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Pervasive Computing Integration on Healthcare Environments

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Abstract — Large number of heterogeneous medical devices integrates Intensive Care Units (ICUs) with different technologies to provide a variety of healthcare services. Recent researches have proposed platforms and architectures that integrate multiple healthcare services in different equipment to provide an environment of intelligent routing and monitoring of vital signals, in which the patient's welfare and health are the main requirements. Pervasive computing enables evolving the concept of autonomous systems that could possibly integrate varied technologies and devices considering the environmental context to perform a set of rule-based actions and message exchanging. This work discusses relevant challenges and requirements for integrating pervasive computing on healthcare environments such as ICUs. We present a requirements gathering about integration of devices, technologies, solutions, and approaches towards to a modular logical architecture to efficiently integrate healthcare services.

Keywords — Healthcare monitoring systems, Intensive Care Units, Mission-critical environments, Pervasive computing, Pervasive services, Wireless networks.

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I. INTRODUCTION

This work objective is the discussion of challenges and requirements for pervasive healthcare computing towards an integrated service-oriented platform for the management of mission-critical *Healthcare Environments* (HEs), such as *Intensive Care Units* (ICUs).

Due to the large amount of equipment and technologies for patient monitoring, especially for those patients in intensive care as well as the vast amount of available information about patients' health to deal with, there is a great motivation related to the environment integration on an intelligent computing platform capable of processing messages, providing healthcare services, and eventually, making decisions autonomously and safely, to ensure the health and well-being of patients.

The challenge of integrating medical equipment for monitoring patients' health goes beyond the economic and social aspects, i.e. deals with aspects related to technology, infrastructure and even technology acceptance by institutions, physicians and society, in general. Regarding to the technological aspects is possible to physically integrate medical devices through different communication networks, since equipment is available in each ICU, and specific communication protocols are defined. Medical devices can be connected whether by a central monitoring or connected through a system with a wider spectrum of application, e.g. a pervasive system that manages the equipment's activities and enables the sharing of information and resources [1].

The advancement of mobile applications and wireless technologies for communication between users, and even machines – machine-to-machine (M2M) communication enabling autonomous components to be interconnected and controlled remotely, with low-cost, scalable and reliable technologies [2], [3] – enabled the ubiquitous interconnection of medical equipment and many other wireless mobile devices, such as pagers, smart phones and PDAs (Personal Digital Assistants), in order to enable efficient contact with patients, caregivers, and clinicians that are responsible for the health of several patients.

Mark Weiser's research inspired the creation of a new vision of environment management by means of pervasive and ubiquitous computing. The idea is to blend computing capabilities with

wireless and mobile communications to provide fully integrated services with human actions, anytime and everywhere [4], [5]. In this context, various proposals for pervasive healthcare platforms become to emerge as an alternative to create an intelligent environment able to efficiently manage and distribute messages between patients' monitoring devices, clinical staff, equipment, and devices in healthcare environments. Some approaches are proposed within the specific context of ICU with wireless sensors, or even within the context of hospitals with multiples ICUs using more complex networks [6], [7].

Pervasive computing technologies and applications also can broadly be spread considering their possible support to mobile ambulances, health centers, or even in homecare environments, where experts could not be available all the time, nor could the information be periodically or constantly collected with the required accuracy or proper treatment [8].

From a technological perspective, ICUs environments need greater capillarity of communication networks, i.e. support for intercommunication between heterogeneous devices and monitoring centers joint with providing greater computational access to patient information, using multiple communication channels [9]. Hence, there are major barriers and challenges related to integration of devices for monitoring patients in mission-critical environments, e.g. obtaining real-time information triggering actions is the subject of recent researches related to emerging technologies [1], dependability on proprietary equipment [10], efficient routing algorithms in wireless communication networks [11], application of robust fault tolerance mechanisms [12], as well as defining accurately the business rules applied in each healthcare environment, which includes knowing the standards of privacy and security for patients and personal clinical information [13].

