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Information Systems in Healthcare
The Case of INEM: use of mobile systems

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SUMMARY

Information systems are an asset in the capacity of institutions to improve their business. As the potential of mobile systems is increasing especially in healthcare, a diagnosis is made of the information system of INEM (National Institute for Medical Emergency) in terms of some of its weaknesses and changes. In the case of human lives, which require speed and quality of care in a specific context and location, it is essential that healthcare institutions implement mobile and context-aware systems in order to prevent gaps in care from the time of first contact with the patient. This paper presents a system's architecture, provided by the technical and functional development department of a company (*Algardata*) for context-oriented systems in dynamic environments. The aim is, whenever the patient changes his location, to immediately discover the services that best fit his needs and determine the resources required, including the position of professionals who are on duty nearby.

Key words: Information systems, ubiquitous systems, mobile systems, INEM, healthcare.

1. Introduction

One way to manage and process the information that organizations need today is the creation of a supportive structure based on technology that integrates mobile and easy-to-use tools. Some of them are ERP systems (Enterprise Resource Planning), CRM (Customer Relationship Management), CMS (Content Management Systems) and SOA (Service-Oriented Architectures). These have contributed to the development of new services, improvement of existing processes and creation of new processes in real time. Given their enormous potential, which can range from changes in procedures to a complete

reconfiguration of the business model, professionals and users must be familiar with tools of this kind and be involved in their implementation from the start.

In particular, health services require a significant transformation in order to achieve greater interoperability, efficiency and quality. Most information systems (IS) in healthcare require a rapid delivery of services in the appropriate locale and context. The method for managing patient care is not always personalized and flexible, especially when there is interaction between several entities such as hospitals, health centers, firemen, insurance firms, etc. It also involves a variety of contexts, including a range of physiological and behavioral factors. Healthcare providers make decisions based on a series of data, for which services provide real-time information such as how much of which product is needed, how best to administer it, how to organize the treatment, where it should be done, etc. This requires the use of tools specially based on integration processes and which are simultaneously mobile and flexible to the context.

Using mobile platforms, one can consolidate information from different sources or channels of communication (phone, email, web, wireless points) and meet diverse requirements and issues. Then organizations can use the information obtained to improve their services, streamline service, accelerate procedures, etc. Also, using CRM tools one can combine this information to help the organization to create unique services or understand critical situations. Since these tools are the result of advanced analytical techniques that capture missed characteristics, attitudes and behaviors, they produce an IS more effective in identifying patterns with complete conditions. However, one difficulty of these tools is that users in organizations are not often familiar with their operability and associated analytical criteria, which means that they require relevant training.

2. Trends in information systems

Organizations should consider implementing IS from a strategic point of view, like any other investment. In order to assess the benefits and costs involved (tangible and intangible), it is essential to define a business plan for evaluating the results of the IS activity in the context of business requirements. Before analyzing the information system of INEM, a survey was conducted in order to learn about the trends of IS in different sectors, including healthcare. Table 1 shows a comparison between surveyed organizations from the construction, technology, services and trade sectors, located in the Algarve region. There are

Table 1. Comparison of companies from different sectors of the Algarve region, in the adoption and implementation of IS (source: own compilation)

Company (sector)	Type of systems	Differentiating aspects
Euroaço; Metalofarense; Joaquim& Fernandes. (Construction)	The databases and systems are more departmentalized (separated). Rely more on outsourcing IS.	Lack of integration leads to delays, errors and redundancies. Repetitive tasks lead to more staff than is necessary.
Visualforma; Algardata. (Technology)	Have specialists in IS; develop systems they use: ERP (Sap, Primavera).	Advantages in controlling the software, some limitations for different systems.
Ctt (post); Algar (waste); **INEM** (healthcare). (Services)	Envision the potential of ubiquitous systems and geographic information systems. Integrated systems.	Better management of routes; services more locally appropriate and on time. Greater variety of services. Increased traceability of tasks and creation of new services.
Aquashow; Zoomarine (leisure); AutoJardim (rent-a-car). (Services)	Benefit from seasonality to restructure their information systems.	
Santander; Deutsche Bank. (Services)	Integrated systems. Also envision the potential of ubiquitous systems.	Include legislation differences between countries.
PingoDoce; AKI (distribution channels). (Trade)	These channels have adopted ERP (Sap, Primavera).	Greater flexibility and functionality in operations; more efficient businesses.
NewCork (cork); Chaveca & Janeira (tires). (Trade)	Resort to consulting IS. Outsourcing of IS; poorly integrated systems.	More logistical problems and higher transport costs.

some differentiating aspects, in terms of the support provided by IS, that should be considered in the context of a plan for IS implementation.

