Proceedings of the 7th International Conference "Day of New technologies" (DoNT'2015), 12. November 2015, Žilina, Slovakia republic, p. 66-75. ISBN 978-80-554-0932-0
University of Žilina, the Faculty of Operation and Economics of Transport and Communications, Univerzitná 1, 010 26 Žilina

RESEARCH OF IOT CONCEPT IN MONITORING THE ACTIVITIES OF THE ELDERLY PERSON

Dragan Peraković[1], Marko Periša[2], Vedran Sedlar[3]

[1]Faculty of Transport and Traffic Sciencs
Zagreb, Croatia, Vukelićeva 4
dragan.perakovic@fpz.hr

[2]Faculty of Transport and Traffic Sciencs
Zagreb, Croatia, Vukelićeva 4
marko.perisa@fpz.hr

[3]Student
Zagreb, Croatia, Barutanski jarak 72
vedran.sedlar@gmail.com

Today's development of information and communication technology have brought up possibility of raising the quality of life of elderly people. The concept of the Internet of Things - IoT includes characteristics and capabilities that provide better quality of life for the elderly. The architecture of IoT concept contains relevant elements providing health monitoring and tracking of user activity. The research in this paper shows everyday needs of users in terms of possibilities of using new technologies. The final chapter will propose the architecture of service that makes the best fit for the selected group of users.

Keywords: Assistive Technology, IoT, e-Health, Indoor location, RF sensors, fall detection

1. Introduction

Within the development of new technologies there's been a rapid development of IoT concept of new technologies raising the quality of life for the elderly (i.e. users). By the definition of World Health Organization, an elder or 'elderly' person correlate with the chronological ages of 60 to 75 years, old person is between 60 and 75 years old and very old person is above 90 years old [1]. Today's research of application of new technologies to users are based on the technology of automatic identification and data collection (Automatic Identification and Data Capture – AIDC) and the Cloud Computing concept [2], [3]. These technologies can be displayed in Ambient Assistive Living (AAL) environment allowing users to enable automatic informing of emergency services, family or medical personnel in the event of significant changes of monitored parameters. In order to collect data from sensors located on the body of the user in the AAL environment it is important to have an accurate and real time data [4]. The possibilities brought by new technologies have high importance in the field of locating users in closed areas where there is no GPS coverage and systems rely on RFID and NFC technology, wireless network (Wi-Fi) and *Bluetooth* [5], [6]. In the field of eHealth, sensor technology is frequently used for monitoring the work of the heart or other organs in the body, the experimental phase explains in detail the work of prototype with aim to collect such information with the use of sensors [10], [11].

2. Development of technology in the field of monitoring the activities of the elderly

Nowadays, the development of new technologies allows the application of these technologies in various fields. Thus, the development of technologies such as IoT, wearable sensor systems, RFID technology and various methods and technologies to detect sudden changes in movement (fall detection), makes it possible that all listed above can be applied to help users (i.e. the elderly). One of the main technologies used in this concept is the AIDC technology. AIDC is a wide term of technologies that are used to collect information from individual objects, pictures or sounds without manual data entry. These systems are used to manipulate the list of goods in the warehouse, shipping, property and documents. The application of these technologies is widespread and it is used in business sectors such as transport, medicine, IT sector and so on. Currently, AIDC technology involves the use of:

- Barcode;
- Magnetic tapes;
- Smart cards;
- Optical character recognition;
- Radio frequency identification and
- Biometric applications.

Biometric systems consist of reader, software that converts the collected biological data in digital format and compares the points of similarity and the database that stores all the collected data for the comparison [7].

In the last few years design and development of wearable sensor (hereinafter WHMS) systems have attracted the attention of industrial and scientific communities. The main motivation of this development was the increase in the cost of health care. Constant growth and development of supporting (bio) sensor systems in the future will certainly improve health.

Therefore, with the possibility of monitoring and informing user about his health condition, there is an additional option of alarming emergency services, specialists in hospitals and relatives in case the user's health condition suddenly change.

The transfer of the measured data in WHMS architecture should consist of two different sides of architecture intended:

- to transfer the parameters measured by (bio) sensors to the central node and
- to send the collected data to remote medical facility or directly to the mobile phone of personal physician

In the first case, the architecture is commonly using wireless transmission for the transfer of data. The simplest solution is that all sensors are connected to each other in a sensor network (BAN) and the sensor network is connected to a central node, which in this instance can be a smart MTU. The technologies used by BAN network are Bluetooth (IEEE 802.15.1) and the ZigBee technology (802.15.4).