In the case of patient monitoring, a key issue is to prioritize the transmission of patients' vital signals, e.g. via M2M communication networks [1], [14]. The signals coming from monitoring equipment can be transmitted to a central monitoring station that receives and processes data, generating alerts when needed; or signals can also be transmitted directly to clinicians responsible for the care of that particular patient, e.g. in their personal devices.

The selection of a specific mode of transmission and the destination of these signals through different communication channels and technologies involves developing robust interfaces between existent communication protocols to ensure the correct signals transmission and processing, for further generation of alerts and support on medical decisions [8]. In a medical

environment, where heterogeneous devices are interconnected via wired or wireless technologies, and the environment itself can also be sensed generating other observation variables (e.g. a wireless sensor network or a sensor application), all these monitoring information are useful for influencing medical decisions about the patients' health and possible preventive actions [1].

The motivation of this work is related to the challenging research of applying pervasive computing concepts joint with emerging communication technologies to efficiently integrate specific healthcare settings (i.e. the ICUs) in order to primarily ensure the well being of patients.

This technical report is organized as follows. Section II discusses characteristics of healthcare environments for the mapping of essential requirements for intelligent healthcare computing systems. Section III presents concepts and challenges related to pervasive computing in mission-critical healthcare environments such as the ICUs. Additionally, the section describes functional requirements for implementing pervasive computing in HEs, discussing about services and technologies integration as well as about architectural issues of pervasive system platforms proposal and integration. Section IV presents conclusions and discussions about the trends for pervasive healthcare environments.

II. HEALTHCARE ENVIRONMENTS

Healthcare Environment (HE) is defined as any medical setting where there is concern about the health and welfare of patients, using the support of human and computational resources for provisioning health services [1], [7], [8], [15].

Additionally, the management of a HE can be considered as a mission-critical operation in several aspects. The key points in mission-critical HE are, for instance, maintaining availability on current services and equipment, responding quickly to changes in the patients' vital signals and environmental sensors, and at top priority providing welfare and health for patients [16], [17]. For ICU's patients the maintenance of patient safety and the well-functioning of equipment are crucial activities in which any error or failure can be hazardous in different ways, depending on patient's health condition and response time on events [18].

HEs are dynamic by nature, considering the high turnover of patients and healthcare professionals responsible for different tasks in different work shifts. These environments are composed of heterogeneous medical devices and equipment, managed by complex processes and

activities, with numerous people and resources that ensure their daily functioning. Currently, there are many technologies used in these environments supporting a wide range of activities, e.g. medical equipment are increasingly modern and capable of integration with other monitoring devices, mainly by the advances in computer networks, wireless networks and sensing technologies [6]. Within ICUs there are specific equipment monitoring and specific patient care procedures that can be performed or configured either manually or automatically [18]. Moreover, also the *Electronic Medical Records* (EMR) could help in decision making for clinicians and other healthcare professionals to execute patient follow-up and take the necessary steps for its proper care [19].

The integration of medical equipment, smart devices, people (e.g. patients, clinicians), business processes, and HE information can be done through a service-oriented model of computing that brings together all things necessary to ensure the welfare and health of the patient by means of ubiquitous and pervasive computing [17], [20]-[23]. Therefore, this section highlights the main features of HE to extract the essential requirements for the implementation of an autonomous and intelligent computing system, which can support and make computational decisions in ICUs (e.g. react to unexpected situations, safely and efficiently).

A. Heterogeneity of Individuals

HE is populated by different individuals that are classified according to their needs and functions together within the environment, such as patients, clinicians, and more generally, citizens. Considering the heterogeneity of individuals, to deploy any automatic or computational procedure for support in the medical environment is necessary first to map and to identify each person in the environment context, i.e. their specific roles and responsibilities. Moreover, patients are the key point of the environment, for which all actions and decisions are directed. Moreover, the main concern in these environments should be to promote health and welfare for patients, to reduce health risk, and to predict the list of actions necessary to ensure healthcare delivery [24].

