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DESIGNING AN INTELLIGENT HOME MEDIA CENTER

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Abstract. *This paper presents design and implementation of a personal intelligent home media center. The primary goal was to increase the quality of life with the use of ambient intelligence in smart homes. The solution presented here uses client-server architecture with network-attached storage for storing all multimedia contents. Sensors are used to identify person's presence and ambient intelligence techniques to recommend the most suitable multimedia content to end-users. The major advantages of this personal intelligent home media center are speed, intelligence, inexpensive components and scalability. The implementation was done in within one home media center, for the evaluation purposes.*

Key words: *smart home, ambient intelligence, media center*

1. INTRODUCTION

Ambient Intelligence (hereinafter: AmI) offers an opportunity to realize an old dream - the smart or intelligent home. People spend a lot of time in their homes and both social and technological drivers are broadening the scope of activities to be undertaken at home. Advances in technology are ultimately improving the way home environment can react and adopt to residents' needs.

Besides sleeping, rest and entertainment are main functions performed at home. Radio, TV and music records/CDs have been the dominant entertainments in home environment for decades. With advances in technology, all these contents became digital and new form of multimedia entertainment (listening, watching, and interacting) was developed. Each home has potentially many devices that store different digital contents (videos, music and photos) and media storage units (CDs, DVDs, etc.). Each device has limited memory available, and often the same content is stored in many places. Idea behind home media center is to integrate all these devices and units and to allow centralized storage, search, and playback, Internet streaming and often even recording of digital contents. There is no universal plug and play solution since each home has different setup of devices.

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In this paper we provide an overview of ambient intelligent applications in smart homes and technological challenges behind implementation of intelligent home media centers. We also explore some of the existing smart or intelligent home media center solutions. In particular, we specifically focus on implementation of broadly implementable and affordable intelligent home media center based on inexpensive hardware and open source software. Our goal was to develop intelligent home media center which can respond to specific needs and moods of its users. Our system is in testing phase and future research will rely on users' feedback.

2. LITERATURE REVIEW

2.1. Ambient intelligence in smart homes

Ambient Intelligence is a new paradigm for an intelligent environment which uses information and communications technologies to become an active, adaptive and responsive to people presence and their needs, and thereby improving the quality of their lives [1]. There are various definitions of AmI, but they all highlight the following features of underlying technologies: sensitive, responsive, adaptive, transparent, ubiquitous and intelligent [2].

According to European Information Society Technology Advisory Group, AmI is "a set of properties of an environment that we are in the process of creating" and that it should be treated as "imagined concept" and not as a set of specific requirements [3]. AmI focuses on user(s) in their environment and emphasizes ease of use, user-empowerment and support for human interactions in seamless, unobtrusive and often invisible way [4].

AmI is emerging discipline today. We have not only necessary supporting technology present, but the user demand has also reached that critical point for prosperous development. As Cook, Augusto and Jakkula point out, AmI incorporates aspects of context-aware computing[1], disappearing computers[2], and pervasive/ubiquitous[3] computing, and enriches them with artificial intelligence research in the fields of machine learning, agent-based software, and robotics [2]. AmI applications have been developed in many fields such as smart homes, health monitoring and assistance, hospitals, transportation, emergency services, education, workplaces, etc.. In this project we have focused on smart homes.

"Smart Home" is the term commonly used to define a residence that has appliances, lighting, heating, air conditioning, TVs, computers, entertainment audio & video systems, security, and camera systems that are capable of communicating with each other and which can be controlled remotely [5]. Another definition according to the Smart Homes Association is: "*the integration of technology and services through home networking for a better quality of living*" [6].

Smart homes make life easier and more convenient. No matter where you are, smart system will alert you if something is going wrong in the house. For example, not only a resident will be woken up with notification of a fire alarm, the smart home would also unlock doors, dial the fire department and light the path to safety.

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[1] „Context-aware computing is a style of computing in which situational and environmental information about people, places and things is used to anticipate immediate needs and proactively offer enriched, situation-aware and usable content, functions and experiences." – Gartner IT Glossary (www.gartner.com/it-glossary/)

[2] „The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it"[30]

[3] „Ubiquitous Computing" was first defined by Weiser[31]; IBM later called it „Pervasive Computing"[29]

There are many areas where AmI is applied in functions of smart home applications: home automation, communication and socialization, resting, refreshing, entertainment, sport, working and learning [7].

