sciendo

# Smart solutions for improving working processes. A research experiences from dental clinic

**doi:10.2478/mape-2019-0059**
Date of submission to the Editor: 04/2018
Date of acceptance by the Editor: 07/2018
**MAPE 2019, volume 2, issue 1, pp. 600-611**

**Joanna Bartnicka***
ORCID ID: 0000-0003-1639-5804
Silesian University of Technology, **Poland**

**Jorge Lara**
**Mexico**

## INTRODUCTION

"Smart" is now a fashionable marketing slogan. The smart item (that can be product, city, environment, technology etc.) (Kaźmierczak at al. 2018) implies that it represents better functions, makes a life or work better and more effective for the user than his "non-smart" or “dumber” counterpart. One of the crucial subject that can be recognized as a smart one are working conditions or working processes. Generally speaking smart work is a new paradigm of working thanks to the possibility of using modern and innovative technologies. This approach can positively affect the modes of working processes because of such advantages like creating a working atmosphere that promotes collaboration and innovation or reducing working time and loads. It is therefore not just about doing the same tasks with new technologies, but about creating new ways and approaches to working processes (Preto and Gomes, 2018).The main assumption of smart concepts is the ability to both explore and exploit knowledge in reference to opportunities of digital solutions (Filos, 2016). In this sense smart solutions based on integrations of two interconnected processes: management of knowledge and the use of knowledge contextually. Each of these processes characterise specific tasks and functionalities. In the Figure 1 a basic theoretical model representing smart approach to human activity is showed.

Particularly the premise of knowledge management is based on a new paradigm in processes where knowledge is a central point to organizational performance (Newell et al., 2002; Swan et al., 1999) and is treated rather as necessity now then an option (Zhao et al., 2012).

In the literature, the attempts of model descriptions of knowledge management are presented mainly based on the industrial sector. Two different approaches to the subject of knowledge management dominate in previous research. The first approach is a technological approach (Davenport and Prusak, 1998; Liebowitz and Wilcox, 1997; O'Leary, 1998; Ruggles, 1998) and is focus on the databases, intelligent systems or ICT. This approach is based on explicit knowledge that is easy to codify and process (Nonaka and Takeuchi, 1995).

* joanna.bartnicka@polsl.pl

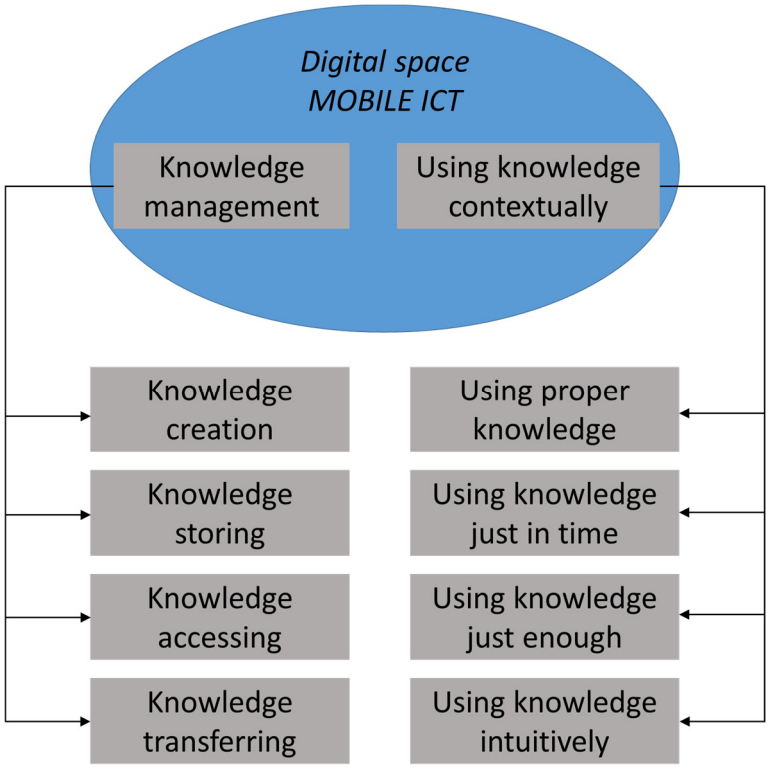


**Fig. 1 Theoretical model representing smart approach to human activity**

The second approach concerns the process of creating and sharing knowledge, with particular emphasis on the role of organizational culture and employees' knowledge (Ghosh and Scott 2008, Nonaka 1994). This approach emphasizes the importance of tacit knowledge (Polanyi 1966). Naturally, these two mentioned approaches create two associated grounds, one of which (Approach 2) represents the contextual relationship between the information resources in the work processes, and the other of the technical execution (Approach 1).

