A Motivational Study Regarding IoT and Middleware for Health Systems

A Comparison of Relevant Articles

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***Abstract*—In this paper, we present the main concepts of the Internet of Things (IoT), which consists of a mix of smart devices, sensors and the Internet itself. In this research, we also address the concept of middleware, which is a platform that links both sensors and devices on IoT. In addition, we analyze selected research on IoT in order to gather information to construct a synopsis of the main facts in these articles. We identified paramount facts studied in each of these articles, so that we could perform a comparative analysis to highlight similarities with broader relevance.**

Keywords - IoT; middleware; e-health; health systems.

I. INTRODUCTION

In the last few years, we have witnessed a great excitement about the Internet of Things, also known as IoT. It is possible to notice the engagement of both companies and universities searching for solutions to make the concept of the "Internet of Things" become real. Each day new researches, studies and tools emerge and innovative ideas are born, creating a vast exploration of the field.

Nowadays, we live surrounded by electronic devices, at home, at work or in in the simplest environments. Even inside people's bodies, they have many different roles which makes us believe that the era of interconnected things has already began.

In health, we find an opened and motivated field in the search of technological solutions in order to achieve better efficiency in business and also to be accessible by a larger percent of the population. This way, patients who are informed daily about their health can take a proactive role in health care [1]. The contribution acquired by the evolution of interactive technologies is deeply linked to a significant improvement of productivity and quality of life.

In this context, e-health is introduced. It is defined as the use of electronic devices and other technologies in order to help with the practice of health care. That includes electronic medical prescriptions and remote monitoring of patients [2]. The possibility of using wireless sensors on one's clothes or body increases comfort, convenience and the effectiveness of the patients' health treatment. Considering that these can be monitored at distance without affecting the patients' routine [3].

The IoT is growing impressively in the scope of health and general medical care. Such great expansion generates increasingly interactive manners to deal with the patients' clinical situation through apparatuses such as wireless sensors and nanotechnology. It is remarkable the fact that the medical monitoring can be done in real-time through various devices, allowing patients to check their situation and getting new orientations via smartphones or tablets. Although, the immense potential brought by the insertion of the IoT in e-Health brings forward some facts that demand to be evaluated. The observable fact here is the interoperability among gadgets, considering that it demands transparency about the data shared on the devices. As Bui and Zorzi have put it [4] this constitutes a myriad of heterogeneous devices from many different manufacturers, each having their own interfaces and this way creating operational barriers. Besides that, another great concern points to a massive amount of data transmitted in a single network, which raises questions involving privacy and security.

The corcern in the questions above will mainly consist in the insertion of middleware platforms. These have been created to provide interoperability and to manage a variety of objects associated with the users and interconnected applications [5]. To e-health, the middleware platform can be described as a moderator for the data shared, integrating different devices of a heterogeneous environment and providing users the possibility of consulting their information through the Internet.

Baring the mentioned factors in mind, this study has as its main objective to focus on investigating and presenting articles that discuss the reasons of the motivation for creating a middleware to helpful gadgets concerning human health care, as well as the examples of mildware that already exists.

II. INTERNET OF THINGS

Giving the definition for the Internet of Things is not an easy job, since it is such an abstract idea, and yet there is much more to be done until its concept is built. In her article published in 2012, Talyta Singer [6] addresses various concepts of IoT from different authors. As she describes there, the IoT concept is an allusion to a global network in which devices can interact among themselves without human interference. This definition permeates one of the many views about the concept of IoT, leading to us believe that a lot has already been done. However, there is still a long road until it becomes real.

This article holds no intention on formalizing or defining the meaning of IoT, but only to point its use in health care. When it comees to IoT, Atzori [7] points out three great pillars: middleware, sensors and a basic knowledge to be stimulated. So, it is confirmed the need to show some of the reasons and implicationswhen using this technology concerning well being, monitoring, prevention and treatment of any disease [8].

