Preface

Interoperability is a concern in many domains of Information Technology, and healthcare is no exception for that. On the contrary, the nature of health information calls for advanced interoperability for the benefits of the individual patients, a better management of health institutions, organizations and centres, and also in general for the benefit of clinical practice and science in general, as the ability to combine data opens new avenues for gaining scientific insights.

That was the motivation for compiling this book, since the field of interoperability in health systems is now subject to intense development and research but at the same time is struggling with the practical impediments of deploying interoperable systems that achieve higher levels of integration at the local, regional, national and transnational levels.

In this preface, I try to provide a motivation for the necessity of the book together with an overview of its contents.

MOTIVATION

Interoperability is about sharing information across organizations, administrative domains or countries. And it is about transferring that information in the most effective and efficient form beyond particular micro-integration cases. This entails the alignment of protocols, configurations and data models between computer systems, along with aligning the authorizations, regulation and processes between the organizations sharing the information. And this is thus a complex problem for which there are no easy solutions or "silver bullets", given its inherent complexity.

The domain of healthcare represents a particularly complex case for interoperability still looking for solutions at the macro-scale (Woolman, 2011). This is not only due to the fact that the systems supporting healthcare information are heterogeneous (which is something that occurs in many other domains), but also due to the privacy and security issues surrounding the medical record (Gritzalis, 1998) and also the inherent complexity of representing healthcare-related information (Plsek & Greenhalgh, 2001). This latter aspect is in many cases overlooked in approaches to healthcare interoperability. However, it is an intrinsic, essential characteristic of the domain. Scientific progress and innovation in the healthcare domain are continuous, and the data models required for recording associated information needs to be adaptable in a quick way. In consequence, it is in practice unrealistic to attempt to build comprehensive models for the healthcare domain, and this complicates interoperability. A different approach is needed that accounts for change in its core foundation.

In recent years, this fact has been acknowledged explicitly in the approach to interoperability known as "two-level modelling", of which the OpenEHR initiative represents the most prominent example (Kalra, Beale & Heard, 2005). In this approach, the definition of the models is purposely left open via the provision of a domain-specific language that allows a community-approach to develop new micro-models of clinical information. In OpenEHR, these model fragments are called "archetypes". An archetype may represent known and old measurement concepts as "blood pressure" or "smoking habit" for which conventions exists. But they can be used also to represent new forms of evaluation or measurement instruments that will exist only in the future. In this way, the collection of archetypes openly available can evolve seamlessly in time. Moreover, the provision of a domain specific language enables non-computer professionals to develop archetypes (of course with the appropriate user-friendly tools). This allows the healthcare professionals to drive the development of the models, if needed as a community process with all the practitioners and researchers involved.

In addition to the abovementioned specificities, healthcare information requires the understanding and consistent use of the vocabularies of the different healthcare domains. There is a long, established tradition of using ontologies in the biomedical domain, and the OBO Foundry site provides a good example of them (Smith et al., 2007). Currently, SNOMED CT is arguably the more widely adopted terminology for the clinical domain (Stearns et al., 2001), providing a backbone for achieving a degree of semantic interoperability. However, no current terminology or ontology is perfect for every domain and there is also a lack of guidance and best practice distillation in how to associate terms with information models as archetypes.

The areas within healthcare which benefit most from semantic interoperability can be categorized as follows:

- **Patient care:** The benefits in this area include medical staff saving time, gaining efficiency and improving safety and clinical outcomes through better access to patient information across disciplines, care settings and countries. These influence patient safety, dissemination of good practice, integration of education and care, connecting multiple locations for collaborative care delivery and empowerment of citizens, among others.
- **Public health:** Benefits are also associated to being able to use richer clinical detail, leading to improvement and greater confidence in information used for audit, planning and performance management. These influence international statistics, comparative outcome assessment, pharmacovigilance, coordination of risk assessment, management and surveillance of large-scale adverse health events and population health research, among others.
- **Research and translational medicine:** Semantic interoperability achievement can also lead to the development of multi-centre studies and trials, health data repositories, bio- and tissue-banks and personalised medicine based on genetic and genomic analyses, among others.
- **Support for diverse markets:** Semantic interoperability provides means for the identification of solutions with superior benefit/cost ratios, enabling plug and play best of breed, encouraging industry involvement, stimulating innovations by health service providers and involving clinicians and harmonising legal and regulatory frameworks.

Semantic interoperability not only offers means for new methods and services in the health domain but also contributes to maximise all the benefits from the relation between medicine/healthcare and information technology, given the constraints in resources.

It should be noted that the benefits listed above can be achieved to a greater or lesser extent depending on the degree of level of interoperability achieved. The definition of such levels has evolved from a general perspective oriented to any kind of information system (Sheth, 1999) to a more specific definition in accordance to the requirements of a particular domain. In this manner, Garde et al. (2007) provided three levels adapted to the healthcare environment. Two years later, the levels of IOp established by the SemanticHEALTH report (Stroetmann et al., 2009) were the following:

- **Level 0:** No interoperability at all.
- **Level 1:** Technical and syntactical interoperability (no semantic interoperability)
- **Level 2:** Two orthogonal levels of partial semantic interoperability
  - **Level 2a:** Unidirectional semantic interoperability
  - **Level 2b:** Bidirectional semantic interoperability of meaningful fragments
- **Level 3:** Full semantic interoperability, sharable context, seamless co-operability, that will allow gaining the benefits of computerized support for reminders, alerts, decision support, workflow management and evidence based healthcare, i.e. to improve effectiveness and reduce clinical risks.