In reference to this literature background on knowledge management and its implications, the developed theoretical model (Figure 1) over-builds the presented two Approaches with additional specific functionalities making the proposed new approach “smart”. Particularly, smart approach to organization aims to improve working processes providing intelligent capabilities by using technology to response, in real-time, to the ever-changing working conditions. These functionalities represent specifically:

- Using proper knowledge that means that the knowledge is strictly adjusted in substance to contextual working situation.
- Using knowledge just in time that means reducing times within working processes to look for knowledge. It is provided in accurate time neither too early nor too late to the user.
- Using knowledge just enough that means to provide knowledge strictly adjusted to contextual situation in terms of scope and form of representation.
- Using knowledge intuitively that means providing knowledge without using of special procedures, the knowledge it provided automatically.

## MATERIAL AND METHODS

An in-depth case study was performed to evaluate proposed smart solutions improving working processes at the known private dental clinic. The clinic is well known for providing high quality services with the most innovative techniques, standards and technology that are inter alia: dental implants, endodontics, surgery, bone reconstruction, prosthetics, aesthetic dentistry, dental caries treatment, laser-based dental treatment, orthodontics, ozone therapy treatment of gum diseases etc.
The proposition of using smart solutions was the results of three main research stages.

**The first stage** was diagnostic research covering following methods:

- interview partially categorized conducted with participation of clinic manager and clinic owner;
- direct observations and photo registrations;
- documentation of building and equipment testing.

**The second stage** was to develop smart solutions that improve selected working processes base on the theoretical model provided in the Figure 1. The ideas for the solutions were created with the use of unified modelling language (UML) tools. The solutions' prototypes were developed, based on three different tools:

- Radio Frequency Identification (RFID) technology that connects with an interfaces using a microcontroller that enable the manager to the on-line feedback.
- Quick Response (QR) Technology to identify the rooms with equipment inside.
- Solution based on communication with application client - server (Android or iOS) – server (PC).

**The third stage** was validation and evaluation of solutions that was done with participation of the clinic manager.

Particularly, the RFID technology allows the user the identification of objects in a wireless way. For this identification an object called "tag" that transmit all the data is needed (Jia, 2012). The RFID communication is based mainly on the interaction of two elements that exchange information; a tag and the lector. The tag contains a microchip that stores a unique code, the lector sends frequency waves in a given area, and when these waves are captured by the chip of the tag, the tag sends the information (the unique code) to the lector, once this happens the information in the lector can be manipulated using applications, data bases, etc. (Bhuptani, 2005).

The QR code is a square pattern with black lines on a white background that can store significant information like simple text, URL´s or numeric information, that can be read using QR readers. The desired information has to be encrypted or encoded in a QR code, and only a decoder (scanner) is able to make the decryption of the information and in this way the final user can decipher the final message (Brokaw, 2014).

Application client – server works using Bluetooth technology and emits a broadcast signal using low energy (BLE) that can communicate with smart devices in order to send significant information, even if the devices are not synchronized (Arm Mbed., 2018).

## RESEARCH OUTCOMES AND DISCUSSION

### The first stage

After analysing the materials gained within diagnostic stage, it was possible to describe working processes including type of tasks, type of staff and its roles, the medical equipment and materials as well as space parameters and architectural infrastructure. The quality and quantity assessment of the working processes provided conclusions that the main factor influencing work efficiency is time.

The reason of time extension of services offered and well as internal working processes was the lack of knowledge about location of medical devices and people and the necessity to look for them within the clinic infrastructure. In the clinic although some equipment is stationary, there are some devices that are constantly in movement, for example, mobile x-ray machines or anaesthesia machines.

### The second stage

Taking into account the functionalities describing smart approach to working processes three different scenarios were developed that objective was to overcome the time-consuming resulting from the equipment management.

The conversion of the theoretical model representing smart approach to human activity into practical smart solutions for improving working processes of equipment management is presented in the Figure 2.

