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Supporting a distributed execution of clinical guidelines

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ABSTRACT

Clinical guidelines (GL) play an important role in medical practice: the one of optimizing the quality of patient care on the basis of evidence based medicine. In order to achieve this goal, the interaction between different agents, who cooperate in the execution of the same GL, is a crucial issue. As a matter of fact, in many cases (e.g. in chronic disorders) the GL execution requires that patient treatment is not performed/completed in the hospital, but is continued in different contexts (e.g. at home, or in the general practitioner's ambulatory), under the responsibility of different agents. In this situation, the correct interaction and communication between the agents themselves is critical for the quality of care, and human resources coordination is a key issue to be addressed by the managers of the involved healthcare services. In this paper we describe how GLARE (Guideline Acquisition, Representation, and Execution), a computerized GL management system, has been extended in order to support such a need. In particular, we have provided: (i) an extension to GL actions representation languages, (ii) proper scheduling and (iii) querying services. By means of these enhancements we aimed at guaranteeing (1) treatment continuity and (2) responsibility assignment support in the various steps of a coordinated and distributed patient care process. We illustrate our approach by means of a practical case study.

1. Introduction

Clinical guidelines (GLs) are defined as "systematically developed statements to assist practitioner and patient decisions about appropriate healthcare under specific clinical circumstances" [1]. GLs exploitation is meant to improve the quality and to reduce the cost of healthcare, putting evidence based medicine into practice, and is progressively spreading in several countries. As a matter of fact, a lot of national and international medical institutions have recently been engaged in developing and disseminating GLs. Moreover, the medical community has started to recognize that a computer-based management can further increase GL advantages, providing relevant benefits (e.g. automatic connection to the patient databases and decision making support) to care providers and patients.

Many different systems and projects have been developed to this end (see e.g. [2–5]). Such systems usually provide facilities to acquire, represent and/or execute clinical GLs, and are mainly devoted to support physicians in patient care. Different forms of support may be provided. Simulation facilities (such as, e.g. GLARE's "what if" facility [6]) can be useful for planning purposes; *on-line* execution facilities support action selection and execution; *off-line* a-posteriori execution can be used for external evaluation or auto-evaluation. Noteworthy, though some GL systems provide decision facilities (e.g. applying decision theory to the medical context [7]), in

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all cases these systems do not aim at substituting physicians, in the sense that, although physicians may take into account the suggestions of a system, the final decision is always left to physicians themselves. Specifically, physicians retain the full responsibility of choosing the proper actions for the patients, and of executing them. Of course, delegation of actions (still retaining the responsibility) is also possible, as well as referring patients to other agents (e.g. to specialists, nurses).

While some GLs are specifically related to an execution context (e.g. they have to be entirely executed in an hospital), others, mainly dealing with chronic disorders, require that patient treatment is not completely performed in a single location, but is continued in time, often in a life-long perspective, and distributed in *different contexts* (e.g. at home, or in the general practitioner's ambulatory), under the responsibility of *different agents* (not only physicians). In this situation, the *correct interaction and communication* between the involved agents is critical for the quality of care, and *human resources coordination* is a key issue to be addressed by the managers of the involved healthcare services. None of the available computerized systems for GL management explicitly addresses these needs, and interaction is nowadays completely left to the different agents. Sometimes the responsibility notification is even left to the patient, without a check of communication completeness and correctness. For instance, after an hospital discharge, the general practitioner is not directly notified by the hospital physician about the need for the patient's follow up.

In this work, we propose an extension of a computerized GL management tool to deal with these needs. In particular, we first introduce an extension of the GL representation formalism with new dimensions, meant to *color* (i.e. to further detail) the GL actions with *context, role* and *competence* information. Then, we describe how human resources coordination and human interaction and communication can be supported through notification and query answering services. The querying facility, in particular, can help both *on-line* and *off-line* GL execution. A practical implementation of this work is represented by an extension of GLARE, a domain-independent system for GL acquisition and execution [8]. Resorting to the GLARE formalism, we will illustrate the application of our approach to the "Management of harmful drinking and alcohol dependence in primary care" GL developed by the Scottish Intercollegiate Guidelines Network (SIGN) [9], which we have adapted to the Italian context. However, although we have implemented our approach in GLARE, it is worth stressing that the methodology we propose is completely general and application-independent.

The paper is structured as follows: in Section 2 we describe the main features of GLARE. In Section 3 we introduce the extension to the basic GL representation formalism required to deal with distributed GL execution support. In Sections 4 and 5 we describe the scheduling and the query answering services respectively. In Section 6 we exemplify a practical application of our approach considering the treatment of alcohol-related disorders. Finally in the Section 7 we address some comparisons and concluding remarks.

2. GLARE

GLARE is a domain-independent system for acquisition and execution of GLs [8], which we are developing since 1997, in collaboration with the physicians of Azienda Ospedaliera San Giovanni Battista in Torino, Italy. In the years, GLARE's core architecture (see Section 2.2) and functionalities have been progressively extended, exploiting advanced Artificial Intelligence (AI) techniques [8], such as temporal reasoning [10], model-based verification [11], decision support based on decision theory [7], and semi-automatic contextualization [12].

In this section, we present the main elements of GLARE (i.e. the representation formalism, and the core architecture), which are needed in order to describe how we cope with distributed GL execution support in GLARE. Some details about more advanced features (namely temporal reasoning) will be provided in Section 4.

2.1. *Representation formalism*

In GLARE, a GL is represented as a hierarchical graph, where nodes represent the actions to be executed, and arcs are the control relations linking them.

GLARE relies on a limited but clear representation formalism [13], in which the basic primitives are *atomic* and *composite actions* (*plans*). Atomic actions are used to model elementary steps in a GL, while composite actions represent more complex procedures, which can be defined in terms of their components via the *part-of* relation. A GL itself is a composite action, which can be progressively refined by following the part-of chain, until atomic actions are reached. Three main types of atomic actions have been introduced in GLARE: *work actions, query actions*, and *decisions*. *Work actions* represent operative steps which must be executed at a given point of the GL. *Query actions* are requests of information from the outside world (physicians, databases, knowledge bases). *Decision actions* are the means for selecting among alternative paths. Decision actions can be further subdivided into *diagnostic* decisions, used to make explicit the identification of the disease the patient is suffering from, and *therapeutic* decisions, used to represent the choice of a path, containing the implementation of a particular therapeutic process. Actions are described in terms of their attributes.

The order of execution of actions is established by means of a set of *control relations*: *sequence, constrained, alternative* and *repetition*. In particular, repetitions state that an action has to be repeated several times (maybe a number of times which is not known a priori, until a certain exit condition becomes true). On the other hand, *control* relations are used in order to represent temporally constrained actions, such as "start of A at least 1 h after the beginning of B", and so on. (Possibly imprecise) action durations and temporal delays between actions can be specified, as well as complex temporal constraints, as discussed in Section 4.1.

2.2. *GLARE's architecture*

The general architecture of the kernel of GLARE is graphically shown in Fig. 1.