Indoor Monitoring System for Senior Citizens with Alzheimer's or Mental Illnesses

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Abstract: Actually, the development of increasingly powerful systems and information technologies capable of monitoring in real time the vital signs and the location of people are providing significant changes in the functions that Social Solidarity Institutions (IPSS) have in society, from simple treatment of disabling diseases and palliative care, to prevention and monitoring of users, promoting their mobility, with the ultimate goal of improving the quality of life of institutionalized people. The main objective of the system presented here is to monitor the elderly or with problems within institutions through the acquisition and treatment of data and information related to their location and health status, in a discrete and non-intrusive way, through information and communication. So, that both the institution and the family members can monitor in real time the status of the users they have under their responsibility. Considering that the systems focused on the monitoring and data management of people are in great evolution, that pervasive and ubiquitous computing is present in our daily life, with the present work we hope to contribute positively to the improvement of the quality of life of the users of the social solidarity institutions, especially in the senior population, with special attention to people suffering from psychological pathologies such as Alzheimer's and other types of dementia. The system utilizes low-cost communication and data processing facilities that couple heart rate sensors among others, allowing the system operator to access user information at any time. Being a low-cost system, social solidarity institution can easily implement your custom solution for new social responses.

Keywords: IoT, ubiquitous computing, monitoring systems, ICT, RFID technologies.

1. Introduction

Today, the computing based on Internet of Things is present in most home systems, we find it in small devices of regular use, as a mere blood pressure meter, but also in larger equipment, namely home appliances, energy efficiency controllers, among others [1].

The health area is the one that has most benefited from this type of technology, miniaturized and often overlooked, with application in the field of vital signs monitoring, in telemedicine, in the use of equipment permanently connected to the Internet, miniaturized and that without being invasive will transmit and adapting their behaviour according to the needs of their user [2].

The Internet of Things (IoT), a terminology recently used to designate miniaturized systems permanently networked, is currently revolutionizing the way we use technology at the highest level [1], [3]. With the technology currently available, it is possible to combine devices with heterogeneous systems, such as Smartphones with mobile network (3G / 4G and future to 5G), Bluetooth devices, Wireless networks, sensors, among others, interacting among them, providing operating environments fully automated, adaptive, taking advantage of these infrastructures, naturally improving people's quality of life.

The emergence and expansion of smart cities is also an excellent example of the use of the Internet of Things, the use of Artificial Intelligence, in which ubiquitous computing systems are collecting and generating huge quantities of data that require no only the storage location, using Cloud Storage, but also its immediate processing, helping citizens to take advantage of this processing [4]. An example of this is the use of real-time processed data, decision support systems, stock management in a large warehouse or a store, without the need to account for the units manually.

Another application of the Internet of Things in the area of management, is to control the passage of certain objects by certain locations inside the companies (controlled by special gateways), allowing real-time tracking of the location of object [5].

Using the concepts associated with the monitoring of articles in stores and the use of ubiquitous and pervasive computing in people's quality of life, we developed a concept and an application model in the field of people monitoring within IPSS, which will allow monitoring and follow-up in real time while preserving your privacy.

The Portuguese third cycle review and evaluation of the Regional Implementation Strategy (RIS) of the Madrid International Plan of Action on Aging (MIPAA) shows that the percentage of the aging population is increasing in Portugal, without to respond efficiently and in a timely manner to all requests [6].

Recent studies prove that the world population that suffers or will suffer from some type of pathology of the mental area is growing frighteningly, so it is imperative to associate and put the existing technologies, at the service of the people, minimizing the negative impact that these pathologies have in the quality of people's lives [7], [8]. Based on this reality, using the concepts already defined in other monitoring and monitoring environments based on sensors and miniaturized telecommunications equipment, we present in this article a system for monitoring and protecting both elderly people and people suffering from some type of dementia or mental disability, designated by IMS4EP.

2. System Modelling - Use Indoor

The study and application of certain types of portable sensors and easy operation has been growing considerably.

The use of portable sensors, namely the accelerometer, small size, low power consumption and high precision has been used in many tests in individuals who have some types of diseases that limit their mobility, allowing validation in real time if a particular individual suffers an abrupt drop [9].

Several authors have worked with these and other sensors, showing the advantage of using these small devices to aid and monitor people.

In [10] the use of accelerometers showed that it is possible to determine the cause of a fall, through Machine Learning algorithms, exploring a previously unfinished strand in the field of adult monitoring mainly.