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IoT connects countless smart devices to a specific network. This way, technology may improve services in hospitals, health care centers and the practice of home care. To Paiva [9] the IoT is something that has to be present in our daily routine and is a source of great motivation in the health care research field for being a very promising area. The perspective for such an event grows through the popularization of the "Wearables", which can collect data without the need of human intervention. The data that comes from these devices, such as pulse rate, temperature and else, can go into a database, allowing medical monitoring from distance. The benefits of IoT are quite notorious when it comes to efficient diagnosis.

Figure 1. IoT –Health System Scenario. Source: [33]

It is clear that the IoT has very high potential for solving communication problems between health care centers and patients, this way, revolutionizing the treatment of diseases.

III. MIDDLEWARE

The IoT's environment is characterized by the heterogeneity among many devices and softwares involved; Those can execute various functions through distinct protocols, which makes it a challenge to implement such technology. To unify many resources of IoT, it is necessary to provide models of high-level interfacing, abstracting physical devices and services and guaranteeing a good interoperability.

The interoperability can be described as the possibility of interconnection in heterogeneous environments with transparency, as Marcondes and Sayão have said [10]. This unique interface doesn't demand the users to know about where and how their data is stored. In addition, to achieve a cohesive interoperability it is necessary to establish a pattern of communication among the gadgets. The model that offers such integration with transparency is what we call a middleware.

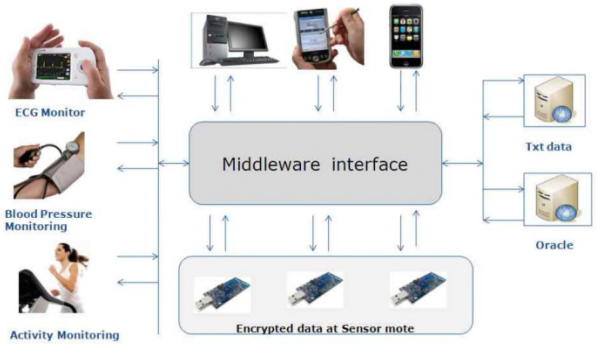

Figure 2. Middleware Interface in Personal Healthcare Information System [28]

For IoT, the middleware is the platform that integrates the applications and involved gadgets, as well as processing their communication. The middleware yet foments the reuse of generic services in order to streamline the development of applications, once it helps developers to deal directly with the specifications of both devices and network. We can also infer that the middleware mediates systems that are in different layers. The use of an intermediate middleware layer is needed to make interactions with the database from specific XML [11],[12],[13].

The differentiated middleware platform for IoT is being studied, but, for Teixeira [14] these proposals have not yet reached a stage of maturity. Also according to the author, several researches reveal points that require concentration on analysis and even more research, such as: robust infrastructures tolerant to failures able to manage and process the data collected through integrated intelligent devices; a better management of uncertainties and resolution of conflicts; and an adequate support to adapt environment and dynamic applications in order to minimize the overload of relevant security functions on the platform of the middleware.

When searching a better foundation, it is necessary to present the main requirements and elements of a middleware platform that includes the IoT environment, according to Maia [15]:

- A scalable interoperability support for the myriad of heterogeneous devices to enable intelligent objects (things) to communicate with users, Internet service and with each other;
- Mechanisms for detection and management of efficient devices that allow dynamic integration of new devices in the IoT's environment, as well as to manage the condition and location of these devices;
- Awareness of capacity for data processing management;
- An efficient dynamic support, since IoT's environment is inherently dynamic and applications

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can be reconfigured at runtime according to the changes in such environments;
- The management of large amounts of data collected from smart devices that must be made available to applications and/or final users;
- Issues related to security and privacy, authenticity and integrity, which are important highlights, especially in critical applications; and;
- Providing a high-level interface to access heterogeneous devices transparently. Hiding the specifications of the integrated device applications and/or final users;

This way, the middleware platform comes as a promising solution for promoting interoperability between the IoT's devices and applications, as well as the final users.

