Classification of Functions in Smart Home

P. Hamernik, P. Tanuska, *Member, IACSIT*, and D. Mudroncik

***Abstract*—The new trends in decoration of family homes are aimed at solving home called smart home (hereafter SH). Looking definition for intelligence SH is different for the user, investor, architect or designer SH devices. This means that the SH functions are chosen differently, the definition of SH is inconsistent. This paper presents a new approach in the proposal optimum choice of functions, which are based on a hierarchical categorization of functions; classification of types of user SH and SH defined the concept of intelligence. Our approach to the solution of SH provides the direct use of the software support system design specification of user requirements in a form that is suitable for hardware and software implementation of SH functions.**

***Index Terms*—Smart home, functions of smart home, type of user**

I. Introduction

The current developments features and industrial automation equipment allow the implementation of SH. Their functionality, affordability and versatility allow them operate even in family homes. Such devices are called as home automation devices. Home automation includes a broad class of sensors, actuators and control devices [1], [2] and the application software.

In Fig. 1 you can see illustrates that today home automation has several groups of devices. The bottom chart you can view the most prevalent part of the home automation, which is caused by economic easier accessibility.

Optimizing the selection the individual functions of SH is determined by specific user requirements. Each user can select various functions to different levels. Function selection affects so many factors [3]. Often the choice of functions SH is made intuitive and reflects the experience and knowledge of the designer. This paper presents a systematic view of SH functions, which are divided into several functions, depending on their importance in terms of performance SH and user requirements SH.

There are selected functions of smart home so as to cover the greatest range of users. In Fig. 2 we can see the distribution of groups of functions in SH.

Group Electro is a collaboration of several functions such a s control system with touch panels, planning operations in a specified time, control appliances, control kitchen appliances, irrigation control systems, and control via SMS. Very important part is the placement of individual elements and components. Therefore, control of the individual functions has been to centralize in a single control. The big advantage is centralized in a single controller that can facilitate access to the system, which is desirable for a group of seniors [5].

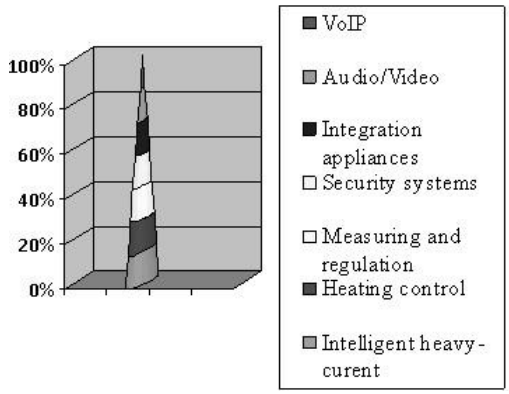

Fig. 1. The use of home automation on market [4]

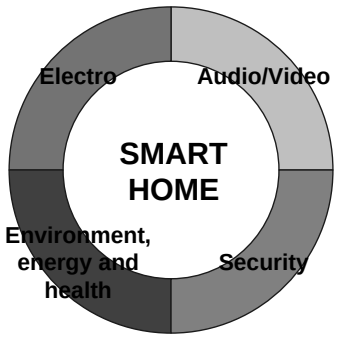

Fig. 2. Integration for complex functions for smart home

The groups of Audio/Video include individual functions home theatre, music and games. Functions of home theatre offers live the same movie experience as in the cinema. The great advantage of home theatre is the central library of multimedia, internet access and email. Music brings users of SH the perfect atmosphere for example to relax in the sauna, bathroom, with fireplace. Games are not just for children, but became a part of family fun without limits of age, because with a simple operation and control can play everyone [6], [7].

Every home should be not only beautiful but also friendly to the environment and energy. The group Health covers the functions, which oversee the health of the user [8]. For example, a simple download window shutters can save costs on cooling, saving modes in the absence of users, family doctor, drug dosage.

