INTEGRATED CLOUD BASED SYSTEM USING WAREABLE DEVICES FOR HEALTH AND SAFETY AT WORK

George CARUTASU, Nicoleta Luminita CARUTASU

Abstract: The development of IT and its acceptance in all fields of activity rose new challenges and possibilities, regarding the improvement of health state using wearable devices. The COVID-19 pandemic accelerated the IT adoption for working at distance, e-working or working at home. Such, the workers care under the envision of professional diseases prevention and dangerous situation avoidance can be enhanced by using mHealth solutions. The present article proposes a cross-platform design of an integrated system using wearables devices as sensors, for monitoring the health condition, dangerous situations, and physical effort of worker during work time, with various user categories, emergency squads, medical care, ergonomist, management, and workers.
Key words: health and safety, mHealth, wearable devices, integrated systems, cloud computing.

1. INTRODUCTION

The technological development of the last decades together with the increase in the mobility of individuals have generated profound changes in a society now made up of individuals with a high degree of dependence on mobile devices. Health has accompanied these changes thus defending the concept of mHealth.

MHealth is an innovative field that offers countless possibilities for developing and providing end-user medical services to prevent and monitor diseases, telemedicine services and, ultimately, health control in an accessible and effective way. To this end, on the market, there is a wide variety of electronic devices that carry out measurements of vital signs and that, through a Bluetooth connection, transmit data to specialized platforms.

The World Health Organization defines MHealth (mobile health) as "medical and public health practice supported by mobile devices such as smartphones, patient monitoring devices, personal digital assistants and other wireless devices" [1]. However, the Grand View Research, one of the largest consulting and market research companies in India and the US, expect that the mHealth sector will grow exponentially. The report estimates that in 2025 the market it will be worth more than \$151 billion globally, with significant growth in Europe [2].

Among the benefits that mHealth can have, we mention:

- Patient empowerment – with the help of mobile applications the patient is closer to his own disease and actively participates in monitoring the state of health,

- Changing habits – the applications monitor everything we do (how many steps we take, what blood pressure we have, the amount of sugar we consume and others) and help us develop healthy habits,

- Ease of communication – more and more health professionals use, as a working tool, smartphones and tablets, which facilitate the communication and treatment of diseases, especially those of a chronic nature, contributing to the efficiency of the health system,

- Managing a large amount of data – applications allow continuous monitoring and tracking of the patient's health status by recording a huge amount of information about the patient, which, if well integrated and managed, can be useful for improving the results obtained or in the early identification

of diseases and the development of health promotion strategies,

- Cost reduction – applications allow to reduce unnecessary visits and hospitalizations through greater control over patients with chronic diseases.
- Efficient supply chain management – similar to any field of activity, health must also have at its disposal the products or services it offers. With mHealth apps, healthcare professionals can query the stock of pharmaceuticals on their availability and communicate in real time directly with companies for replenishment with the necessary materials/services.

The rapid growth of mHealth has led to the development of more than 9,000 apps for Health sector only [3].

2. WEARABLE DEVICES FEATURES

The competition for measuring the vital signs of the human body is increasingly intense [4]. Thus, in recent years, a wide variety of wearable solutions have appeared on the market that perform measurements and that, through a Bluetooth connection, transmit the data to the user's mobile phone.

Fitness bracelets or smart bracelets have a screen that presents vital information about fitness and health such as: heart rate, the number of calories burned, the distance traveled, the total number of steps taken in a day, the quality of sleep, the intake of nutrients, etc. In the top of these wearable devices is the Fitbit Flex bracelet, designed to monitor the state of health and physical activity, followed by other manufacturers such as: Xiaomi, Samsung, Huawei, Garmin, Aipker and Amazon that has developed a bracelet, without a face, in which a series of sensors are found aimed at monitoring daily physical exercise.

With the help of wearable solutions for monitoring workers, their safety and health will improve considerably. Of the electronic devices on the market, the best known, and all the time the most used device, is the smart watch (the smartwatch). In addition to functioning as a timing device, a smartwatch is a "general-purpose network computer, worn on the wrist, with a series of sensors" [5].