B. Heterogeneity of Medical Devices

In addition to people who populate the HE, there are several devices that are part of the environment as well. Basically, there are at least three types of equipment found in medical settings: (i) infrastructure equipment (e.g. air conditioning), (ii) support equipment (e.g.

sterilization equipment, laboratory equipment) and (iii) medical equipment (e.g. vital signals monitor (VSM), electrocardiogram (ECG), defibrillators, ventilators and computerized tomography). Integrated medical devices are also called multi-parameter monitors that integrate multiple devices into one [1]. They consist of several sensors, which are usually monitoring devices (e.g. blood pressure, cardiac monitors, respiration rate, pulse oximeters, oxygen saturation, pressure, and temperature).

For the integration of heterogeneous medical devices in a collaborative computational environment is necessary to map and to identify at least the devices characteristics, operational communication protocols, and the variety of services that can be available from them.

C. Heterogeneity of Therapy Units

The HE can consist of several ICUs with its processes, dynamicity and protocols. For each environment under study is necessary to identify the operational units, i.e. their functions and interrelationships. For example, ambulances and homecare units are related to a given hospital, because they generate monitoring events for the hospital, which shall react according to the received signals. In the case of communication between healthcare centers with a hospital, there may be demands as virtual consultation or second opinion on diagnosis, just to name a few. Within the hospital itself may be several and specialized ICUs [18], e.g. *Neonatal* (NICU), *Pediatric* (PICU), *Psychiatric* (PICU), *Coronary* (CCU) and *High Dependency Intensive Care Unit* (HDU). The heterogeneity provides challenges and roadblocks when integrating computational processes for the improvement in patient care processes.

D. Heterogeneity of Technology and Support Systems

Numerous HEs contain a wide variety of technologies and computer systems. Among the most common systems found in these environments are legacy systems, data storage systems, electronic registration of clinical data, multipurpose wired networks, wireless networks and medical equipment.

The major difficulty in integrating technology and equipment comes from its natural heterogeneity that imposes the need for protocols and interfaces able to establish communication between them [14]. Moreover, integration is not a trivial task as it requires the determination of the technologies and their roles in the environment, in relation to the processes they support. For example, integration of technologies such as *barcode* or *Radio-Frequency Identification* (RFID)

for patient identification, specific technologies applied in the network infrastructure (for data communication) as for wireless asset monitoring and optical fiber networks for high-speed transmission of imaging. Additionally, there may be different networks and applications to be studied within the environment such as networks for image area, laboratories, corporate network, telemetry, monitoring, in general. Support systems are also potentially numerous, then also become essential to understand the processes and procedures in the medical field to extend the systems capabilities to share information (e.g. control systems for medicines, patients, hospitalization process) [25].

E. Security and Privacy Policies

Every HE is governed by policies, standards and procedures established where privacy and security of information plays an important role due to the sensitive nature of the data stored and possibly transmitted [13]. The sensitive information (i.e. those that cannot be accessed without prior permission) may be patients' clinical information as well as biomedical signals that are sensitive from interference of any kind in the transmission or in the collection process itself. In this case, the security refers at least to guaranteeing correct and reliable transmissions. Regarding to the information/patient privacy is necessary to establish policies for managing resources, users and their respective access [26].

III. PERVASIVE HEALTHCARE ENVIRONMENTS

With an increasingly mobile society and the worldwide deployment of mobile and wireless networks, the wireless infrastructure can support many current and emerging healthcare applications. This promotes the vision of *Pervasive Healthcare* or healthcare to anyone, anytime, and anywhere by removing location, time and other restraints whereas increasing both the coverage and the quality of healthcare services [1].

Pervasive Healthcare Environments (PHE) must be defined on the basis of general concepts of pervasive computing systems, but must, above all, meet the demands of the HE under study (Section II). In this work, the integration of a pervasive system in medical settings (i.e. HE) has focused, for instance, on the management of ICUs. These units are composed of heterogeneous devices responsible for patient monitoring, and for the professionals involved in healthcare. These professionals need faster response times by the pervasive system given patients' critical

conditions. As aforementioned, the assumptions for PHE systems should consider, first of all, the patient welfare and health.

