Exploration of the Decision Model and Notation (DMN) Standard for Representation of Knowledge Bases Encoded in the Arden Syntax

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Abstract

Context: Arden Syntax encodes knowledge as Medical Logic Modules (MLMs). Current work involves improvement of its representation of business processes. Objective: Assess how DMN can represent decision-making in MLMs. Method: A sample of 340 MLMs was tabulated for DMN representation. Result: While DMN can represent all MLMs at the decision requirements level, some are not supported at the decision logic level. Conclusion: DMN facilitates representation of business processes but would not address all decision logic.

Keywords:

Clinical decision support systems; knowledge representation.

Introduction

Arden Syntax is a formalism supervised by Health Level Seven International (HL7) for representation of procedural medical knowledge to facilitate sharing units of knowledge known as MLMs that are executed in clinical decision support systems (CDSS) [1]. Each MLM consists of four categories—Maintenance, Library, Knowledge and Resources—each of which consists of one or more structured attribute value pairs that contain descriptions of the knowledge and executable statements. Each MLM typically renders a single decision. Key to interoperability of knowledge bases used in clinical decision support (CDS) is the use of standard formalisms for knowledge representation in order to reduce the need to translate from one representation to another when sharing knowledge. As part of an overall clinical knowledge representation, workers have become interested in recent years in developing formal constructs for representing business processes [2]. Indeed, prior work has established the ubiquity of business processes in clinical knowledge bases and the potential importance of developing such constructs for their representation [3].

In part to realize such standardization, workers in the Object Management Group (OMG), a standards development organization with a portfolio that touches on that of HL7, have collaborated with HL7 to identify how the standards of both organizations could be improved and leveraged to further implementation of CDS. Part of this collaboration includes the possibility of using OMG's Business Process Model and Notation (BPMN) in part to represent CDS knowledge bases. Indeed, prior work has established that BPMN can adequately represent business processes encoded in Arden Syntax MLMs [4]. However, BPMN per se lacks the expression language needed to encode the decision logic of such processes. In part for this purpose, another OMG artifact, the Decision Model and Notation (DMN) standard, can be integrated with BPMN [5]. DMN also can be used independently. This formalism provides a notation

for a Decision Requirements Diagram (DRD) that can be used to spell out the input data, knowledge source and decision service needed to render decisions in business processes as well as the Friendly Enough Expression Language (FEEL) to model decision logic in order to render it executable [5]. The present work was undertaken to expand our knowledge of how these OMG standards could be used generally to improve representation of clinically business processes and decision logic and specifically the extent to which DMN could be used to represent decisions encoded in the Arden Syntax.

Methods

A previously assembled convenience sample of MLMs was examined. MLMs were examined and tabulated to assess their alignment with and the extent to which they could be represented by DMN Version 1.3 [5]. In particular, the text of the MLM corpus was concatenated in a single file. Using a text editor guided by Backus-Naur form of Arden Syntax v2.10 [6] and the format of the various kinds of statements, regular expressions were created in order to extract the instances of logic statements and business processes, recognizing that some of the latter, because of the lack of formal constructs to represent them in Arden Syntax, may be present in narrative format in the Explanation slot of the Library category. Each of these batches of statements then was compared to the corresponding representation in the DMN standard manually.

Results

A total of 340 MLMs were pooled from 5 source CDS systems, including 24 from 2 vendor knowledge bases and 316 from 3 academic medical centers. MLMs concerned with lab tests were the most common (138/340 = 41%), followed by clinical assessment (75=22%) and medication (45=13%). The remainder addressed administrative and miscellaneous topics.

In part because the Arden Syntax provides for explicit data mappings in its data slot and explicit Boolean logic in its logic slot, both in the Knowledge category of an MLM, the DMN DRD adequately can accommodate at the decision requirements level these key aspects of MLMs. All extracted business processes and decision-making in the corpus of MLMs at this level could be expressed in a DRD.