Modern smartwatches include various applications, similar to applications for smartphones and tablets. While these apps run directly on the smartwatch, a smartphone is needed to work. This is because the data is received first by phone and then transmitted for viewing. Most smartwatches don't include Wi-Fi and don't have a SIM card for cellular data. Therefore, most applications rely on a compatible smartphone to provide data through a Bluetooth connection, for example, the text message application on the smart watch allows us to transmit a text message, but the real message is transmitted using the phone. If the watch is not within range of your phone's Bluetooth signal, the message will not be transmitted. Smartwatches are an emerging, preventive technology, with health-related research currently in its early stages. That is why the studies, carried out so far, have classified these devices into three categories. The first category, dedicated to consumers, refers to devices that can be purchased through online stores, physical stores, etc., the second category represents watches designed as development platforms, and the last category is represented by devices developed in laboratories by researchers.

Smartwatches have the potential to transform healthcare by supporting or evaluating health because they:

- Most have built-in GPS and are increasingly available as a consumer device,
- Provides applications for continuous, real-time health monitoring and effects of physical activity,
- Allow communication between patients, family members and healthcare providers,
- Check the user's behavior based on the measurements made by the sensors,
- Presents tailored support, messages, and reminders,
- Facilitates immediate access to email, phone, calendar, pedometer, personalized training and are resistant to microclimate factors.

The key findings of the study indicates that the wearables devices mentioned above might act as sensors into an IoT architecture, having as

main goal maintaining the health state of the workers and preventing possible accidents. The limitation of presented technologies lies in the data ownership, the data beneficiary being the user and possible the doctor who assist him. Nevertheless, in the following section, the central play role is given to the employer, who can use data, having the worker acknowledgement, to trace the working condition effect over the workers. Partially, the model is validated by eCall technology who is already in place for car accidents, as an emergency warning system.

3. PROPOSED ARCHITECTURE OF THE INTEGRATED SYSTEM

The cloud-based integrated system architecture comprises at sensors level, the wearable devices, using the internal company network through a IoT Gateway which assures a secure connection of data transfer between wearable devices and cloud application, presented in Figure 1. The data stream is captured into an IoT Hub inside of cloud structure, filtered using the identification of the wearable and forwarded to the scope of the inquiry. However, the filtered data against the scope, might trigger alerts and notifications and pushed back to the wearable device to signalize the worker related to the dangerous threshold passing of a surveilled physical parameter.

The second function of the system covers the emergency caused by immediate medical emergency signalizing the internal rescue teams or to be forwarded to 112 public emergency system. Using the eCall standard [6], after the dangerous situation is advertised into the system, the worker could be called. The incident is signalized by sending through the company internal network, using a Minimum Set of Data (MSD), containing the worker' identification, GPS position, type of the eCall (manual or automatic) and triggered sensors and values.

If the value of data collected, depending on working type, work schedule and historical similar records, passes a threshold given by ergonomic evaluations, the system might propose the further evaluation using different ergonomic evaluation methods.

The last function provides info regarding daily activity of the worker, displayed by the wearable device or to the direct management position. The user of the system covers several categories:

- Workers, wearing the devices with tracked metrics. The workers also are signalized by alerts and notification regarding potential dangerous or harmful situation,
- Ergonomists, receives the tracked metrics and analyses. They use a dedicated module, depending on the work type, schedule, and work conditions the rising of values or passing the threshold (detailed in Figure 2),
- Medical care which uses the personal tracked metrics to enforce the medical file, and to prevent potential professional diseases,
- Emergency squad receives the MSD from the wearable device and uses the data to determine the identity of the worker, medical file and to intervein in the shortest time possible.

4. CONCLUSION

The challenges of the system implementation are mainly focused to the GDPR section, regarding collected data. Such system requires a GDPR agreement between employee and the company. However, the data security issues are covered using company internal network, and the IoT Gateway. Regarding the advantages of the system implementation, main benefits are the prevention of the professional diseases or musculoskeletal conditions, improving the ergonomics occupational risk evaluation, by using the historical data, and the occupational risk assessment method and decreasing the severity of the injuries caused by a work accident, by shortening the intervention time of the rescue teams.

