Modelling medical operational knowledge for e-health applications.

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Introduction: Medical applications and electronic healthcare have special requirements that conventional relational database systems cannot satisfy. To name but a few: Electronic patient records need modelling based on complex objects such as component hierarchies, image data and structured texts. E-health applications should be able to represent complex objects directly and implement them effectively. Relational databases simulate complex object by joining relations, an approach that complicates modelling and results in performance problems. Healthcare applications use text, graphics and image archives. Therefore they should be able to model, store and manipulate extensive multimedia data efficiently, while still operating at a reasonable speed. Relational systems are good at handling number and string-based data, but have difficulty dealing with the types mentioned above. In the case of medical knowledge derived from imaging data, hardware limitations mean that all this knowledge may not be possible to reside in main memory at any given moment, in which case tailor-made storage and access techniques are required. The system described in this paper uses the technological advances in information technology in order to influence and improve healthcare practice by enabling the modelling, direct representation and flexible use of medical knowledge that supports the use of complex objects and multimedia content. It aims at significantly reducing the complexity of the development of distributed healthcare systems and e-health applications.

Materials and methods: Aiming at overcoming the problems and limitations mentioned above, our approach follows the FDM (Functional Data Model) for the modelling of medical information. The resulting system is (i) persistent, by means of the back-end functional database, and (ii) interoperable by means of XML. (a) Unlike the relational model which is record founded, the functional approach is based on graphs, and as such, it provides a finer semantic granularity which facilitates data modelling. Complex data structures are supported, allowing the use and manipulation of complex objects and multimedia content, the two most important elements of medical data. Missing or incomplete information is also efficiently handled. (b) On the client interface front the system was designed to be fully XML compatible, adhering to XML's principal features of structure, extensibility and validation (by means of DTDs rather than schemas). The feature of compatibility was of high priority as it guarantees the interoperability between our system and other existing e-health applications. Furthermore, the issue of validation was deemed especially relevant to medical applications, as it allows for agreement on a common format for interchanging data among independent sources.

Results: A prototype system following the above design and specification has been implemented with a back-end functional database and a query-specific XML compatible web interface. The modelling of medical information follows thus the functional paradigm, incorporating complex objects and multimedia content into a compliant schema. The fundamental schema transformation rules between the functional database and XML have been established [1], and the implementation of a basic translator framework has been carried out [2]. This grants full interoperability between our system and other medical data banks over the Internet, since most existing relational or object-relational medical systems in use are also XML compatible. The implementation of the two-way prototype translator between the functional database and XML has been done by means of a server-based Perl/cgi script running on a SPARC Enterprise 450 Solaris 8 platform which supports an Apache Web server (chosen for its open source and for allowing safe connections of medical data through SSL). The Perl/cgi script interfaces the back-end database and formats the query output. The local client receives the XML-formatted web data, translates and stores it in the back-end database. The data can then be queried, updated and even sent back over the web, re-formatted into XML.

Discussion: Internet based medical applications include electronic patient records, databases of clinical practice and literature, distance-learning type applications, decision-making tools for diagnosis and optimal treatment selection etc. Patients internet support groups and education packages revolutionise the traditional patient support, while terms such as telemedicine and teleconsulting (but also cyberchondria) find their way into our everyday lives. All of the above applications rely on the fact that it is easier and cheaper to move data than people and/or other resources. Medical operational knowledge can be grouped by its type and source. The type of medical information varies from simple numeric and string-based data residing in traditional RDBMS's, to text, graphics and image data. The source of this information can be as widespread as the web itself. These are the exact parameters our approach aims at: treat medical data in a uniform way regardless of its type and source of origin. Once fully operational, the proposed system will be able to gather data from a variety of different sources, model it into flexible complex objects and store it locally to be queried and manipulated at will. Having finished the prototype phase, we are currently negotiating testing the system with UK NHS (United Kingdom National Health Service) data, which will put to the test the performance and delivery, and prepare the second phase of implementation.

References

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