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CONFERENCE

Health monitoring system for the elderly in Cuba Conceptual architecture

Sistema de monitoreo de salud para adultos mayores en Cuba. Arquitectura conceptual

Sistema de vigilância da saúde dos idosos em Cuba. Arquitetura conceitual

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ABSTRACT

This article proposes remote health monitoring, based on IoT, to increase your probability of survival in medical emergencies and your quality of life. The different scenarios where older adults carry out their daily lives are analyzed and a gJanral architecture of the system is presented. With remote health monitoring, data is collected on the status of the elderly adult, in a discreet and non-invasive way. In the event of anomalies or emergency situations, their family members, caregivers or the emergency system are notified to assist them in a timely manner. With these systems, falls are also detected and elderly people suffering from dementia are followed and located.

Keywords: older adult; remote patient monitoring; IoT; fog computing; cloud computing

RESUMEN

En este artículo se propone el monitoreo remoto de salud, basado en Internet de las Cosas, para aumentar su probabilidad de supervivencia ante emergencias médicas y su calidad de vida. Se analizaron los diferentes escenarios donde los adultos mayores desarrollan su vida diaria y se presentó una arquitectura gJanral del sistema. Con el monitoreo remoto de salud se recopilan datos sobre el estado del adulto mayor, de forma discreta y no invasiva, ante anomalías o situaciones de emergencia se notifica a sus familiares, cuidadores o al sistema de emergencia para asistirlo oportunamente. Con estos sistemas también se detectan caídas y se siguen y localizan a los ancianos que padecen demencia.

Palabras clave: adulto mayor; monitoreo remoto de pacientes; IoT; computación en la niebla; computación en la nube

RESUMO

Este artigo propõe o monitoramento remoto da saúde, baseado em IoT, para aumentar suaprobabilidade de sobrevivência em emergências médicas e suaqualidade de vida. São analisados os diferentes cenários onde os idososrealizam o seudia a dia e apresentadaumaarquiteturageral do sistema. Com o monitoramento remoto da saúde, sãocoletados dados sobre o estado do idoso, de forma discreta e não invasiva. Em caso de anomaliasousituações de emergência, seusfamiliares, cuidadores ou o sistema de emergênciasão notificados para atendê-los de forma imediata. maneira oportuna. Com estes sistemas tambémsão detectadas quedas e acompanhados e localizados idososcomdemência.

Palavras-chave:idoso; monitoramento remoto de pacientes; IoT; computação em neblina; computação em nuvem

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INTRODUCTION

The aging of the Cuban population is occurring at a rapid pace. In the year 2020, 21.3% of the population was 60 years of age or older, and forecasts indicate that by 2050 that figure will be 34.9 %.(1)

In 2017, 80.6% of older people in Cuba suffered from at least one chronic disease and 50.1% from two or more.(2) Older adults need adequate and close control of their pathologies to avoid health complications.

Aging causes stress to the National Health System because it increases the demand for health care while financial and human resources decrease due to the effects of the economic situation. Information and communications technologies (ICT), and specifically the Internet of Things (IoT), have become an important resource for healthcare services because they help to reduce the burden on healthcare institutions and personnel.

In Cuba there are few use cases of IoT devices, cell phones and other wireless devices for patient monitoring. Among the proposals are a wireless electrocardiographic monitoring system for Android devices,(3) a proposed platform and wireless sensor network for biosignal monitoring(4) and a SharExam/FortAM/EPS technology package with the SharExam app used by relatives and caregivers of the elderly, the basic health team (EBS) and students of the Medical Sciences Branch of Colón (FCMC) in conducting the Periodic Health Examination (EPS) at the Primary Health Care (APS) level.(5)

This article describes the conceptual architecture of the Health Monitoring System for the Elderly (HeMSS) which aims to improve the quality of life of older adults in Cuba with the early detection of health complications.

DEVELOPMENT

The adoption of IoT in the healthcare sector is growing at a rapid pace, and one of the fastest growing areas is remote patient monitoring (RPM).[6] RPM is a subset of telehealth, which allows patients to be monitored in real time and outside traditional clinical settings to provide early assistance in emergency situations or to follow treatment. Applications include monitoring blood glucose levels, blood pressure and blood oxygen saturation measurements, heart rate, sleep patterns, among many other applications.[7] In the case of older adults, RPM is also used to detect falls and to track and locate those suffering from dementia.

RPM uses a dedicated network of IoT devices that record the patient's biomedical signals when sitting, getting up, going to the bathroom, watching TV, walking inside and outside the home, sleeping, among others; with the least discomfort for the user because the wearable sensors minimally affect these activities (Example: smart bracelets). The data is transmitted to a server or the cloud through different networks that are responsible for accessing and establishing connections between the different parts of the system from the client end to the server end.