In Level 3 the use of an EHR reference model, a rich library of clinical data structures, and the definitions of terminology bindings to value lists for each element of the data structures have all to be agreed within a record sharing community.

However, reaching high levels of interoperability is a resource intensive task while nowadays it is difficult to associate the benefits of interoperability with those who pay for it. Therefore, one of the objectives of this research is to provide a convincing demonstration of the benefit of migration from ad-hoc to interoperable systems.

Another dimension of the interoperability puzzle is that of guidelines and workflows. Typically, guidelines provide procedural knowledge that has been collected through the careful compilation and study of available evidence for a particular health problem. The application of workflows to supporting guideline-based care processes seems straightforward. However, in spite of having a number of available workflow models for the healthcare domain (Lenz & Reichert, 2007), in practice they are not consistently used, and professionals may consider challenging introducing them in their current information systems.

To complicate things even further, security and cross-national boundaries create barriers that need technology, procedures and attention to privacy. While initiatives as the European epSOS project[1] provide the necessary architectural elements and framework for solving them, again practice lags behind theory, and they are far from being widely deployed nowadays.

The multifaceted and complex context of interoperability just briefly portrayed evidences the importance on investing in healthcare interoperability and associated standardization efforts. The technologies and models have been with us for years, but there are still unclear areas and possibilities to go higher in the level of semantics transferred when moving healthcare data across organizations of countries. We hope that the contents of the chapters in this book contribute to give an additional step in that direction.

OVERVIEW AND CONTENTS OF THE BOOK

This book has resulted from a process of selection of chapters with an open call. Initial proposals were screened in a first phase for scope with the topics of the book. Then, selected proposals were developed by their authors and submitted in full form. The chapters passed through a process of peer review for technical adequacy and then authors of accepted chapters developed the final versions integrating the suggestions and recommendations for improvement for the reviewers.

The process has resulted in a selection of nine chapters that cover a broad range of topics and perspectives. An additional introductory chapter covers the broad scope of interoperability to provide the context and outlook in which the contributions should be framed.

In Chapter 1, Kuziemsky discussed healthcare delivery and interoperability from multiple perspectives. A case study of collaborative care delivery is described, together with a multi-tiered framework of healthcare interoperability devised to address the needs of the case.

In Chapter 2, Costa and Isaias present the elements needed to implement a model of Electronic Health Record based on a standard, open architecture.

Elements from decision support systems and business processes that can be integrated with the system are discussed in that context.

Then, Chapter 3 by Maldonado et al. describes LinkEHR, a software framework for interoperability in Health Information Systems that uses the concept of clinical archetype as the central data mode. Archetypes are used to decouple data representations at different systems while making them interoperable through a reference model. The software framework demonstrates how a global interoperability system can be deployed using archetypes as data mapping mechanism.

Chapter 4 by Martínez-Costa et al. presents different solutions based on the use of semantic models for representing clinical knowledge. Concretely, the chapter deals with an archetype-based dual model-based and presents methods and tools for the representation and transformation of clinical archetypes and for the automatic generation of standardized applications.

Lezcano goes a step further in Chapter 5 by introducing the way to use rule-base models together with semantic representations generated from archetype models. This brings an additional dimension in the kinds of clinical knowledge that can be integrated in these systems, and opens the possibilities for new types of reasoning that are not directly supported in other base ontology languages like that of the different OWL variants.

In Chapter 6, Sahay et al. present a case motivating current limitations of ontology based systems in the domain of this book and identify two key features, namely the type and scope of knowledge, within a knowledge base could enhance the overall effectiveness. The idea of separating knowledge bases in types (e.g., general or constraint knowledge) with scope (e.g., global or local) of applicability is discussed as a central concern in this domain.

Chapter 7 by Preve discusses the role of Wireless Sensor Networks (WSN) deployed to monitor the health of patients suffering from critical diseases are presented. This is combined with the needs to standardize internetworked infrastructures according to standards as the Open Geospatial Consortium (OGC) and Health Level (HL7).

Chapter 8 by Koufi et al. brings a new dimension to the scenario of interoperability presented in previous chapters by introducing workflow and agent technologies as supporting machinery for achieving interoperation goals.

Chapter 9 by Carenini et al. analyse several existing large-scale eHealth systems and analyse their ability to cope with the high heterogeneity challenges of a Europe-wide solution. The concept of triplespaces as a semantics-based middleware is described as a key infrastructural element for solving cross-national needs for interoperability.

Chapter 10 by Lezcano et al. deals with a case integrating interoperability and data mining in the context of a concrete pathology. It serves as a prototypical example of dealing with the complexity of data representations and the different kinds of knowledge that needs to be tackled with in real contexts.

CONTRIBUTIONS

This volume contributes to the field of interoperability and healthcare by providing an overview of current research and development in the context of integrating healthcare information. The book includes topics that are related to how advanced techniques as computational semantics can be applied in that context, and also cases and overview information portraying the field of health interoperability nowadays.

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