

Supporting Collaboration and Information Sharing in Computer-Based Clinical Guideline Management

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Abstract

Collaboration and information sharing for facilitating patient and clinician mobility is important to consider in supporting computer-based clinical guidelines and protocols. This paper presents part of ongoing work to develop a generic approach to supporting information sharing and collaboration in computer-based clinical guideline management. A framework for guideline management is presented with enhancements for supporting collaboration and information sharing. The generic approach combines the active rule paradigm and XML technologies to create the basis for supporting collaboration and sharing in a distributed healthcare environment.

1 Introduction

Healthcare information systems are noted to be highly heterogeneous, widely distributed and fragmented into many islands of strong local autonomy. This is in contradiction to the *modus operandi* of the patient care practice environment, which is highly collaborative and demands information sharing [1]. As a result of patient and clinician mobility, the medical record needs to be exchanged and shared among healthcare locations or institutions. Furthermore, the occurrence of co-morbidities, e.g., in diabetes management, means that a single patient undergoes concurrent care processes possibly spanning several healthcare institutions. In computer-supported guideline-based patient care, Clinical Guidelines or Protocols (CGPs) are formally specified and used to create instances of patient care processes. Clinical guidelines are "a set of systematically developed statements to assist the medical practitioner and the patient in making decisions about appropriate healthcare for specific clinical circumstances." [5]. A clinical protocol is a more detailed clinical guideline [13]. The major challenge is to provide support for information sharing and collaboration in the computerised guideline-based patient care process. This paper presents an extended framework and its architecture for computer-based CGPs management with support for information sharing and collaboration. The approach taken here is unique in its provision for the dimensions of collaboration and information sharing to computer-based CGP management. The rest of this paper is organized as follows: Section 2 presents related work; Section 3 presents the SpEM framework that we developed for the management of computerised CGPs; Section 4 presents the sharing and collaboration support extensions to the SpEM framework; Section 5 presents a conceptual architecture for realising the extended SpEM framework; and Section 6 presents a brief discussion before concluding this paper.

2 Related Work

To support collaboration and information sharing, distributed support is required for sharing and access to facilities for the manipulation, querying and visualisation of the clinical guideline information as well as the associated electronic patient record and clinical workflow. Research on computer-based CGPs has, hitherto, focused on supporting mainly the specification and execution of the CGPs [6, 17]. Most efforts in supporting information sharing in guideline management approaches have been concentrating on making the formal CGP specification sharable across healthcare institutions [7, 3]. The problem of sharing CGP specifications has been dealt with in literature [15, 16]. However, these works did not consider the specification and the execution of CGPs within a computer-supported collaborative environment. Furthermore, the means for sharing knowledge and information in patient care practice continues to be based mainly on paper-based methods. Thus, patient information continues to be shared between collaborating clinicians primarily through referral and clinical notes. However, significant research efforts have been expended into supporting the sharing of electronic patient records among healthcare institutions [9, 8]. Little effort has so far been expended in supporting information manipulation, sharing and collaboration with respect to the key aspects of guideline management.

3 SpEM: A Framework for the Management of Computer-Based Clinical Guidelines and Protocols

Figure 1 illustrates the SpEM framework developed for supporting the management of clinical guidelines and protocols. The framework is presented in terms of the planes for managing CGP knowledge and information [4]. The *specification plane* provides the methods and tools that allow

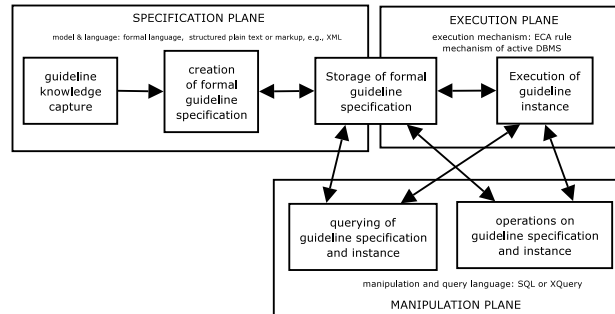


Figure 1. The SpEM framework for supporting clinical guideline management

guideline knowledge to be captured, formally specified and stored for easy access, use and maintenance. To support guideline specification, use is made of the language, PLAN [19], which is a declarative language that follows the event-condition-action (ECA) rule paradigm [18]. The *execution plane* provides methods and tools for facilitating the creation and execution of patient-specific guideline instances from the generic formal specifications in the guideline database. Support for guideline execution is provided through an execution engine that is based on the trigger mechanism of a modern DBMS. The *manipulation plane* provides the facilities for querying and operating on guideline information. The manipulation of guideline information is achieved by using a high-level query and manipulation language that is based on the SQL. This paper is part of work that seeks to

address the inadequacies of our proof-of-concepts system in supporting the collaborative healthcare environment due to the limitations of the client-server paradigm [1].