Mishra and Pandey[8] classified RPM systems into three classes, depending on network access: systems without network access, systems with direct network access, and systems with network access through a gateway.

Systems without network access store patient health data on a smartphone, tablet or other device intended for signaling and gJanrating alerts for patients or caregivers. These include HealthGear and BioHarness™.[9,10] These systems are closed and standalone. The data, analysis mechanisms and other utilities reside on the patient-owned device, which is designed exclusively for that purpose.

In direct network access systems, no intermediate devices are used; sensors access directly, via an embedded network interface, to a hospital or other healthcare facility. Among the proposals are those mentioned by Niyato and Kheirkhahan.[11-13]

Systems with network access through a gateway are those that use an intermediate device whether it is a special-purpose router, smartphone, tablet, or PC. In work such as that of Iranpaky Yıldırım,[14,15] the gateway collects data from sensor devices and transfers it to the remote monitoring system located in the cloud, or in a hospital or other institution, for processing, analysis and subsequent display to caregivers or healthcare personnel.

In other systems[16-19] data processing and analysis is performed at the gateway to respond quickly to health emergencies. The latter approach has recently been adopted with the emergence of fog computing.

Fog is composed of a network of interconnected nodes that aggregate, process and store data closer to the end devices.[20] The nodes analyze data and make decisions in real time.[21] This technology provides improved interoperability, scalability, geographic distribution, low latency, fast processing and geolocation.

Health monitoring system for the elderly in Cuba

In Cuba, care for the elderly is articulated in the main scenarios where they carry out their daily activities: in hospitals, in institutions such as nursing homes, and in the community.[22,23]

In nursing homes, a multidisciplinary team carries out check-ups every three months for older adults with chronic diseases or risk factors, and every six months for those at risk due to age.[24] If necessary, these check-ups are carried out more frequently.

The community provides for the monitoring and control of the elderly with chronic diseases through periodic health examinations by the basic health team (EBS).[25] This examination is aimed at searching for elements to evaluate the state of their diseases. If aggravated, the elderly are admitted to the home if conditions permit.

The HeMSS system uses IoT, artificial intelligence and cloud computing to improve the diagnosis and follow-up of the elderly in Cuba, both in the community and in health institutions.

The project also developed seven low-cost prototypes of devices for monitoring and assessing the health conditions of the elderly. As a first version, an electrocardiographic monitoring system was developed that operates in a wireless local area network (WLAN).[26] A wireless device acquires and transmits the electrocardiographic signal from one or several patients to a server for storage and processing, in real time or not. A wireless access point connects the sensor devices to the network. The transmitted data and its analysis can be consulted by the medical specialist on a computer (desktop or laptop), tablet or mobile communications device from a Web browser.

Figure 1 shows the overview of the architecture of the proposed monitoring system. The main components are the physical devices, the smart gateways and the remote patient monitoring platform.

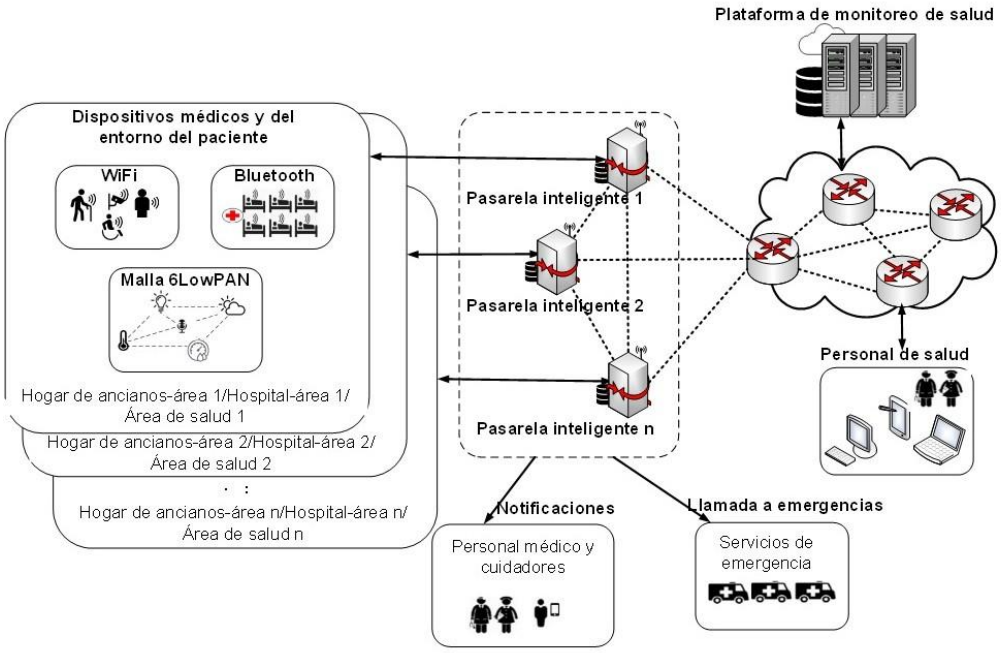

Figure 1 Architecture of the IoT based remote monitoring system for the elderly in Cuba