Security protects the home from the first seconds of leaving users, but as can be in control of the children so that screen can see the movement of children in baby's room, the pool or around the home [9].

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P. Hamernik, P. Tanuska, and D. Mudroncik are with Institute of Applied Informatics, Automation and Mathematics, Slovak University of Technology, Paulinska 16, 917 24 Trnava, Slovakia (e-mail: peter.hamernik@ stuba.sk, pavol.tanuska@ stuba.sk, dusan.mudroncik@ stuba.sk)

II. Hierarchical Three-Dimensional Structure of Functions in Smart Home

Commonly used definition of SH necessarily requires specific architectural design. Our definition of SH includes the existing classical solutions of homes, because intelligence is understood as the sum of the functions, which SH provide to user. It is therefore possible to provide intelligence and the home, which was originally proposed as an intelligent solution. The current hardware and software resources, especially wireless solutions allow it. The present categorization of functions has the general nature of an open solution that is substantially independent on layout of the SH.

The proposal of three-dimensional structure of functions in SH contains three levels:

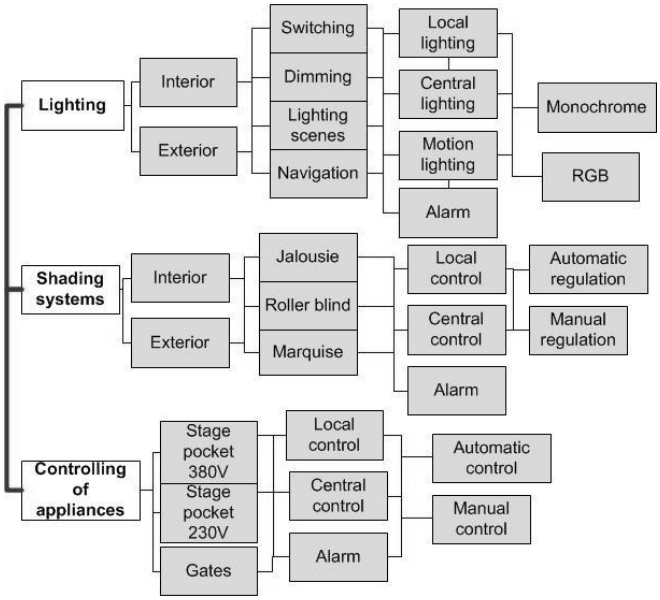
- the categorization of functions by level of importance to the operation of SH and user comfort required,
- a summary of the functions of each category of functions,
- the classification of functions according to the type of user SH.

Note that today's hardware and software make it possible to design functions for each individual room in a home. Their flexibility allows even the same room to adapt to the different types of users according to their specific requirements.

A. Categories of Functions

The functions of the SH can be classified into several groups. The proposal of groups was taken into account for the SH-users. Functions of the SH groups are proposal to:

- the standard group (Fig. 3) are assigned functions which are an essential part of SH. Each SH should include the functions listed in the basic group. The criteria for selecting functions in this group are functions ensuring standard needs of users, functions providing automation of routine activities,