In the second case, the transfer of data is over long distances because the WHMS and the cell receiving transmitted data may be in different locations. In this case, it is possible to use a wide range of wireless technologies that include WLAN, all the generations of mobile networks supporting transfer of data (GSM, GPRS, UMTS and LTE) and WiMAX [8].

Table 1. Overview of types of sensors and the measured parameters

Bio signal type	Sensor type	Description of the measured signal
electrocardiogram (ECG)	electrodes placed on the skin or chest	electrical activity of the heart (display of contractions and relaxation of the heart in the form of visible waves in pictured on the paper)
blood pressure	pressure gauge for mounting on the hand	measurement of the force with which the blood that circulates presses walls of blood vessels, especially arteries
body and skin temperature	temperature probe	measurement of body's capacity to generate and reject heat
dynamics of breathing	piezoelectric or piezoresistive sensor	number of breaths per time unit
oxygen saturation	pulse oximeter	indication of the oxygen rate in the blood circulating through body
heart rate	pulse oximeter or electrodes placed on the skin	frequency of cardio cycle
reaction of the skin (sweating)	galvanic sensor	electrical conductivity of the skin, which is associated with the activity of sweat glands

heart noises	phonocardiograph	record of the sounds created by heart
level of glucose in the blood	glucose meter	measurement of the amount of sugar in blood
electromyogram (EMG)	electrodes placed on the skin	electrical activity of muscles (EMG)
electroencephalogram (EEG) of	electrodes placed on the head	measurement of electrical activity in the brain and the brain potential (EEG)
body movements	accelerometer	measurement of the acceleration forces in the 3D space

Source [8]

Table 1 shows a list of sensor technologies that can be integrated into the bearing system of health monitoring with appropriate physiological parameters measured by these sensors. Measuring of mentioned vital parameters and their processing is leading to real-time collection of physiological parameters that can be further used to assess the health of the user at any time.

3. Analysis of the needs of elderly people in their daily activities

Currently, in the Republic of Croatia there is no conducted research of the application of new technologies for the selected group of users referred in this paper. For this reason the research was carried out in 7 different homes for the elderly and the infirm in the city of Zagreb. Data for the survey were collected through online questionnaires and interviews [9]. The survey is conducted on a sample of 209 test subjects who are placed in homes for the elderly and disabled located in the city of Zagreb. The structure of test sample (users) by gender is shown in Figure 1 obtained according to collected data and subsequent data analysis. The figure shows that the research containing sample of 153 subjects is made of (73%) female population and 56 (27%) of male population.

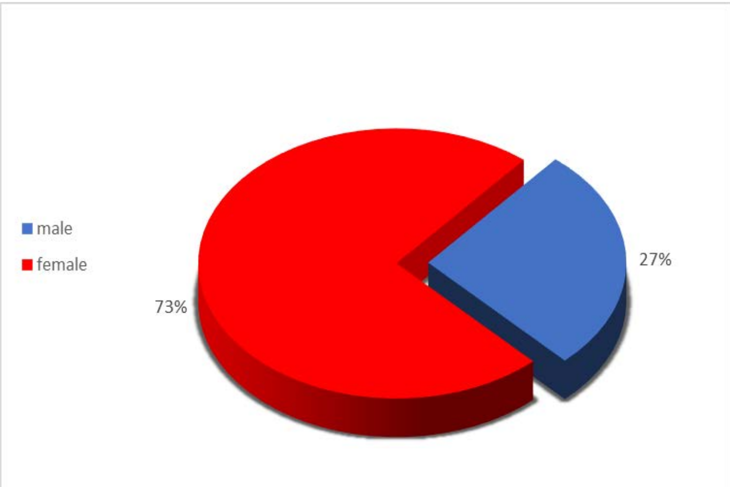

Figure 1. *Structure of the test sample (i.e. users) according to gender*

The structure of test sample by age of test subjects (Figure 2) shows the age of users, according to which 54% of users are over 80 years old, which is an important prerequisite for defining services based on the concept of IoT.