Most organizations interviewed, under analysis of threats and opportunities (SWOT analysis: strengths, weaknesses, opportunities, threats), do not have an integrated view of the problems in their activities and the potential of IS to solve them. Once it is examined how opportunities can resolve some weaknesses (or how threats may turn out to correspond to taking advantage of certain opportunities), they do not explore how their IS can be restructured to incorporate other emerging tools in order to realize those strategies more fully. In the organizations that have this view, particularly those engaged in the technological sector and in distribution channels, there is a greater alignment between the IS infrastructure and its activities, with resulting improvements in speed, efficiency and image. This is mainly related to the fact that the technology sector dominates IS management and implementation, and in the case of distribution channels, to their considerable organizational capacity and the nature of their business processes.

On the other hand, it is interesting to note that sectors with more mobile activities such as INEM (medical emergency), Ctt (post office) and Algar (waste/eco-points), as well as banks, which increasingly depend on real-time knowledge about financial markets, recognize the growing potential of mobile IS platforms. They highlight the mobility that is achieved through a PDA (Personal Digital Assistant) or a simple mobile phone, as well as the easy access to these devices, regardless of their location, from the central system of the organization.

3. Brief diagnosis of Inem's information system

INEM is the Ministry of Health's responsible institute for coordinating medical emergency in Portugal through an Integrated Emergency Medical System (SIEM), in order to ensure that victims of accidents or sudden illness receive prompt and proper healthcare. INEM includes the following central services:

- Support offices (legal, quality, auditing, planning, management, control, communication and image);
- Department of medical emergency;
- Department of medical emergency training;
- Department of telecommunications and information technology;
- Department of transportation;
- Department of administration and finance;
- Human resources department.

To carry out its activities, INEM has means such as ambulances operating directly or through protocols and agreements/contracts with other entities such as firemen, the Portuguese Red Cross and hospitals. These facilities include BLS ambulances (for basic life support); SIV ambulances (for immediate life support); ambulances specialized in providing care to newborn or premature infants at risk; VMER vehicles (for medical emergency and resuscitation); and medical emergency helicopters. INEM's mission is to organize, coordinate and evaluate the activities and operations of the SIEM in order to ensure that patients receive effective healthcare.

SWOT analysis, as mentioned before, is an approach used to perform scenario or environment analysis. In this respect, it is the first analysis made to identify strengths, weaknesses, threats and opportunities. It can help in determining how far information systems are contributing to that identification for further evaluation of the potential of IS activity to support the strategies outlined from it. Interviewing one INEM executive, one of the strengths pointed out is the existence of efficient means for appropriate support from the SIEM such as modern software that displays the original location of the emergency call while another screen presents the defined itinerary with the optimum route for the ambulance.

As to weaknesses, there are several testimonials from users about the provision of emergency services, stating that they often become ineffective. For example, despite having aircraft for rescue in areas of difficult access, they often do not have permission to use them. Another issue is the process of victim

assistance, which includes filling out a form by hand with personal data. After having administered the service, the medical team carries out manual entry of information about that service. Some errors have resulted from this process, due to discrepancies between those records or to confusion between terms due to failure to understand handwriting. Therefore, it has been proposed that SIEM will allow teams to enter those records through an electronic form. Also proposed is an automatic call-back process which will allow the return of an incoming call that was interrupted or lost due to a technical problem. This analysis may also overlook possible threats: one is that the SIEM faces a stream of false calls, and another some negligence in giving information on the phone may pose a serious threat to service efficiency. Hence the commitment of SIEM workers is essential in all its services to develop good integrated emergency care. Currently, the INEM subdivides its IS into two parts: operational and logistical. The logistical part covers the targeting of emergency vehicles to the required destination and also the areas of institutional storage and accounting. Taking the example of the financial department for a quick explanation of its features, in some cases of emergency it is necessary to use other means of assistance such as cars from firemen. In this case, the INEM has to pay some fees related to the fuel used by those available vehicles. When these services are used, the SIEM automatically sends this information to the financial department and calculates all charges, issuing a payroll.