More recently in [11], it can be verified that portable sensors have enormous potentialities in the field of monitoring people's movements and for the analysis of incidence of falls.

Currently, mobile communication devices, commonly referred to as Smartphones, have several sensors, including accelerometer, GPS, etc., but are difficult to operate by the elderly population, not used to this type of technology. often with great physical limitation and barriers in the use of technologies, as referred in [12], [13].

Thus, we propose in this work to explore and enhance the use of these sensors, in order to monitor in real time the IPSS users who move freely in the external areas, prone to eventual falls, monitoring not only their location, but also their movement capacity, pulse, displacement and fatigue resistance, using non-intrusive pervasive devices incorporating the various sensors.

The system consists of an application developed for portable devices, similar to a smartphone, with wireless access, which will access a web server, incorporating a microcontroller that interconnects in addition to the sensors already mentioned, sensors of body temperature [14], humidity [15] and pulsation [16].

The equipment will be installed in a bracelet appropriate to each user, in order to make it safe, concealed and comfortable, avoiding the interaction of the user for obvious reasons.

The communication is done automatically via Web Services, sending in real time the monitoring data of the users to a server that will store it in database with real-time analysis.

The passage through the portals where the RFID readers are located is carried out without any kind of blocking and the user's TAG identifier is read.

2.1. Functional Requirements

At the level of functional requirements, the following operations are considered mainly:

- Secure connection service with registration, authentication and user validation;
- Differentiation of available services for different user types - Administrator, User (User's family, active user), User (passive user);
- Data collection function of the coupled sensors (accelerometer, temperature, Pulse);
- Indoor data collection function (RFID Readers);
- Function of sending of data of the user by Web services;
- Parameter setting and configuration function of portable devices;
- Real-time analysis of the collected data (local processing), for detecting deviations beyond the allowed tolerance;
- Abnormal occurrence alert for the operator (Local Administrator).

2.2. Non-functional Requirements

No less important are the non-functional requirements, which are responsible for guaranteeing functionality and operability in accordance with the minimum quality standards, namely at the level of:

- Reliability - the system must be tested so that its robustness is observed, guaranteeing its operation in situations of weak signal, implying the use of redundant RFID readers;
- Security - the system must be secure from the point of view of the user, namely placing the sensors in places that do not compromise the user's mobility, or so fragile that it deteriorates easily rendering the collection of incorrect data useless;
- Usability - should be user friendly. At this level it is intended that the system has an easy-to-use interface and does not require user intervention.

In order to ensure the functionality of the system, the integration and operational tests will be extremely important, foreseeing an effort of between 20% and 30% of the total effort of the development team.

3. Interface

The application suite of support to the system of monitoring and monitoring in the inside (Indoor) includes several modules, namely:

- Data collection module, consisting of an Arduino UNO [17] microcontroller with accelerometer,

temperature and HRM sensors;
- Module for reading and sending data by RFID, using the reader Adafruit-PN532 (works with 13.56Mhz frequency) interconnected with Raspberry PI3 (RPI3 that includes BLE and WI-FI);
- Core web services module (core server core);
- Module for sending and processing data;
- Management module for the monitoring of crossing areas (portals);
- Configuration and parameterization module;
- User management module;
- Web module for access by family members.

In Fig. 1 we show the system design and the interaction scheme, consisting of several steps:

1. The passive user (user of the institution) carries a small device that sends vital data collected by the sensors to the server over a wireless network.
2. Whenever the user enters a division of the building, it must pass through a portal, which identifies it through the RFID TAG and the RFID readers, which data is sent by the RPI3 to the web server.
3. The system administrator is constantly monitoring the users, checking the health status (mobility, pulse, temperature, etc.) and their indoor location.
4. The family members of the users may monitor all collected data and statistical information regarding the users that are authorized to consult.