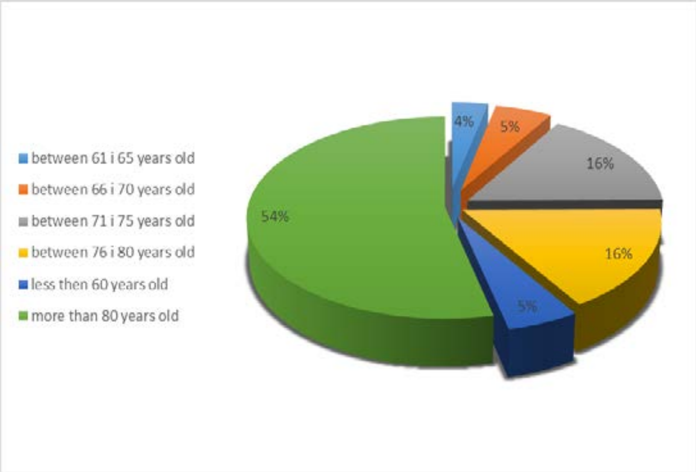

Figure 2. *Structure of the test sample (i.e. users) according to age*

Figure 3 shows how many users would use new technologies in everyday life and be willing to go through training on the use of new services. According to collected data, 68% of users responded positively while 32% said that there is no desire for such education.

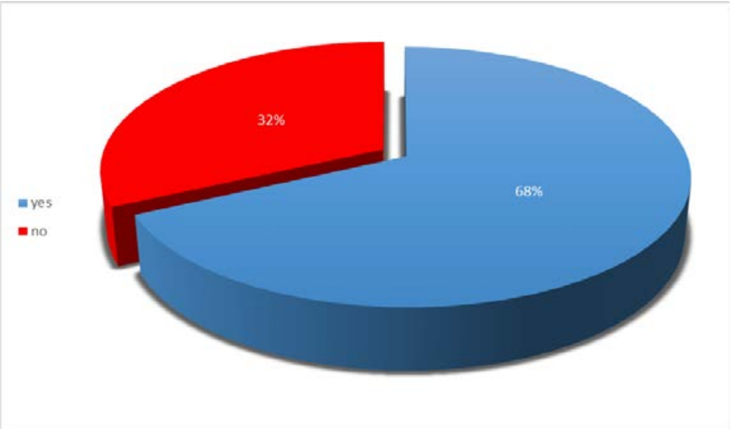

Figure 3. *The number of subjects willing to use services of informing and tracking*

For the type of device that would be most appropriate for informing users about their needs, users have chosen the smart – wristband (62%) as is shown in Figure 4.

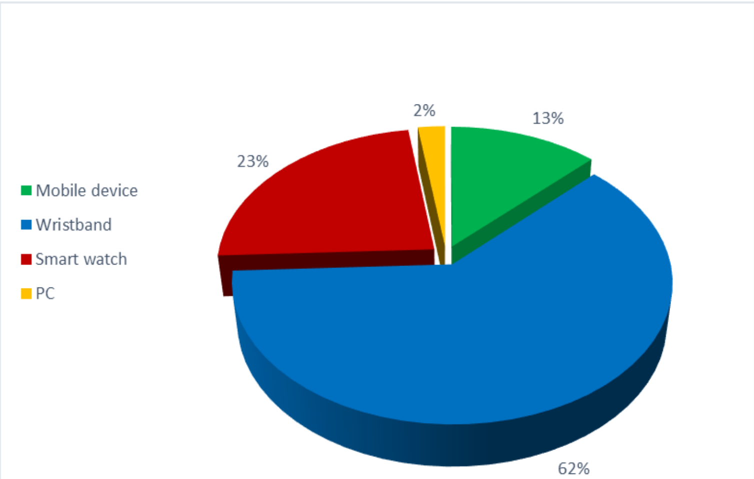

Figure 4. *The type of informing device chosen by test sample of users*

The most of users (80% of test sample) would choose voice control, and the rest of users (20% of test sample) would choose keyboard as the way of service management.

The processed data brings up the conclusion that users would use the service for monitoring the activity and location but under the condition that they learn the very minimum about how to use it. Today's population of users over 65 years hasn't managed to accommodate a large and rapid development of technology, and automatically rejects solutions that are based on smart mobile terminal devices, smart watches or similar devices. This is confirmed by a simple fact that majority of test subjects decided to select a simple device for the application of service, such as smart – wristband. Also a short explanation of functionalities resulted that the majority of respondents, which weren't sure whether to use the service, realized this service could help them and therefor showed great interest in its appliance.

4. Proposal of the architecture of service for monitoring activities of the elderly

Based on the previously obtained data, proposed architecture of service will be funded on the concept of Cloud Computing – CC. CC concept was chosen as a solution because of its advantages, such as: centralized data storage, the constant availability of stored data, controlled user access and security of stored data. This architecture is also simplifying the implementation of the system in homes for the elderly and disabled who would choose to use these services. Figure 6 shows the proposal of the architecture of service for monitoring activities and the location of users based on the CC concept.

