Versatile Clinical Information System Design for Emergency Departments

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***Abstract*—Compared to other hospital units, the emergency department presents some distinguishing characteristics of its own. Emergency health-care delivery is a collaborative process involving the contribution of several individuals who accomplish their tasks while working autonomously under pressure and sometimes with limited resources.**

Effective computerization of the emergency department information system presents a real challenge due to the complexity of the scenario. Current computerized support suffers from several problems, including inadequate data models, clumsy user interfaces, and poor integration with other clinical information systems.

To tackle such complexity, we propose an approach combining three points of view, namely the transactions (in and out of the department), the (mono and multi) user interfaces and data management. Unlike current systems, we pay particular attention to the user-friendliness and versatility of our system. This means that intuitive user interfaces have been conceived and specific software modeling methodologies have been applied to provide our system with the flexibility and adaptability necessary for the individual and group coordinated tasks.

Our approach has been implemented by prototyping a web-based, multiplatform, multiuser, and versatile clinical information system built upon multitier software architecture, using the Java programming language.

***Index Terms*—Clinical information system, electronic health record, emergency workflow management, patient data management, versatility.**

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I. Introduction

Computerization of information management is an effective way to help medical staff in hospital units face hurdles such as organizational change related to budgetary restrictions or workload increase. This can be particularly effective in the emergency department where computer-based support is useful in managing coordination and other daily activities of health-care delivery [1]. Such support must take into account the uniqueness and complexity of the emergency department scenario [2], to which multiple elements contribute.

Emergency health-care delivery is a collaborative process involving the contribution of several individual actors who accomplish their tasks working autonomously under pressure, and sometimes with very limited resources. Moreover, it is mainly characterized by unpredictability and flurry: Patient arrival rates vary enormously during the day as does the nature of the emergencies and pathologies staff have to face, prioritize and handle concurrently. Coordination and quick access to information are very important in order to monitor patients' status and location and react promptly to their needs.

Another source of complexity is the fact that an emergency service comprises multiple disciplines, each operating according to its own procedures, acquired knowledge, and specific organization in terms of services offered to patients. Although the final goal is health-care delivery to patients, and the general steps to attain it are the same for every emergency service, there is unlikely to be a single correct way to achieve this. Thus, for a given pathology, there may be differences in the set of tests proposed, medications prescribed, and medical tasks performed. This needs to be reflected in the way medical concepts and information are represented. The flexibility of an emergency department clinical information system is of primary importance.

From a technical point-of-view, there are additional issues to be considered when computer-based support is being introduced into such a complex scenario. These concern the ability of the system to interact with existing applications in the health-care facility, so as to enable data interchange in a heterogeneous environment. Patient data privacy and integration of records need to be well organized and to comply with relevant standards and quality criteria. The simplification of system configuration, administration, and maintenance procedures is also mandatory as these procedures are usually taken over by the service medical staff.

As mentioned above, clinical information systems designed for emergency health-care support are very demanding in terms of providing flexibility and adaptability to the needs of the service and its evolution in the long run (new technology solutions, new medical concepts and procedures, new regulatory prescriptions, changes in the existing ones, etc.). This paper discusses the development of a sophisticated clinical information system specifically addressing these issues and thus enabling versatile health-care support. We first describe the background to the emergency department computerization (Section II). Section III details the problem of emergency department computerization. In Section IV, we explain what our solution consists of and what it does before dealing with methodological and architectural concerns in Section V. Then we describe a hypothetical case scenario of the use of our system to illustrate our results (Section VI). The final sections are devoted to the discussion and the presentation of future plans.

A preliminary version of our system will be tested in two Belgian emergency health-care departments before final deployment.

II. Background

The current work is based on research conducted within the Architecture de Télécommunication Hospitalière pour les Services d'Urgences (ARTHUR) Research Project [3]. This project focused on the emergency department and related services including general practitioners and other units in the hospital such as the intensive care unit, biology test laboratory, radiology department, pharmacy, specialists, and other emergency services within the Regional Healthcare Network. The project aimed to provide complete computerized support for medical and nursing tasks as well as for administrative tasks in the emergency department. Solutions based on automated workflow management, which are typical in most other units of the hospital (such as the radiology department) cannot be employed to handle the emergency health-care process due to the unpredictability and urgency of the activities involved [4].

Many different solutions have been proposed and can be grouped into two major categories: commercial solutions and in-house solutions. Some commercial solutions fail to address the issues altogether. Moreover, they lack adequate data models and present clumsy user interfaces as well as poor integration with other clinical computer systems. Others provide only partial support for the coordination of patient flow, while lacking facilities for the management of electronic health records. Others seem impracticable due to painstaking and complex parameterizations. Commercial systems that do provide a satisfactory solution overall are often prohibitively expensive.

Many emergency departments have, therefore, chosen to develop their computer support system in-house [5]. Although this choice can lead to a satisfactory clinical information system, its drawback is that it is very precisely conceived and tailored to support activities in a particular hospital. Such a system is not easily adaptable to other emergency departments.

