Testmed. Process management in emergency medicine

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Summary

Background: the main problem in emergency medicine is that clinical assessment and treatment decisions are complex activities. Moreover, clinicians operate in a culture of personal responsibility for decisions, by making it difficult to accept automated systems as the primary decision route. In this paper we present the initial outcomes of the TESTMED project, which aims at developing a process-aware system where the emphasis relies on assisting the clinicians through the availability of recommended healthcare pathways, together with the provision of relevant information that reduces the risk arising from a personal decision. The TESTMED project aims at finding an effective way for the clinicians to exploit the guidelines and to acquire, by reading or listening, the guideline itself and to make effective use of it. Moreover TESTMED prototype is able to trace and monitor every choice originated during the guideline execution. Methods: the doctor in charge of handling an incoming patient is equipped with a tablet PC. According to a patient-centered clinical approach, the care pathway is selected on a per-case basis from a dedicated repository and loaded into the backend management system to be executed. The user interface relies on an integrated multitouch and speech recognition/generation framework, able to handle both touch and vocal inputs, and to support device-to-human interaction via text-to-speech capabilities. The first tests concerned the guideline enacted for patients suffering from chest pain. Leveraging the encouraging results of our initial tests, we plan to perform in the next months an extensive system evaluation and validation. This will require the enactment of additional guidelines, as well as the collection of both quantitative and qualitative data for assessing the real impact on clinical work practices.

Results: we produced two mockups of the system (in the months of April and September 2011) and a working prototype in late November 2011. Each mockup/prototype was evaluated throughout a wide range of usability tests made with real clinicians, and the outcomes used for an incremental improvement of the system. Concerning the current version of the TESTMED prototype, we performed a test in the ward of DEA with 7 different users and with the Chest Pain procedure loaded into the system.

Discussion and Conclusions: we can argue that so far main research activities have focused on supporting guidelines modeling and process management in static and well defined clinical contexts. Specific research activities have been carried out in the context of emergency wards and first aid environments. Preliminary evaluation results show a good degree of acceptance among medical staff members, and performance results confirm the feasibility and potential applicability of multimodal interfaces. The rest of the project will be devoted to the engineering of the prototype and to an extensive validation process.

KEY WORDS: emergency medicine, process management, TESTMED prototype, guideline.

Background

Emergency medicine underwent a significant transformation caused by the industrialization process, consisting in new styles of life, the increase of road traffic and especially in the growth of cardio-vascular pathology, typical of the affluent society. We all think about emergency as something quite unexpected – therefore, it seems contradictory to speak about emergency planning. In reality, the only unpredictable thing is the exact time when the emergency may occur, although recent epidemiological data can show us how to calculate the incidence of emergencies. If we consider medical emergencies in terms of a complex system, we can succeed in implementing adequate tools to cope with several critical situations.
Medical emergency planning is primarily depending upon the implementation of efficiently organized regional health care networks operated through Emergency Departments, evenly distributed throughout the area, closely interconnected and with strong ties within the community.

Emergency Units often represent the gateway to the hospital, a check-in and filter-zone before hospitalization, connected with all the inner units and in close contact with its territory. They must be prepared to arrange and follow up on patients’ transfers to different units by timely providing critical information on the pathology in order to help reduce therapy-free intervals, thus improving chances of life-saving and faster recovery. Staff at Emergency Units must be able to monitor patients affected by acute pathologies.

Nowadays, the main problem is that clinical assessment and treatment decisions are complex activities, and many complicating circumstances – often not easily predictable in advance – may arise. Currently, Business Process Management (BPM, also referred to as workflow automation) capabilities, driven through pre-specified and automated rules sets, have addressed only some parts of the lower-level administrative processes (electronic ordering, appointment making); but have made little progress into the core clinical activities. Moreover, clinicians operate in a culture of personal responsibility for decisions, by making it difficult to accept automated systems as the primary decision route.