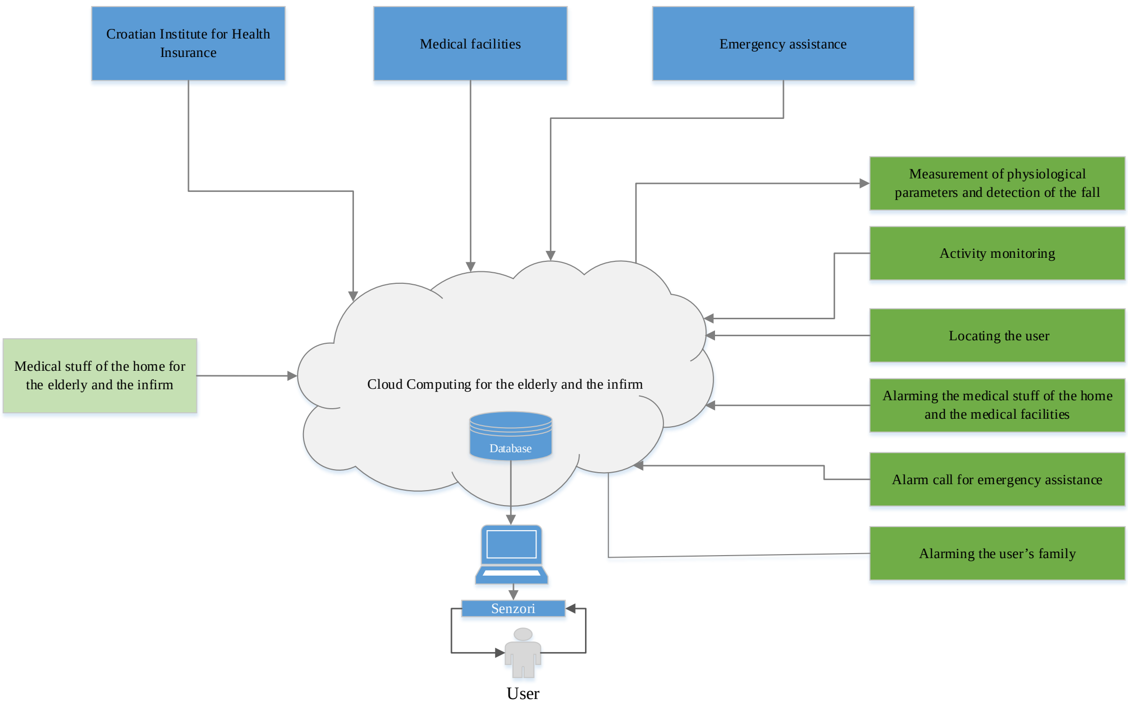

Figure 6. *Proposal of the architecture of service for monitoring the activity and location of users*

Users of this service would be able to use smart – wristbands or smart watches that would have the ability to monitor their physiological parameters and activity, the ability to detect falls and the ability to establish the call for help with specific voice command (Figure 7).

After one of the use cases being conducted, measured parameters would be sent to the sensor through a wireless connection, the sensor would transmit collected data to a central computer and the data would be sent further on saving and processing in CC. Therefore, the CC would be a central part of the system that would contain a database and would perform processing of stored parameters for each user. This system would "learn" through storage and processing of data for each user, so it would know the limits of monitored parameters (blood pressure, heart rate, temperature) and set that parameters to the normal limit for each user. If within one of the measurement appears that, for example, the measured pressure has a specified value that deviates from the set limit, the system automatically generates an alarm displayed to the medical staff on computer or on mobile terminal device. Access to information stored by the medical staff of the home where the user is located, would only be permitted to Croatian Institute for Health Insurance, medical facilities, and emergency assistance in the case of alarm that requires their reaction.