Home automation covers basic housing supporting functions, like heating, piping, ventilation, air-conditioning or HPAC, lighting, electrical installations, but also home security functions and the functions to increase the autonomy and support the independent living, especially of elderly residents. One example is the European IST Amigo project which developed a networked home system of heterogeneous devices and services from the following domains: personal computing, mobile computing, consumer electronics and home automation [8]. Besides improving quality of people's lives, home automation solutions are addressing energy efficiency by providing comprehensive support for energy savings [9]. Electric bills go down when lights are automatically turned off when a person leaves the room, and rooms can be heated or cooled based on who's there at that moment. Some devices can track how much energy each appliance is using and command it to use less. Communication and socialization functions are already well established at homes by the use of landline phones, Internet, TV, mobile phones and other hand-held/hands-free devices. One of the further developments in this area will be dynamic networking where AmI technologies would seamlessly put people in contact based on comparable permanent patterns of interest or specific requests with the use of context modeling techniques [10]

Applications of ambient intelligence embedded in clocks, beds, lamps, windows, floors, ceilings, furniture, etc., can improve sleeping and other forms of relaxation in home. Important issues to address here are activity recognition and conflict resolution [11]. Another AmI trend is to optimize the time which is anyway consumed in the bathroom for other functions, for example bathroom mirror could display clock, news, weather, advices on health improvement based on person's weight [12].

Entertainment and sport activities are not necessarily done at home, but AmI technologies can again enrich this experience. For example, voice recognition could be combined with databases so that resident can turn on the music by simply humming a few lines of a song [12]. One of the challenges is to allow the right balance between relatively passive enjoyment of multimedia entertainment and interactive engagement in them. Regarding exercising at home, Friedewald et al. envision that future trend is to integrate physical exercise capacities into ‘‘ordinary’’ furniture placed in living room, bedroom or even kitchen [7].

AmI technologies promise tremendous benefits for an elderly persons living alone. Smart systems can notify residents when it is time to take the medicine, alert the hospital if a resident fell, track how much residents are eating, automatically turn off the water before a tub overflow or turn off the oven if no one is present in the home. Smart home systems provide an opportunity for adult children who live elsewhere to participate in the care of their aging parents [6].

AmI environment consist of sensors, controllers and intelligent agents. Sensors gather data from the real world based on which intelligent agents perceive the state of the environment and users. Intelligent agents are systems that can decide what to do and then do it [13]. They reason about the gathered data using a variety of AmI techniques, and act upon the environment using controllers. Thus, sensing, reasoning, and acting are the main functional parts of AmI algorithms [2].

There are wired and wireless sensors. They can be integrated into the environment or they can be attached to persons or items. The example of the latter case is RFID tags that can be coupled with an RFID reader to monitor the movement of the tagged objects. When analyzing sensors data, AmI systems may employ a centralized or distributed model [14]. Resent research implies that wired and wireless distributed computing are a key mean to accomplish established AmI goals [1].

Reasoning is accomplished through modeling of user's behavior, activity prediction and recognition, decision making, and spatial-temporal reasoning [15]. In the MavHome (Managing an Intelligent Versatile Home) smart home project a data mining pre-processor identifies common sequential patterns in data, and then uses those patterns to build a hierarchical model of resident behavior [16]. Luhr goes even further and uses video data to find sequential association rules in resident actions [17]. Other examples of projects which all adaptively control home environments by anticipating the location, routes and activities of their residents are the Neural Network House [18], the Intelligent Home [19] and the PlaceLab [20].

AmI systems execute actions through various controllers, robots and other intelligent and assistive devices. Mobile robot assistants are already found in nursing homes [21], developed to assist elderly individuals with mild cognitive and physical impairments, as well as to support nurses in their daily activities. The goal of many leading smart home projects associated with wearable/implantable monitoring systems and assistive robotics is to allow older people to live autonomously in a comfortable and secure environment [22].

Important challenge for ambient intelligence is how to make technology learn about the people and their identity and how to apply such knowledge in varying contexts but at the same time how to secure a sufficient degree of privacy and prevention against misuse so that people will trust intelligent world that surrounds them. The future of Ami depends on how successful it will address those important security and trust issues [23].

Other areas of further research within domain of smart homes are better use of resources, home security, appliance management, digital entertainment, energy management and assistive computing/health care, as well as smart environments to support elderly and disabled persons [6].

2.2. Intelligent home media centers

Various solutions for intelligent media players are accessible on the market with numerous advantages as well as some challenges. In this paper we discuss some of the best media players that were examined as a starting point in our development of a personal intelligent home media center.

One of widely used open-source media player is Kodi (formerly XBMC), developed by the XBMC Foundation, a non-profit technology consortium. It is Media center for playing videos, music, pictures, games, and more. Kodi operates on a Linux, OS X, Windows, iOS and Android, with a 10-foot user interface for use with televisions and remote controls. It allows users to play and view videos, music, podcasts, and other digital media files from local and network storage media and the Internet. One of the challenges is that it needs a 3D capable graphics hardware controller for rendering. Additional issue is that Kodi's internal cross-platform video and audio players (DVDPlayer and PAPlayer) cannot play any audio or video files that are protected/encrypted with DRM (Digital Rights Management) technologies for access control [24].