In this paper we present the initial outcomes of the TESTMED\(^1\) project (1), whose purpose is to reduce the gap between the fully automated solutions provided by the BPM community and the clear difficulties of applying a traditional process management approach in the healthcare context; it has developed a process-aware system where the emphasis relies on assisting the clinicians through the availability of recommended healthcare pathways, together with the provision of relevant information (such as the impact of certain medications, contraindications, etc.) that reduce the risk arising from a personal decision. Care pathways are presented in the form of “best practices” (or clinical “guidelines”) and provide clinicians with appropriate knowledge to enact the medical treatments.

TESTMED aims, on one side, at finding an effective way for the clinicians to exploit the guidelines, i.e., to acquire, by reading or listening, the guideline and to make effective use of it. We believe that the adoption of mobile devices with specific user interfaces (which do not distract the clinician from assisting the patient) can be a valuable solution. We have investigated the integration of voice and touch interfaces with interesting results that will be shown in the following. On the other side, the TESTMED prototype is able to trace and monitor every choice originated during the guideline execution. The TESTMED prototype has been jointly developed and evaluated with the Emergency Department (DEA) of Polyclinico Umberto I – the main hospital in Rome (Italy). The first tests have concerned the guideline enacted for patients suffering from chest pain\(^2\). Leveraging the encouraging results of our initial tests, we plan to perform in the next months an extensive system evaluation and validation. This will require the enactment of additional guidelines, as well as the collection of both quantitative and qualitative data for assessing the real impact on clinical work practices.

### Methods

The doctor in charge of handling an incoming patient is equipped with a tablet PC that enables the clinician to select, instantiate and carry out the specific care pathway to be followed. According to a patient-centered clinical approach, the care pathway is selected on a per-case basis from a dedicated repository and loaded into the back-end management system to be executed. Client components deployed on the tablet device provide support for both multitouch and speech-based interaction modalities. In particular, the user interface relies on an integrated multitouch and speech recognition/generation framework, able to handle both touch and vocal inputs, and to support device-to-human interaction via text-to-speech capabilities. The interaction between client and back-end components is supported by communication and notification services. According to a service-oriented approach, all system components are abstracted as service endpoints and interact through message-based service invocations. In addition, event-based notification services provide support for asynchronous communication patterns, required to enable the routing of events produced during the execution of a care pathway. This allows the clinician to receive reminders, alerts and notifications when the status of an active process changes, new information is available, or additional actions are required.

Similarly, all members of the medical staff (other clinicians, nurses, etc.) are equipped with mobile devices and are notified of the progress of the care processes and of the different activities to be executed.

Care pathways are executed and managed by back-end system components, which provide the run-time environment for interpreting, instantiating and activating a care pathway specification. The execution of clinical guidelines is supported by properly routing data, events and activities, according to a process-aware and content-based approach where activity scheduling and message dispatching are data/event-driven. Specifically, the interaction between all involved components and services is managed by a routing engine that manages the routing of clinical activities, relevant data and generated events among the different actors, services and information systems (Fig. 1).

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\(^1\) The acronym TESTMED stands for “meTodiche e Tecniche per la gestione dei processi nella Medicina D’urgenza” (in English, methods and techniques for process management in emergency healthcare).

\(^2\) Chest pain is defined as a pain that ranges from the base of the nose and navel and between the neck and the twelfth vertebra and that has no clearly identifiable traumatic cause, which is one of the most common reasons for the admission to the emergency room (5% of all visits) with high mortality in case of misdiagnosis and improper dismissal (2-4%) (2).
The routing engine relies on a scheduling component for the timely execution of activities with temporal constraints (e.g. examinations and diagnostic laboratory tests that have to be scheduled and performed within specific time intervals), and interacts with the enterprise Electronic Medical Record (EMR) system to (i) access and retrieve clinical and administrative patient data (Fig. 2), (ii) schedule and manage examinations, lab tests, drug prescriptions, etc. according to the clinical process (Fig. 3), and (iii) receive events and notifications about test results and examination findings to be routed and delivered to the clinicians (Fig. 4).

