Chapter 11
A Formal Investigation of Semantic Interoperability of HCLS Systems

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ABSTRACT

Semantic interoperability facilitates Health Care and Life Sciences (HCLS) systems in connecting stakeholders at various levels as well as ensuring seamless use of healthcare resources. Their scope ranges from local to regional, national and cross-border. The use of semantics in delivering interoperable solution for HCLS systems is weakened by fact that an Ontology Based Information System (OBIS) has restrictions in modeling, aggregating, and interpreting global knowledge in conjunction with local information (e.g., policy, profiles). This chapter presents an example-scenario that shows such limitations and recognizes that enabling two key features, namely the type and scope of knowledge, within a knowledge base could enhance the overall effectiveness of an OBIS. This chapter provides the idea of separating knowledge bases in types with scope (e.g., global or local) of applicability. Then, it proposes two concrete solutions on this general notion. Finally, the chapter describes open research issues that may be of interest to knowledge system developers and broader research community.

INTRODUCTION

Nowadays, Health Care and Life Sciences (HCLS) systems are facing challenges to bring healthcare stakeholders together, such that healthcare resources (e.g., data, schema, and applications) are seamlessly accessed across all related domains. Knowledge and HCLS specialists have advocated the use of semantics to (1) create interlinked networks of HCLS resources and (2) overall manage-

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ment and integration of HCLS resources. Ontology Based Information Systems (OBISs) have recently received attention for their flexibility and automation in maintaining, updating, exchanging schemas and underlying data. This strength is due to the fact that schema and data are loosely-coupled (as compared to cohesively-weak schema and data in traditional databases) and both represented and integrated in a logical fashion. However, OBIS in its current form has limitations in dealing with the requirements imposed by heterogeneous information systems. One major limitation is its inability to distinguish between various types of knowledge used or exchanged between information systems. Additionally, knowledge expressed within any typical information system are generally tied to a context (e.g., place, event, time) and their appropriate interpretation is scoped or limited to that context.

Semantics and the reasoning mechanism behind ontological knowledge bases are centralized in the way data and schemas are accumulated and processed. Therefore, when an OBIS experience the use-cases where data, schema, and applications are heterogenous and distributed then that impedes the expected results. This limitation has roots in formalism and corresponding reasoning mechanism underlying ontology-based knowledge bases. Ontology as the symbolic layer is closest to concepts in the real world. An ontology may be defined as the specification of a representational vocabulary for a shared domain of discourse which may include definitions of classes, relations, functions and other objects (Gruber, 1993). Ontologies are good in describing general invariant concepts and mappings or relation among those concepts. When ontologies are applied for information systems, then they describe information which is attached to multiple parameters, for example, information that is local and specific to some domain, time-dependent, constraints applicable to certain domain of discourse.

This chapter discusses how to formally represent information in use in electronic health records (EHR) and related knowledge bases, where the data are distributed, heterogeneous and multi-contextual. We especially explore how existing formalisms are able to deal with the difficult issues provoked by heterogeneity in a globalized information system. To do this, we present in a plausible use case scenario where two hospitals in different countries are involved, as well as labs and clinics. This serves to identify essential issues arising in such environment. We then show that Semantic Web technologies can help solving these issues and consolidate interoperability. Yet, these technologies fail at several levels in this multi-scoped situation. Therefore, we investigate formal approaches that have been proposed on top of Semantic Web technologies to deal with these crucial aspects of world-wide knowledge base systems. As a result of this investigation, we classify the approaches according to five essential features that are meaningful to dealing with our example scenario. We conclude that no approach fully solve the issues but some can be combined to improve the overall formalism. Especially, we notice that those issues eventually amount to delimiting the *scope* and *type* of a knowledge base or its subparts. Subsequently, we detail how to define an extension of existing work to treat more appropriately the identified features. Finally, we discuss the remaining foundational problems that are still not addressed by the presented approaches but are critical to the interoperability of these systems. This way we hope to offer a roadmap and directions for future research in semantic-enabled HCLS system at Web-scale.

We start the chapter with background information about semantics in HCLS systems (Section: Semantics for HCLS). We then describe our use-case scenario (Section: Use-Case Scenario: Lab-Test Order). We show how to apply various formalisms to this scenario in four sections overviewing the state of the arts: first, we present two general theories of reasoning with context (Section: State of the Art - 1: Context Formalisms); second, we detail some instantiation of one of the