Other examples of home media center solutions are: Noontec N5 GigaLink and Cisco-Linksys Media Center Extender with DVD.

Noontec N5 GigaLink is a reliable storage server, which can back up a large number of multimedia files (hard drive required), such as digital pictures, music and movies. It supports UPnP and DLNA functions, so users can go through pictures, listen to their favorite music or watch the 1080p high definition movies on the high definition TV, PS3, XBOX360 or other players connected to the home network, which can give them the experience of truly digital home. It supports mobile access from iPhone, iPad, Android Smartphone and tablets connected through the local area network. It also supports File Server, FTP Server, and SAMBA Server [25].

The Linksys DMA2200 connects the latest 1080p DVD players with Windows Media Center and streams user's digital music, movies and photos to any TV in their home wirelessly. With elegant and easy navigation menu screens, users can play DVDs, view family slide shows, browse music collection by cover art, listen to entire playlists or choose from a vast selection of Internet Radio stations from all over the world. The Linksys Media Center Extender and user's Windows Vista Media Center PC give a complete PVR solution-allowing them to watch, pause, rewind and record live TV (PC-embedded or optional TV tuner required).

Another approach is self-made personalized smart TV which uses client-server architecture together with AmI to implement popular TV functions. The best three unique functions of this approach are recognizing user's gestures to control a TV, creating collaborative recommendations from social opinions and using environmental collaboration for enabling context-aware services [25].

And final approach, similar to our solution, is custom-made intelligent home media center such as Intelligent Multimedia Service System (IMSS) [27] and Ubiquitous-Hybrid Multimedia System (U-HMS) [28]. IMSS is based on context awareness and ubiquitous computing. It provides multimedia interoperability among incompatible multimedia devices, device specific video encoding, copyright and license management. Similarly, U-HMS system offers multimedia interoperability among incompatible devices, transparent services, authentication method and security services. It is based on Wireless Sensor Network (WSN), Context Awareness, and MPEG-21 DIA/Video transcoding. Disadvantage of these two systems is that there are based on external services such as Certificate Authority (CA), Digital Object Identifier (DOI), Multimedia/Content Management System (MMS/CMS) and License Management System (LMS).

3. DESIGN OF AN INTELLIGENT HOME MEDIA CENTER

In this chapter development of an intelligent home media center will be described together with the basic usage scenarios. All needed components will be listed together with the short description and required and desirable features. For setting up an intelligent home media center the following hardware components are needed:

- Network-attached storage (in further text NAS) for storing all data
- Main server for sharing meta data between clients and for hosting web server
- Two microcomputers
- Sensors
- Power switches
- Mobile devices (mobile phone, laptop)
- Router
- Output device (TV).

Main communication between devices will go through the Main server. One microcomputer will communicate with the NAS storage when its multimedia content is played. All other communication will go through the Main server. This approach will provide a possibility to store history of all actions in the system.

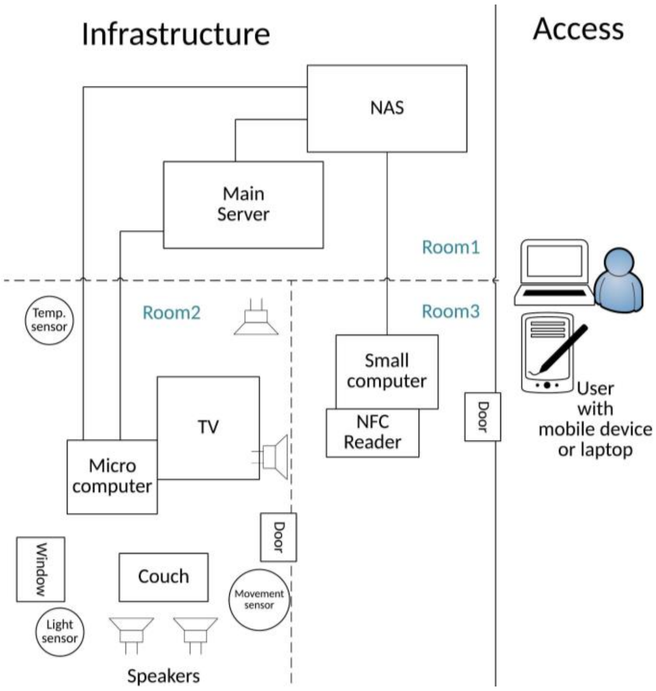

Fig. 1 Design of an intelligent home media center

3.1. Infrastructure overview

NAS Storage

NAS storage will be used to store all multimedia content. This storage should be always on and accessible for all users inside the private network. For the outside world this storage should be invisible. Server which will be used for NAS storage should have a large hard drive for storing a lot of multimedia content. Processor does not need to be too powerful and amount of RAM is not crucial. Scheduled tasks will be running on this server to scan the whole system and send information about new available multimedia content to the Main server. File share on this server should be available all the time for all users in the network. This server does not need to have any kind of graphical user interface (GUI) since only data will be passed between NAS storage and other devices. Additional requirement is to have a file share which is accessible from different operating systems, both mobile and computer.