Neither in-house nor commercial solution providers have published many details of the methodologies and architectures they have used. These solutions are often based on proprietary technologies that are growing obsolete and on software models that fail to provide the necessary flexibility and user-friendliness to the system.

III. Goals and Objectives

The quality of emergency care could be enhanced by combining new information technology solutions (mobile devices, wireless networks, web-based multitier architectures, and electronic health record systems) with ergonomic user interface design. This can provide system flexibility and seamless interaction between multiple devices and platforms in such a critical working environment.

Our research work was performed as an interdisciplinary project in collaboration with clinical experts. Improved access to information for patient management (order status, patient tracking, monitoring of patient waiting times) and enhanced revenue (because inaccurate charge capture causes monetary loss) were among the goals of the system. A preliminary analysis had identified these as the two major problems currently affecting a large number of Belgian emergency services where most access to information is still paper-based and existing computer support relies on applications with legacy character interfaces and out-dated inflexible architecture [6]. Our project sets out to explore the use of intuitive graphical user interfaces (GUIs) for immediate and universal access to patient-oriented data, while developing more sophisticated clinical information systems for health-care delivery in the emergency department. In particular, the solution we developed did not aim to address the specific needs of a single emergency department, but to be generally applicable and easily deployable in disparate situations (large and small emergency services, etc.).

Basically, the system aims to meet a set of requirements raised by the activity of an emergency department. It covers the totality of patient care tasks from admittance, through diagnosis and therapy, to discharge. Fig. 1 summarizes the complex scenario of patient care in an emergency department. It is an abstraction combining three main aspects as follows:

1) patient flow through the department represented in Fig. 1(a);
2) the activities of emergency health-care delivery [Fig. 1(b)], i.e., tasks relating to patient management and the functioning of the emergency department and its resource management;
3) relations with other entities [Fig. 1(c)], which are external to the department but part of its working environment (general practitioners, other units in the same hospital such as the intensive care unit, biology test laboratory, radiology department, specialists, pharmacy, etc.).

This view is simplified, as it does not represent the actors and disciplines (e.g., general medicine, gynecology, pediatrics, etc.) involved. Emergency health-care delivery is an overall process requiring the cooperation of many different individuals (administrators, secretaries, nurses, doctors, medical assistants, etc.) who act autonomously to maximize the quality of care and the number of cured patients. Due to the unpredictability of situations (the service workload, the availability and timing of external resources, etc.), it is impossible to formalize a precise