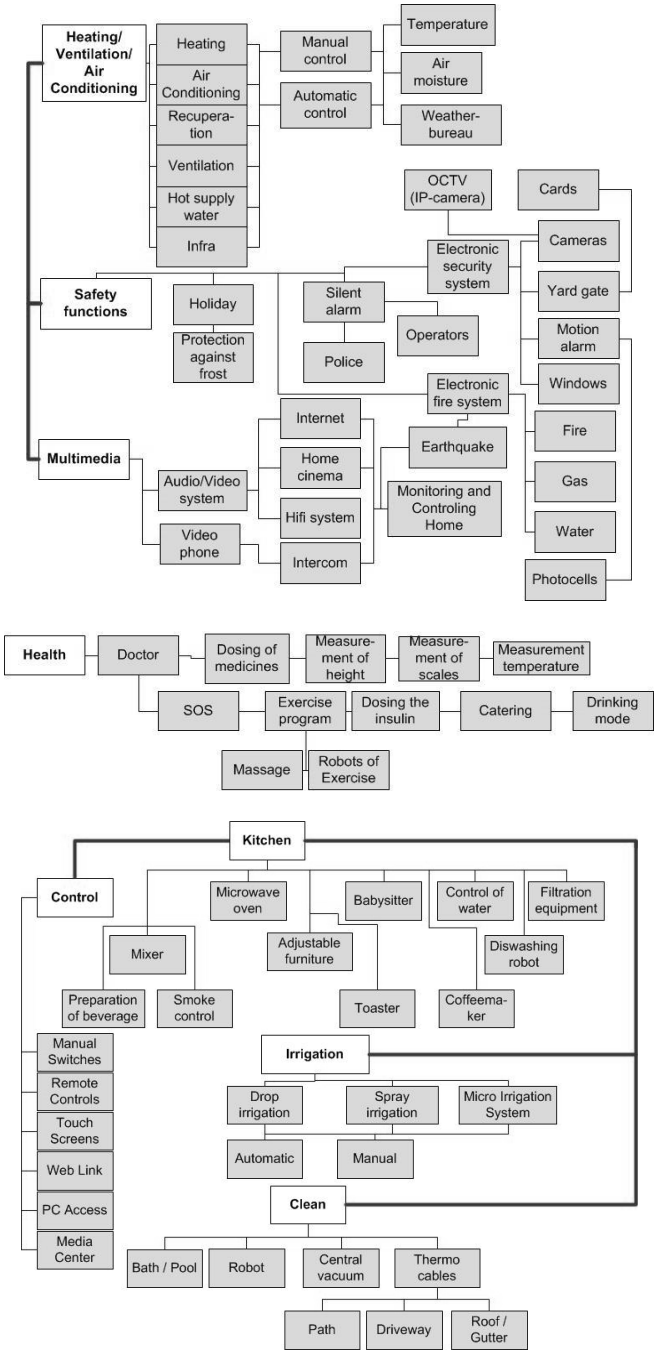
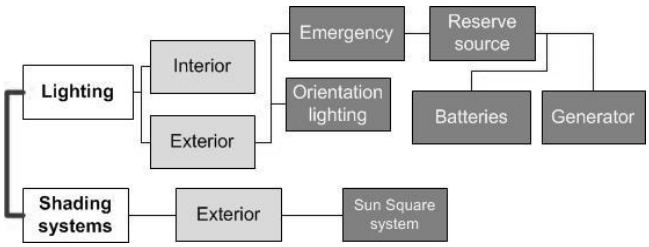


Fig. 3. Functions included in the standard group

- assistance group (Fig. 4): in this group included functions that are directly linked to a basic level. These functions are intended for specific users and are like a superstructure of functions in basic group,