4 Supporting Collaboration and Information Sharing: Extending the SpEM Framework

Figure 2 illustrates the extension layer that has been introduced into the SpEM framework as a foundation for supporting information sharing and collaboration. As can be seen in Figure 2, the enabling technology layer forms the base on which collaboration feature support is built by using active database and XML technologies. Due to space limitations, the next discussion focuses only on the collaboration features as an extension to the SpEM framework.

The following six features are necessary in order to provide a strong foundation for facilitating

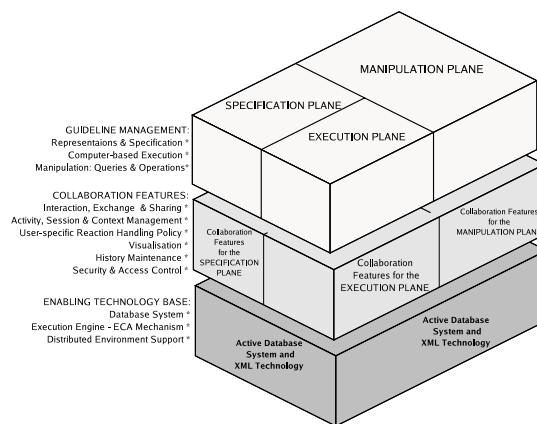


Figure 2. The extended SpEM framework: supporting collaboration and information sharing.

collaboration and information sharing within each of the three planes of the SpEM framework:

Interaction - Exchange and Sharing. Collaboration within the SpEM framework demands new interaction requirements. Interaction can be synchronous or asynchronous depending on the urgency of the clinical situation. For instance, during guideline execution in the Execution Plane, joint performance of a surgical procedure on a patient requires synchronous interaction while patient transfer from a general practitioner to specialist requires asynchronous interaction.

Activity, Session and Context Management. Activity management enables clinicians to share activities. Thus, activities are made first class objects that can be accessed and joined by new participants. For instance, in the Specification Plane, the activity of creating a formal guideline specification should be accessible and clinicians should be able to collaborate in it. Session management allows the process of guideline management to have social awareness. It helps clinicians and patients to know with whom and how to initiate a collaboration session. Thus, participants are able to be aware of what others are doing. Context management allows the system to monitor the clinician's working context and to gather context information, which can then be accessible to collaborating clinicians or other applications and can be used to trigger context-related notifications or displays. For example, a relevant part of the electronic patient record can be displayed based on the clinician's current activity.

User-specific reaction handling policy. A policy mechanism for handling user-specific reactions

facilitate the support for collaboration within the SpEM framework. The legal and ethical requirements in patient care practice requires that interactions between the user and the guideline system be dependent on the individual user's role and rights with respect to the patient. There are two types of user-specific reaction handling policy. The *collaborative-transparent policy* treats all interactions in the same way regardless of patient care giver's role. The *collaborative-aware policy*, provides a specific system reaction based on the patient care giver's role and, hence, could be seen as a security or access control policy. The SpEM framework may require a hybrid policy where the collaborative-aware policy is applied in all interactions that involve sensitive patient information and the collaborative-transparent is applied in interactions that do not involve patient information such as creating a generic guideline specification. It should be pointed out that certain interactions that do not involve patient information may still require collaborative-aware policy to be applied. For instance, only specific individuals with the appropriate roles and rights should be exposed to system reactions that are consistent with actions to modify specifications of guidelines that have been passed and authorised for use on patients.

Visualisation. The visualisation feature enables clinicians to see guideline information and data that are used collaboratively depending on user-specific reaction handling policy. For instance, the *what-you-see-is-what-I-see (WYSIWIS)* paradigm may not be appropriate for the collaborative-aware policy of handling user-specific reaction but could be appropriate for viewing generic guideline specifications in the Manipulation Plane.

History maintenance. The maintenance of historical information in computer-based guideline management is necessary for allowing collaborating clinicians to review past situations with respect to guideline specifications in the Specification Plane, the execution of guideline instances in the Execution Plane and manipulation operations in the Manipulation Plane. Reviewing past history is necessary in supporting collaboration because it allows clinicians to track situations and activities taking place during the collaboration process. In the Specification Plane, version management and change propagation are required for protocol specifications. In the Execution Plane, the history of the execution of guideline instances is required. In the Manipulation Plane, a history of all modification operations and together with information of the clinician who performed the operations is required.