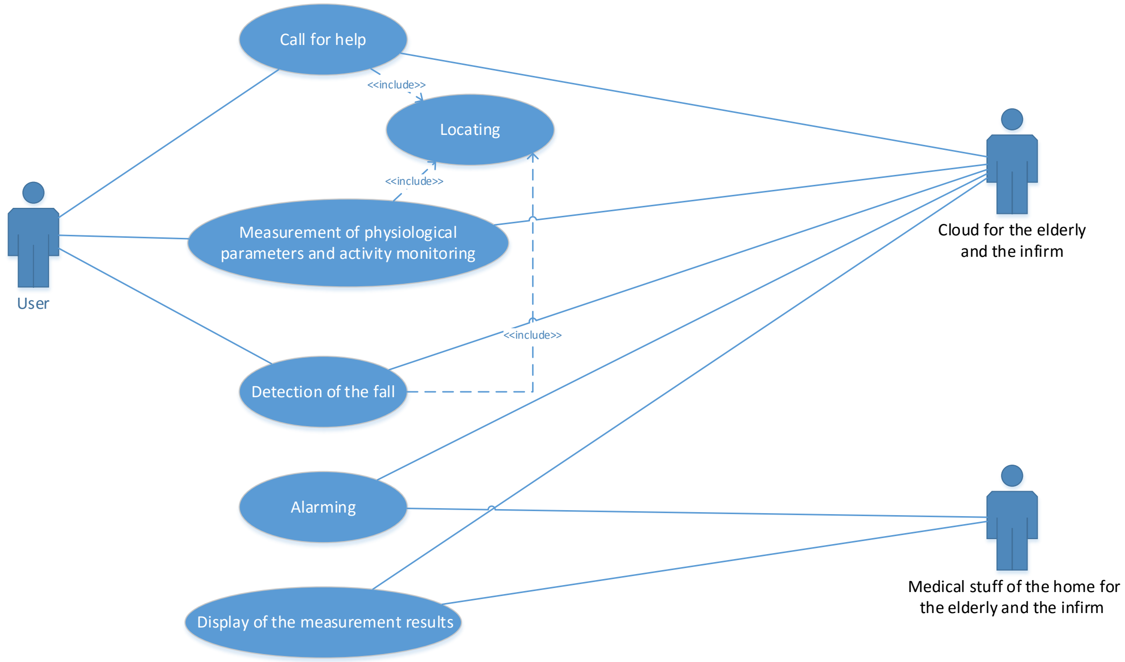

Figure 7. *Use case diagram of the service for monitoring activities and location of users*

The device would also be able to monitor and indicate user activity through physiological parameters. Which implies that each time data on blood pressure, heart rate and body temperature would be sent, it would include the information data about the distance that the user has passed between the two measurements, calculated burned calories, mileage steps, stairs, etc.

4.1. The measurement of physiological parameters and the activity on the system demand

The functionalities of the system are based on two methods of performance. The first method is the measurement required by the system according to the schedule entered by the user (once a day, every hour, every morning, etc.), while the second measurement is required by the user who through his smart – wristband gives a voice command to start the measurement. An important detail is that all cases of use have extended functionality to locate the user.

Figure 8 shows the activities performed by the system when it requests to perform the function of measuring on the customer by a given schedule. From the attached diagram of activities, it is evident that the measurement begins by generating a request by the system itself. The system generates a request because the database contains schedule of measurements for each beneficiary. After the system generates this request, the request is forwarded to a central computer located in the home where the user is located, then the computer locates the user and forwards the request to the sensor attached to the user's smart - wristband . The sensor system in the wristband receives a request for measurement, performs the measurement and sends measured parameters and other data to the CC by the same route.