Main server

This server should have more processing power than NAS server. Also, amount or RAM on this server should be bigger than one on the NAS server because it will communicate with a certain amount of end-users and devices at once. On the other hand, hard drive space does not need to be too big. This server will have a database with meta data about all multimedia content which is available in the system. The content meta data should have an option to be shared inside a private network through HTTP protocol and with outside network with HTTP and email protocols. That requires an email server running on the Main server. Main server should also have a Web server installed, through which other devices will access the list of available multimedia content. In addition, Main server should work as a "main switch" which will allow end-users to turn off any device in the system. Also main server will be able to automatically turn on any device in the system if it is needed. These features should be also accessible over the Web through implemented Web services. There is no need to have a desktop GUI on the Main server, but access to terminal over SSH protocol is required.

Microcomputers

With the use of microcomputer(s) end-users will browse multimedia content over HTTP protocol. Some software for playing multimedia content is required, as well as graphical card which can handle high quality videos. Processing power and amount of RAM for these computers should be average. These computers should have an option to work with some kind of sensors or readers which are able to recognize presence of certain persons and notice Main server about it. Amount of hard drive for these computers can be very low. These computers must have a GUI which could be controlled with some input device (such is TV remote).

Sensors

System should contain sensors which can note a presence of a certain person or device inside the network. These sensors should just note the presence. Microcomputer should send the information to the Main server about the detected person.

Also, sensors should have an ability to record some additional variables inside an intelligent home media center such as: what's the weather, is the light on, is this person moving, etc. According to this requirement, for example, temperature sensors could be used to measure temperature, NFC tag readers to recognize persons, etc.

Other devices

System should also contain power switches, mobile devices, router and one output device. Power switches should be used to turn on microcomputers.

Mobile devices will be used for controlling the system through native application which will communicate with the Main server. This application will provide a basic functionality for controlling the system. This application should have an option to communicate with the Main server from private and public networks.

The system must have a router which will provide Internet access for all computers inside the private network. This router must have an option to set a static identifier for all devices. Also, some services on devices must be visible even from the outside world.

Client output device must be in the system. Over the output device users will watch multimedia content and see the status of the system.

3.2. Software communications and relations

Communications between software components is illustrated in the figure 2. On the Main server MySQL database will be installed. Only Main server should have access to this database. On the Main server also should be a web page together with an API visible to the outside world and a possibility to communicate over SSH protocol. Android application will be communicating with Main server through Web page and REST API and over SSH connection. Microcomputer with various sensors will be communicating only with the Main server and only via REST API.

NFC tag reader will be connected to one microcomputer. Other microcomputer with a bundle of sensors will be connected to a TV and it will communicate with both Samba share server on the NAS and with Web interface on the Main server.

NAS storage will have SSH connection open to the outside world and a Samba file share which makes all multimedia content available to all users of an intelligent home media center.