Therefore, the future research will detail the model into a functional state and a prototype of the entire system is foreseeable. Furthermore, the cross-platform Cloud App will integrate at least several wearables' devices provided by different manufacturers.
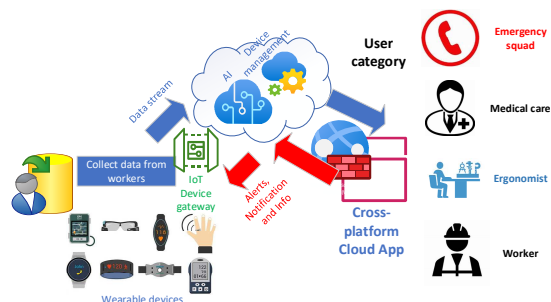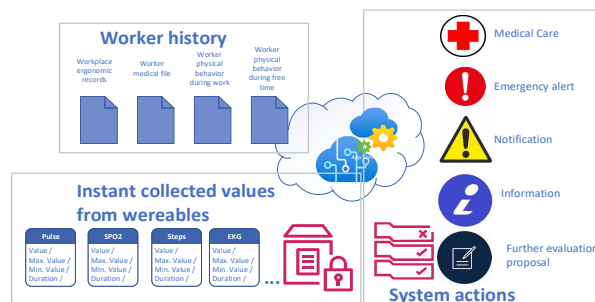
Fig. 1. Integrated system architecture and users.

Fig. 2. Integrated system functions.

5. REFERENCES

[1] World Health Organization, *mHealth: New horizons for health through mobile technologies: second global survey on eHealth*. World Health Organization, 2011. Accessed: Mar. 31, 2022, http://www.who.int/about/

[2] *mHealth Market Size & Share, Trends Report*, 2022-2030, https://www.grandviewresearch.com/industry-analysis/mhealth-market.

[3] Statista, *Health mobile apps worldwide by focus area 2018*, https://www.statista.com/statistics/1180843/health-related-mobile-apps-worldwide-number-by-focus/.

[4] Patterson, A. L., *et al.*, *SmartWatch by SmartMonitor: Assessment of Seizure Detection Efficacy for Various Seizure Types in Children, a Large Prospective Single-Center Study*, Pediatric Neurology,53(4), pp. 309–311, doi: 10.1016/J.PEDIATRNEUROL.2015.07.002, Oct. 2015.

[5] Rawassizadeh, R., Price, B. A., Petre, M., *Wearables, has the age of smartwatches finally arrived?,* Commun ACM, 58(1), pp. 45–47, doi: 10.1145/2629633, Dec. 2014.

[6] Perju-Mitran, A., Zirra, D. Căruţaşu, G., Pîrjan, A., Stănică, J.-L., *Applying the Technology Acceptance Model to Assess the Intention to Use an Aftermarket eCall Based on 112 Device for Passenger Vehicles to Ensure Sustainable Rescue Operations on European Roads*, Sustainability, 12(22), p. 9488, doi: 10.3390/su12229488, Nov. 2020.

Sistem integrat folosind dispozitive purtabile pentru sănătate și securitate în muncă

Rezumat: Dezvoltarea IT și acceptarea în toate domeniile de activitate au ridicat noi provocări și posibilități, în ceea ce privește îmbunătățirea stării de sănătate cu ajutorul dispozitivelor purtabile. Pandemia de COVID-19 a accelerat adoptarea IT pentru munca la distanță, e-working sau munca la domiciliu. Astfel, supravegherea lucrătorilor din perspectiva prevenirii bolilor profesionale și a evitării situațiilor periculoase poate fi îmbunătățită prin utilizarea soluțiilor mHealth. Prezentul articol propune proiectarea pe mai multe platforme (prin integrarea lor) a unui sistem integrat care utilizează dispozitive purtabile ca senzori, pentru monitorizarea stării de sănătate, a situațiilor periculoase și a efortului fizic al lucrătorului în timpul lucrului, cu diferite categorii de utilizatori, echipe de urgență, asistență medicală, ergonomist, management și lucrători.

George CARUTASU, Prof. PhD. Habil., Romanian-American University, Informatics, Statistics, Mathematics, george.carutasu@rau.ro, Expozitiei 1B, Sector 1, 012101, Bucharest, Romania, PhD Supervisor, University Politehnica Timisoara, Doctoral School, Timisoara, Romania, george.carutasu@upt.ro, +40372120324

Nicoleta Luminita CARUTASU, Prof., PhD. Habil., University Politehnica of Bucharest, Engineering Robots and Production Systems, nicoleta.carutasu@upb.ro, +40214029759, 313 Splaiul Independentei, Sector 6, 060042 Bucharest, Romania.