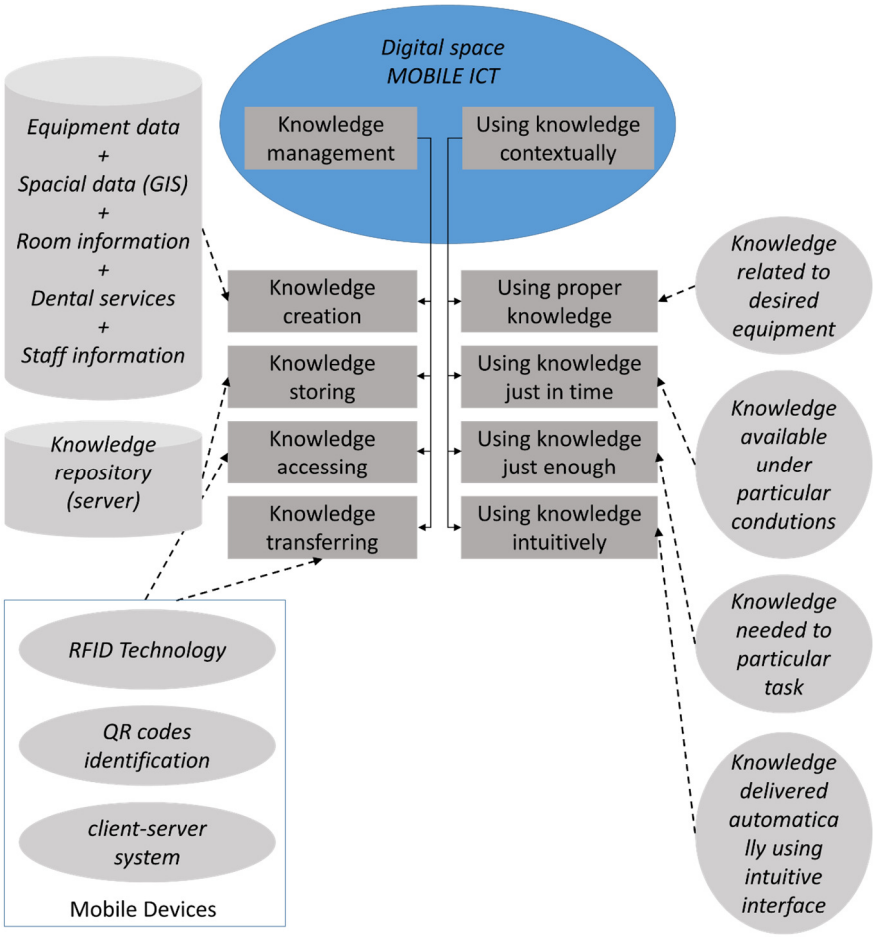


**Fig. 2 Model for smart solutions in improving working processes of equipment management**

To the theoretical model it was added certain data and information that related in contextual mode create consequently the knowledge needed to effective management of equipment. These data and information are represented with the use of dedicated formats and stored in knowledge repository. E.g. data representing space infrastructure of dental clinic is based on geographic information system (GIS) that relates maps of certain storey of the building to specific descriptions of equipment located into a certain place. These locations can be dynamic.
Thanks to use mobile devices with implemented automatic identification solutions based on ICT the knowledge from repository can be transferred regardless of the place and time. Such approach to knowledge management makes it possible to have access to knowledge in each situation where it is useful for a working process and certain task.
The proposed smart solution has attempts to restrict rules of cognitive ergonomics. For this purpose the portion of knowledge is sufficient to achieve a specific purpose while working, and therefore there is neither excess knowledge (which can cause mental overload related to the assessment of quality and usefulness of knowledge and the loss of time caused by this) or insufficient knowledge (which can cause stress and additional time needed to acquire missing knowledge).

*Development of a solution based on RFID technology*
The first prototype developed is based on the integration of a RFID module in an interface created on the software NI Labview 2018. The dedicated application was designed to be simple and interface intuitive for the staff including dental assistants.
The user has to read the RFID tag on the reader and verify that the information was sent correctly to the interface and the location appears on the map. In the Figure 3 the graphical interface is presented.
On the map it is located one LED indicator that will turn on, when the data of the RFID tag is read, showing the location of the device.
After reading the RFID tag, and once that the information was received on the interface, the LED indicator will turn on, showing the position of the device in the map (Figure 4).