IV. E-HEALTH SCENERY

Standards for interoperability have been proposed in the past twenty years to allow information exchange within a health care environment and the establishment of an accessible Electronic Health Record (EHR) to any health institution and/or patient. Standards for interoperability in health care need rules for sharing typical information of an EHR, as the description of health status, treatments given and results [16] Most standards currently broadcast use messages in text mode or Extensible Markup Language (XML) documents to provide health information that can be exchanged between systems. Nevertheless, there is still not a finished and worldwide used standard, which indicates that the interoperability of health systems can still be considered one of the greatest challenges to be faced in the field of health [17]

The use of a standard for interoperability allows any local system to interpretate data using universal concepts and terminology [18] Based on this definition, the idea of using a standard for interoperability in health to integrate distinct systems and use these same concepts and standardized terminologies to access data internally, or to access the database emerged itself. Representing requests by sending messages according to syntax and semantics established by a health standard model makes it possible to maintain compatibility and consistency between systems and database.

V. ANALYSIS OF RELEVANTS ARTICLES

In this section, we present a summary of the most relevant articles for this research; the analysis criteria was made based on the number of references and respective year of publication.

In the article "A Web Platform For Interconnecting Body Sensors And Improving Health Care", [19] the authors present the Health Care Devices' Ecosystem EcoHealth (EcoHealth), a web middleware platform that allows you to connect and approach doctors and patients through the use of body sensors, and thus provide better monitoring of health and diagnosis for patients. EcoHealth is supposed to integrate the information gathered from multiple heterogeneous devices in order to provide subsidy to monitor, process, display, store and send notifications about the patients' health as well as vital signs in real-time by using Internet standards. The article also presents the EcoHealth's proposed models, its logical architecture, implementation and propitious scenario for the use of middleware. Thus, the article shows relevance to this research by the extent of middleware information, IoT and e-health, and presents the implementation of EcoHealth middleware, which we will analyze in a further study.

During the analysis of these researches, we also selected the study "On Middleware for Emerging Health Services" [20] due to the fact that it shows the initial implementation process of a middleware for emergency health services. It also addresses the middleware requirements and challenges arising from the development of technologies applied in health care. Finally, this study describes the specific requirements of the middleware "SBUS" since its early stages.

The article "Uma Plataforma de Middleware para Integração de Dispositivos e Desenvolvimento de Aplicações em E-Health" [21] is another research that contributes immensely to this research. This detailed study presents the EcoHealth middleware platform to promote the integration of heterogeneous body sensors to allow remote monitoring of patients. It also brings an evaluation of the Eco Health platform performance, considering an eHealth application developed as proof of concept. It yet shows the main objectives of the applicability of middleware, consisting of monitoring through body sensors. Variables related to environmental health enable diagnosis via control, visualization, processing and real-time data storage, enabling the performance of hardware platforms in order to provide emergency aid to patients at risk. The evaluation showed that this platform can support a lot of physical devices working with appropriate frequencies for monitoring vital signs. Validating the middleware EcoHealth.

The article "E-Performance Modeling Of Proposed GUISET Middleware For Mobile Healthcare Services In E Marketplaces GUISET" [22] proposes middleware for using in South Africa. The referred platform provides useful services for small and medium-sized companies in the context of mobile services. The results of this study show that the average unconditional waiting time remains the same with the reduction of this as a priority in relation to the preferred model. It is expected to be beneficial in mobile health services where events are prioritized and attention has to be given to urgencies.

In "Service Oriented Middleware Architecture for Mobile Personal Health Monitoring" [23] the authors present a middleware service oriented approach. This platform aims to facilitate the development of health and welfare applications, enabling semantic interoperability of heterogeneous objects, services and applications. They also demonstrate the functionality of collecting values of medical devices, fusion of many sensors data, service orchestration, and export of medical data in a service-oriented approach.

A connectivity kit of medical devices to access the middleware available for developers to create applications based on open standards is also displayed.

