantage of WiFi is that the network connections and data transport use TCP/IP protocol, which is used on the internet.

Wifi is also used to connect the IP camera in home automation. IP cameras are connected to the supply network and are independent of the battery. Transmitted data stream is stored in the home data storage at specified intervals and quality. That can be controlled by designated recording equipment, which is increasingly common in the home but now being replaced by a universal solution in the form of a WiFi access point with household data storage.

In addition to transmission the video from IP cameras, WiFi is also used to connect any media device in the home, including mobile devices and computers, among which it is possible to share multimedia content.

Bluetooth

Bluetooth is defined by The Bluetooth SIG [5] and is standardized in IEEE 802.15.1 as wireless ad-hoc point-to-point technology for Personal Area Networking **PAN** (*Personal Area Networking*).

This technology has been proposed also to achieve low demand for power, but is limited on the roughly 10-meter radius (unobstructed). Bluetooth is used mainly in mobile phones and wireless headsets, tablets and PCs, especially as a replacement for wired peripherals.

The new version of the communication technology called Bluetooth Low Energy or Bluetooth Smart brings in PAN new opportunities. The development of this technology in home automation focuses on the field closely related to eHealth, which includes the so-called Assisted Living. It can be device or equipment placed on the body or as part of subject used daily, sensing biometric characteristics of the user.

This technology is very interesting also for the manufactures of mobile devices and tablets. The newest devices and the equipment containing Bluetooth interface referred it in specifications as Bluetooth 4.0. The latest version has become part of the Bluetooth standard in 2010, officially unveiled by Nokia under the name Wibree.

Bluetooth operates in the 2.4 GHz band using frequency hopping spread spectrum **FHSS** (*Frequency Hopping Spread Spectrum*), achieves data transfer rates do 3Mb/s and PAN supports the adding of additional seven nodes.

EnOcean

EnOcean is a wireless technology, which uses the energy from the surroundings to supply sensors, i.e. converts thermal, electromagnetic or solar energy into electricity. The principle of obtaining energy allows ultra low energy to power the sensor module.

EnOcean has become a standard in 2012 (ISO / IEC 14543-3-10). This standard covers three layers of the OSI model, namely physical, link and network. The patent owner is the company EnOcean, founded as a spin-off of Siemens AG. The aim of EnOcean was to develop wireless modules that can power themselves, without the need to add battery pack.

The transmitted packets are relatively small, only 14 bytes long with a transmission rate of 125kbit/s (kilobits per second). EnOcean is in specific implementation mainly used for not data-demanding applications, or sensors which do not transmit many data. This can be specifically the light switches, movement sensors, humidity and temperature sensors etc.

EnOcean uses multiple transport frequency: 902 MHz, 928.35 MHz and 315 MHz.

This standard is mainly used in building automation, logistics and goods transport in industry. Nowadays it becomes quite popular also in the area of home automation. Again, the module manufacturer must be a member of the EnOcean Alliance.

3 Type of sensors

The best idea of the types of sensors and their applications in the home environments describes the figure (Fig. 3.1) with model installation of the whole system. For better illustration several types of sensors and other equipment were used that are followed their description.

Fig. 3.1 – Example of smart home

An essential element in the system installation is the control unit, otherwise referred to as a HomeHUB or *Access Point* (**AP** in the figure). The access point is the common name for home routers used in households for connecting devices to the Internet.

Some manufacturers therefore try to broaden the functionality of these devices towards smart home. In some cases it is even possible to upgrade to the new firmware to support the smart home functionality. The assumption for this is that the other peripheral equipments (e.g. sensors) are connected by a wireless technology that is supported by AP. However this is related mostly to WiFi technology, which is very demanding to power supply and the associated battery life of the sensor. So this method is not ideal. The most common solution currently is adding AP to the existing home router and to connect them together via Ethernet.

The control unit is usually provided directly by a smart home services provider or through the sales network. From a technical perspective, the choice of appropriate AP influences used sensors that have to support the same wireless communication.

Now we will go through sensors used in the figure (Fig. 3.1).

Movement sensor called also PIR sensor is one of the most common sensors. It fulfills not only comfort needs (automatic turn on/off lights) but also security needs (monitoring area in case of absence). These sensors are in the market for a few years as part of dedicated security systems, connected to the control unit via the already pre-prepared infrastructure in the apartment. The current trend is to control the sensors wirelessly, with the possibility of placement anywhere in the home.

Smoke and fire sensor can be part of one peripheral. While the smoke sensor checks the conductivity change to detect the presence of smoke or gas in the room, fire sensor works on the principle of temperature sensors.

The temperature sensor was previously and currently is part of other sensors. This approach has not changed and the temperature sensor can be found for example, as part of door magnetic contact or PIR sensor.

The magnetic sensor is simple and well known sensor used in security systems for monitoring entrance or balcony door to the apartment, working on the principle of controlling contact through magnet controlled microswitch.

IR generator (**bar**) can be used as so-called infrared wall for protection e.g. the balcony area or even in the comfort mode as part of the entry garage door. Start the selected action is caused by interruption of the light flow between receiver and transmitter diode.