The recent emergence of pervasive system architectures has brought new opportunities to propose distributed platforms for HE management. These platforms aim to integrate infrastructure equipment, support equipment of HE as well as medical devices on an integrated system with shared resources, smart enough to support medical decisions based on biomedical signals, and provide varied healthcare services, anywhere and anytime. However, along with the opportunity to improve services in HE, there are some roadblocks to deal with, such as devices heterogeneity, unreliable wireless communication, routing messages based on priorities and service time, and acceptable response times for mission-critical environments as the ICUs.

Pervasive middleware, frameworks, and architectures for implementing service-oriented approaches, that enable PHE has been proposed in recent years. However, there are still some challenges to overcome the difficulties related to the design of this type of application, which is not trivial and it is very error prone. An example of application-oriented middleware, addressing the concept of community computing, provides mission-oriented dynamic computing communities that perform tasks for users and devices [27]. The pervasive system is composed of autonomous software entities that interface with users and services, seeking resources as efficiently as possible whereas maintaining transparency in HW/SW communications [17], [21], [28], [29].

Another example of middleware technology to PHE was proposed in [30]. In this approach, the resilience of wireless transmission is achieved by DTN (*Delay-Tolerant Network*) technology. The “store-and-forward” feature of DTN has shown to be an effective approach for communicating in emergency situations and highly stressed environments that lack continuous network connectivity, e.g. PHE based on wireless communication. Using DTN as the mobile middleware, a mobile application operates in both infrastructure and ad-hoc modes, and have seamless transmission with multiple radio access technologies. The hop-by-hop reliable delivery on different transport layers can provide increased probability of communication, despite intermittent link connectivity.

Apart from middleware technology, there are other approaches applied do PHE that deal with important characteristics of “Ambient Intelligence” in the integration of physical and digital spaces [7]. Example of these approaches are: agent-based systems that are able to pick up the

appropriate devices for specific critical medical tasks; development of medical ontologies for providing better decision support systems; and sophisticated algorithms for decision support that are able to provide prior knowledge of heart failure conditions.

Among the proposals for pervasive systems, some of them focus primarily on HE monitoring in general [1], [8], [16]. In this work, our major concern is to discuss about the specific integration of mission-critical environments such as ICUs, on a service-oriented layered architecture for pervasive system integration in HE. In this context, the pervasive system should provide a modular integration of devices, providing services in the PHE, with transparency to users, i.e. the pervasive system copes with the heterogeneity between devices and other various existing systems to support the environment. Following, we proceed with a requirements gathering for PHE, considering the importance of background concepts such as distributed systems, network intelligence, and service provisioning.

A. Pervasive Services Assessment

The PHE should be based on three basic entities to compose a straightforward service-oriented pervasive system: users, resources and services. The HE requirements are related to the functions and the relationship between these three entities. The requirements and discussions in this section only refer to service-oriented pervasive features to be considered in the integration of technologies and heterogeneous medical devices towards the PHE management.

PHE services provisioning are basically dependent on the HE available resources and on the user permissions settings. Moreover, the plentiful offering of services requires specific control and management algorithms and solutions that are far different from the general healthcare services.

The PHE available services, or *Pervasive Services* (PSs), should fulfill the HE requirements and facilitate the user's activities, but mainly should offer computational intelligence for the HE. The identification of a PS is not a trivial task, and should be based primarily on analysis of HE requirements associated to pervasive computing concepts. The identification of new computing services aims to facilitate the management and integration of the HE resources (in relation to users, processes and services).

Fig. 1 generically illustrates the complex process of HE requirements analysis for the PS assessment. The PHE should take into account not only HE requirements, but also their priority levels on the management of HE.

