INTERNATIONAL RESEARCH JOURNAL IN ADVANCED ENGINEERING AND TECHNOLOGY (IRJAET) E - ISSN: 2454-4752 P - ISSN : 2454-4744
VOL 4 ISSUE 5 (2018) PAGES 4015 - 4020
RECEIVED : 21.09.2018 PUBLISHED : 22.10.2018
Oct 22, 2018

A DESCRIPTION OF CLINICAL DECISION SUPPORT FRAMEWORK PREDICTION IN HETEROGENEOUS DATA SOURCES

P.Punithavalli[1], P.SathishKumar[2]
[1]Research Scholar, Computer Science and Engineering, Vivekananda College of Engineering for Women, Tiruchengode, India.
[2]Assistant Professor, Computer Science and Engineering, Vivekananda College of Engineering for Women, Tiruchengode, India.

Abstract:
The interoperability of Clinical Decision Support (CDS) sys- tems is an important obstacle for their adoption. The lack of appropriate mechanisms to specify the semantics of their in- terfaces is a common barrier in their implementation. In this systematic review we aim to provide a clear insight into cur- rent approaches for the integration and semantic interopera- bility of CDS systems. Published conference papers, book chapters and journal papers from Pubmed, IEEE Xplore and Science Direct databases were searched from January 2007 until January 2016. Inclusion criteria was based on the ap- proaches to enhance semantic interoperability of CDS sys- tems. We selected 41 papers to include in the systematic re- view. Five main complementary mechanisms to enable CDS systems interoperability were found. 22% of the studies cov- ered the application of medical logic and guidelines represen- tation formalisms; 63% presented the use of clinical infor- mation standards; 32% made use of semantic web technolo- gies such as ontologies; 46% covered the use of standard ter- minologies; and 32% proposed the use of web services for CDS encapsulation or new techniques for the discovery of systems. Information model standards, terminologies, ontolo- gies, medical logic specification formalisms and web services are the main areas of work for semantic interoperability in CDS. Main barriers in the interoperability of CDS systems are related to the effort of standardization, the variety of termi- nologies available, vagueness of concepts in clinical guide- lines, terminological expressions computation and definitions of reusable models.
Keywords: Clinical Decision Support Systems; Semantic Interoperability; Terminologies; Clinical Models; Ontologies.

1. INTRODUCTION

Clinical Decision Support (CDS) systems are applications to assist users in health care decision making. They contribute to improve health care and reduce costs [1]. Current initiatives to power the adoption of health information standards are setting the basis for the general use of CDS systems. However interoperability to enable CDS systems smooth integration into clinical workflows and reuse across health care providers are considered as main barriers hindering CDS systems broad adoption [2–4]. New CDS specific standards such as the HL7 Virtual Medical Record (VMR) [5] are improving their modu- larity and interoperability. Nevertheless, the specification of precise semantics for the concepts used in CDS modules are hampering their successful adoption [3]. This has unveiled that advances in clinical information architecture standards are necessary but do not suffice to grant semantic interoperability (SIOp). Also, advances in other aspects of SIOp such as web services architectures that link information models, terminolo- gies and knowledge models of CDS systems are needed [6]. This paper presents a systematic literature review of SIOp in CDS Systems that extends and includes the studies published since our previous work [7]. We have extended the publication period (adding the period from November 2014 to January 2016). We have modified the keywords in the search from our previous work in order to focus the discussion on the standards available to implement CDS systems attempting to provide a comparative overview of them. considered as main barriers hindering CDS systems broad adoption [2–4]. New CDS specific standards such as the HL7 Virtual Medical Record (VMR) [5] are improving their modu- larity and interoperability. Nevertheless, the specification of precise semantics for the concepts used in CDS modules are hampering their successful adoption [3]. This has unveiled that advances in clinical information architecture standards are necessary but do not suffice to grant semantic interoperability (SIOp). Also, advances in other aspects of SIOp such as web services architectures that link information models, terminolo- gies and knowledge models of CDS systems are needed [6]. This paper presents a systematic literature review of SIOp in CDS Systems that extends and includes the studies published since our previous work [7]. We have extended the publication period (adding the period from November 2014 to January 2016). We have modified the keywords in the search from our previous work in order to focus the discussion on the standards available to implement CDS systems attempting to provide a comparative overview of them. Eligibility assessment was performed by a single reviewer mapping the identified publications into the aforementioned criteria. Titles and abstracts were first screened rejecting irrel- evant papers. A second revision reviewed the studies in full- text selecting those compliant with the eligibility criteria. No specific data collection form was used. Instead, for each included publication we extracted aspects related to mecha- nisms used to enable syntactic and semantic interoperability; and how these mechanisms (syntactic and semantic) are com- bined to grant SIOp. Special attention was paid in identifying barriers and advantages linked to the use of every approach.