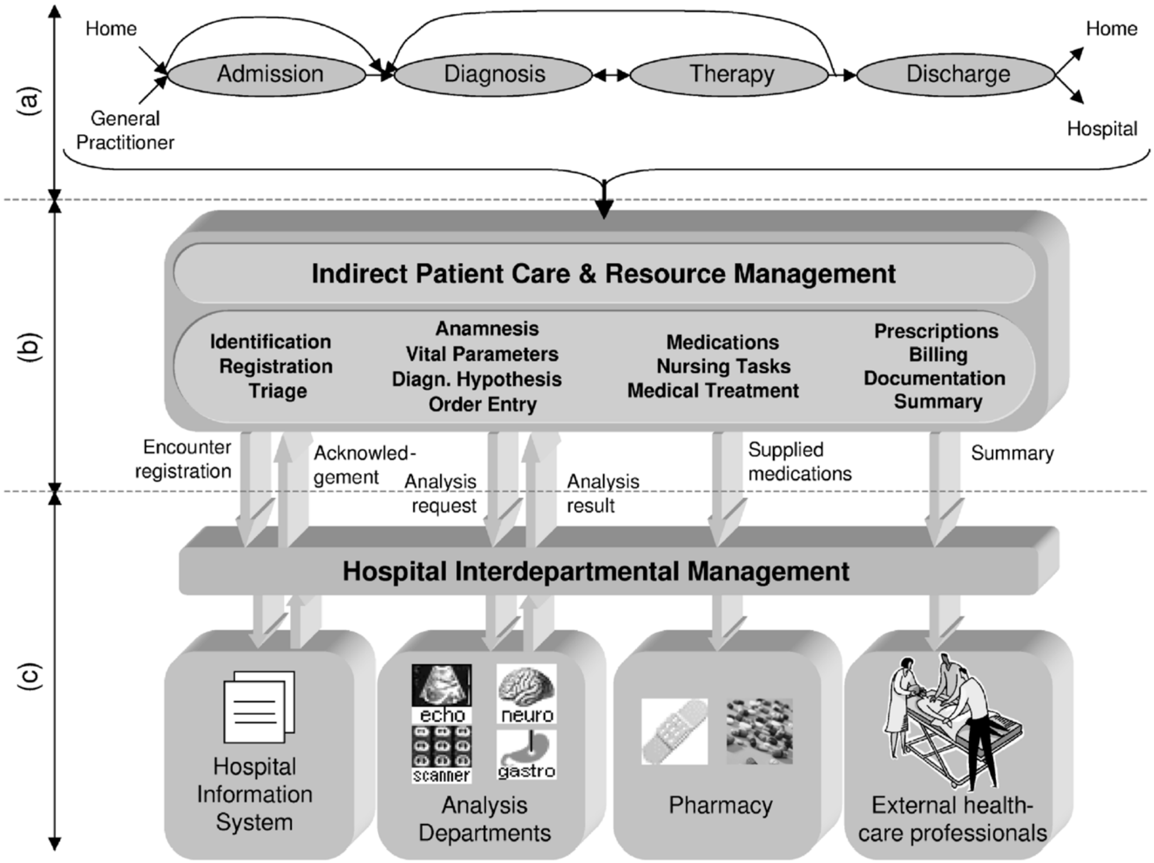

Fig. 1. Emergency service environment. (a) Patient flow. (b) System functions. (c) Other entities.

schedule of operations. Fig. 1(b), however, illustrates the fact that the functionalities underlying the scenario can be divided into two groups:

1) *real-time management of the emergency service* (patient registration, entry of anamnesis data, test requests, nursing tasks, etc.);
2) *indirect patient care and resource management* (definition of clinical protocols, extraction of statistics, management of access rights, etc.).

Relationship with other entities external to the department is established according to general hospital interdepartmental policies and rules.

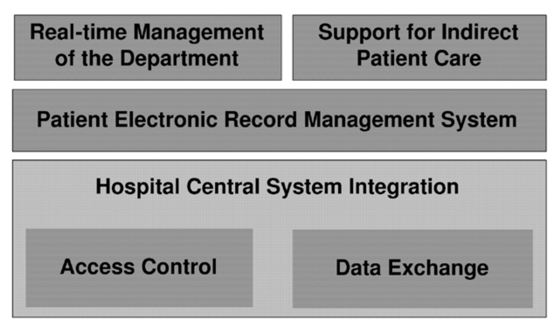

Fig. 2. Functional components.

IV. System Specification

The ARTHUR clinical information system relies on an integrated patient electronic record management system to provide support for the real-time emergency department management as well as for indirect patient care activities. Fig. 2 illustrates the functional view of the system.

A. System Integration Functionalities

Access control encompasses authentication and authorization procedures. Authentication to the ARTHUR emergency department clinical information system is based on that of the central system. This enables users to employ the same credentials they are already using for other applications in the hospital. The authorization policy is that of the emergency department.

Our system allows message-based integration by providing a software module implementing the HL/7 standard [7]. This module is in charge of establishing connections with external resources. For example, each time an encounter is created for a patient at the main hospital information system (HIS) level, an HL/7 message is sent to our system. This checks whether or not an electronic health record exists for that patient. If necessary, it automatically creates the record and displays information to users.

B. Patient Record Management System

Offering an entirely computerized patient record management system to manage the whole of the medical and administrative data flow during a patient's visit is the best way to achieve the goals detailed in Section III. For each patient, information about anamnesis, diagnostic hypothesis, analyses requested, medication supplied, etc., is stored in the patient record management system. Our system design meets the requirement of flexibility and adaptability by separating the domains of information and knowledge. Information is stored in the patient record management system according to evolving knowledge structures (constructed by domain specialists) in such a way that the versatility of knowledge structures does not affect the system.

In addition to adaptability, the patient record management system is able to trace actions performed by users. This traceability includes audit logs (created by most operating systems and database systems) as well as the version of the data being handled.

C. Real-Time Support Functionalities

Our project did not address the admission step of the emergency health-care delivery. This is because the emergency departments involved in the project already have computerized support (namely the central HIS) for these activities. Our system aims to focus on functionalities pertaining to diagnosis, therapy, and discharge, providing horizontal support (usable throughout any of these steps) as well as vertical support (the functionalities within a single stage) for these activities.

1) Horizontal Support: Multiuser Interface on Wall Display: The multiuser interface supports coordination functionalities, which are denoted as *whiteboard management.* This is a noninteractive view of the service activities, where doctors and nurses can have a glance at the service status and patient-flow management by looking at the GUI on the wall display. It shows a snapshot of the patient waiting list and related tasks. Patients may be listed according to their pathology, their location, or the priority of their care. Tasks are grouped into two distinct sets: The first relates to diagnostic tasks and the second to therapeutic ones. Clinical staff can also monitor patient waiting time as it appears on the whiteboard. The look-and-feel of the computerized whiteboard can be adapted to reflect existing custom and practice in each emergency service. The whiteboard is also interactively accessible on desktop workstations, tablet personal computers (PCs), and pocket PCs.

2) Vertical Support: Monouser Interfaces on Desktop, Tablet, and Pocket PCs: Unlike the wall display, devices such as desktop, tablet, and pocket PCs also provide interactive access to vertical support facilities including functionalities for diagnosis, therapy, and discharge steps, which are denoted as *patient record management*. In each of these steps, users save time thanks to intuitive interfaces.