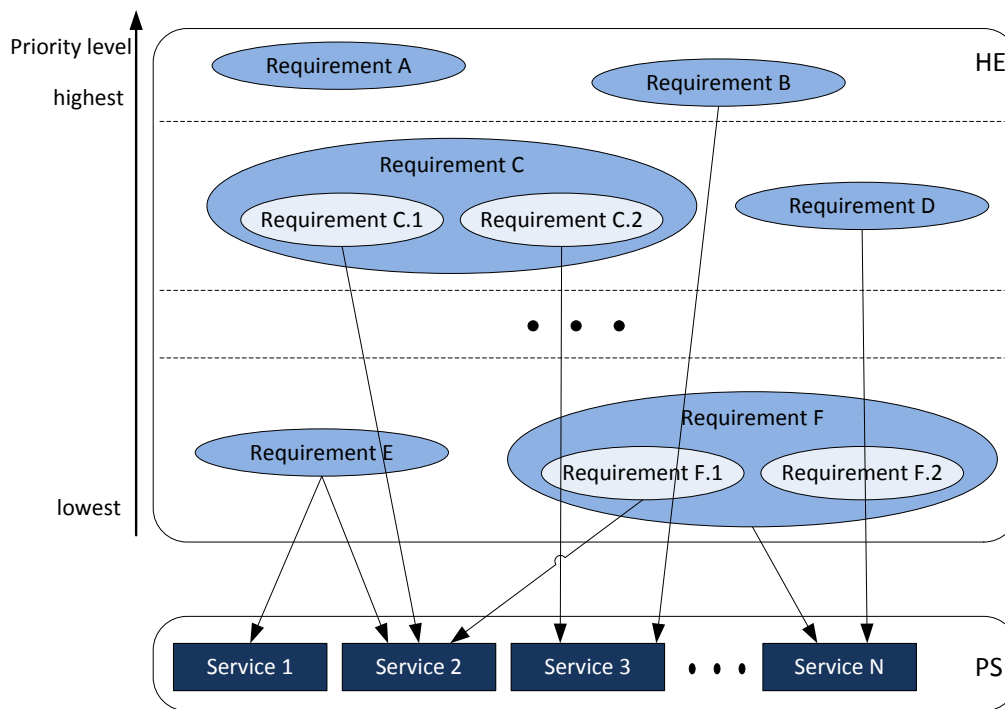


Fig. 1. PS assessment based on HE requirements.

In addition, some requirements may be composed by a set of other requirements, performing a hierarchical definition; for instance, Requirement C is composed by C.1 and C.2. Thus, PS can be based on one (or more) HE requirement, and sometimes aggregating different priority levels, i.e. the highest priority found on the HE requirements can define the respective service priority (e.g. *Service 3* is based on both *Requirement B* and *Requirement C.2*, thus the highest priority - referent to *Requirement B* - can be assigned to this service).

This approach aims to propose service-oriented PHE with an integrated model for pervasive computing based on HE requirements. Remark that PS shall be dynamically offered and disabled according to the context of available HE resources.

Following we present some selected PS regarding to some HE requirements.

PS.1. Integration: promote the integration of HE elements, aiming efficiency in patients’ care, thus ensuring their health and well-being.

PS.1.1. facilitate the communication among professional staff for increasing the quality of healthcare processes.

PS.1.2. prioritize the healthcare of critically ill patients (i.e. those in life-threatening), providing the necessary professional staff and equipment, all ready for use.

PS.2.Monitoring: provide efficient monitoring service, developing processes to monitor a larger number of patients with fewer attendants (e.g. through intelligent monitoring centers).

PS.2.1. enable greater integration of the environment elements, e.g. integration of medical equipment and several devices as well as systems (e.g. cell phones, pagers, PDAs, RFID tags, legacy systems) – *also refer to PS.1.1.*

PS.2.2. provide notifications (warning or alarms) to clinicians, and general staff involved, in case of changes in patients' clinical status. This status should be constantly monitored by devices, rather than patients wait for visits and consultations.

PS.2.3. perform the prioritization of biomedical signals. The PHE should prioritize communication of biomedical signals generated by medical equipment, i.e. should provide routes for signal transmission in the network with short (or fast) paths, signaling the routes as reserved at least for high-priority messages.

PS.3.Architectural definition: represent an embedded system with dynamic and pervasive network functionalities that allows several services emerging from resources.