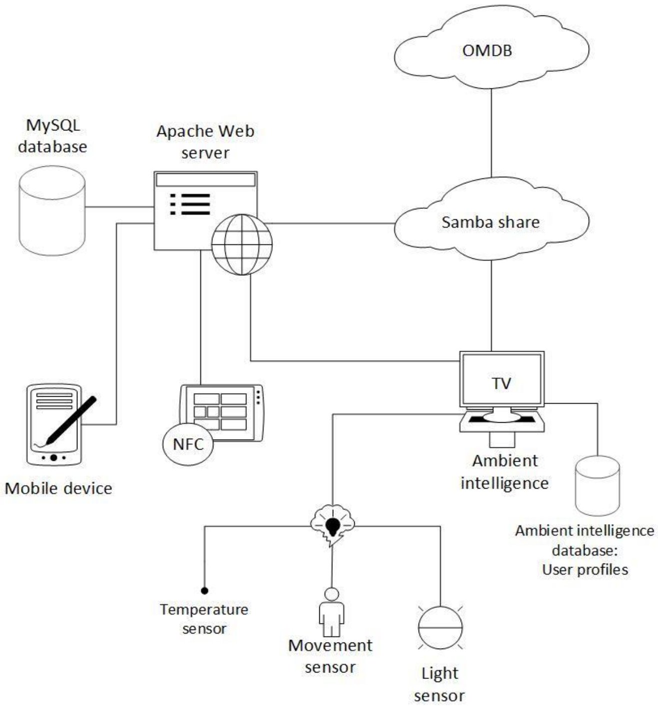

Fig. 2 Software communications and relations

3.3 Usage scenario

Activity diagram for usage scenario is presented in Figure 3. When a person comes in a range of an intelligent home media center, microcomputer is noticing that over sensors. Micro computer is contacting the Main server to inform it about presence of a person. Main server is turning on all devices in the network. Users of an intelligent home media center can control the center over mobile devices or over microcomputer which is connect to the output device. Over microcomputer and output device user will have an option to browse all multimedia content in the network. System will also have a functionality to offer to end-user what to watch or listen. For this particular use case concept of ambient intelligence should be implemented. Micro computer will, based on the data received from sensors and user profile, offer the appropriate content.

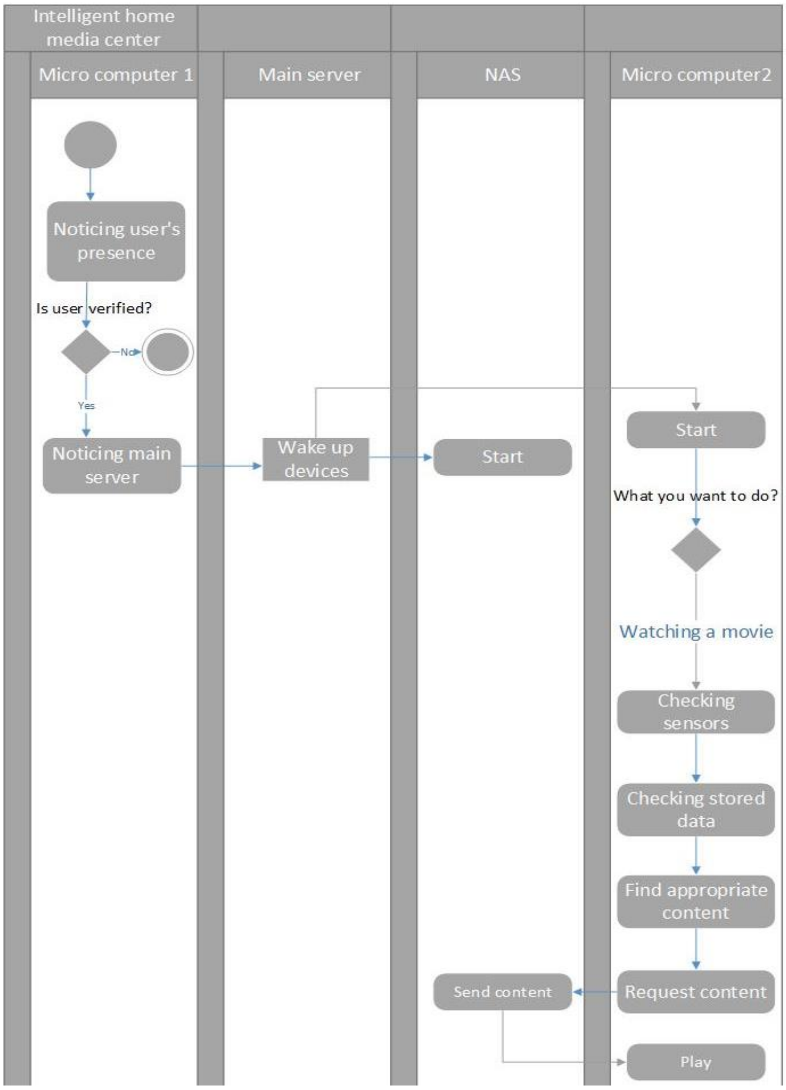

Fig. 3 Activity diagram for the usage scenario

4. IMPLEMENTATION

In this chapter implementation of an intelligent home media center is described in detail. Implementation details for each component are discussed, together with best practices and approaches.

4.1. NAS storage

For an operating system on the NAS storage we chose Linux CentOS 7 with minimum installation. Samba file share is installed on the server. Beside Samba share, only Perl programming language and Apache server are installed. This server communicates with the Main server over REST (Representational state transfer) protocol.

There is an xml settings file on this server which stores all paths for multimedia content inside the system. For scheduled scanning the system cron jobs are used. Cron jobs are running each day at 5:00am in a form of a PERL script. PERL script first reads the xml settings file and for each of the paths search is performed for available content. For each movie, PERL script is, over REST client, getting meta content from Open Movie Database Api (OMDB). When all data is collected, it's packed in JSON format and sent out to the Main server again over REST. Since this operation is very performance consuming, it is run when NAS does not have any other pending requests. If system usage is over 50%, bash script will create a new cron job which will start the same PERL script 30 minutes later.