By using tablet and/or pocket PCs, doctors and nurses can access up-to-the-minute medical records and scheduling information anywhere. They can consult and capture information at the point of care without having to scribble it down.

D. Indirect Patient Care Support Functionalities

This group of functionalities covers activities that impact on patient care, although not directly related to it. One of the most relevant facilities for indirect patient care is clinical protocol definition. A clinical protocol associates a group of diagnostic hypotheses with a set of proposed tests, medications, treatments, and technical acts. In our system, clinical protocols can readily be created or modified in a dedicated client application. Only a limited number of clinical staff members are usually permitted to undertake this task. Once defined, clinical protocols allow caregivers to save time and execute their tasks more precisely.

Support for indirect patient care also includes system administration (access right management, color code definition, etc.) and activity reporting (medications used, statistics, etc.). By reviewing the activities that have been recorded and extracting performance measurements, it is possible to gain a detailed insight into each step of the workflow.

V. Methods and Design

In this section, we first describe the modeling methodologies we adopted in order to achieve the necessary user-friendliness and versatility. Then we present our architectural and implementation choices.

A. Participatory Approach

As speed and improvization characterize their daily work, emergency health-care professionals generally accept computerization only if it enables them to provide better care in emergency situations without imposing any artificial constraints. They generally express very strong requirements for the user-friendliness of the system. They also sometimes express contradictory needs. Our project team very quickly realized that heavily involving the various users in the design process was a key factor in success.

Our design approach is an iterative process that maximizes the participation of the various actors. Among these actors are all potential users (medical and administrative staff) and the people in charge of the systems and services our solution will have to interact with (central computer system in the hospital, technical departments such as radiological examinations, laboratory analysis, etc.). To formalize the system's requirements and its design, our project team repeatedly undertook the elicitation, representation, and validation steps.

Participatory design proved to be effective for the rapid prototyping [8] of the GUIs of the ARTHUR system. Rapid prototyping has the advantage of allowing fast feedback from users and iterative derivation of more precise specifications. Informal user testing and heuristics evaluation [9] also permit early evaluation of the interfaces.

The participatory method is far from being particular to the ARTHUR project. We want, however, to emphasize the fact that the complexity of the emergency health-care delivery scenario requires such a method.

B. Two-Level Software Modeling Approach

Computerization of patient records raises the problem of medical domain data representation and organization. Although medical practitioners work in the same knowledge domain, it seems to be almost impossible for them to come to an agreement about the best way to conceptualize their knowledge domain into a machine-readable format. For example, one health-care professional might consider that the concept of patient's *antecedents* includes the patient's *contagion list*,