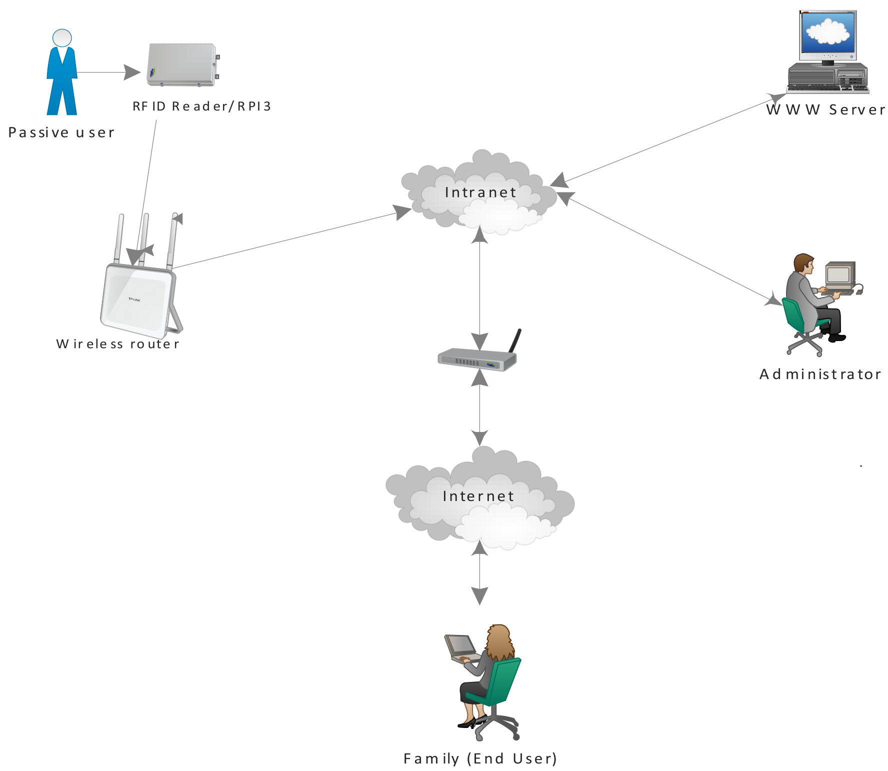

Fig. 1. System architecture.

In the next figure (Fig. 2.), we show an example of the interface of configuration of the access points in a plan of the institution building, we can identify with the mouse the location points of the RFID readers to identify the user's location. It should be noted that the algorithm records the relative location in the image, thus allowing the image to be enlarged, always maintaining exact location in terms of visualization. The user of the system will have the view of the location of users, based on the data that is being collected.

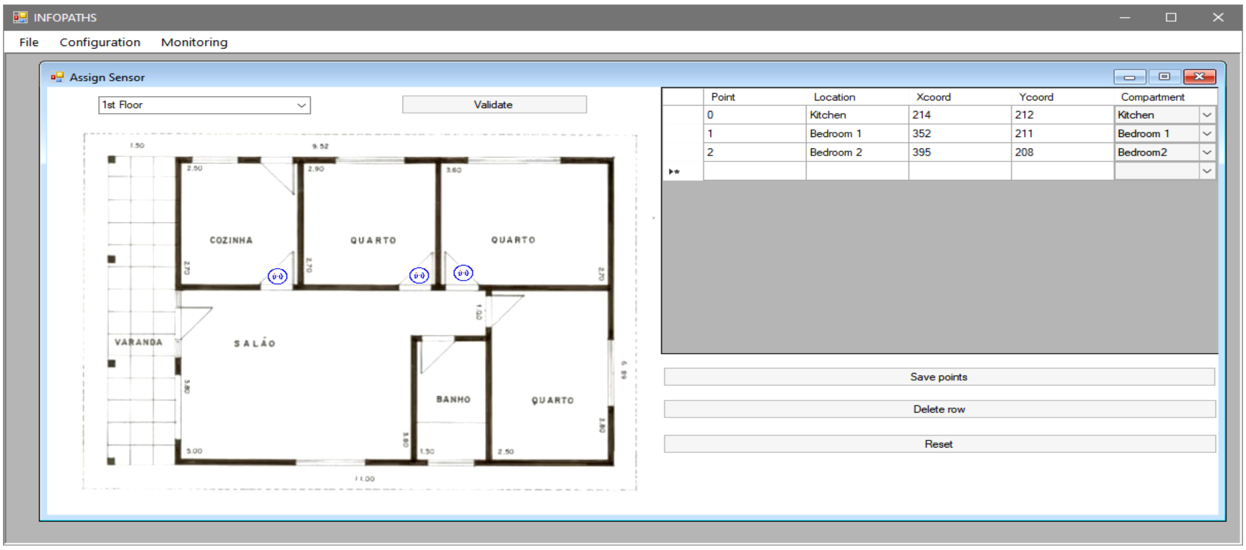

Fig. 2. Interface of floor plan configuration.