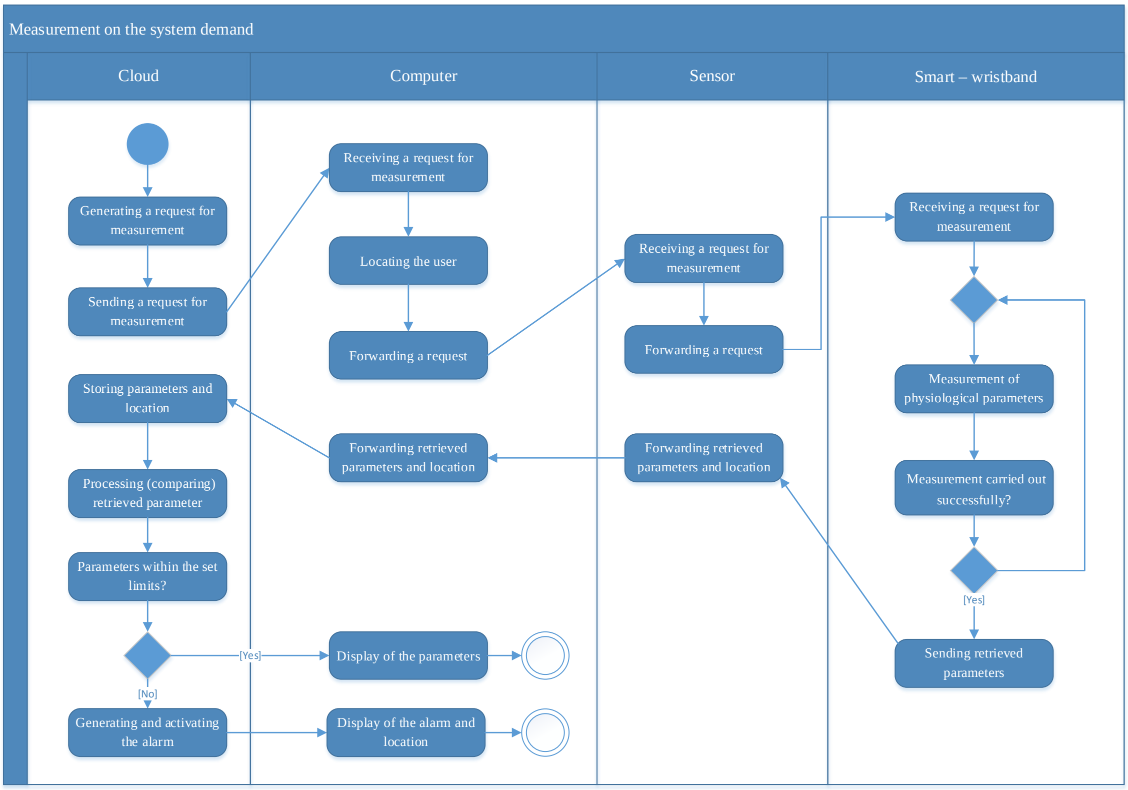

Figure 8. *Activity diagram – measurement on the system demand*

When CC receives the data, it stores them and performs processing, and then depending on whether the received parameters are within the limits it displays measured parameters to the medical personnel of the user's home or it generates and activates an alarm in case of deviation parameters. This use case ends by displaying the measured parameters or the activation of an alarm on computer (mobile terminal device).

4.2. The measurement of physiological parameters and the activity on the user’s request

According to data obtained from the survey conducted on the test sample of users, it was concluded that users want to manage their device with voice commands.