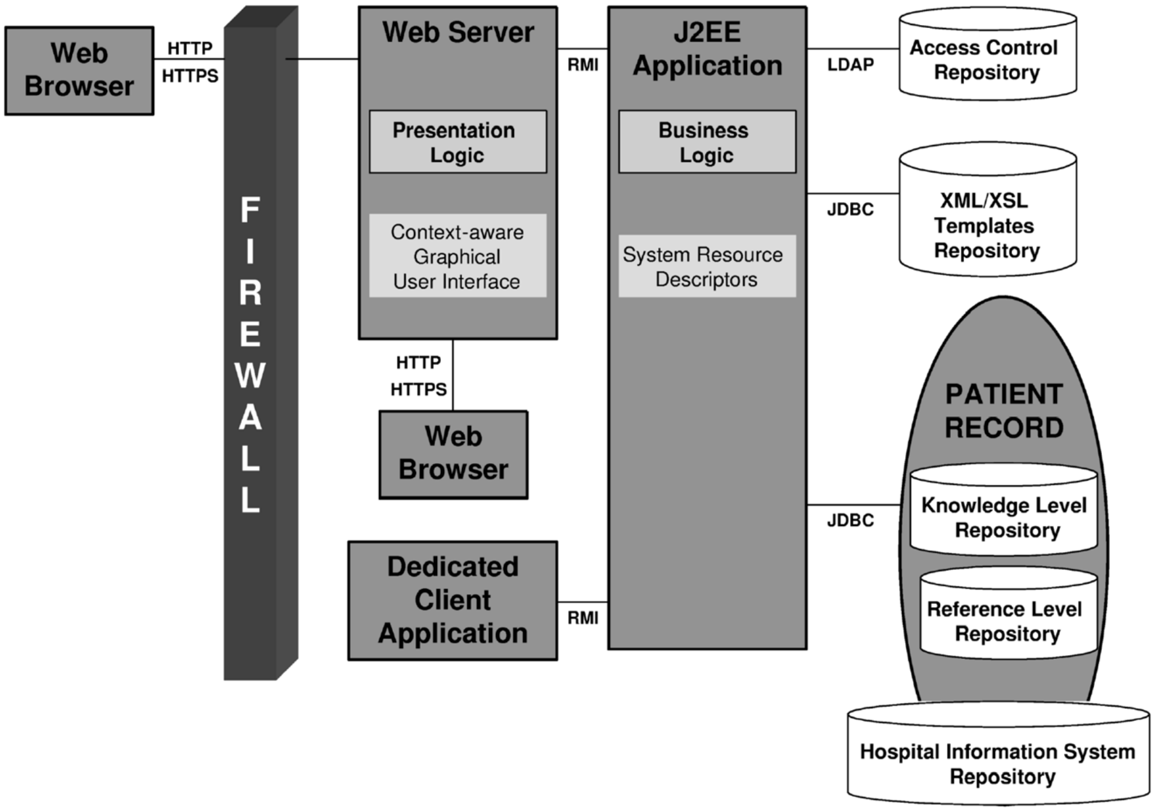

Fig. 3. ARTHUR system architecture.

while another professional would not group the two concepts together. The problem of structuring clinical data is even more severe when we consider that, in the health-care domain, there are thousands of constantly changing concepts. For example, clinical terminologies such as SNOMED [10] and UMLS [11] each code thousands of atomic concepts and over a million relationships. Not all these concepts and relationships are volatile. But, according to Rector [12], not only is the medical domain huge, it is open-ended in breadth (more and more information is constantly being acquired), in depth (more and more finer-grained detail), and in complexity (more and more relationships).

To tackle clinical domain data representation and organization issues, we used a two-level software modeling methodology [13]. Such a methodology overcomes the problem of finding a unified representation of concepts and that of constantly changing concept representation. The first level of the methodology is a reference model made of nonvolatile concepts, and its second level provides knowledge-level concept definitions (volatile and domain dependent), which help to specify the valid information structures of the reference model. Using this methodology, systems can be built from reference models only, and dynamically driven at runtime by knowledge models constructed by system users.

One of the challenges in devising a two-level methodology is knowing how to structure the models at each level. The structuring adopted in our project is inspired by the one proposed in the *open*EHR project [14]. The *open*EHR project has its roots in the European Good Electronic Health Record (GEHR) project in the early 1990s and the more recent Australian-developed extension of GEHR. The *open*EHR community has been working on the design of a framework for structuring, storing, and managing patient data in such a way that the volatility of medical domain concepts does not affect the system's stability.

C. System Architecture

An n-tier J2EE architecture [15] (Java 2 Platform, Enterprise Edition) was chosen for this project. J2EE is a collection of multiple server-side technologies that together form the basis of powerful enterprise applications. Fig. 3 represents the overall architecture of the ARTHUR system. The n-tier J2EE architecture decouples the user interface tier, the application logic tier, and the data management tier.

Light clients only need to run a web browser to access the system. Dedicated clients provide the high interactivity needed in some information processing tasks. For both light clients and dedicated clients, user interfaces are displayed based on extensible stylesheet language (XSL) [16] templates available in our repository along with extensible markup language (XML) [17] representations of patient data. The use of XSL technologies provides users with a dynamic environment that is able to produce role- and context-specific user interfaces. For example, as nurses and doctors require personalized views of the same patient data, a software component running on the web server generates GUIs adapted to the device and the user. The component actually exploits the context information from the request to detect the resource that is able to fulfil the request. It then uses this resource to generate the web page to be delivered by applying XSL transformation (XSLT) [18] to the patient data stored in

XML. A similar mechanism produces XSL-FO (formatting objects) [19] representations that can be rendered on paper for report printing.

The web and the application servers jointly implement the application logic tier, which is the central coordinating part that receives the requests, accesses the databases, and dispatches the results. Basing the application server on J2EE technologies enables better management of the overall architecture because J2EE provides containers, which free the developers from some low level configuration and data transaction management tasks. Examples of J2EE containers are JDBC (Java Data Base Connectivity), RMI (Remote Method Invocator), JNDI (Java Naming and Directory Interface), servlets, EJB (Enterprise Java Beans), and JAAS (Java Authentication and Authorization Service). Our software components are deployed over these containers.

The data management tier represents the database management systems for handling the patient records, XML/XSL templates for GUIs, and a directory of user credentials. For access control, we opted for the use of lightweight directory access protocol [20], which enables the reuse and synchronization of staff credentials with those of the HIS.

D. System Implementation

By applying a two-level software modeling methodology, we achieved flexibility and future-proof implementation at each tier of our architecture. Database and application objects depend only on nonvolatile concepts from the reference-model. As indicated when discussing the two-level modeling approach, our implementation builds on the *open*EHR reference model [21].

As an example of implementation of the two-level modeling approach, we consider the ability our system provides users to dynamically define groups of clinical tests and medications to be employed in prescriptions. We will now explain the implementation of these dynamic groups (termed "*profiles*") at each tier of our architecture.

1) Databases: The unified modeling language (UML) diagram [22] in Fig. 4 illustrates the segment of our reference model that is directly translated into database and business entities.