SOS button is actually very simple driver which triggers the appropriate action. In this case the button can fulfill the role of callingduf help. Button may be as a part of the bracelet on the arm of an older family member. The supply of bracelet in this case can be settled by the simple lithium battery, since sending a signal happens only when you press.

The cameras are mainly the domain of security systems and are mostly used for this purpose. These peripherals require continuous power supply, no independent battery power as the main source is used. Their use is wide and also for the monitoring of movement of older or smaller family member in the absence or in the next room.

Lighting control can also be realized by wireless switches, intelligent dimmers responsive to the touch. Due to greater comfort simple controller is installed in every room. Cheaper solution is a combination of existing switches with the actuator, which is controlled wirelessly.

Thermostat belongs to the controllers designed to control the temperature in a room or at home. Using of existing thermostats installed in the apartment can be problematic. Therefore its replacement solves application on the tablet or touch control panel. The thermostat can also contain a temperature sensor.

Drapery control, multifunction controls are mostly simple, single-purpose remote controls designed to control a particular case, i.e., curtains or even lighting. Their advantage is ease of use (older persons who may have a touch panel problem).

The touch control panel is a universal remote control that can operate and control any device connected to the system via the application. It allows you to set scenes and program a sequence of events. Currently these types of remote conrol are replaced by selfphones or smartphones.

Data storage is designed to store multimedia content (video, audio, photo) and also serves as a storage server for recordings from cameras. It can also be used to backup data from other devices in the home (PC, tablet, smartphone).

TV or **Smart TV** can play multimedia content in addition to serve as a monitor for the installed cameras, as well as lighting control via special application while viewing the desired content.

Mobile user end device are in terms of smart home remote control system as well as the devices connected to the home network that can access the multimedia content.

External conditions impact on process management

Influence of external conditions on the process management means mainly energy management. Managing energy consumption is the main motivator for implementing home automation system in homes. Second place belongs to the safety and comfort of users.

Fig. 4.1 – Energy management

Energy management is particularly the effective use of renewable energy sources when supplying electrical appliances during favorable weather conditions combined with the power distribution system. The system in this case effectively regulates the use of these resources in order to minimize withdrawals from a distribution system.

In the area of solar panels significant progress was made. This advanced technology manufacture solar panels that are cost-competitive with conventional collector, designed primarily for heating water. This means that electricity derived from solar conversion can solve the problem of hot water used at homes, while at the same time it is possible to power by the energy other appliances.

A novelty is also the improvement of production technology of battery cells, which essentially revolutionized the ability to store the energy generated during the day and use this energy at night for heating or lighting, or during the next day to cool the interior.

Use of renewable sources in combination with intelligent electrometers offers plenty possibilities for energy management.

Home automation systems can manage energy consumption for heating by measuring not only the interior and exterior temperatures, but in combination with electrically operated exterior shutters to regulate the conditions in the interior and at the same time saving energy required to illuminate the space. The combination of these criteria is using the correct user interface and good control algorithm by the very simple choice of the user.

Energy management domain was in an industrial area and with the arrival of home automation systems gaining popularity amongst end consumers.

4 Cost management

Cost management is an economic criterion especially for energy management described in the previous chapter. Equally, however, cost management can be reflected in the solutions for the protection of property or for comfort.

In all areas one tries to achieve effective cost reduction like the energy consumption or even human power (unless we are talking about the security of property).

Significant entry is input costs to build the system and their overall returns. Before installing home automation end customer must identify the primary objective for which he plans to use the installed system. The current market in this area is becoming more and more saturated, which has a significant impact on cost solutions. It also addresses a very wide group of prospective users with various functionalities and ease installation.

5 Use cases

In previous chapters were discussed type of sensors and several examples where home automation can be used.

The Smart Home market is based on "home automation" and covers four distinct areas:

- Security: alarms, presence simulation, remote information and intervention
- Health: support for the elderly, home care
- Energy efficiency: automatic control and regulation of all utilities (water, electricity, gas)
- Comfort: ambiance, lights, shields, interconnection of existing devices

Since these areas overlap and can be combined, one can say that options in home automation area are limited only by user's imagination. Specific use cases are described below.

RFID and location services

Radio-frequency identification is the wireless use of electromagnetic fields to transfer data, for the purposes of automatically identifying and tracking objects via tags (labels), the tags contain electronically stored information.

User can have several profiles based on RFID: home profile, office profile, car profile etc. Via application in smartphone RFID is detected and correct profile is set. The RFID tags can be simply attached to almost anything as a sticker, and RFID function is featured in modern smartphones as well.

Other ways of knowing location are already used nowadays: GPS and location transfer via mobile network and location based on Bluetooth.

Once the system finds out someone has arrived, it can perform pre-defined set of actions.

Controller

Automation controllers is central to the automation concept and causes entire home to operate automatically when an intelligent controller becomes the brains of the smart home. Automation controllers control lighting, climate controls, entertainment components, irrigation, and any other systems/sensors.