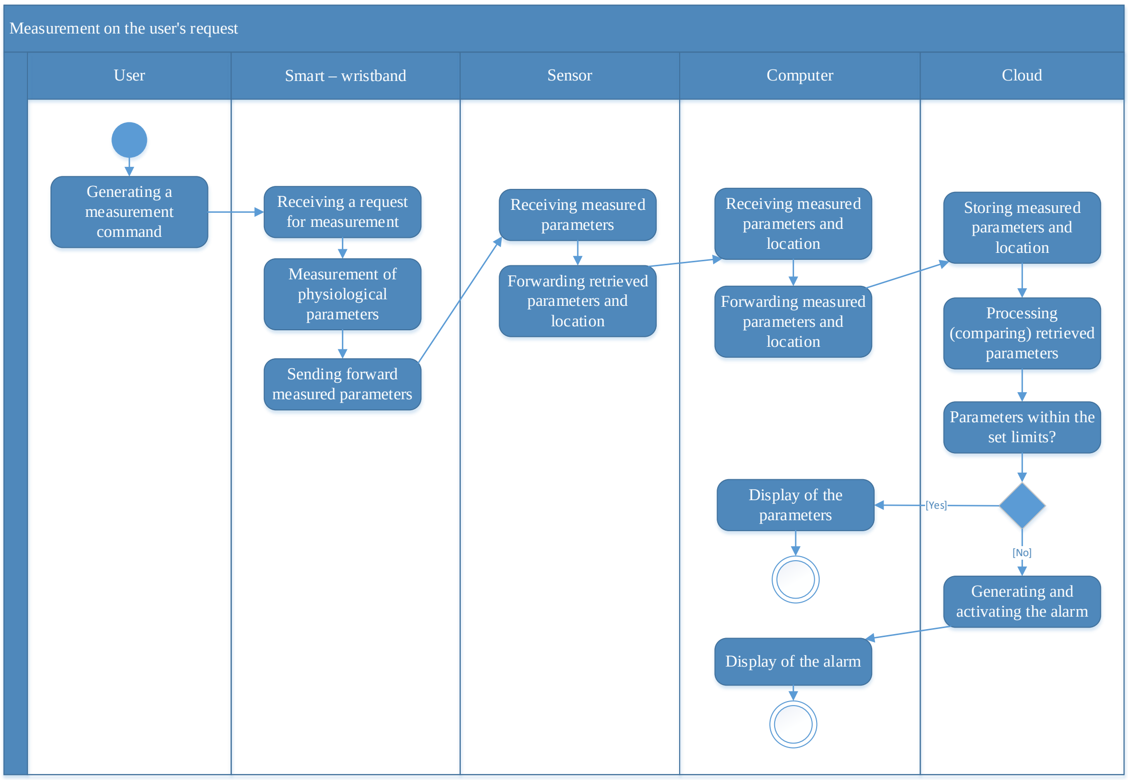

Figure 9. *Activity diagram – measurement on the user's request*

Figure 9 shows how this use case begins by receiving user's command to measure. By pressing the button located on the device (smart – wristband), users activate a module for receiving voice commands. A simple voice command (e.g. measurement) can to start the process. The rest of the process would be almost the same as in the case when the system requires the measurement. After performing required measurement, the device transmits data to the sensor, the sensor forwards the data to the computer, which sends the data to the CC. CC processes the data, compares them with the limits from the database and displays the measured parameters to the medical staff or triggers an alarm.

4.3. Detection of the fall

Fall detection is one of the simplest case of use of this system (Figure 10). User device would contain devices that can detect sudden changes in height, movement and orientation of the body.

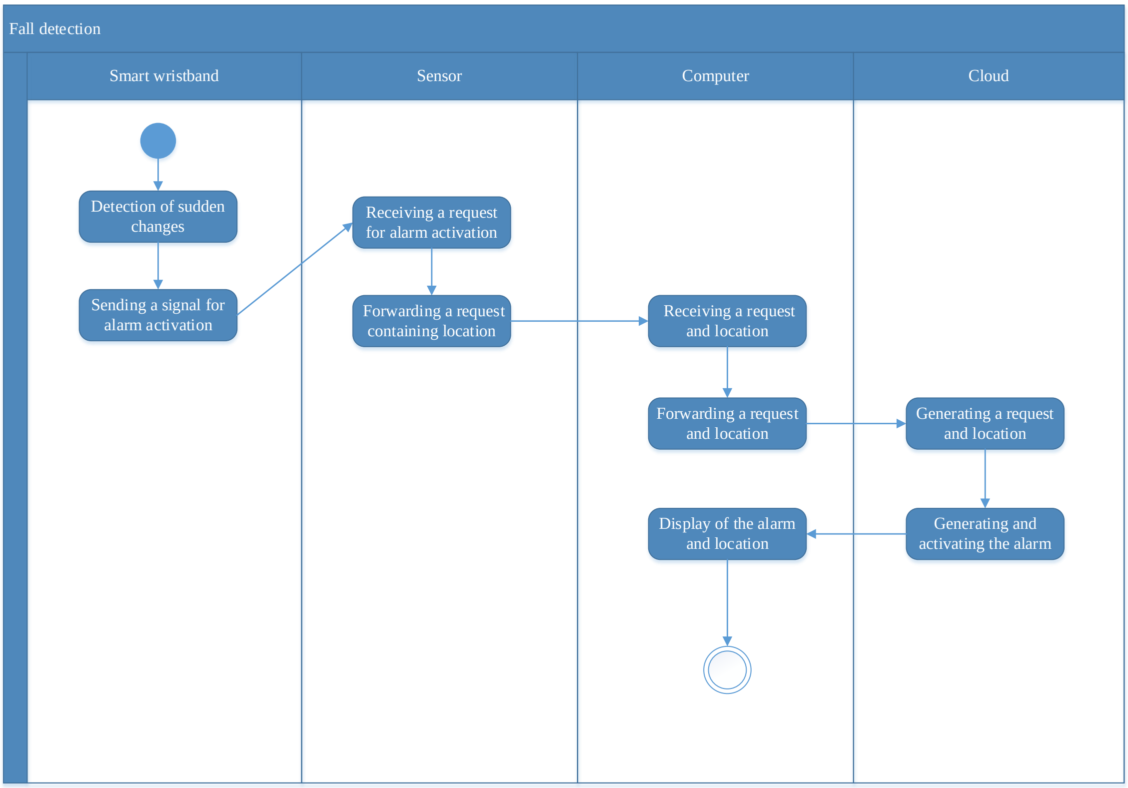

Figure 10. *Activity diagram – detection of the fall*

After detecting sudden changes in the movement of the user, the device sends a request to activate the alarm, CC system recognizes it, generates an alarm and sends it to the computer that display the alarm to the medical staff of user's home along with the location of the user who fell. In this use case, it all starts when the user's device detects a fall and generates a request to turn on the alarm, and everything ends by alerting medical staff at the home. Alarm contains a description of the events, in this case a fall, and the location where the fall occurred.