Fig. 4 is a meta-model that does not make use of any particular structure for clinical test or medication. It states that a *profile* can be made of two or more *components* (clinical tests, medications, etc.) and that a *component* can be used in any number of *profiles*.

The "value[1]:COMPOUND" attribute of **COMPONENT** class is the generic part of the model. It enables domain specialists to specify structures for clinical tests, medications, or any other concept. The COMPOUND/ELEMENT composite pattern from the *open*EHR framework is a simple node/arc structure, which allows any logical structure to be encoded. The "type[1]:TEXT" attribute (of **PROFILE** class, for example) is a generic attribute that enables objects to be named according to what they really are (e.g., a diagnostic hypothesis) rather than being understood only by reference to the class name. The LOCATABLE interface from the *open*EHR framework has been added to ensure that every object in an instance network has a meaning and a name

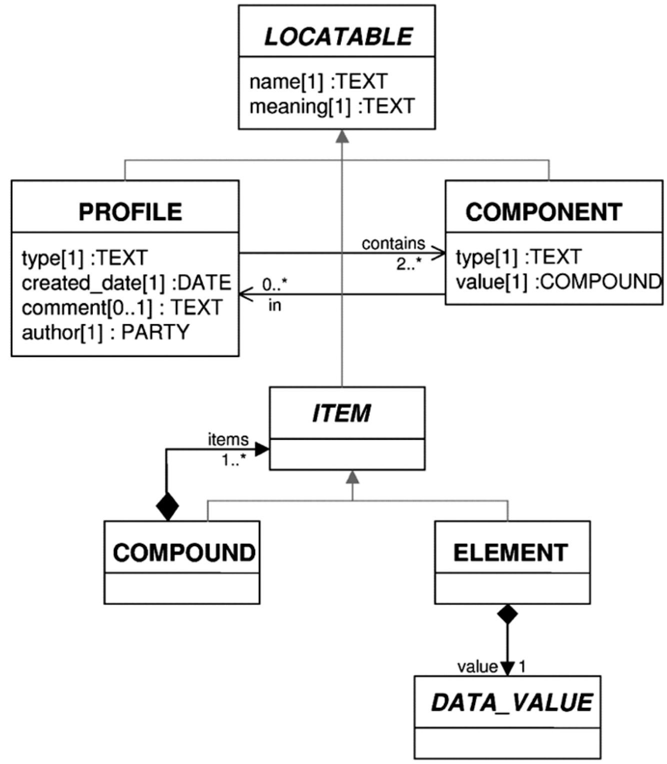

Fig. 4. Reference model fragment.

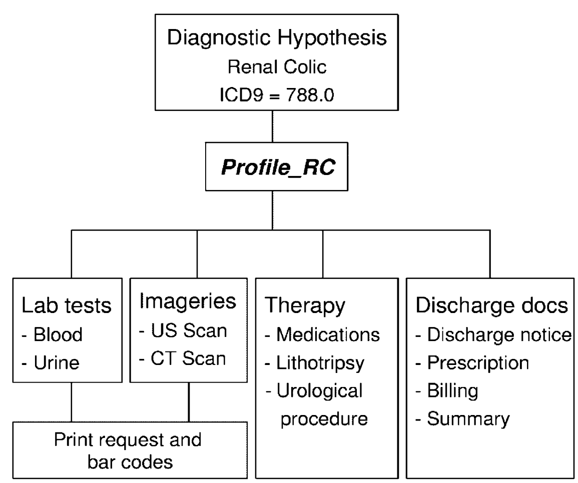

Fig. 5. Clinical protocol.

making it locatable by URL-style path. The DATA_VALUE interface from the *open*EHR framework has numerous subtypes such as TEXT, QUANTITY, DATE, and TIME.

The particular structure (of examinations and medications) that users may want to put into a *profile* is a matter of domain knowledge. By means of a dedicated application implementing XML-schemas [23], domain specialists can create knowledge-level structures and store them in the appropriate data repository.

2) Web and Application Servers: Web and application servers, respectively, hold the presentation and the business logics of the application. Whenever users create a profile to group clinical tests or medications, the business logic instantiates and processes business entities to validate this profile

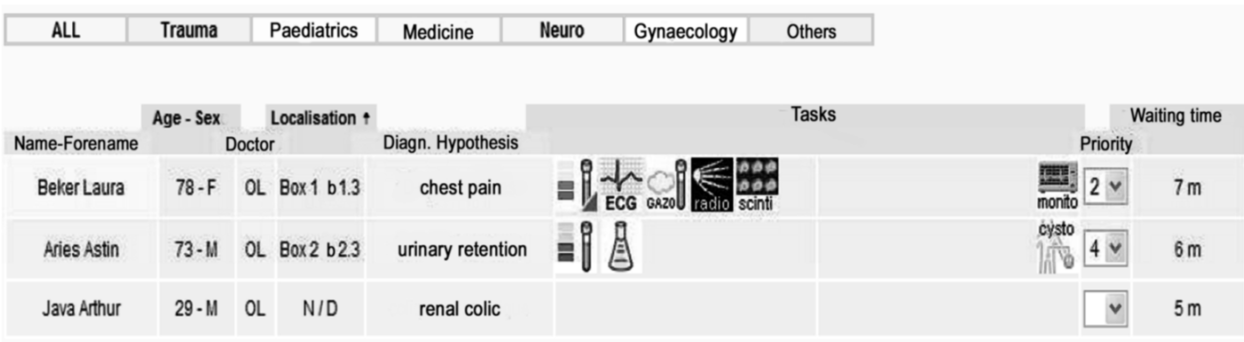

Fig. 6. Whiteboard on wall display.