4. Database Model

To ensure the efficient storage of recorded data and subsequent analysis in real time we developed a support relational database model as showed in the following diagram (Fig. 3).

The main Tables are described as:

Institution_SS - is used to register the institution for which the service is being used and may be for one or more institutions.

Map_floor - serves to record and store building plan data by floor, identifying the image file that should be in the Images folder of the application. This image will be used to interactively register RFID readers so that they can be associated with the location in the building. An institution may have several plans.

Room_Space - is used to record the divisions of the institution and the places where readers will be installed to control who passes through them. A floor plan can have several compartments, among bedrooms, bathrooms, living rooms, dining room, among others.

Card_Reader – is used to record RFID readers and their location (relative coordinates) in relation to the building plan.

Client_User - allows the management of institution users, system passive users and they will be monitored in real time.

Tag_Identification - Used to register all RFID tags that will be used by system users.

User_Register - table that allows you to record all pass readings of the various tags by each RFID reader. The tag identification is registered, not the user's, and there is an association that specifies who is the user of each tag at a given time.

Familiy_Manager - allows the registration of the family members of each user (passive user), who will be responsible for managing the data of their family member, who will only have access to the data collected from their family members through the web application.

Data_Sensors_Read - this is the table that allows you to record data collected by passive user sensors. The data is sent in string format by the Arduino equipment and is thus stored. It is subsequently decrypted by the data access application. Since each device is registered for a given time and passive user (Assigned_device association), we can thus know to whom the data collected belongs by comparing the date of collection.

Device_sensors - this table allows the registration of the devices that will attach the body temperature sensors, heart rate monitoring and others.

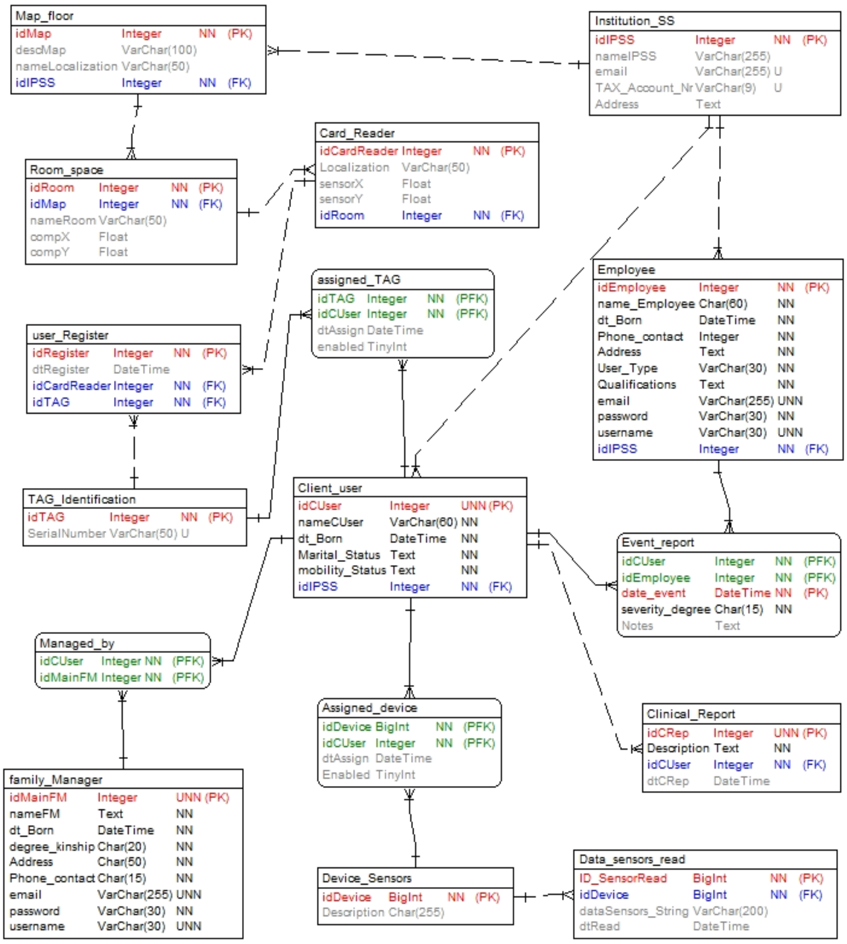

Fig. 3. Entity relational diagram.