At the decision logic level, FEEL is sufficiently robust to represent most logical expressions in MLMs. In particular, Arden Syntax has a rich collection of operators to manipulate temporal and textual data, as these constitute a substantial part of clinical decision-making, and the corresponding expressions in FEEL

could be used to represent clinical decision-making that involves temporal reasoning and interpretation of textual data. Further, the list is a key data structure in Arden Syntax, and FEEL contains adequate list operators to represent this aspect of Arden Syntax.

Nevertheless, while FEEL is robust, not all executable decision logic or actions in this corpus of MLMs could be rendered as DMN boxed expressions using FEEL. In particular, FEEL, while it does support a tri-value logic, lacks specific constructs to support fuzzy logic, which has been incorporated in the latest version of the Arden Syntax because of its ubiquitiy in clinical reasoning. However, because the sample MLM corpus antedates the incorporation of explicit fuzzy logic constructs in Arden Syntax, this is not a bar to representation of the corpus used in this analysis although it may be so in other contexts. In addition, FEEL does not explicitly support iteration, while Arden Syntax offers iteration operators. On the other hand, iteration occurs only occasionally in the present MLM corpus, so this may not be a significant issue. Finally, owing to its nature as an expression language, FEEL lacks operators that would help actualize decisions, such as operators for communicating messages to human decision-makers, while these occur in nearly every MLM in the present corpus.

Discussion

While a common formalism for representation of computable clinical knowledge would be beneficial to promote the deployment of CDSS and reduce the cost of knowledge engineering therein, no widespread agreement has been reached on a specific formalism for doing so [1]. Workers have demonstrated the utility of the Arden Syntax in this space, and this solution for knowledge representation has been adopted by several software vendors, with resulting implementations in a number of countries. Nevertheless, several issues concerning interoperability have hindered uptake, particularly the lack of agreement on a uniform data model, as this has with other formalisms [7]. Additional work has demonstrated the need for improved explicit representation of business processes within CDS knowledge bases, and meeting this need will introduce further complexity and utility in CDS standards. The present work and related prior studies illustrate ways in which existing standards can be leveraged or harmonized to improve the utility of Arden Syntax for its original goals of standardizing knowledge representation and reducing its cost.

Conclusions

DMN is adequate in many respects for representing the decision logic of a robust corpus of MLMs encoded in the Arden Syntax. In light of the capability that supports integration of DMN and BPMN, use of DMN would enhance the structured representation of business processes in the Arden Syntax. This in turn would improve the utility of Arden Syntax for clinical knowledge representation and thereby facilitate executable knowledge sharing. However, DMN, through its FEEL expression language, does not represent some features of and constructs in the Knowledge category of MLM, and this would have to be taken into account in work to leverage these OMG standards to improve the Arden Syntax for representation of business processes. Consideration should be given to using DMN to help represent business processes in the Arden Syntax.

Acknowledgements

References

[1] R.A. Jenders, K.-P. Adlassnig, K. Fehre, P. Haug. Evolution of the Arden Syntax: key technical issues from the standards development organization perspective. *Artif Intell Med* 92 (2018), 10-14.

[2] K.-P. Adlassnig, P. Haug, R.A. Jenders. Arden Syntax: Then, now, and in the future. *Artif Intell Med* 92 (2018), 1-6.

[3] R.A. Jenders. Business process modeling in the Arden Syntax. *AMIA Annu Symp Proc* (2017), 2068.

[4] R.A. Jenders. Utility of the Business Process Model and Notation standard to represent business processes in the Arden Syntax. *AMIA Annu Symp Proc* (2019), 1616.

[5] Object Management Group. *Decision Model and Notation Version 1.3*. OMG, Milford, MA, March, 2021.

[6] Health Level Seven International. *Arden Syntax for Medical Logic Systems Version 2.10*. Health Level Seven International, Ann Arbor, MI, 2014.

[7] R.A. Jenders, W. Sujansky, C.A. Broverman, M. Chadwick. Towards improved knowledge sharing: assessment of the HL7 reference information model to support medical logic module queries. *AMIA Annu Symp Proc* (1997), 308–312.

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