Security and access control. Security and access control are important features that allow collaboration among clinicians to take place during the guideline management process without exposing sensitive information to unauthorised individuals. For example, in the Specification Plane security and access control will allow collaborative modification of a guideline specification by authorised personnel without exposing the specification to manipulation by unauthorised persons.

5 Architecture for Supporting the Extended SpEM Framework

Figure 3 illustrates the conceptual architecture for supporting the extended SpEM framework. The architecture consists of the Guideline Management Server, which is accessed by other health-care systems and the Clinical Guideline Users who use the Clinical Guideline Management Client and the Internet or intranet. The functionality of the three planes within the SpEM framework are supported by the active DBMS where guideline specifications are stored, guideline instances are executed by using active rule mechanism and all information is manipulated by using the SQL. XML technologies are used in the architecture as the basis for supporting collaboration and information sharing within the guideline management framework, SpEM. The *active rule extensions* in Figure 3 serve the purpose of extending the host DBMS's ability to support guideline events, condition and

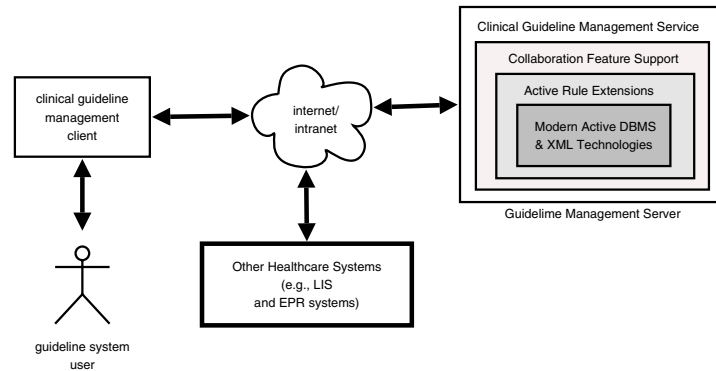


Figure 3. The conceptual architecture for supporting the extended SpEM framework

actions. The support for collaboration features is provided within the architecture in Figure 3 as a layer between the Guideline Managements Services and the ECA Rule Extension layer. This strategic positioning of *collaboration feature support* layer ensures that these collaboration features can be generic enough to be re-used by different applications. The two inner layers of the Guidelines Management Server in Figure 3 serves to provide the implementation infrastructure for collaboration features. Through the *clinical guideline management service*, the three planes of the SpEM framework are presented to *guideline system user* via the *clinical guideline management client* and to other healthcare systems. Thus, the clinical guideline management service will provide tools and facilities to specify, execute, query and perform operation on guidelines.

6 Discussion and Conclusion

Discussion. The Semantic Web, which is based on XML, focuses on structuring the content of the Web into meaningful information and providing machine readability and understandability for the content of the web [2]. Unfortunately, the Semantic Web languages, such as RDF [11] and OWL [12], do not have the ability to express event-based behaviour, which is considered in this paper as the core primitive for guideline support. ECA rule languages for XML have been used to extend the RDF with the ECA rule paradigm as a way to enhance the support for the Semantic Web [14]. Thus, the ECA rule paradigm is a possible future Semantic Web technology [10] that could be used to specify ECA rules that can be shared among different applications over the Internet. The guideline information within each plane in the SpEM framework can therefore be easily shared using XML technologies.

Conclusion. Hitherto, efforts towards supporting computer-based clinical guidelines and protocols have not adequately considered the incorporation of collaboration and sharing as an important dimension within their guideline management frameworks. The SpEM framework presents the problem of clinical guideline management in terms of the three planes for specification, execution and manipulation. This paper has presented an extension of the SpEM framework that actually incorporate features to support collaboration and information sharing within the unified framework. The paper has also presented an architecture for realising the extended SpEM framework by using a modern active DBMS and XML technologies. The implementation of a prototype system that supports the extended SpEM framework is currently on-going in the School of Computing at the Dublin Institute of Technology.