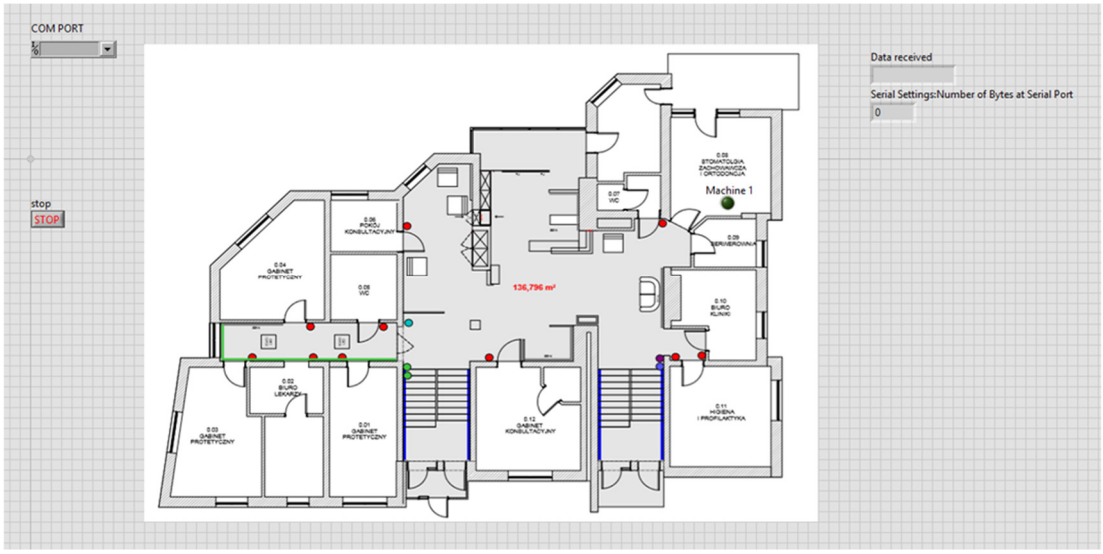


**Fig. 3 The panel of the application based on RFID Technology**

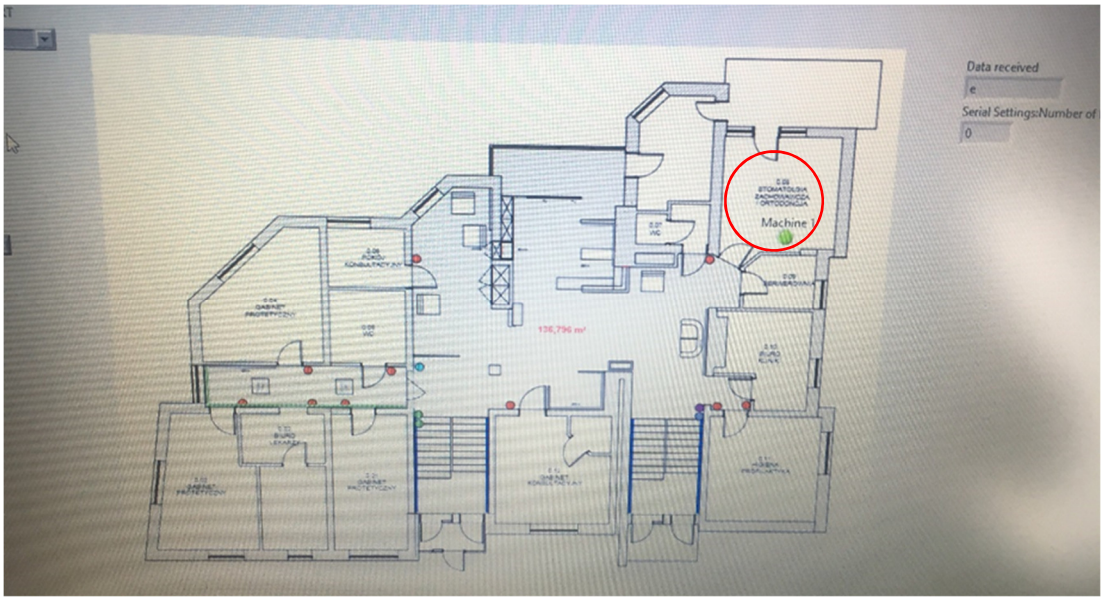


**Fig. 4 Device location within the space**

The design of the interface is very simple, by clicking on COM Port is possible to select on the drop down list the port where microcontroller is connected, the indicator called “Number of bytes at serial port” is useful to know if there is data transmission between the microcontroller and the interface, and the indicator “data received” shows the data that the program is receiving, in this way the administrator can check if there is any communication problem in the system.