After the system is programmed, it operates on its own to decide what the home should do under various circumstances. User can also manually control system with user-friendly keypads and touch screens, and even through a smartphone or the

Internet. The controller can incorporate heuristic or fuzzy logic to correctly access all inputs and even learn one's habits to correctly determine actions that are based on sensor inputs.

Wireless home automation networks (**WHAN**) comprise wireless embedded sensors and actuators that enable monitoring and control applications for home user comfort and efficient home management. A WHAN typically comprises several types of severely constrained embedded devices, which may be battery powered and are equipped with low-power *radio frequency* (**RF**) transceivers. The use of RF communication allows flexible addition or removal of devices to or from the network and reduces installation costs since wired solutions require conduits or cable trays.

Sophisticated controllers can even be connected to the cloud and harvest it's computing power enable user to control everything by voice and provide him with human like voice responses, similar to systems provided by Apple's Siri, or Microsoft's Cortana (which is available via **API** - application program interface even today).

Security

Security systems include control panels, keypads, sensors, sirens, locks, lights, access control and more. Locks can be controlled remotely via application in smartphone, either by Bluetooth, RFID or internet. Security system can be extended by selected multimodal features, like face or voice recognition. So user can be identified and based on his role gets access right (like family can have access everywhere, gardener only to outdoor gate and into storage with tools, etc.).

Smoke detectors can be also installed as part of security system, to cooperate with automation system and protect homes again fire. Perimeter sensors alert user when a person crosses home property line. Movement sensors can be installed on walls, on ceilings, in light switches or outdoors and inform about every motion. Glass break sensors alert user security system when a window is broken. Flood sensors know if the washer or water heater breaks, and can even automatically shut off the water supply before a potential disaster. Driveway alerts let you know when visitors arrive.

Video and cameras - home can be monitored with surveillance cameras, cameras that see in the dark, large and small cameras, bullet, dome and hooded cameras or hidden cameras. User can view his home from any computer over the Internet, from a smartphone or though his personal digital archive. The archive can be stored for preset time since time lapse and digital video recorded keep a log of what goes on around user's home. Monitors let user watch different areas of the house, like the pool area or nursery.

Environmental controls

Environmental controls include everything connected to heat and humidity and water. Window shades, **HVAC** (*heating, ventilation, and air conditioning*), central heating, even perhaps a smart fridge may be controlled depending on the information collected by several types of sensors that monitor parameters such as temperature, humidity, light, and presence. Unnecessary waste of energy can thus be avoided. In addition, smart utility meters can be used to detect usage peaks and alert the household devices that may be causing them.

Irrigation systems can be thought of as subset of outside environmental controls that can be programmed to operate on a preset schedule by event (or even a set time before dawn). It can be controlled also by an underground humidity sensor, so in case the soil is not dry the system won't do anything. If connected to internet, customized application can read weather forecast and based on it adjust irrigation plan (i.e. in case of forecasted rain the system won't do anything).

Using solar collectors can significantly help with saving energy. Solar collectors collect heat by absorbing sunlight or convert it directly to electricity. The main use of this technology is in residential buildings which are used for heating water. This generally means a situation with a large family, or a situation in which the hot water demand is excessive due to frequent laundry washing. Commercial applications include laundromats, car washes, military laundry facilities and eating establishments. The technology can also be used for space heating. Electricity generating solar collectors (heat generating collectors are mainly used because they currently have higher efficiency than electricity generating ones) can be connected to batteries to store energy, which can be later efficiently distributed based on house needs. This energy can be used during hours when the electric energy is more expensive (in case of different price in day and night), so water heating, washing machine etc. is using energy from battery. All electronic devices can be configured to use either energy form batteries or from company distributing electric energy. All can be configured or controlled by user via application at computer or smartphone.

The energy stored in batteries can be used in smart grid scenarios, when surplus generated electricity and electricity from a battery is used to feed (sell) electricity to public grid. Such applications are very useful for distribution companies, as they provide cost effective way of dealing with spikes in demand for electricity and in sufficient numbers provide a good way of preventing blackouts.

Sample usage scenarios

Lighting and appliance control – turn lights on or off, dim or brighten lights according user's needs. This can be managed from outside or inside home using powerline or RF/wireless remote control. It is possible to control both lights – indoor and outdoor according family schedule or special events (i.e. turn lights on in the evening when it's get dark and off again a few hour later). Based on RFID user can be identified approaching home and lights can be automatically turned on and the way to garage and home is not dark. When it gets light in the morning, some home appliances can be turned on, like coffee maker or hair curlers. Also once a

TV is powered on, the lights can dim automatically, the drapes or sun blinds could shut and home entertainment components would turn on. Wind sensor can send command to open sun blinds or shutters to prevent damage in case of strong wind or based on weather forecast (strong wind, rain). System can be set to automatically close drapes/sun blinds on a schedule, by remote control or automatically when the sun shines directly in, when temperature is too high or their combination. It's possible to control windows by wall switch, remote control or an automation system to automatically close them when it starts to rain. It's perfect for skylights that are hard to reach. Robotic vacuum could be powered on once nobody is in a house, but only if somebody was inside since last cleaning session.