Apache server is used to show images over HTTP protocol. Since not all images are accessible on the server, there is another daily cron job which creates symbolic links from images folder to the root folder of Apache server.

There is also a REST service which is used to start bash scripts. Bash scripts are used for basic data manipulation and for shutting down the system.

Each time NAS server receives a request from network, it is informing the Main server about it.

4.2. Main server

Main server machine has more processing power than one used for the NAS server. Main server also does not require GUI, but it requires stable and powerful operating system. Again CentOS 7 with minimum installation is chosen.

On the main server Apache Web server is installed alongside with MySQL database, Email client and PHP REST server.

PHP REST server is used to collect all requests from devices in the system. Main server is receiving meta data about multimedia content from the NAS server. All received meta data is stored in a database. Also, Main server can receive a REST request for turning off a device in the system, sending an email content or displaying data. Main usage scenarios are:

- Meta data about multimedia contents is synchronized between NAS server and Main server database: when NAS server is sending meta data about multimedia content, all meta data content which is not anymore on the NAS server is removed from the Main server database. All new content is added to the database
- When a request for turning off a device is received, Main server is turning off the selected device through SSH connection. Turning off can be scheduled over SSH also.
- When a request for sharing a meta data through an email is received, Main server is sending meta data content via email to desired addresses.
- When a request for displaying data is received, Main server is collecting data from the database and sending it in JSON format. This use case can occur only when native mobile application is communicating with the server.

Apache Web server is hosting a Web page which is displaying all multimedia meta data from the database. Besides that, Web page also implements the following functionalities: turning off request for a selected device, power status of all devices in the system, requests for putting devices to sleep and download request for desired content through torrent client.

One of implemented Web pages is “What to do” page. When user visits this page, system is asking if user wants to watch images, play music or watch videos. Based on a few simple questions (“How do you feel?”, “How much time do you have?”, “What would you like to do?”) and user responds, system will offer an appropriate multimedia content to the user. This small feature is based on a concept of ambient intelligence. Each time user is looking at some multimedia content, microcomputer is writing to a database what was the genre of the content, what was the weather, time of the day (so we can track what user wants to do at what time) and user’s mood. Based on user’s answers, time of the day, weather and previous data, system is offering a certain multimedia content to the user. Table with user’s profiles contains zero or more entries for the each user. When user fills out all the questions, data from user’s profile database is checked. If there are no entries for the user, all content that fulfills user’s request gets displayed. If there are entries in the user’s profile database, only content younger than two months (we assume that user is changing habits and expectations for multimedia content) gets selected. If there are entries with the same weather and time of the day like in the time user filled out questions, they are used. Otherwise all available content from user’s profile database is used. In the end hash of user’s preferences is created.

For example, if user wants to watch a movie, hash with user’s preferences contains favorite genre, average time of movies user watched, average IMDB rating of movies user watched, etc. User’s preferences hash, together with user’s request is used to search for an appropriate content for the user. If user wants to exercise and user has less than half an hour available, main server will offer p90x cardio training to the user since this training lasts only 20 minutes and can be done indoors.

Example of using “What to do” feature over Android device is presented below:

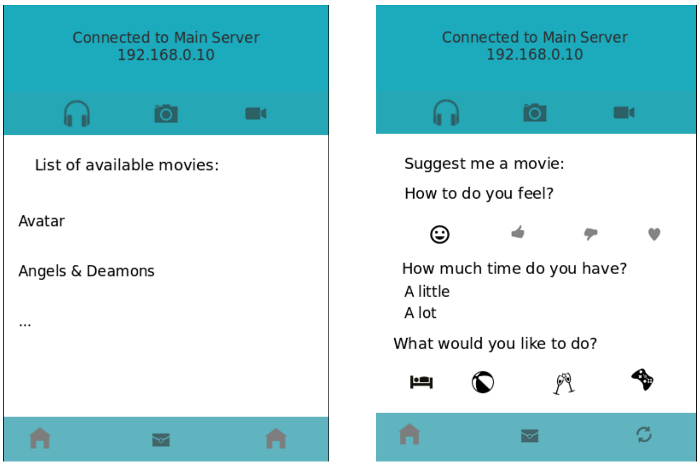

Fig. 4 Android application for the intelligent home media center

4.3. Micro computers

We chose two Raspberry Pi 2 model B microcomputers because of their price, performances and availability. We have chosen Rasbian operating system because of its expandability and big user community.
One microcomputer is connected to the Output device. On this Raspberry Pi two additional features have been installed - lib-cec library and Kodi media player

Lib-cec library have been installed to monitor events from the Output device’s remote to which Raspberry Pi microcomputer is connected. Keyboard arrows and enter keys have been mapped together with few other buttons to allow browsing menus with output device’s remote and turning off Raspberry Pi over remote.