*Development of a solution based on QR codes*

For the implementation of the second case of solution, a QR code for every room space was generated by using an online QR generator. The Figure 5 shows a button to scan the QR code placed experimentally at the entrance to one of the room and the process of QR identification process with the use of mobile phone.

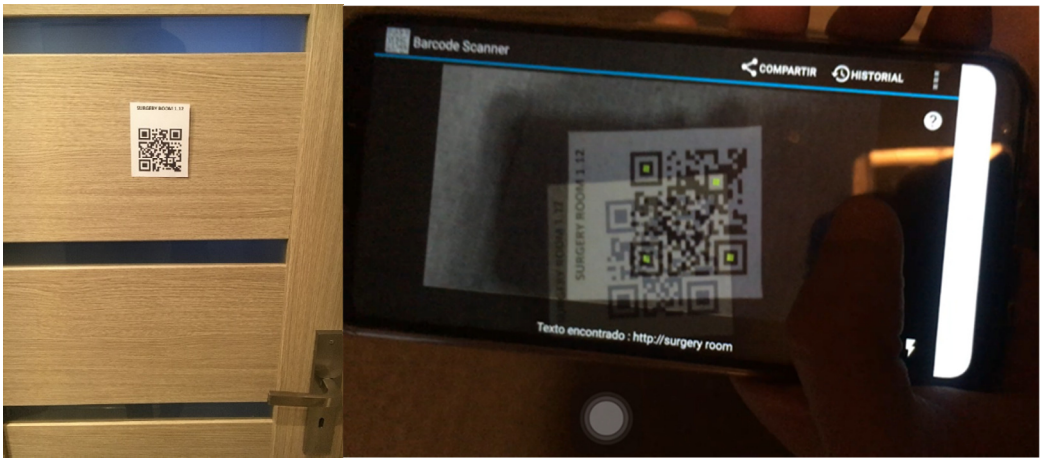


**Fig. 5 QR code located at the entrance to a room and a moment of scanning code by using mobile phone**

After opening dedicated application for scanning the code, the contextual information is decoded and send to the database on the google spreadsheet that is presented in

the Figure 6. Thanks to this action the users, especially the manager are able to see the location of the device, and the date and time when the location was registered. Immediately after sending a notification from the web service all the users are receiving the notification on the screen as it is shown in the Figure 7.