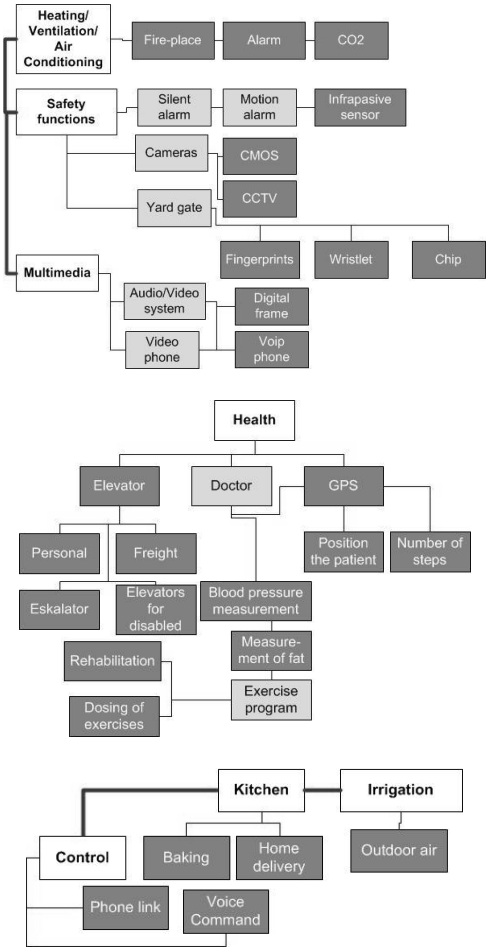


Fig. 4. Functions included in the assistance group

- comfortable group (Fig. 5): this group includes functions that contain the maximum available functions for amenities SH. The implementations of these functions are a higher cost. These functions are not necessarily required to operate the SH.

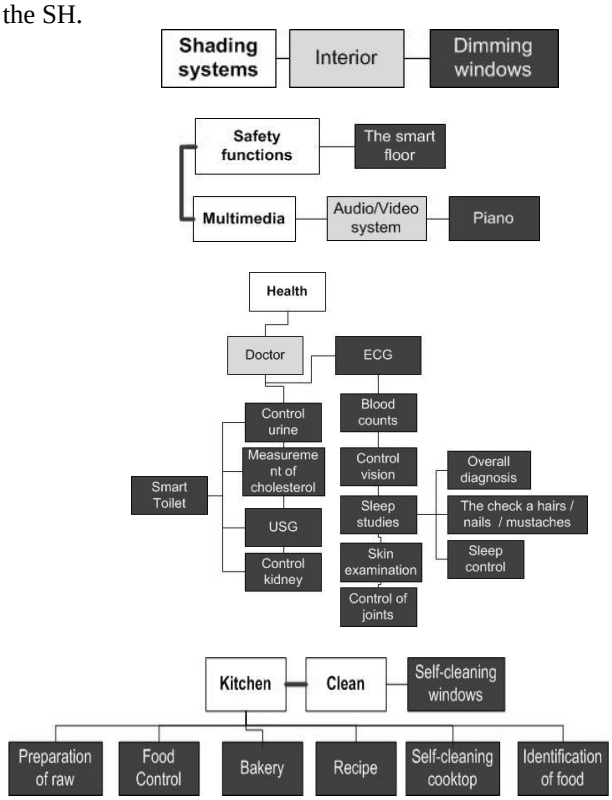


Fig. 5. Functions included in the comfort group

B. Group Functions

Group functions are divided according to their application in the SH. They are the group as follows:

B1 Lighting
B2 Shading system
B3 Controlling of appliances
B4 Heating, ventilation and air conditioning
B5 Safety functions
B6 Multimedia
B7 Health
B8 Kitchen
B9 Irrigation
B10 Clean
B11 Control

B1 Lighting

- is most often used to optimize the users activities. The group of lighting includes:

- local lighting – lighting for each room separately, the possibility of using light scenes,
- central lighting – is used mainly in holiday mode,
- navigation lights – is mainly used for outdoor lighting such as walkway, pool,
- emergency lighting – lighting that is triggered when an alarm is triggered,
- lighting scenes – help create a pleasant feeling in everyday activities,
- interior or exterior light is monochromatic, RGB light or their combination.

In defining the requirements for lighting help both the standard EN 12464-1 and the EN 12464-2 (Light and lighting) as well. [10]

B2 Shading system

- shielding elements of the interior or exterior not only provide a comfortable temperature of users SH, but also ensure the security and privacy. The summer is not only pleasant shade areas from sunlight as well as economic, which relieves energy-intensive cooling. In winter, the opposite is true, when the heat gain from solar radiation is welcome. In this case, cooperation is key to the heating respectively cooling. Among other things shading system also protects the interior from UV rays. The most effective shielding element is adjustable exterior jalousie. Automation ensures the electric drives the best with variable speed control; saving the drive mechanism itself screens [5].