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References

- [1] Jakob E. Bardram and Henrik Brbak Christensen. Supporting pervasive collaboration in healthcare: An activity driven computing infrastructure. Technical Report CfPC-2004-BP-63, University of Aarhus, 2004.
- [2] Tim Berners-Lee, James Hendler, and Ora Lassila. The semantic web. *Scientific American*, 2001.
- [3] P Ciccarese, E Caffi, L Boiocchi, and et al. The newguide project: guidelines, information sharing and learning from exceptions. In M Dojat, E T Keravnou, and P Barahona, editors, *Artificial Intelligence in Medicine, 9th Conference on Artificial Intelligence in Medicine in Europe, AIME 2003*, volume 2780, pages 163–167. Lecture Notes in Computer Science, Springer, Protaras, Cyprus, 2003.
- [4] K. Dube, B. Wu, and J.B. Grimson. Framework and architecture for the management of eca rule-based clinical protocols. In P. Kokol, B. Stiglic, M. Zorman, and D. Zazula, editors, *15th IEEE Symposium on Computer-Based Medical Systems (CBMS 2002)*, pages 288–294, Maribor, Slovenia, 2002. IEEE Computer Society.
- [5] M.J. Field and K.N. Lohr. *Guidelines for Clinical Practice: From Development to Use*. National Academy Press, Washington, DC, 1992.
- [6] J. Fox, N. Johns, A. Rahmzadeh, and R. Thomson. Proforma: a method and language for specifying clinical guidelines and protocols. In *Medical Informatics Europe*, Amsterdam, 1996.
- [7] R.A. Greenes, M. Peleg, A. A. Boxwala, S.W. Tu, V. L. Patel, and E. H. Shortliffe. Sharable computer-based clinical practice guidelines: Rationale, obstacles, approaches, and prospects. In *Medinfo 2001*, pages 201–5, London, UK, 2001.
- [8] W. Grimson, D. Berry, J Grimson, G Stephens, E. Felton, P. Given, and R. O'Moore. Federated healthcare record server - the synapses paradigm. *International Journal of Medical Informatics*, 52:3–27, 1998.
- [9] John D. Halamka, Carsten Osterland, and Charles Safran. Careweb tm, a web-based medical record for an integrated healthcare delivery system. *Medinfo 98*, 1998.
- [10] Kevin Keenoy, Alexandra Poulouvasilis, Vassilis Christophides, Philippe Rigaux, George Papamarkos, Aimilia Magkanaraki, Miltos Stratakis, Nicolas Spyrtos, and Peter T. Wood. Personalisation services for self e-learning networks. In *International Conference on Web Engineering (ICWE)*, pages 215–219, Munich, Germany, 2004.
- [11] Frank Manola and Eric Miller. Rdf primer. Technical report, W3C Recommendation, 10 February 2004.
- [12] Deborah L. McGuinness and Frank van Harmelen. Owl web ontology language overview. Technical report, W3C Recommendation, 10 February 2004.
- [13] S. Miksch. Plan management in the medical domain. *AI Communications*, 12(4):209–235, 1999.
- [14] George Papamarkos, Alexandra Poulouvasilis, and Peter T. Wood. Event-condition-action rule languages for the semantic web. In *Workshop on Semantic Web and Databases, at VLDB'03*, Berlin, 2003.
- [15] E. Pattison-Gordon, J. J. Cimino, G. Hripcsak, S. W. Tu, J. H. Gennari, N. L. Jain, and R. A. Greenes. Requirements of a sharable guideline representation for computer applications. Technical Report SMI-96 -0628, Stanford University, 1996.
- [16] M Peleg, A.A Boxwala, O Omolala, Q Zeng, S.W Tu, R Lucson, E Bernstam, N Ash, P Mork, L Ohno-Machado, E.H Shortliffe, and R.A Greenes. Glif3: The evolution of a guideline representation format. In Overhage MJ, editor, *AMIA Annual Symposium*, LA, CA, Philadelphia, 2000. Hanley and Belfus.
- [17] S. W. Tu and M. A. Musen. From guideline modeling to guideline execution: Defining guideline-based decision-support services. In *AMIA Annual Symposium*, pages 863–867, Los Angeles, CA, 2000. Hanley & Belfus Inc.
- [18] J. Widom and S Ceri, editors. *Active Database Systems: Triggers and Rules for Advanced Database Processing*. Morgan Kaufmann, San Francisco, USA, 1996.
- [19] B. Wu and K. Dube. Plan: a framework and specification language with an event-condition-action (eca) mechanism for clinical test request protocols. In *34th Hawaii International Conference on System Sciences (HICSS-34): the Mini-Track in Information Technology in Healthcare*, page 140, Maui, Hawaii, 2001. IEEE Computer Society, Los Alamitos, California.