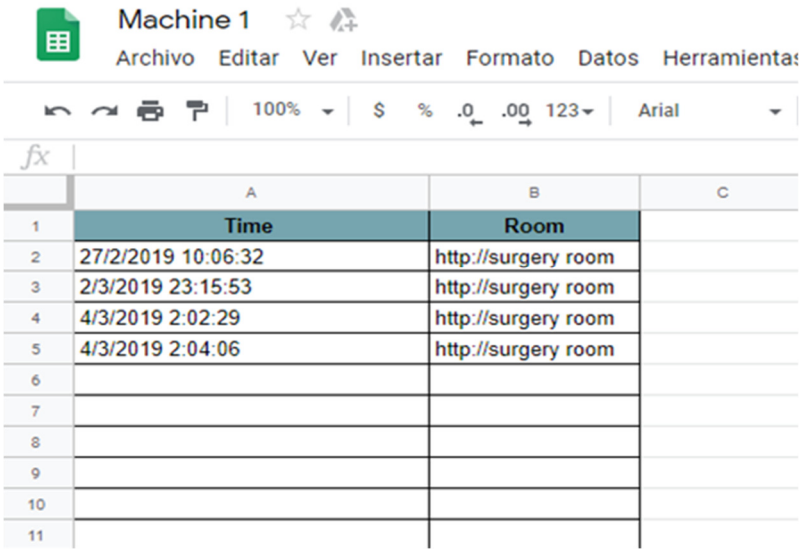


**Fig. 6 Google Spreadsheet**

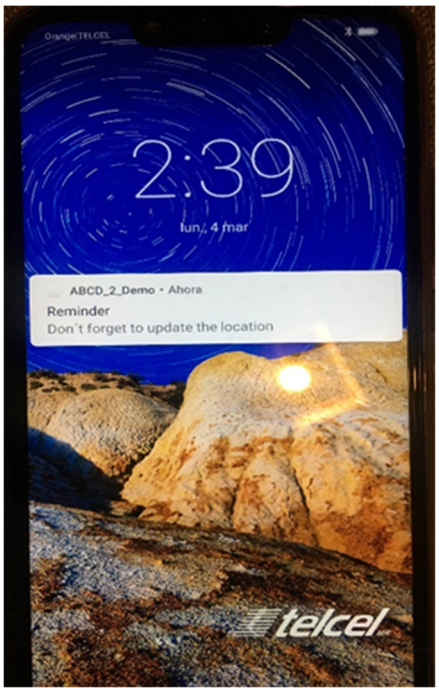


**Fig. 7 A moment of receiving the notification**

*Development of a solution based on a client-server system*

The Figure 8 shows the front panel of the interface, the front panel is one of the most important things in the system because is the part where the final users (dental assistants, managers, doctors) interact.

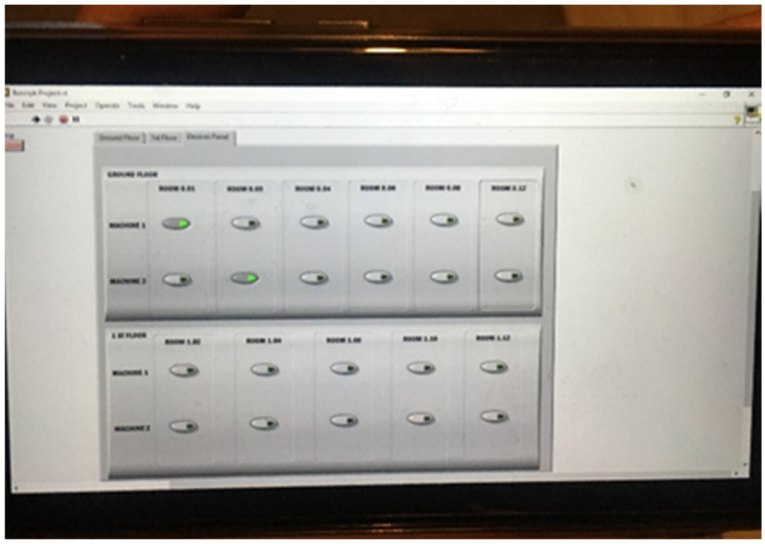

**Fig. 8 Interface of client-server solution available on mobile phone**

The design is simple in order to facilitate the interaction of the users with the environment, the devices panel contains all the rooms of interest in the building.
Every room has a push button associated and when the dental staff wants to indicate that one machine will be used in a certain room, he or she has to press in the panel the button that corresponds to that room, in that moment the push button turns on with a green indicator, showing that the device is active in that location.
When the device is no longer used in that position, the dental assistant has to press the button again to turn it off and update the new position of the machine, in that way all the users connected to the application will know the last position of the device.
In the front panel is also possible to visualize the map of the clinic and to see in a more graphic way the location of the devices as its shown in the Figure 9.
When a push button is pressed on the devices panel, automatically turns on the indicator associated to that specific button. If a button that belongs to the machine number 1 is active the indicator turns on green, if it belongs to the machine number 2 the indicator turns on red.
However, every user is able to update the location if they realize that someone forgot to determine the last location.

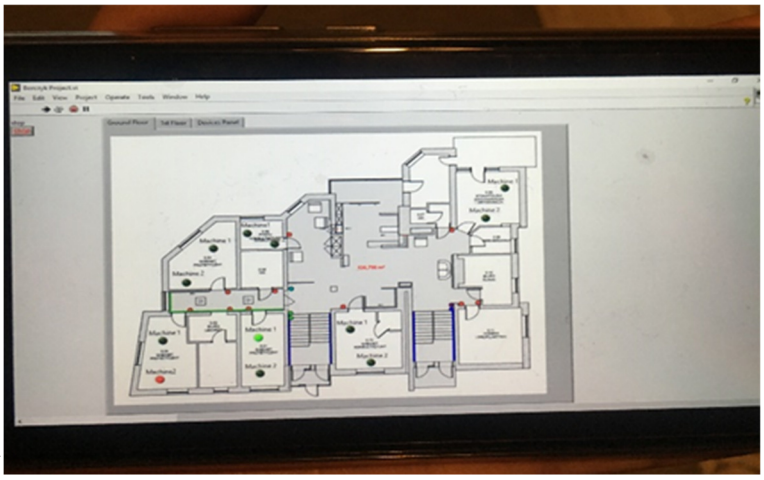

**Fig. 9 Front Panel Ground Floor map available on mobile phone**

**The third stage**

A comparison among the solutions developed were performed according to expert panels with clinic manager and the owner. Ten parameters were assessed:

1. Interface: Refers to how user friendly is the final interface in terms of usage.
2. Feasibility: The possibility of implementing the presented solutions in the short term, considering the economic aspect.
3. Scalability: The possibility of add more features, devices in the application in the future.
4. Mobile App: The presence of a mobile application as a part of the system.
5. Cross platform system: If the system or solution created can be used in devices with different operative systems.
6. Comfort: The facility for the users while using the app.
7. Response: How fast the system performs the activities (for example the location of the devices).
8. Connectivity: The possible dependence of the system with the local network connection.
9. Robustness: How vulnerable is the system to the technological issues.
10. Data visualization: How the information (location of devices) is presented on the final interface.

The above characteristics where evaluated from 1 to 5 using Linkert scale method (Table 1).

**Table 1**
**Assessment outcomes of proposed smart solutions**

| Characteristic | RFID solution | QR solution | Client-Server Solution |
|---|---|---|---|
| **Interface usage** | 5 | 5 | 5 |
| **Feasibility** | 2 | 5 | 5 |
| **Scalability** | 2 | 5 | 5 |
| **Mobile App** | 1 | 5 | 5 |
| **Cross-platform integration** | 1 | 1 | 5 |
| **Comfort** | 5 | 5 | 3 |
| **Response** | 2 | 4 | 4 |
| **Connectivity** | 3 | 5 | 3 |
| **Robustness** | 1 | 5 | 3 |
| **Data visualization** | 5 | 2 | 5 |
| **Total** | 27 | 42 | 43 |

After a deep analysis of the smart solutions generated, the best solution in general terms was the system based on client-server architecture.

Regarding interface usage, all solutions were well evaluated because of their intuitive and simple procedure of operating.

The solution based on RFID is more complicated to implement, as more elements are needed, like several readers (one per room) or at least 4 microcontrollers with more capacity in order to read several lectures at the same time. For the solutions based on QR codes and client-server, the elements needed are more easy to manage. For QR code a device with Android System and any PC with internet access is needed and for the client-server only a PC and a smart device with any operative system.

For the fourth criteria, in the solution based on RFID there´s no mobile application, the only way to see the information is on the interface (which can be a disadvantage for the manager), the other two solutions include a mobile app to determine the location of the device and to visualize the information.
The next characteristic evaluated was cross-platform integration, it means the opportunity of the system to be implemented on different operative systems, in this case the solution based on RFID just run on a machine that has installed Labview, and the solution of QR codes is just available for Android while the client-server systems can be integrated in all systems (iOS, Android, Windows).
Comfort is one of the most important aspects for the final users, because they will always choose the option that save their time. In this case the options based on RFID and on QR codes are more practical, the user has just to scan the tag and the QR code respectively. For the client-server system the users have to indicate the location on the simple panel that is more time consuming for them.
Response time that is crucial factor to be improve, in the case of RFID solution the response time depends on several factors. The first one is the characteristics from the reader itself, every reader has a different lecture time, in this case it was 3-5 seconds. For the other two solutions the data transmission were performed with no delay and were stable.
Regarding connectivity issues, the best solution is based on QR codes because it needs a Wi-Fi connection with no necessity to work within the same network, while in the client-server solution both devices (client and server) must be on the same local network, otherwise will not work. The connectivity of the RFID solution will depend always in the correct performance of the readers and the stability of the serial transmission.
For next criterion that is robustness, the best solution turned out to be is QR codes, because no additional hardware infrastructure is needed. In case of RFID if the reader or the microcontroller is not working properly it will affect completely the system, the same for the client-server if for some reason the server is not working the whole system will collapse.
Regarding the last criterion evaluated that was the visualization of the data, the worst solution in this case was the QR codes as the manager just see the solution in the written form in a traditional and simple database, while they preferred to visualize the application on a map as its more attractive and intuitive to read and interpret.
Based on the results obtained, the best solution is the one that uses client-server architecture. Particularly, the implementation is possible in the clinic with no additional financial investments because all the resources needed are available in the clinic as a standard devices and the application is ready to be installed.. The application designed can be used by 15 users connecting at the same time.