2. RELATED WORK

The search of the three databases provided a total of 117 rec- ords after removing duplicates. Also 11 studies from other sources were considered for review. After screening by title and abstract 75 were discarded for not accomplishing criteria, 53 were selected as relevant for full text review. Of the 53 selected for full-text examination 41 remained to be included in the synthesis and 12 were discarded as they did not comply with the eligibility criteria. features to enable syntactic interoperability while others en- hanced those features to share information at a semantic level. Of the 41 papers reviewed 22% (n=9) described the applica- tion of medical logic and guidelines representation standards (e.g. GLIF, Arden Syntax etc.); 63% (n=26) described the use of clinical information standards such as HL7 CDA, HL7 RIM, OpenEHR or HL7 VMR; 32% (n=13) employed seman- tic web technologies such as ontologies; 46% (n=19) outlined the use of standard terminologies; and 32% (n=13) reported the use of web services to offer CDS functionalities. Table 1 presents the mechanisms used to enable interoperability in the studies reviewed. It is important to notice that those categories are not disjoint but complementary.

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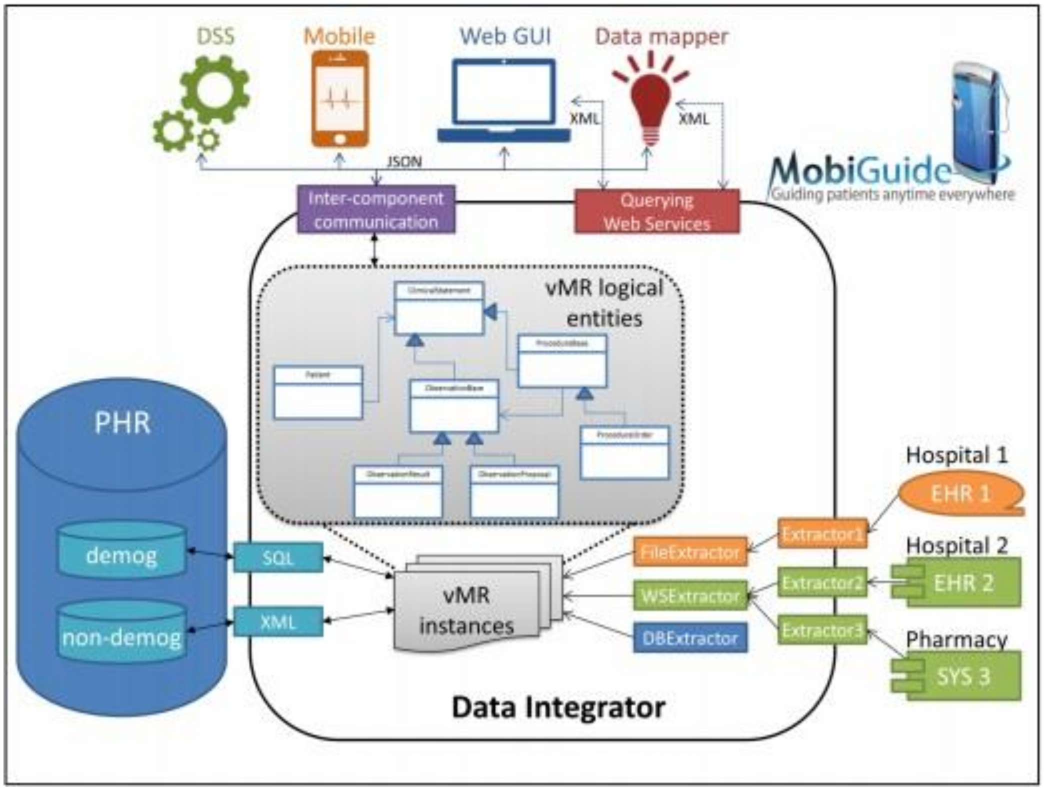

Fig.1.Data Integrater

Thus a particular study may pertain to several of them. Currently, several information architecture standards exist for the documentation and exchange of EHR extracts. Several works propose their use to specify the interface to interact with the CDS system. Thus, the logic references a standard infor- mation model rather than a proprietary data schema. This alle- viates the 'curly braces' problem Preparing the data specified in standards such as CDA or RIM to be used by the decision logic is challenging as a conse- quence of the impedance mismatch between the information model and the inference model. Works to map the RIM VMR to the guideline specification can be found in Peleg et al. [4]. Specifically, they use a mapping ontology (KDOM) to create the abstract concepts required by the logic from the fine grained information contained in the RIM-based VMR. To solve this problem in CDA-based VMRs, Saez et al. [22] pro- posed to use a wrapper in order to link CDA documents to the CDS rules. Although both RIM and CDA can be used as in- formation models to build a VMR, they are complex and too detailed for the requirements of a CDS data schema. Kawamo- to et al. studied the requirements to create a CDS specific in- formation standard to build VMRs based on a simplification.