Jalousie, roller blind or marquise can be controlled by time program, depending on other variables (data from weather station), the state of other objects (security subsystem), or manually as required. Manual control is realized through the wall push-button controls, such a s lighting. In the summer can shade Windows automatically when the temperature rises and the intensity of external lighting increases above specified threshold. When the sun goes down behind the clouds is no longer shade. Shooting blind of jalousie are made according to the external lighting on each side of the world or in any room regardless of the timing of the program. Calculating the position of the sun in the sky can be controlled angle of blades and thus a sufficient shielding to maximize natural lighting in the room. Roller blind can be operated individually, in groups or all at once. When leaving the home retracted roller blind serve as a barrier against

intrusion into the interior. Electric operated blinds are blurred at dawn or in conjunction with an alarm. Marquise is typically found time in retracted position. The need for sunny days, the marquise is stretched.

Automatic control sensor ensures wind and rain, which in case of bad weather to bring shading system to the security screening position, followed by blocking the re-launch.

Newest no need to use shielding jalousie or roller blind, shades can be using „smart glass“ in the windows, which vary smoothly shaded. This method is not yet a great application, supported by the high acquisition costs.

Specifically, the conversions to the same conditions and compare the results of overheating and shielding interior are standardized tests and calculations in accordance with standards EN 12567-2, EN 13363-2 and ISO 15099.

B3 Controlling of appliances

- all appliances in the home are connected via a network of 400V and 230V for the European network. Controls:

- can be automatically or manually via a local or central controls,
- specific functions and settings for individual devices is possible via the serial port (RS-232), which is two-way communication with the device (for example: feedback information of off),
- through the infrared port is mainly used for A/V technology, which is a disadvantage only one way communication.

The latest equipment is emerging Ethernet port when the device is part of the computer network and provides a wide range of control.

B4 Heating, ventilation, and air conditioning (HVAC)

- are important functions that make up a significant part of SH functions. They provide thermal comfort. This group of functions includes:

- *Heating*– provides individual regardless of air temperature in individual rooms and spaces SH. Controlled by the type of user, depending on the time and the presence of the user.
- *Air conditioning*– as in the previous sections, but for space cooling mode.
- *Air quality*– management and recovery of ventilation air supplied from outside.
- *Preparation of hot water* – depending on the energy source such as a combination of gas, solar energy or heat pump to achieve the minimization of costs for water heating. It takes into account the criterion of time and amount of consumption of hot water.
- Management of additional sources of heat such as fire (heat output, fuel supply, distribution of heat in space heating, minimization of pollutants in the flue...) [11]
- Hybrid heat sources offer several combinations of heat sources, such as:

- Combination of heat sources – a solid fuel boiler connected to an electric boiler, or with systems used by renewable energy.

- Window panels and air – warm air between the Windows by gravity or ventilator is discharged to tray. In space between glazing and the wall, the air heats up and rise, where it is discharged into the channel system tray.

- Hybrid photovoltaic power plant is particularly suitable for family homes, businesses or industrial facilities, where is available conventional electricity connection. The biggest advantage of solar hybrid systems, is that almost all electricity production from photovoltaic panels is used for own consumption, whether in the form of electricity or for heating, water heating, air conditioning, irrigation, or operation of the pool.

B5 Safety functions

- provide not only protection of property against burglary but also control the award on leaving the home, monitoring the concentration of CO, CO2, and deficiency O2. The safety system, as a whole can be subdivided according to type:

- electronic security system,
- an electronic fire alarm system,
- protection against flooding,
- a camera monitoring system.

B5.1 Electronic security system

At any given moment is an overview the safe operation of the household in the form of alarms, which give rise motion detectors, window contacts, glass break detectors, infrared barriers, shock sensor for safes, camera systems and others.