One should note however that the main aim of this institute is to save lives. So, in the operational part, each emergency call to 112 (the emergency number) is forwarded to the Center for Urgent Patient Orientation (CODU) where a summary action is generated from the collected data. This center then sends an email to the SIEM, automatically sends a text message to the duty healthcare team. On receiving it, as the message refers to a vehicle already selected after a screening of the incident’s level of urgency, the team develops its intervention with means available in the respective vehicle, already knowing the severity of the incident. It is here that the current situation could reach an impasse, as the rescue team determines whether the received information actually corresponds

to reality. What can often happen is ‘over-supply’ of an event, where several vehicles travel to the locale when in fact only one would suffice.

Importantly, the CODU, upon receiving the information about what has happened, usually screens it from a clinical point of view, which determines the kind of response it makes to the situation. The function of CODU is not making diagnoses, but rather examining the signs of severity. This center aims to sensitize the persons performing its services to be aware of false calls and other disruptive factors. Users recognize a growing awareness and competence from call handling personnel. Care services also require users to remain calm and provide accurate information about the location, number of people involved and seriousness of the situation, because doing so will avoid deadlocks in the process of saving lives. After first aid being administered, the team completes a form concerning the incident along with a report of all the services provided. Today, the form is filled in at the base unit supplementing the data already provided by the first phone contact. To improve the data flow, the possibility will be implemented of such reports being sent directly from the mobile units through a service known as GPR. That is, by means of a mobile system the team can send a report of any occurrence through a simple direct text message.

In short, SIEM manages three major processes: normal service by telephone means; medical screening which makes a referral to the available resources, and geo-referencing of the location of the incident for more effective care in the locale. However, recent reports show that the public are not sufficiently satisfied with INEM’s services. They refer to errors, delays, and information which is incomplete and insensitive to the context. It should be noted that several improvements made through the new processes mentioned above have solved problems such as lack of information, missed calls (forwarding them), retracing the set of medical teams (for its computerization) and breaks in the system (the call is forwarded to a terminal that is available enabling a call to be answered by the CODU of another region). It is also worth mentioning that the SIEM is integrated with the communication system of the institute, including cars and mobile equipment that work in an integrated manner for enabling

higher speed of response. However, there are weaknesses in linking SIEM with various entities that cooperate with INEM in assisting victims of accident or sudden illness, such as PSP and GNR (police services), the Portuguese Red Cross and medical units such as health centers. Some architectural and operational aspects of SIEM are summarized in Figure 1. This system requires ubiquitous mechanisms, both mobile and pervasive, allowing entry, selection and transmission of data in each context. The aim is, whenever the patient changes his location, to immediately get the services that best fit his needs and determine the resources required, including the position of professionals who are on duty nearby. This will contribute to making medical practice more agile and dynamic across different related health entities.

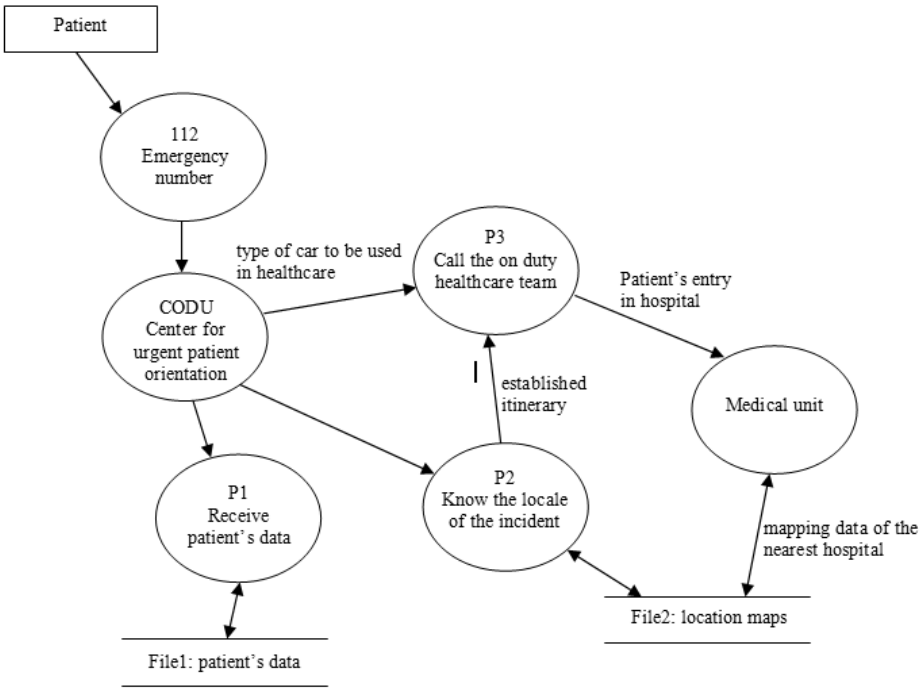


Figure 1. Diagram of data flows and main processes in INEM's information system (source: interview with an INEM executive)