PS.3.1. provide a distributed management of medical equipment, mainly those at ICU.

PS.3.2. provide an abstraction of heterogeneous medical devices through an implemented interface or specific communication protocol.

PS.3.3. provide more efficient means of communication through mobile devices, such as allowing communication of warnings and alarms (*also refer to PS.2.2, PS.2.3*), and any other data types.

PS.3.4. include two-way communication (between medical equipment and professional attendants) according to predefined parameters, e.g. security, response time, signal range, authorized persons, clinical records – *refer to PS.2.1.*

PS.3.5. provide dynamic routing of messages over multiple communication channels, exploiting network capillarity (especially to ensure messaging reliability).

PS.3.6. provide the system modules definitions (i) for capturing data from events of heterogeneous medical equipment (mostly biomedical signals); (ii) for data processing (sorting and grouping of messages); (iii) for messages prioritization; (iv) for routing and (re)transmission of messages ensuring dynamic characteristics; (v) for fault tolerance mechanisms – *also refer to PS.2 and PS.3.*

PS.5. Context awareness: provide a computational service of resources context update, where

the PHE allow the network elements to continually update their information (e.g. routing tables). The objective is to identify the best routes to ensure, e.g. the traffic of priority messages, or issuance of warning signals.

PS.5.1. provide connection and disconnection of resources, and consequently providing their services. The PHE must continually identify resources (e.g. medical equipment) providing information to update the network routing paths.

PS.5.2. provide a service for authenticating users and resources on the network (from the connection service), only allowing authorized access to persons, data and equipment.

PS.5.3. provide HE context management to update the network global context in order to enable fault tolerance and quality of service.

PS.6. Historical information: provide historical patient information. The PHE should be able to keep track of relevant information from patients care, and also about the HE events. By using historical information the PHE might be improved, e.g. operation failures information should contribute for future performance appraisals and routines improvements. Moreover, maintaining historic events enable the use of fault tolerance mechanisms in a variety of contexts and PHE levels.

PS.7. Global integration: facilitate the integration among ICUs in the PHE in order to provide broad cooperation in diverse activities and processes, for instance: (i) ambulances transmitting data directly from a medical equipment (monitoring a patient) to the hospital, thus the HE can be prepared to receive the patient; (ii) healthcare centers that are distant from hospitals providing the patient tests previously performed to the HE; (iii) access to the hospitals database for patients who are outside their physical area; (iv) establishment of homecare services to patients in a more efficient way.

B. Pervasive Environment Manager (PEM)

In this work, we assume the PSs are focused on the HE requirements, i.e. the business application requirements. Thus, the architecture aims to be designed in a modular way to allow aggregating business application rules in a highest level, and to cope with specific devices specifications in a lowest level.

One direction towards a pervasive architecture for HE is to support a service-based computational environment that improves the patient care activities. This approach considers

building a pervasive platform, which is called *Pervasive Environment Manager* (PEM), that autonomously and intelligently connects the elements of HE.

Furthermore, the PEM platform should be able to provide anytime, anywhere procedures for services discovery, taking into account mobile and heterogeneous environments. These procedures must be responsive and effective, allowing a high level control layer in which applications can transparently manage the identification of user (or other applications) needs.

One of the first steps to achieve HE elements integration is to collect PSs aiming a platform responsible for managing all events generated in the HE. Therefore, it is necessary to design a modular system encompassing hardware and software, efficient enough to meet the demands of ICUs.

There are different ways to propose a PEM platform, which makes extremely difficult to propose an abstract and conceptual implementation model that represents all possible alternatives. Therefore, Fig. 2 illustrates an example of PEM implementation, which is a distributed architecture composed by logical modules arranged in layers.