Medical devices and patient environment
Nursing home - area 1/Hospital - area 1/Health area 1
Nursing Home - area 2/Hospital - area 2/Health Area 2
Nursing home - area n/Hospital - area n/Health area n/ Health area n

Smart Gateway 1
Smart Gateway 2
Smart Gateway n
Notifications
Medical staff and caregivers

Health monitoring platform
Health personnel
Emergency call

The sensor devices acquire biomedical signals, and where possible also environmental signals, for continuous health monitoring of older adults in hospitals, nursing homes and at home. In spaces where there are several patients, sensor devices can communicate with each other to form networks. Medical devices are attached to the patient's body, either on clothing or on the body. They provide data on temperature, heart rate, physical activity, blood pressure, blood oxygen saturation level (SpO2), electrocardiography (ECG), among others. Environmental sensors provide contextual information about the patient's environment and activities. Examples of these are sensors for presence, sound, pressure (for bed or wheelchair), brightness, proximity, temperature and humidity, etc.

Patient signals are transmitted to a network of geographically distributed smart gateways to form the fog layer. These support different communication protocols and act as bridges between sensor devices and the cloud. They receive data from different subnets, perform protocol conversion and provide other higher level services. Examples of these are data preprocessing tasks such as filtering, cleaning, feature extraction, understanding, data dimensionality reduction techniques to reduce the volume of data sent to applications.[27]

A continuous health monitoring system needs quick decisions and agile responses for various chronic diseases and emergency situations. In these cases, data processing and transmission time must be minimized. In cloud computing raw data is transferred from sensor nodes to the cloud, but when network conditions are unpredictable there is uncertainty about the latency of responses.[17] The situation is more critical in those systems that need real-time data processing, for example, ECG signal processing.[19,27] High-priority data analysis in smart gateways, and making critical and sensitive decisions in the shortest possible time make the system more robust and predictable.

Interoperability plays a key role in the success of RPM systems.[19] With such a heterogJanous mix of network technologies and protocols the integration of these is an obvious challenge. Smart gateways provide interoperability to the system. Sensor devices connect to them using different standards (e.g., Zigbee, 6LoWPAN, Bluetooth, WI-Fi). These have multiple interfaces; the protocol adapter facilitates message exchange between protocols and format conversion, thus ensuring technical and syntactic interoperability in the system.

In the cloud, each patient's data is stored in a database for subsequent analysis. Artificial intelligence or big data algorithms are also used to interpret the data collected and extract information about the patient's state of health in order to predict the worsening of a disease. Cloud servers offer advantages such as accessibility, scalability, high availability and fast recovery time from problems.

The monitoring platform provides a graphical user interface (GUI) that converts the processed information into rich content and displays it for medical staff and caregivers to follow the patient's condition in real time. It is accessed from devices such as: computer, tablet or smartphone. Alerts are also gJanrated from the platform in case of emergency.

In a first phase the system alerts are audible. In a second phase, SMS to doctors and caregivers should be implemented and in the future it would be important to evaluate the integration with the country's Integrated Medical Emergency System (SIUM).

CONCLUSIONS

Remote monitoring systems allow informal caregivers (family, friends, neighbors, etc.) and/or professionals (in health or social institutions) to be aware of dependent persons without the need to be in the same place. Family members do not have to stop working to care for them, thus bJanfiting the economy of the family and the country. In the case of institutions, with these technologies, caregivers can attend to a larger number of patients.

For health services, a preventive action allows reducing the number of hospitalizations and medical visits and with them the costs of medical care.

The article introduces the concepts of fog computing and smart gateways in the context of IoT-based RPM systems. Smart gateways located in the vicinity of sensor nodes in homes, nursing homes or hospitals can take advantage of their unique strategic position to address the challenges of healthcare systems to serve the aging population.

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The authors declare that there are no conflicts of interest.

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Lidice Romero Amondaray: conceptualization, research, methodology, writing-original draft, writing-revising and editing.
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