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Another selected article was the "AMBIENT HEALTHCARE SYSTEMS, Using The Hydra Embedded Middleware For Implementing An Ambient Disease Management System" [24], which presents the Hydra middleware. This platform consists of a modular approach that solves interoperability problems among devices used in health care environments. Hydra provides an interfacing between interactive devices, such as the biosensors and data from the software to be involved. The approach of this middleware is in three layers, which guarantees structured design applications and extensions. The Hydra is still established as an effective platform for health ecosystems that integrate foundations, as well as the services offered by others.

We also selected the study "SIXTH: A Middleware For Supporting Ubiquitous Sensing In Personal Health Monitoring" [25]. This article brings a middleware called SIXTH, which was motivated by the importance of identifying the context in an AAL configuration and how this can be best achieved through the convergence of various sources of heterogeneous data. This study's middleware is open, extensible and offers integration of typical AAL settings and wearable smart devices.

The "CORBAMed And DHE: Middleware Service Approach In Healthcare Information Systems" [26] analyses both situation and challenges health care system faced nowadays, besides introducing two structures of middleware systems of information, the CORBAMed and the DHE. According to the authors, these two architectures can meet the requirements of a system of health information due to the maturity, scope and availability of middleware offered.

The article "Middleware For Heterogeneous Healthcare Data Exchange: A Survey." [27] Brings a survey about the HL7 middleware directed to the area of health. The presented middleware is an international standard, based on the model Open System Intercommunication (OSI), which sets a pattern of exchange and transport information among health organizations. This study is a survey of various middleware cataloged through an exploratory research in the archives of the Association for Computing Machinery (ACM) and the Institute of Electrical and Electronics Engineers (IEEE). After the analysis of the selected researches presented in this paper is an overview of the resource selected middleware.

Another selected article is the study entitled "A Novel Middleware Architecture for Personal Healthcare Information System" [28] has a progressive middleware architecture directed to the medical sector and personal health. The approached architecture is not just a middleware, but provide a tool for analysis of data coming from the sensors deployed in the patient's body. In this article we implemented a Ubiquitous healthcare prototype that has a data analysis report for physicians, patients and health centers. The main data were obtained by a series of sensors used in the experiment such as the ECG, temperature that are considered important aspects for basic health.

VI. COMPARATIVE ANALYSIS OF THE ARTICLES

In this section, we decided to address the issues that we considered of vital importance to the thematic context and its applicability in the real context.

The IoT already permeates the lives of many people in the world, so the possibility of using it for better quality of life is what instigates the surveys conducted. As there are countless devices involved with different manufacturers, protocols and through different communication, it becomes a challenge to face insertion of such technology. Currently, the key focus areas of the IoT have developed massively with the creation of middleware platforms.

Another important challenge for this issue is to ensure interoperability in order to provide back the need of the users. Thus, the articles were selected, [19],[20],[21],[22],[23],[24],[25],[26],[27],[28],[29],[30],[31] to support the motivational research in middleware development for IoT in e-health.

In general, the articles that were the basis for this research are characterized by an attempt to solve these problems in the e-health environment. Most of the studies propose the development of a middleware architecture to mediate devices, trying to solve the interoperability problems applied to e-health. The results show that there are several middleware platforms being developed, what shows a tendency of use of the IoT to improve the monitoring process in general health.

VII. CONCLUSION

This article made a simple introduction about Internet of Things, middleware, and e-health, and the relationship between these elements. This study also showed a range of researches related to the insertion of middleware for e-health, leading us to believe that there is a significant motivation for this feature. In many parts of the researches, the authors encourage new ways of carrying out mediation between interconnected devices on the Internet of things, so that, creating new middleware ideas.

Although this paper was not meant to go deeper into the development of a middleware, it was intended to foment subsidy for a better comparison among the existing ones.

For further research, we plan to explore a middleware architecture model best suited to the unique system of Brazilian health. After a more appropriate analysis of the advantages and disadvantages, to make a comparison study of each middleware platform presented in this work.

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