In the event of a fall or some other form of alarm situation the user begins the activity by pressing the button located on the device which enables giving a direct voice command to call for help. Once the device receives and recognizes the voice command, it sends it to the sensor that locates the user and then sends the data to a central computer. The central computer forwards everything to the CC that performs signal detection and generates and activates an alarm that is finally displayed to the medical personnel of home. In this use case it all begins when a user makes distress call through his device, and everything ends by alerting medical staff at the home. Alarm contains a message stating that the user has called for help of the staff and the location where the user is located inside the home.

5. Conclusions

The development of technology, as well as the research and development of the IoT concept, allow its application in various fields in order to facilitate and simplify the life of users. In such a situation described service aims to increase the quality of life of beneficiaries in homes for the elderly. Nowadays, there is a schedule for pressure measurements in homes for the elderly and all the users have to come in a specific room for their blood pressure to be measured and entered into the medical record. This concept would made possible for users to have their blood pressure measured, regardless of their location inside the home, and their measurement results would be enrolled in their medical charts located in the CC database. An additional benefit of described solution is automatically informing of medical or other staff, in the case of deviations from the normal pressure, to speed up time to react and help a specific user. This service has the ability to work 24/7 which is an additional advantage in the currently available solutions. The assumption is that the concept of IoT will expand and grow in future and that it will soon become dominant in monitoring and locating health of a large number of people who will apply this concept for themselves or for their elderly family members.

Acknowledgements

This research has been carried out as part of the project "*System of automatic identification and informing of mobile entities in the traffic environment*". Faculty of Transport and Traffic Sciences, University of Zagreb, 2015.

References

1. WHO - http://www.who.int (August, 2015)
2. Forkan, A., Khalil, I. and Tari, Z (2014) CoCaMAAL: A cloud-oriented context-aware middleware in ambient assisted living. *Future Generation Comuputer Systems*, 35, 114-127
3. Peraković, D., Periša, M., Bukljaš-Skočibušić, M. (2014) Possibilities of Implementing Ambient Assisted Living Concept in Traffic – *Archives of Telematics Transport System*, 8 (1), 30-34
4. Sufi, F., Khalil, I., Tari, Z. (2010) A cardiod based technique to identify cardiovascular diseases using mobile phones and body sensors, *2010 Annual International Conference of the IEEE Engineering in Medicine and Biology Society,* EMBC, IEEE, 5500–5503.
5. Ivanov, R (2010) Indoor Navigation System for Visually Impaired, *International Conference on Computer Systems and Technologies* - CompSysTech’10.
6. Periša, M., Peraković, D., Vaculík, (2015) Adaptive Technologies for the Blind and Visual Impaired Persons in the Traffic Network, Transport, 30 (3), 1-6, doi:10.3846/16484142.2014.1003405
7. Hsu, C.-C.; Chen, J.-H. A Novel Sensor-Assisted RFID-Based Indoor Tracking System for the Elderly Living Alone. *Sensors* 2011, 11, 10094-10113.
8. Pantelopoulos, A.; Bourbakis, N.G. (2010) A Survey on Wearable Sensor-Based Systems for Health Monitoring and Prognosis, *IEEE Transactions on Systems, Man, and Cybernetics, Part C: Applications and Reviews*, 40(1), 1-12. doi: 10.1109/TSMCC.2009.2032660
9. Sedlar, V. (2015) Research of IoT Concept in Monitoring the Activities of the Elderly, *Graduate thesis*, Faculty of transport and traffic sciences.
10. Picazo-Sanchez, P.; Tapiador, J.E.; Peris-Lopez, P.; Suarez-Tangil, G. Secure Publish-Subscribe Protocols for Heterogeneous Medical Wireless Body Area Networks. *Sensors* 2014, 14, 22619-22642.
11. Kartsakli, E.; Lalos, A.S.; Antonopoulos, A.; Tennina, S.; Renzo, M.D.; Alonso, L.; Verikoukis, C. A Survey on M2M Systems for mHealth: A Wireless Communications Perspective. *Sensors* **2014**, *14*, 18009-18052.