3. PROPOSED SYSTEM

Present a pure semantic web-based approach. They defined the Clinical Pathway Ontology (CPO) for the specification of clinical pathways. The ontology is implement- ed as a combination of a new defined model, the process on- tology specified in OWL-S and an entry ontology of time. They rely on their CPO rather than other formalisms as they consider: (a) CPO to be more accurate to specify pathways were multidisciplinary teams interact; (b) CPO to be more adequate to manage knowledge documentation and

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evolution. For temporal rules specification they used the Semantic Web Rule Language (SWRL) which guarantees a seamless integra- tion with the OWL-based model. In their case study they use their framework to specify Cesarean guidelines. Another ex- ample of semantic web technologies used for CDS implemen- tation is presented by Zhang et al.

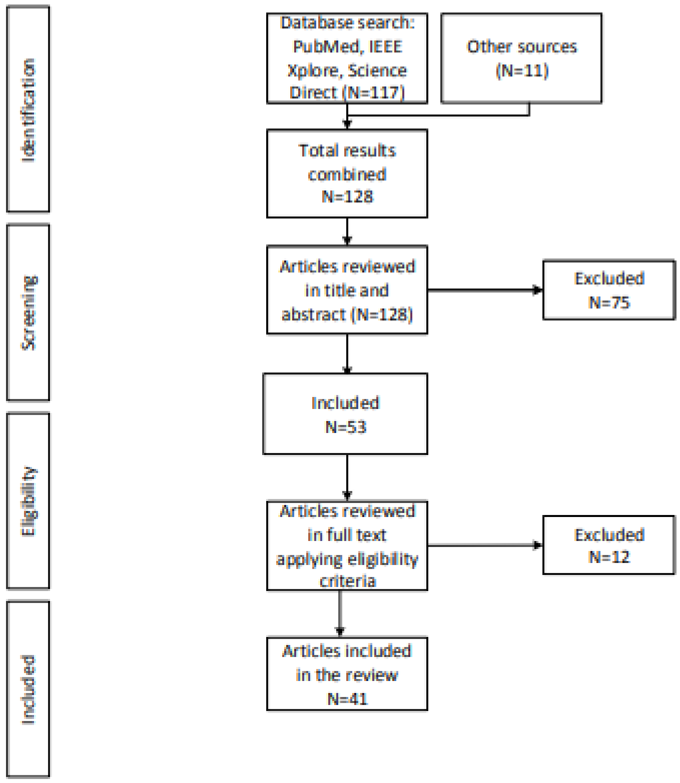

Fig.2.Workflow

They implemented a CDS for diabetes management over a RIM-based information model using OWL for knowledge specification, SPARQL for queries definition and Jena rules for specifying decision logic. Ontologies have also been used for integration of heterogene- ous data models in several studies. For example, the project Advancing Clinico-genomic Trials on Cancer – Open Grid Services for Improving Medical Knowledge Discovery (ACGT) describes a complete framework where the ACGT master ontology is used to integrate heterogeneous distributed databases and clinical genomic data The combination of ontologies and archetypes is of special interest as enables reasoning over clinical data stored as arche- type instances. Lezcano et al. [16] transformed archetypes into OWL and enabled decision support defining SWRL rules over the OWL representation. The work of Lezcano et al. annotates the ontology concepts with SNOMED-CT allowing the appli- cation of SWRL over standard terms. The use of semantic web technologies appeared in 32% of the studies (n=13). Table 4 shows the field of application of se- mantic web technologies. 69% (n=9) of studies used ontolo- gies to represent the conceptual models of the knowledge base; 38% (n=5) used ontologies to integrate different conceptual models or to overcome the impedance mismatch between the EHR and the CDS logic. Regarding inferences, OWL reason- ing or SWRL were used in 31% of the studies (n=4).

CONCLUSION

Five main complementary mechanisms are currently used to grant SIOp of CDSS. Clinical information standards are used to define standard data models to interoperate at a syntactic level. Semantic Web technologies are used to define conceptu- al models of knowledge bases, integrate them, and, in some cases, specify procedural knowledge (decision rules). Logic specification formalisms aim to define shareable algorithms among systems. Terminologies provide a standard language to attach accurate terms descriptions to data and conceptual mod- els. SOA is used as architectural paradigm to encapsulate the CDS and allow several clients to reuse its functionality. The mechanisms presented have effectively helped to decouple CDSS from the EHR and advanced in their interoperability capabilities.

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