The interoperability with the EMR system is achieved exploiting the Health Level 7. In this context, doctors and nurses need to collaborate in order to enact the proper medical treatments for each patient. The use of mobile devices and applications is valuable for the improvement of collaboration and coordination amongst clinicians, but there are also risks in their usage; for example, most of the care activities could be highly critical and time demanding, and the challenge concerns in developing a user interface that captures the users' attention onto the system only when it is strictly required. The development of specific interaction principles has required the use of user-centered design (UCD) techniques during the life cycle of the TESTMED project. Such methodologies rely on a continuous involvement of users in each phase of the project, by guaranteeing that the final system may meet the user expectations.

Results
To be more specific, we produced two mockups of the system (in the months of April and September 2011) and a working prototype in late November 2011. Each mockup/prototype has been evaluated throughout a wide range of usability tests (controlled experiments, thinking aloud techniques, etc.) made with real clinicians, and the outcomes have been used for an incremental improvement of the system. For example, despite users appreciated the touch interface provided in the first mockup, they asked for an interaction with the system still less invasive. To match such a request, the vocal interface (which can be used in addition to the touch interface) has been introduced in the second mockup and definitively improved in the first working prototype. Concerning the current version of the TESTMED prototype, we performed a test in the ward of DEA with 7 different users (specifically, 3 clinicians, 2 PhD student in medi-
Figure 2 - Access and retrieve clinical and administrative patient data.

Figure 3 - Schedule and manage examinations.
cineme and 3 experts in Information Technology) and with the Chest Pain procedure loaded into the system. We also collected user opinions through a survey, and in general the feasibility of the twofold interaction and the idea to coordinate medical treatments through a workflow engine have been accepted and deemed usable. We would like to mention that, as a consequence of the introduction by the medical community of evidence-based clinical guidelines to support decision processes, many research groups have focused on computer-interpretable clinical guidelines (CIGs) and different languages have been proposed (3). All languages define a computer-interpretable representation of clinical guidelines and most of them follow a task-based paradigm where modeling primitives for representing actions, decisions and patient states are linked via scheduling and temporal constraints, often in a flowchart-like structure. Many representation models are supported by systems that allow the definition and enactment of clinical guidelines. Supporting systems are based on distributed architectural models that include a guideline modeling editor, a model repository and a run-time execution engine, as well as tools and services to access electronic medical records (EMRs). Similarly, the introduction in healthcare of workflow-based models and technologies has fostered the development of so-called Careflow Management Systems (CfMSs) that aim at providing an integrated solution for supporting both administrative and medical processes. The NewGuide system (4), for example, relies on a Petri Nets based formalism for modeling guidelines and implements a distributed architecture for integrating a Guideline Management System (GMS), an Electronic Patient Record (EPR) and a CfMS.

Discussion

We can argue that so far main research activities have focused on supporting guidelines modeling and process management in static and well defined clinical contexts. Specific research activities have been carried out in the context of emergency wards and first aid environments. According to reported results about the procedures, interaction patterns and supporting systems, the main causes of delays, inefficiencies and medical errors can be ascribed to the lack of proper interaction between the
medical staff and the IT systems, which are, in turn, loosely integrated in healthcare workflows, leading to duplicated or suboptimal task allocation policies. In emergency departments, which today represent the main access point for citizens to healthcare services, the medical staff operates under stress conditions in a rapidly evolving environment. Our work and initial effort can be broadly positioned in this context, where the introduction of a process-aware system can lead to significant benefits for both patients and clinicians, allowing to identify and analyze the sources of errors, delays and complexity (which may often go undetected) in order to improve the overall performance.

Conclusion

In this paper we have presented the initial outcomes of the TESTMED project, aiming at studying and developing a system supporting clinicians during their daily activities in hospital wards, through the interplay of advanced user interfaces (i.e., mixing touch and vocal features) on mobile devices and the enactment and tracing of clinical guidelines. The system prototype has been evaluated in clinical settings through the chest pain diagnostic and treatment process. Preliminary evaluation results show a good degree of acceptance among medical staff members, and performance results confirm the feasibility and potential applicability of multimodal interfaces. Starting from our initial results, the rest of the project will be devoted to the engineering of the prototype and to an extensive validation process. By providing support for additional guidelines, our evaluation plan includes the collection of quantitative and qualitative indicators that in the long run will enable a deeper understanding of how the overall clinical decision making and collaboration process is impacted.

References