Kodi media player is used to play movies and music from the NAS storage. On the other Raspberry Pi NFC tag reader is connected. Purpose of NFC tag reader is to note when some persons are nearby, in the radius of intelligent home media center. When a person’ presence is detected, system is sending a REST request to the Main server to turn on all devices. NFC tag reader is placed on the door’s entrance. Users have NFC tag bracelets and key chains. When user is entering the door, she or he should place NFC tag near the reader so tag gets recognized.

4.4. Mobile devices

We used mobile phone with Android operating system. Native application has been developed to communicate over REST API with the Main server. This application can communicate with the Main server even outside private network because port 80 on the Main server is visible to the outside world.

4.5. Output device

We have used LG TV as an output device. Out TV has hdmi-cec support (this feature is called simplink on LG TVs). It is important to use a hdmi cable with cec support, otherwise TV’s remote events won't be passed to the microcomputer.

4.6. Components setup

Main server, NAS server and router are in the same room. Since over NAS server a large amount of data is transferred, NAS server is connected to router via LAN cable. Main server is also connected to router over LAN cable because it communicates frequently with the NAS server. All other devices in the system are connected to router over WI-FI. Since microcomputers don’t have WI-FI receivers, small WI-FI receivers are provided. NFC card reader is connected to one of microcomputers to notice the presence of certain tags nearby. Second microcomputer is connected to TV. One or more mobile devices can be in the private network.

5. CONCLUSION

In this paper we have explained in detail design and implementation of a personal intelligent home media center. There are multiple advantages of our solution comparing to a classic home media center, such as DVD player. Comparing to a DVD player or a home theater, our solution offers more comfort in using by allowing users to control the system over multiple devices (such as mobile phone, laptop, TV remote, etc...). Also, the most of movie theaters have support only for several multimedia content types. Self-built solution offers a possibility to stream almost any content. Comparing to a Smart TV, our solution is cheaper, with a richer set of features and it is open for communication with any device over the REST server. The intelligent home media center is developed to satisfy the personal needs of the end-user. Solution is very scalable and it is easy to add more components such as clients, servers and other devices. It is inexpensive to build, it is fast and it is intelligent. It uses sensors to detect person's presence and concepts of ambient intelligence to recommend appropriate media to the user. It is easily maintainable, devices can be replaced or upgraded and additional software features can be implemented

There are also some disadvantages of the design and implementation of this personal intelligent home media center. It requires well knowledge of various information technologies. Consequently, comparing to other alternatives, it is not a plug & play solution. There are many components in the system and if one component is not configured correctly, the whole system will not work. We will try to address these disadvantages in our future work.

Further development of our personal intelligent home media center will be focused on the integration with the digital interactive television. Based on the recognized mood of the user and user's individual profile, system could automatically select TV content. This integration could be especially exploited in the interactive TV advertising landscape [32], [33]. In addition, further development will introduce additional security features, such as parental control and user privacy.

REFERENCES

[1] C. Benavente-Peces, A. Ahrens, J. Filipe, "Advances in technologies and techniques for ambient intelligence", *Journal of Ambient Intelligence and Humanized Computing*, 2014, Vol. 5, No. 5, pp. 621-622.

[2] D. J. Cook, J. C. Augusto, V. R. Jakkula, "Ambient intelligence: Technologies, applications, and opportunities", *Pervasive and Mobile Computing*, Vol. 5, No. 4, pp. 277-298.

[3] K. Ducatel, M. Bogdanowicz, F. Scapolo, F., Ambient intelligence: From vision to reality. *IST Advisory Group*, 1–31. Retrieved from http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Ambient+Intelligence+:+from+vision+to+reality#1

[4] K. Ducatel, M. Bogdanowicz, F. Scapolo, J. Leijten, J.-C. Burgelman, ISTAG Scenarios for Ambient Intelligence in 2010. *Society*, 58. Retrieved from ftp://ftp.cordis.europa.eu/pub/ist/docs/istagscenarios 2010.pdf

[5] Internet source: http://www.smarthomeusa.com/smarthome, retrieved 2015

[6] J.-C. Rosslin, K. Tai-hoon, "Applications, Systems and Methods in Smart Home Technology : A Review", *International Journal of Advanced Science and Technology*, 2010, Vol. 15, pp. 37-48.

[7] M. Friedewald, O. Da Costa, Y. Punie, P. Alahuhta, S. Heinonen, "Perspectives of ambient intelligence in the home environment", *Telematics and Informatics*, 2005, Vol. 22, No. 3, pp. 221-238.

[8] *Amigo: Ambient intelligence for the networked home environment*. (2008). Retrieved from http://www.hitech-projects.com/euprojects/amigo.