- On any touch-panel screen TV or a computer to check all windows, doors and gates. If an alarm is shown in plan view visualizations of place where the alarm occurred with the image of the camera.
- Use the infrared barriers can be careful that children do not exceed a safe distance to the pool or staircase.
- When leaving the last family member is brought into the house „away from home“ and automatically turns on alarm, shutdown, turn off lights and sockets required, switch the air conditioning/ heating to sleep.
- When we press the central button in reach of the bed, the house is put into the „night“and, among other central functions of the alarm is activated, or only on the lower deck. Because of movement at night can be activated only shell protection, in which sensors are active only opening windows, doors and glass breakage.
- Alarm can be triggered by several levels with different priorities. If a disturbance outside the home motion sensor turns on the lights in the exterior and starts the warning message through the speakers. A user gets a warning SMS with the next. If the alarm in the interior of the mission system in addition to warning SMS runs the external and internal siren, turn all the lights in the interior without turning off switches, exterior lights will flash, pull the roller blinds, curtains and run the security grilles.
- When glass breaks, the roller blind run contrary to the difficult access to the bottom.
- The alarm will be notified police.
- The sense of danger or attack can trigger a silent alarm that is connected to the police or security service.
- Simulation of presence in the house evokes the neighbourhood apparently occupied home.
- When leaving home for longer holiday function ensures against adverse home visit.
- In the winter months to ensure the health protection function is used to frost protection, which ensures protection against slipping on sidewalks and surrounding roads around SH.

B5.2 Electronic fire system

The security system is an integrated fire system, which

extends the electronic security system for other necessary elements.

- Smoke detectors (smoke detectors) are particularly warranted when installed in the house is tiled stove or fireplace. When it comes to triggering an alarm, run to the outside and indoor siren, shut the gas supply to the home, pull the roller blind and jalousie, open the windows, unlock the door locks and prepare to fire exits.
- The presence of minors is necessary to supplement alarm voice alarm spoken voice instructions to parents an escape route.
- If is user outside the home, an alarm message is sent on his phone. Report on fire with the address or GPS coordinates of the home can be simultaneously sent to the operational centre of the Fire and Rescue Service.
- The smoke and hot air system ensures automatic opening power operated windows; turn on exhaust air to the maximum. Installing fixed fire extinguishing system, control system has the opportunity to actively intervene and start extinguishing.
- Fire gases reduce the oxygen content o fair necessary for combustion or absorb heat form the flames.
- Upon detection of a gas leak inside the siren starts, turn off the gas appliances, with the solenoid valve closes the main gas, temporarily turn off power supply open the windows and run the ventilation.

B5.3 Protections against flooding

This is especially the room with fitted appliances with continuous supply of water (washing machine, dishwasher) or a room with a risk of water such as bathrooms or basement areas. These places must be equipped with sensors on the floor flooding.

B5.4 The camera system

The primary purpose of a camera system is protecting property during a robbery. Cameras are usually combined with a motion sensor, or microphone and speakers. It is advisable to use a camera with night vision with infrared LED's. The use of third generation mobile network (3G), it is possible to watch mobile video online.

B6 Multimedia

- are divided into two basic groups: audio/video system and public address systems. The functions assigned to these groups (home cinema, hi-fi system, digital images, Voip phone, intercom or piano) allow you to control and monitor the SH.

B7 Health

- integral part of SH is health care. Health is divided into subgroups:

- Lift is mostly used for disabled people.
- GPS system controls the position of head, number of steps and working with a subset of a doctor.
- Subgroup doctor includes functions: SOS – call for emergency medical services, drug dosage, ECG, blood count, measurement of pressure, measuring height, weight measurement, visual inspection, USG, skin testing, control joints, temperature, stability control ones body.
- Exercise program – SH with consultation of doctor ordered for a controlled rehabilitation robots to recommend exercise with exercises dosage or recommend a massage.
- Smart toilet – using this functions, obtain information: check urine, cholesterol measurement, control diet, fluid intake and control kidneys.
- The best values are obtained when a person sleeps and using the sleep studies can be done diagnostics of user, control the length of hair/nails/beard and total control of sleep.