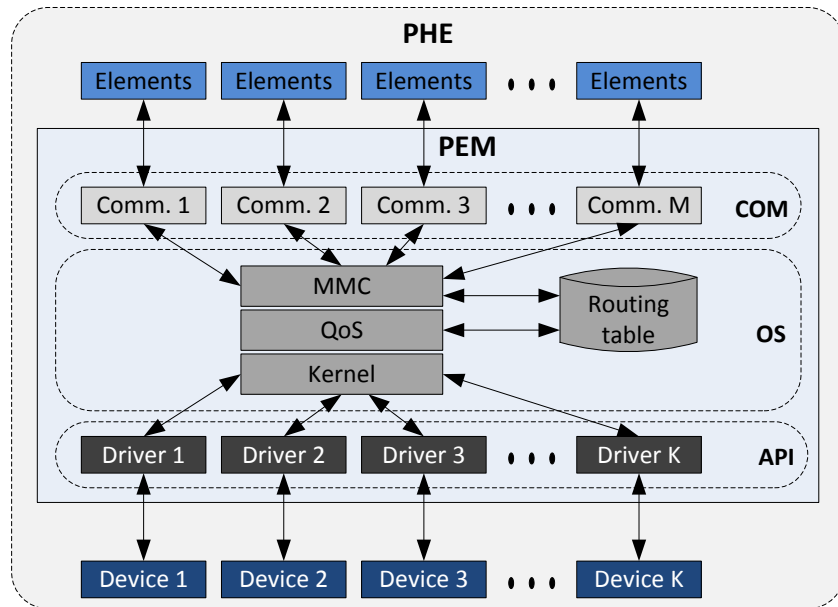


Fig. 2. An example of PEM architecture implementation.

OS is the core layer of the PEM platform, which is composed by three basic modules: *Kernel*, *QoS* (*Quality of Service*) and *MMC* (*Message Monitoring and Control*). The *Kernel* module provides the basic services of PEM operation, such as memory management and processes scheduling, but also provides interfaces for communicating with hardware resources through

specialized drivers. The *QoS* module is responsible for meeting the HE requirements, e.g. choose of routing paths that fulfill the maximum delay for a given service, prioritization of messages and generation of warnings and alarms. The *MMC* is a special module to handle the communication with all other elements that compose PHE. Herein, it is proposed the main services to provide the distributed concept of the PEM, which is discussed in Section III.C. Some features of *MMC* module are: (i) monitoring of possible routing paths and their communication rates, e.g. accessing and updating the *Routing table* with varied information; (ii) analysis of routing paths among the possible alternatives; (iii) sending and receiving of control messages through the communication hardware available; (iv) messages failure treatment for guaranteeing the packets delivery; e.g. when a PEM is transmitting an incoming message, it stores unrouted packets for future retransmission in a possible new path. In addition, the *Routing table* might be seen as an auxiliary module of *OS* layer containing information about paths quality, which enables routing and priority decisions for both *MMC* and *QoS* modules.

The *API* layer provides communication interface with medical devices. This layer complexity resides on dealing with several heterogeneous communication protocols. Thus, *API* layer contains some relevant and most used driver's implementation but also provides a general programming interface for new ones, which is supported by *Kernel* module.

The *COM* layer provides the wired and/or wireless communication with other PHE elements (e.g. devices and other PEMs). Likewise to *API* layer, the *COM* layer also provides general programming interface that enables to implement other protocols. All incoming and outgoing messages that pass through each *Comm* are transmitted to or received from *MMC* module, which is responsible for message control. Emerging technologies can be incorporated into the PHE communication layer, i.e. transport technologies domains and specialized medical profile for ISO/IEEE 11073, e.g. Zigbee, WUSB – *Wireless Universal Serial Bus*, 6LoWPAN – *Ipv6 over Low-Power Wireless Personal Area Networks*, and IEEE 802.11 standards [14].

C. Services and technology integration

In a future perspective we highlight a computational integration among hospitals, healthcare units, homecare, ambulances, and HE in general, performing efficient access and processing of relevant information, regardless its location. This perspective must accompany the evolution of mobile devices, wireless communication, computing hardware and communication bandwidth to meet the demands of many healthcare applications.