[9] A. De Paola, S. Gaglio, G. Lo Re, M. Ortolani, "Sensor 9k: A testbed for designing and experimenting with WSN-based ambient intelligence applications", *Pervasive and Mobile Computing*, Vol. 8, No. 3, pp. 448–466, 2012.

[10] A. Sorici, G. Picard, O. Boissier, A. Zimmermann, A. Florea, "CONSERT: Applying semantic web technologies to context modeling in ambient intelligence", *Computers & Electrical Engineering*, Vol. 44, pp. 280-306, 2012

[11] F. Sebbak, A. Chibani, Y. Amirat, A. Mokhtari, F. Benhammadi, "An evidential fusion approach for activity recognition in ambient intelligence environments", *Robotics and Autonomous Systems*, Vol. 61, No. 11, pp. 1235-1245, 2013

[12] Peterson, K. E. (2002). If high-tech it is your idea of paradise, welcome to Valhalla.

[13] S. Russell, P Norvig, "Artificial Intelligence: A Modern Approach", *International Dental Journal*, Vol. 60.

[14] I. F. Akyildiz, W. Su, Y. Sankarasubramaniam, E. Cayirci, "A survey on sensor networks", *IEEE Communications Magazine*, Vol. 40, No. 8, pp. 102-105, 2002.

[15] Galton, A. (2000). *Qualitative Spatial Change*. Oxford University Press.

[16] D. Cook, M. Youngblood, S. Das, "A Multi-agent Approach to Controlling a Smart Environment", *Designing Smart Homes*, pp. 165-182.

[17] S. Lühr, G. West, S. Venkatesh, "Recognition of emergent human behaviour in a smart home: A data mining approach", *Pervasive and Mobile Computing*, Vol. 3, No. 2, pp. 95-116, 2007.

[18] M.C. Mozer, "Lessons from an Adaptive Home", *Smart Environments*, pp. 271-294. 2005

[19] V. Lesser, M. Atighetchi, B. Benyo, B. Horling, A. Raja, R. Vincent, S. X. Q. Zhang, "The intelligent home testbed", *Environment*, Vol. 2, No. 15. 1999.

[20] S. S. Intille, K. Larson, J. S. Beaudin, J. Nawyn, E. Munguia Tapia, P. Kaushik, "A Living Laboratory for the Design and Evaluation of Ubiquitous Computing Technologies", In Proceedings of the *CHI '05 Extended Abstracts on Human Factors in Computing Systems*, 2005, pp. 1941-1944.

[21] J. Pineau, M. Montemerlo, M. Pollack, N. Roy, S. Thrun, (2003). Towards robotic assistants in nursing homes: Challenges and results. *Robotics and Autonomous Systems*, Vol. 42, No. 3-4, 271-281, 2003.

[22] M. Chan, D. Estève, C. Escriba, E. Campo, "A review of smart homes-Present state and future challenges", *Computer Methods and Programs in Biomedicine*, Vol. 91, pp. 1, pp. 55-81, 2008.

[23] M. Friedewald, E. Vildjiounaite, Y. Punie, D. Wright, "Privacy, identity and security in ambient intelligence: A scenario analysis", *Telematics and Informatics*, Vol. 24, No. 1, 2007.

[24] Interner source: http://kodi.tv/about/, retrieved 2015

[25] Internet source: http://www.digilifeonline.com.au/, retrieved 2015

[26] L. Wei-Po, C. Kaoli, and J.-Y. Huang. "A smart TV system with body-gesture control, tag-based rating and context-aware recommendation."*Knowledge-Based Systems*, Vol. 56, pp. 167-178, 2014.

[27] J. Park, H. Park, S. Lee, J. Choi, D. Lee, D. "Intelligent Multimedia Service System Based on Context Awareness in Smart Home", *Context*, pp. 1146–1152, 2005.

[28] J. H. Park, S. Lee, J. Lim, L.T. Yang, "U-HMS: hybrid system for secure intelligent multimedia data services in Ubi-Home", *Journal of Intelligent Manufacturing*, Vol. 20, No. 3, pp. 337-346. 2009.

[29] Krill, P. (2000). IBM Research Envisions Pervasive Computing.

[30] M. Weiser, M. "The Computer for the Twenty-First Century", *Scientific American*, Vol. 265, No. 3, 94–104. 1991

[31] M. Weiser, "Hot topics-ubiquitous computing", *Computer*, Vol. 26, No.10, 1993.

[32] E. Athanasiadis, S. Mitropoulos, "A distributed platform for personalized advertising in digital interactive TV environments", *Journal of Systems and Software*, Vol. 83, No. 8, pp. 1453-1469, 2010.

[33] G. Lekakos, D. Papakiriakopoulos, K. Chorianopoulos, An Integrated Approach to Interactive and Personalized TV Advertising. Channels, 1-10, 2001.