B8 Kitchen

No household would be complete without a kitchen, so the emphasis on the development of functions in the kitchen, which facilitate the preparation, control and order food. the most important functions used in the kitchen include: control the baking, delivery of goods into the house, bread machine, download recipes, check water filtration system security management, blender, check the date of the food, control of microwave, toaster control, machine control, identification of food, washing operation, a link to the communication system, babysitter, control of smoke in the kitchen, the box programmed beverage, raw materials for pre-treatment of selected food, self-cleaning cook top. An integral part of cuisine in a SH is adjustable furniture.

B9 Irrigation

-irrigation system provides intelligent flora around the house a sufficient supply of water and nutrients that may be using drop irrigation, irrigation or spray irrigation or micro irrigation system. Irrigation using outside air conditioning can also be used for hot days in summer on the terrace.

B10 Clean

To ensure user comfort SH should ensure fewer problems with maintenance. Cleanliness in the house provides a variety of robots, central vacuum and cleaning robots for pools and bath. Clean sidewalks, gutters, roof against snow provide thermo cables.

B11 Control

Manageability of SH must be one of the top priorities in creating a SH. Important role play ergonomics and visibility control techniques. Intelligent control of the house is possible by phone, touch panels, remote controls, and switches, connecting via the internet or by voice.

C. Types of Users

When choosing functions in SH we can not forget the users in these homes. Each user has a different idea about the functions in a SH. Therefore is the relevant rule. Functions in a SH may not exceed a certain level of intelligence because fit is exceeded, it could come to the discomfort which could reduce the value of a SH. Users of SH can be divided into juniors, seniors and users with disabilities. Juniors in the SH are very distinct group. In this group are used by almost all functions in a SH. Seniors already using fewer functions. Gradually begin to add functionality and security of health monitoring. Users with disabilities are highly specific group that needs special technologies. The same we can assign handicap technologies that can be classified as follows:

- Disabled: the convenience of the PC, to facilitate their stay around the house such as furniture adjustability and stair platforms.

- Mentally disabled: a sophisticated system for recognizing and dealing with people „abnormal“behaviour along with guidance on proper behaviour.
- Deaf-mute: technology of communication between system and person recognition through the movements of limbs.
- Visually disabled: technology, communication between systems and people with audio controls.
- Handicapped with multiple disabilities: linking different technologies.

Another important element in SH is the use of assistance systems. These systems allow caregivers to spend the necessary time with the people control them and eventually trigger alarm when trouble. For people with disabilities is the most common problem called trial and error, whereby the system can quite possibly entangle him „lose“. These control systems are not yet fully reliable and have problem to deal with some unexpected events that are not programmed. A good example might be, for example if the user has to bring book on toilet. The system may be injured or the user that has health problems which may cause trigger alarm. Therefore systems for people with disabilities must be easy to maintain, learning and customizable for the needs of users.

Users can be categorizing also by function. An example of this:

C1 *Type of athlete*

- Planning of training, including training of automatic dosing.
- Controlled board by the preparation for the race, conditioning mode, the relaxation recovery after exercise.
- Monitoring of physical parameters and adjustment of training and diet.
- Keeping records of process-driven training.

C2 *Type blind*

- Audio control elements of SH.
- Voice navigation around the SH.
- Control by Braille.

C3 *Type deaf-mute*

- Communication with the system through the limbs.
- View opportunities in the figures.
- Visualization of events in SH.

C4 *Type wheelchair*

- Automatic navigation wheelchair around and in SH.
- Adjustable furniture.
- Planning and management of motion exercises.
- Health check.
- Voice control devices in SH.

III. Specific of Optimal Proposal of Functions in Smart Home

To choose the functions is very important to pay attention to issues of discomfort. The emergence of discomfort occurs when the rate exceeds the optimum intelligence [5]. Then the SH begins to interfere in intimate environment or cause stress for user. An example may be mentioned:

- *resizing a camera system*, that can cause a sensation of freedom,
- *air conditioning*, which can cause health problems hermetically sealed rooms with inability to ventilate naturally,
- *automated shading systems*, can cause loss of visual contact with the exterior,
- *security system*, problems with keeping pets,
- *lighting*, contains a large number of light sources.