**CONLUSION**

Although the solutions presented in the paper are useful and ready to be implemented having the attribute of smart approach, there were recognized several improvements that can be done for the future research. Particularly the improvements should overcome the weak points identified through the evaluation presented solutions.
One of the new recognized smart solution that will make the access to desired information (without user interference) is the use of beacons, specifically automapping

based on location beacons with Ultra Wide Band (UWB). This gives the possibility to create an effective system for quick location of both people and devices taking part in different working processes in the building. However this way of improving presented solutions requires additional financial investments.

The research made is a good starting point and provides a positive vision of how ICT tools can create smart solutions and improve working processes not only in the medical processes, but also in every kind of sector that involves processes with movements of people and machines.

## ACKNOWLEDGEMENT

*The research was conducted with the support of the statutory work titled "Methods and tools supporting development of priority research areas", project number 13/030/BK-19/0052.*

## REFEENCES

Arm Mbed. (2018). Understanding the different types of BLE Beacons, https://os.mbed.com/blog/entry/BLE-Beacons-URIBeacon-AltBeacons-iBeacon/.

Brokaw, S. (2014). The expectation of Quick Response (QR) Codes in print media: An empirical data research anthology. Journal of undergraduate research.

Davenport ,T.H., Prusak, L. (1998). Working knowledge. Harvard Business School Press, Boston.

Filos, E. (2006). Smart organizations in the digital age In: Mezgár, I. (ed.) Integration of Information and Communication Technologies in Smart Organizations. Idea Group, Hershey.

Ghosh, B., Scott, J.E. (2008). Knowledge Management for Healthcare Organizations: Comparing Strategies with Technical Support. Proceedings of the 41st Hawaii International Conference on System Sciences (http://www.ae.isu.edu.tw/upload/83202/12/files/dept_12_lv_3_12612.pdf).

Jia, X. (2012). RFID technology and its applications in Internet of Things (IoT).

Kaźmierczak, J., Loska, A., Kucera, M., Abashidze, I. (2018) Technical infrastructure of "smart city": needs of integrating various management tasks. In: MAPE 2018. Conference proceedings. 1,(1), 467-473.

Liebowitz, J., Wilcox, L.C. (1997). Knowledge management and its integrative elements. CRC Press, Boston.

Bhuptani, S.M. (2005). Components of RFID systems. Deploying Radio Frequency Identification Systems.

Newell, S., Robertson, M., Scarbrough, H., Swan, J. (2002). Managing knowledge work. Palgrave, New York.

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. Organizational Science 5, 14-37.

Nonaka, I., Takeuchi, H. (1995). The knowledge-creating company. Oxford University Press, New York.

O'Leary, D.E. (1998). Knowledge management systems: converting and connection. IEEE Intelligent Systems, May/June, 30-33.

Polanyi M. (1966) The tacit dimension. Routledge and Kegan Paul, London.

Preto, S., Gomes, C.C. (2018). Three Times Smart – Smart Workplaces, Smart Lighting & Smart Glass. In: P. Arezes (ed.), Advances in Safety Management and Human Factors, Advances in Intelligent Systems and Computing 604.

Ruggles, R. (1998) The state of the notion: knowledge management in practice. California Management Review 40, 80-89

Swan, J., Scarbrough, H., Preston, J. (1999). Knowledge management: The next fad to forget people? 7th European Conference on Information Systems, Copenhagen, Denmark.

Zhao J., Ordóñez de Pablos, P., Qi, Z. (2012). Enterprise knowledge management model based on China's practice and case study. Computers in Human Behavior 28, 324-330.

**Abstract.** Smart solutions become an indispensable attribute of today life giving the opportunity to act in a significantly efficient way in both public and especially private sector. For this reason the “smart approach” to business is a crucial component in a process of building the advantage in a competitive services market. Taking this challenging aspect of companies’ activities, the authors present a concept of implementing a smart solutions for improving working conditions in a private dental clinic. Particularly, the smart solutions are based on integration of knowledge management constructs and information and communication technologies (ICT) that enable users to use knowledge contextually and in intuitive way. As a final part of the paper, three different practical ideas were discussed and evaluated.

**Keywords:** smart solution, dental clinic, working conditions, ICT, knowledge management