against the appropriate knowledge model before storing it in the data repository. This new profile will then be available to be used in appropriate functionalities.

3) Clients: We provide JAVA client applications to support indirect patient care activities such as dynamic manipulation of profiles and other knowledge level data. Functionalities that are grouped as real-time management of the department are accessible via web-browsers.

VI. Results

The presentation of our results is based on a hypothetical case study of the use of our system. This scenario models a patient who arrives at the emergency service with renal colic. For the purposes of this scenario, before the patient arrives, an authorized user has defined a clinical protocol called *Profile_RC* (Fig. 5), using the dedicated application provided by the system.

As soon as the patient arrives and has completed the admittance step, a new line is automatically added to the wall display (Fig. 6). Whenever the patient is moved inside the emergency service, nurses can update this information via the interactive version of the whiteboard using a desktop, tablet, or pocket PC. The change is automatically reflected on the wall display.

At the bedside of the patient, nurses use their pocket PC (Fig. 7) to access the system in order to introduce the patient's vital parameters and pain score. They can then modify the priority of the patient on the whiteboard. Nurses come back regularly to the bedside to ask for a new pain score and update the patient's record so that caregivers can monitor the evolution of the patient's pathology during the visit.

Since the doctor has to handle more information while examining the patient, he or she uses a tablet PC, rather than a pocket PC, at the patient's bedside to introduce the necessary information such as complete anamnesis, clinical examination, etc., into the system. The doctor also introduces the diagnostic hypothesis of renal colic. At this point, the system is able to suggest the tests and therapeutic procedures specified in the *Profile_RC*. Once the doctor has made the relevant choices, the system generates all the tasks to be done, updates the wall display (Fig. 8), and prints the requests.

By glancing at the wall display, nurses can see all the tasks needing to be done for this patient. When a nurse takes on a task (blood, urine, intravenous line, etc.), he or she updates the task status via the interactive version of the whiteboard (using a pocket PC) and this change is automatically shown on the wall display. The nurse then completes the task by sending the blood or urine samples to the laboratory.

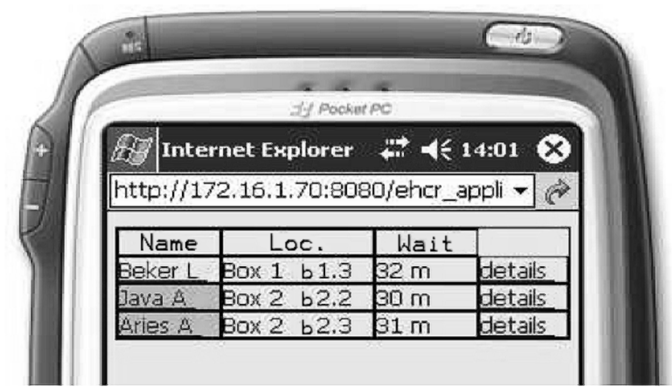

Fig. 7. Whiteboard on pocket PC.

The doctor collects the laboratory test results, analyzes them, and either confirms the pathology of renal colic or proposes another diagnostic hypothesis and requests further tests as proposed by the system. When the diagnosis is confirmed, the doctor makes use of the profile to refine the therapy.

At the discharge step, the system can generate a discharge letter for the general practitioner. Drugs administrated and technical procedures associated with the therapy are automatically charged by the system.

The results of the ARTHUR research activity are currently being further developed and exploited by a commercial organization (Polymedis S.A., Mons, Belgium).

VII. Discussion

The first initiative in this development was to replace character-based legacy interfaces with pragmatic well-established symbols and icons, which are widely recognized in clinical situations and contexts. Clinical safety and quality assurance will certainly be enhanced by this new clinical information system, mainly through avoiding differences of clinical interpretation. All the icons used are symbolically clear, whether referring to the instructions to schedule a test or to undertake a clinical procedure on the patient.