4. Potential of mobile systems in healthcare

The economic relevance of IS continues to intensify and is normally at the core of discussions on growth and performance, especially related to trends in the support technological systems and platforms can provide. For example, one relevant trend is the widespread use of the global navigation system (GNSS). Its equipment gives an autonomous spatial position, which has become an ubiquitous element[1] of new technological applications, as time and position are important attributes of a service. The geographic information is quite valuable when combined with other data in models and diagnostic tools, allowing one to filter or customize information according to the position of the receiver at a given time. In turn, intelligent transport functions can provide data on trafficking in a given area to capture the existing professionals around the area. GNSS is currently being used to coordinate multiple mobile platforms, which are especially useful and efficient in air traffic management, fleets of taxis, INEM services, etc. The combination of the potential of GNSS with information and communication technologies is becoming a key element of new IS infrastructures.

What emerges most in mobile platforms is their ubiquity, which is an attribute that has to do with the critical role played by time in communications. In geographical scale and time-sensitive services, such as healthcare, their application is making a difference. In the provision of rescue services, one of the potentials of mobile systems is the controlled execution of activities in the field by creating processes that will resolve many problems related to on-time care rendered locally. In order to ensure that packets of information (voice, text, video and image) are delivered in the correct sequence, it is important that the recipients of communication, physically distant, are properly synchronized. It is essential that the ubiquitous system provides mechanisms for selection and

[1] Concept of being everywhere at the same time. This is related to mobile and pervasive equipment.

discovery of services that meet the aspects of the context, and accurately reflects its constant changes.

The pervasive[2] nature of ubiquitous technology and its growing practice have changed the way of conducting activities and interacting with stakeholders at various locations and using different systems. When it penetrates activities and institutions, many aspects of management and organizational structure change radically. The speed and extent of connectivity it allows enable the creation of new processes and improvement of existing ones, some of which involve new risks and challenges. One of such challenges is related to confidence or acceptance by people (professionals and users) of new equipment and ways to interact. Another challenge is to ensure data protection due to the interoperability of mobile platforms. There is also a need to ensure total privacy in such environments, facing the widespread manipulation and dissemination of critical information.

There are several ongoing projects on mobile systems in healthcare, seeking to integrate more and more ubiquitous, pervasive and mobile computing (Lupu *et al.*, 2008, Kim *et al.*, 2007, Lee *et al.* 2006). Some of these projects use RFID (Radio-Frequency Identification) technology for integrating local services into a system of healthcare by intelligent recognition of the physical entities involved in the real context and their association with virtual objects in the digital system where the application runs, allowing quicker reactions from the real world (Santos & Rossetti, 2009). For example, in the work of Lee *et al*. (2006), the RFID devices use personnel and logistics flows to identify bottlenecks in patient flow, which allow the application to analyze and improve the management of information for a patient. Other applications allow better control of hospital quality through their connection to monitors placed in patients' beds, enabling detection of the closest health professionals to achieve greater accuracy in the

[2] Concept related to the capacity of different integrated equipment functioning together, context-sensitive, in the same environment.