Current solutions in the literature have demonstrated to be efficient and applicable in several contextual environments. However, most of them are application-specific, device-centric, and have constraints related to scalability, reliability, QoS, context-awareness, service discovery, and so on [10], [14], [25], [31]. The major trend in this area is the achievement of a PHE able to provide multiple services uninterruptedly, based on the available efficient technologies and resources discovered from many connected PEMs, i.e. a pervasive network of healthcare devices and services. The proposed architecture allows the PHE management through several integrated PEMs, in a distributed way.

Each PEM must, based on the pervasive network context identification, be knowledge-aware of the global view of the involved elements and available services. It allows not only the identification of PHE network elements but also the dynamic routing mapping of the most reliable communication paths. Thus, the *OS* layer should provide means to extend the *MMC* and *QoS* modules in order to enable distributed operations. So, all the network elements can communicate and cooperate with their partners ensuring the priority and reliability of messages exchange. Remark that the *MMC* module also is responsible, for instance, for distributing control packets to collect path status information (e.g. delay).

PEM platforms integrate hardware and software elements to abstract PSs operation, and consequently the HE requirements fulfilling. Consequently, a PS may autonomously manage people, resources and services. Fig. 3 illustrates the PHE integration with several PEMs managing various heterogeneous resources in order to provide services efficiently across multiple communication channels.

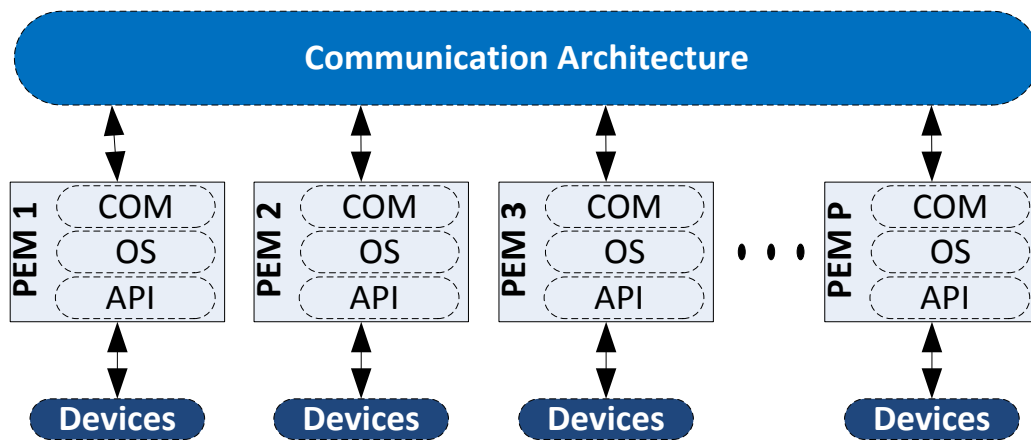


Fig. 3. PHE performed by PEMs integration.

The PEMs integration enables that innumerable platforms cooperate among themselves to provide transparently services to the PHE elements. According to PS, the PHE will be supported by efficient mechanisms of message routing that integrate the network with a high level of capillarity, i.e. first of all guaranteeing messages delivery and in a broader point of view, guaranteeing patients' health and welfare.

IV. FINAL CONSIDERATIONS

The challenge related to pervasive systems integration on diverse healthcare environments comes from making sure all devices, people, applications, and solutions are working together properly and cooperatively. The implementation of multiple technologies, relying on a combination of hardware and software, demands increased performance from HE elements, mainly those on ICUs.

Moreover, several issues related to the HE requirements, and specifically towards to patients monitoring, suffer an impact from barriers imposed by proprietary medical equipment specifications that need to be prepared to be integrated on the PHE.

We illustrate a logical architecture for PHE management using PEM platforms describing features such as providing heterogeneity and interoperability among devices, creation of a high-level architecture abstraction based on pervasive services from available resources, context awareness concepts, low-level device communication abstractions and compatibility with diverse technologies.

The major objective of this technical report is specifically discuss the need of more integration on technological structures for the constant monitoring of patient's vital signals in ICUs, or in hospitals, ambulances, in an ubiquitous way, with efficient response times for transmitting and processing information, with guarantees of end-user quality of service, i.e. patients' welfare, health and safety.

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