Employee - table that allows the registration and management of the main users of the system, the employees of the institution. The type of user determines the level of responsibility of each user, which can be an Administrator, Power User or User. Other types of users may be defined if it's necessary.

Clinical_report - serves to record the clinical status of the patient periodically and can be used to eventually assess the evolution of the user's health status. It allows the elaboration of the clinical report of the user, using the history of the recorded observations.

There are also several associations which are of great importance, some of which have already been mentioned, namely:

Assigned_Tag - allows the historical record of tag assignment to users, and the same tag may be used by more than one user but can only be active at a time and in a single user.

Assigned_device - allows the historical recording of the assignment of sensor devices to users, and the same device may be used by more than one user but can only be active at a time and in a single user.

Event_Report - allows the recording of events that happen to passive users, such as moments of memory loss detected, falls, among others, which can be consulted by family members in the daily monitoring. It will be always associated with the employee who observed the event and registered it.

5. Application Scenario

The Social Solidarity Institutions are currently facing serious economic and social problems. On the one hand, users are encouraged to move, to walk avoiding pleasant problems of blood circulation, hypertension, muscular atrophy, among other pathologies, on the other hand, they are confronted with problems associated with the limited human and technological resources that allow a monitoring and real-time monitoring of users. Another of the problems associated with this reality has to do with certain diseases that the users suffer, which are of various order and degree of severity, namely Dementia (for example Alzheimer's disease [18], Muscular Dystrophy [19], among others, whether neurological or not, but which have a natural aggravation with age and that considerably condition the freedom of movement of patients in the spaces confined to IPSS, since with some frequency they can suffer falls that may in some cases, be fatal.

The proposed system includes several non-intrusive means of communication that do not violate the privacy of users, allowing them to circulate freely through the spaces of the institutions, but are monitored. The managers of the institutions can accompany their users through an application created for this purpose, as well as the family members who remotely have access to the health status of their relatives in the institution.

The monitoring equipment includes several sensors (previously described) interconnected to a small computer system based on the Arduino UNO microcontroller [17] which incorporates WI-FI Shield and Accelerometer connectors, which will allow the IPSS employee specialized in the use of the monitoring equipment to remotely track the users. The use of RFID TAGs as user Identifier and several RFID readers placed at strategic points interconnected with small RPI3 computers, programmed in Python, sends the data to the server in real time, making it possible to know where the passive user is.

The passive user may move freely in the institution's interior spaces. If the employee is confronted with an accidental situation, injury or injury, which requires the mobilization of means of distress, the system incorporates the mechanism of immediate contact with the emergency line, so that the means of assistance are activated.

6. Conclusion

This article explores an area of application very relevant to society, considering the potentialities underlying the equipment and devices that we currently have available in the market, low cost but with enormous potential.

The advent of IoT, directly related to the use of these miniaturized devices in the field of ubiquitous and pervasive computing, has enormous potential in monitoring and monitoring people with some form of dementia or disability.

Using the system, users can move freely through the interior spaces of the IPSS without feeling conditioned in their freedom and privacy. If for any reason you suffer any type of accident, fall or alteration of vital signs, there will be a distress mechanism that will be immediately triggered.

Relatives of users may receive information on the collected data if they so wish, as the data will be recorded in the system.

System support software is already under development, and the first beta is expected to be available in early 2020 and will only be available at the institutions with which we will protocol the full system installation for testing performed in real context of application. In this way, we will gather feedback from users and any users' families, with a view to improving the system, fixing bugs and errors that may occur.

In order to ensure all ethical and data protection principles, the National Data Protection Commission will be notified of the system's objectives and the way of operating. Authorization will be requested for the collection of anonymous data, only for statistical purposes, namely for academic and scientific research.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

José Paulo Lousado is the leader of the INFO PATHS project and is responsible for coordinating the research and development work of the technological and application component, namely the architecture, model and design of the proposed information system.

Sandra Antunes is a teacher of the Masters course in Management of Social Organizations and was co-responsible for defining requirements, taking into account his experience in guiding works and dissertations in the subject of the proposed system. Has made a general review of this article.

Paula M. Santos is also a teacher of the Masters course in Social Organization Management and was co-responsible for defining requirements, taking into account her experience in guiding papers and dissertations in the area of application of the proposed system.

João Paulo Sousa is a master student of Information Systems and Technologies in Organizations and is currently being guided by Professor José Paulo Lousado and is developing system support software.

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