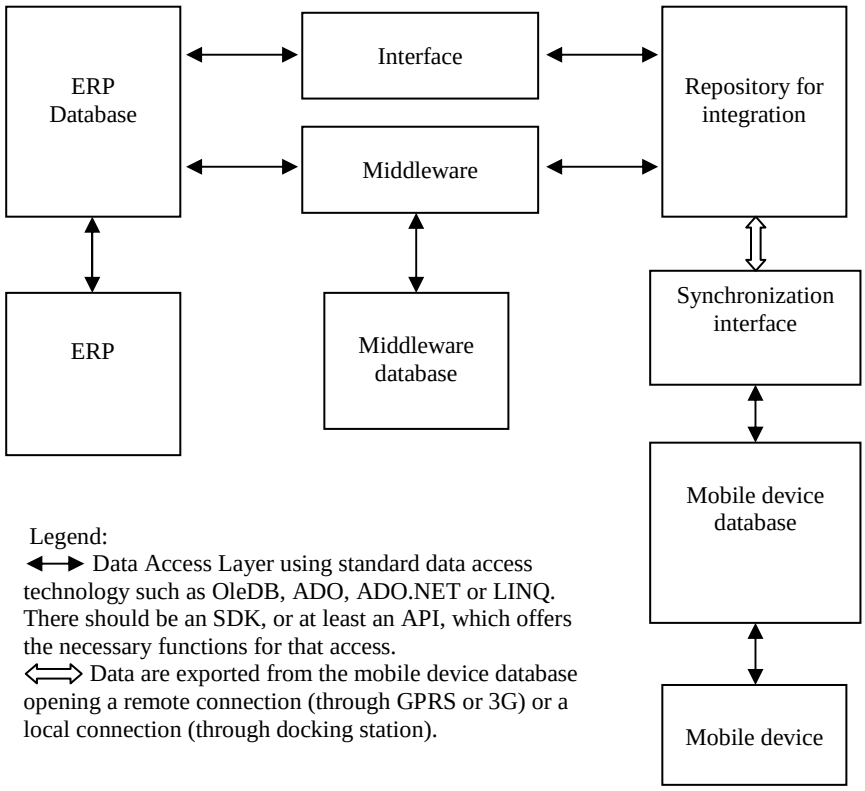
distribution of treatments and medication through better access and navigation in the patients' schedules.

The SOA (Service Oriented Architectures) are important trends to consider in constructing pervasive systems as they combine various services offered by different manufacturers for creating complex and effective new services. The intelligence of these environments requires continuous operation, through technological specific interfaces, for them to become sensitive to changing characteristics and needs of human behavior. This can preferably be activated by a simple human interaction, adaptable to the changing context. Applications should be able to move from one device to another, supporting the heterogeneity and variability of resources. In short, they should be accessible to any user, anywhere, anytime and from any device. At this level there are issues of security, confidentiality and intrusion that must be properly controlled through specific connecting protocols.

Figure 2 shows a model made available by the technical and functional development department of a company (*Algardata*), after an interview with one of its executives, which corresponds to an architecture with service-oriented middleware for dynamic environments such as ubiquitous ones. The purpose of this architecture when applied to the provision of healthcare is, whenever a particular user changes location, to select the services that best fit his needs in the context of that location and also to assist the management of the required resources and to monitor the professionals who are close. The increased use of Web service technology, implemented on today's GPRS or 3G mobile phones, along with the supporting middleware, adds new options for the mobile direction and context-sensitiveness of this kind of environment.

5. Conclusion

Given the opportunities described here for information systems running on mobile and ubiquitous platforms, it is essential to establish an early business plan and, in case of the need to support it with a mobile system, evaluate the



Data can be exported to the Repository in different formats. The most used are:
-XML: preferred solution, allows data validation to a XSD;
-CSV;
-Text files with fields of fixed size: they are less used.
Optionally one develops an interface for direct integration or a middleware whenever a translation is needed.

Figure 2. Model for integrating an information system and mobile devices for mobile platforms of action (source: technical and functional development department of *Algardata*)

results obtained within that plan on the basis of correspondence between the mobile activities and organizational needs. The implementation of effective information systems involves planning and assigning personnel, skills and opportunities assessment along with the objectives pursued, as not all activities need to be supported by mobile operations.

The use of mobile platforms, and relevant experience from several projects underway or others already achieved, explain the growth of these systems in healthcare as they are helping organizations, professionals and patients to enjoy better and faster. This new paradigm of computing, initially discussed on a theoretical basis to which ontologies[3] and other software engineering tools have contributed, is increasingly applied to new dynamically monitoring devices of resources and people in space, becoming sensitive to their change and context. Hence they are adding value to existing healthcare systems through more comprehensive and targeted services.

INEM is an institution where the information system is quite important for the efficiency of organizational processes and activities. It is through it that the beginning of the process of rescue takes place. Its proper functioning is of great importance because it deals with human lives. Although it involves all direct and indirect mechanisms of an enterprise (whose main aim is profit), INEM requires respect for life and commitment from the teams involved in rescue. The middleware architecture presented above can serve as a basis for the development of the required functional ubiquitous modules.

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[3] Ontologies are data models representing a set of concepts within a domain and the relations between them, to make inferences about the objects of the domain. They are used in artificial intelligence, semantic Web, software engineering and information architecture as ways of representing knowledge about objects. Ontologies usually describe individuals, classes, attributes and relations.