The system enables tasks relating to individual clinical staff to be recorded and monitored, thereby enhancing patient safety through improved communication. It should be remembered

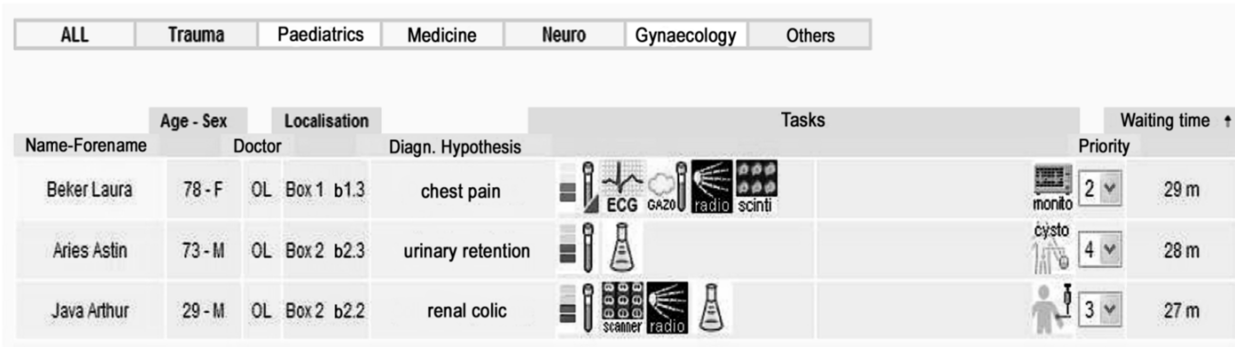

Fig. 8. Updated whiteboard on wall display.

that this level of information is available on all the devices (wall display, desktops, tablet and pocket PCs) providing a seamless interaction throughout the whole department. This has huge benefits for helping trainee clinical staff to become more proficient.

Another important characteristic of this clinical information system lies in the architectural mechanisms, which make it unnecessary to shut the system down for reconfiguration and means that skilled information technology technicians are no longer needed to perform this task. This is a significant practical and clinical advantage for emergency department personnel as our clinical collaborators have confirmed.

Efficient interoperability with other departments (e.g., the analysis laboratory) will increase the benefits of the system. Users could define profiles that instruct the system to automatically send requests for analysis to the laboratory and check for the availability of the results. This information could then appear on the whiteboard.

Due to the lack of documentation on the architectural details of available solutions, it is difficult to provide a balanced perspective on the proposed system. Our approach, however, could have some drawbacks, which partly depend on the existing computerized support, namely the database system and networking. Activity reporting may not be efficient as the implementation of versatile medical domain representation is optimized for the real-time management of the department. A web-based clinical information system heavily relies on the availability of the hospital networking system. Alternative temporary solutions such as paper-based support have to be guaranteed in case of networking failures. Web-based solutions allow for improved data access for patient data management throughout the emergency service, but do not support sophisticated interaction functionalities. These need to be implemented as dedicated applications.

VIII. Future Work

The short-term plan for future activities aims to consolidate the results achieved so far. The current prototype will be evaluated and validated in two Belgian hospitals (one is among the largest hospitals in Brussels and the other is a university-affiliated hospital).

The evaluation will be done in a variety of ways to verify the goal accomplishment. Improved information access will be assessed in usability studies [24] reporting subjective measures such as user satisfaction. Metrics for the quality of care and efficiency of processes will measure errors in drug and test prescriptions, average patient waiting time, the elapsed time before patient intake and the overall time taken to set up medical records for a patient encounter. Concerning revenue enhancement, the quantity of charge captures for treatments and medications will be compared to the old system by means of a scoring system. The evaluation will study the system performance when replacing paper-based and existing computerized medical records with the ARTHUR platform.

At the same time, the implementation of missing functionalities for emergency health-care delivery will proceed progressively, according to user needs. Priorities are the discharge module and its connection to the HIS, indirect patient care, and resource management functionalities (for automatic billing, reports of treatment and care, support for the emergency drug store, mandatory activity reports and statistics for the public authorities, and tools for procedure personalization), establishing electronic connection with the analysis laboratories, and multilingual versions of the GUIs. The admission module has a lower priority, as this is usually available in the emergency department as a front end to the central HIS.

On a longer-term basis, further research will be conducted to extend the clinical information system to other in-patient areas. The first to be considered is the intensive care unit, which is closely related to the emergency department. One promising field to explore is support for stroke victims, where time is highly significant. The goal is to improve assessment and care of these critically ill patients by structuring and monitoring relevant information (neurological tests, EEGs, images, etc.). Investigations will address how best to employ medical imaging techniques to extract features from the different modalities, and how to abstract useful clinical information (stroke volume, localization, etc.).

IX. Conclusion

This project has proposed a new architecture for managing information in emergency departments. Such architecture is designed to manage information efficiently in a multiactor environment. It makes use of the most recent development in electronic health records, namely the XML-based *open*EHR standard. The system relies on a multitier J2EE application server, leading to standard light clients (web browsers). It is adapted to the most recent devices (wall displays, wireless personal digital assistants). A methodology allowing GUIs and medical domain concepts to be specifically adapted is developed. This makes the system a user-friendly and context-aware information system easy to modify for specific medical practices, which vary greatly from one emergency department to another.

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