The big problem is that management of SH take over a system and user loses the feeling of dominance in own home.

IV. The Proposal of Software Support for Designer of Smart Home

On Fig. 6 is a activity diagram of the software support for designer of SH. At the beginning of the award are distinguished administrator and user system. If the user types the administrator has made available to all functions, including data editing, editing of users and passwords. Otherwise, they are accessible only to certain parts of the program.

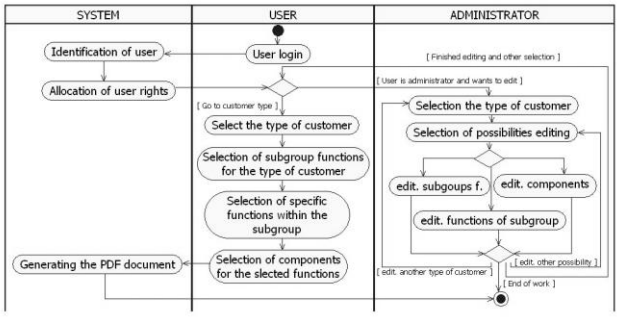


Fig. 6. The proposal of software support for the designer of Smart Home

The proposal software support provides for openness, i.e. in the event that a new type of user or function, it will be incorporated into the system under the user by the support system. Based on user selection of the system will function groups.

After logged in user is allowed to choose the type of user, the user will reveal individual functions. Groups are hierarchically organized and divided into tree basic groups. In the horizontal plane are related to functions that are selected according to specific requirements. The functions are not directly dependent on each other. This division simplifies verification and validation of the implemented solutions. After selecting a set of functions and components that are chosen by the user, the system generates requirements with the individual components in the given format. Generation requirements can be printed or saved to the pdf.

V. Conclusion

SH offer many possibilities, which continuously growing in hardware and software for home automation. In the design phase is to select functions a complex process. Depends on the experience of the designer, and the resulting solution will be optimal. This article presents a proposal to simplify the issue. According the proposed methodology select the first type of user, so defining functions SH. The article proposed

hierarchical structure SH functions to facilitate the optimal selection of functions. The main benefit of this proposal is that the optimal selection process SH function is systematic and is not influenced by experiences and habits designer SH functions.

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Peter Hamernik received his Ing degree (2009) in area of Process automation and informatization from Slovak University of Technology (STU), Faculty of Material Science and Technology Trnava, Slovakia. Since 2009 he is a PhD candidate in Institute of Applied Informatics, Automation and Mathematics at the Slovak University of Technology, Trnava, Slovakia. His research and development activities include the field of The proposal information and control systems for smart home. He has published 4 scientific and technical papers in national and international conference proceedings and journals.

Pavol Tanuska (M '09 IACSIT, M '10 IEEE, M '10 IAENG) received his PhD degree (2000) in area of Applied informatics and automation from Slovak University of Technology (STU), Faculty of Material Science and Technology Trnava, Slovakia. Since 2004 he is an Associate Professor in Institute of Applied Informatics, Automation and Mathematics at the Slovak University of Technology, Trnava, Slovakia. His research and development activities include the field of Information systems development, especially problems of verification and validation and Data warehouse systems. He has published over 140 scientific and technical papers in national and international conference proceedings and journals.

Dusan Mudroncik received his professor degree (2004) in area of Applied informatics and automation from Slovak University of Technology (STU), Faculty of Material Science and Technology Trnava, Slovakia. Since 2004 he is an Professor in Institute of Applied Informatics, Automation and Mathematics at the Slovak University of Technology, Trnava, Slovakia. His research and development activities include the field of automation. He has published over 100 scientific and technical papers in national and international conference proceedings and journals.