ISO/CEN Interoperability Reference Architecture and its impact on HL7 standards development and deployment

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Motivation of this Introduction

• This introduction reasons on, and demonstrates, a new and sustainable approach to comprehensive interoperability in increasingly complex and highly dynamic ecosystems.

• It introduces the system-oriented, ontology-based, policy-driven ISO Interoperability Reference Architecture, applied in a number of ISO, CEN and HL7 Health Informatics standards and meanwhile defined mandatory for any interoperability specification of ISO/TC215 and CEN/TC251.

• It is the background for the ISO/TC215 liaison to the ISO/IEC JTC 1/AG 8 Meta reference architecture and reference architecture for systems integration

• It is the basis for the ISO/PWI ISO 23903 Health Informatics – Interoperability Reference Architecture currently under specification.
Ellen Friedman, MAPR: Even if you're not a data scientist, you may hold one of the most valuable skills in data science: the ability to understand your own business. And that is one type of expertise that data science specialists may lack.
Interoperability Challenge

• Communication and cooperation in dynamic, highly distributed, heterogeneous systems sets special demands on interoperability between all actors (persons, organizations, devices, applications, components, objects) involved.

• The data level consideration is not sufficient and must be replaced by an end-user related perspective. So, interoperability is not sharing data, but sharing knowledge, that way enabling intelligent, context-aware cooperation.

• Interoperability describes motivation, willingness, ability, and capability to cooperate for achieving common goals or business objectives.

• Interoperability requires knowledge, abilities and skills, shared and adapted a-priori or dynamically at runtime, for establishing adequately cooperating associated systems.

• Cooperating sub-systems form an interoperable system as result of systems integration.

• In ubiquitous personalized health, business cases and related policies cannot be pre-defined, but are determined by the subject of care’s status, needs, wishes and expectations, frequently turning him to the health manager. Therefore, highly dynamic interoperability services provided in real-time are needed.

• Differences in meeting those interoperability requirements lead to different interoperability levels for ensuring comprehensive cooperation.

• Interoperability in the context of ICT systems is usually restricted to ICT facilities.

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Interoperability Challenge under the New Organizational, Methodological and Technological Paradigms

• It is impossible to represent the highly complex, highly dynamic, multidisciplinary/multi-domain healthcare system by one domain’s terminology or even by using ICT ontologies (such as archetypes, HL7 RIM, Zackman Framework, etc.)

• There are approaches for representing multi-domain concepts in an hierarchical set of ontologies.

• For representing advanced interoperability settings, different representations must be linked to the same real world component. For that reason, an abstract and generic reference architecture able to represent any viewpoint or domain of interest is needed.

• The mathematical language of Universal Type Theory and its representation by a Parameterized Barendregt Cube provides a proper solution of that challenges enabling to represent any formal or informal language.

• Current approaches claiming to solve that problem do this on the basis of implicit knowledge or by using ICT representation tools the addressed domain experts, which should be in the lead, cannot understand. The aforementioned approach provides an alternative.
Objective of ISO/PWI 23903

- ISO/PWI 23903 provides a model and framework for integrating different standards as well as systems based on those specifications by supporting the use case specific identification and consistent, formal representation including constraints of the necessary components and their relationships without the need for revising those specifications.

- It facilitates analysis and improvement of specifications under revision, the deployment of existing standards and work products as well as the design of new projects.

- The approach is future proof due to its scientific soundness, based on systems theory, knowledge representation and knowledge management via ontology development and harmonization, that way supporting advanced interoperability between dynamic, multi-domain systems through knowledge and skills sharing in the context of intelligent cooperation.
Objective of ISO/PWI 23903

• The approach is successfully deployed in several standards such as ISO 22600, ISO 21298, ISO 13606, ISO 12967, ISO 13940 and ISO 13972 (both under way), but also in most of the HL7 security specifications.

• Meanwhile also other SDOs such as IEEE investigate in the given direction.

• ISO/IEC 10746 doesn’t include the business viewpoint, thereby explicitly excluding non-ICT ontologies, while OMG’s SOA explicitly names domain ontologies for representing the conceptual model, defining ICT ontology just for the information and technology model.

• ISO/PWI 23903 adopts for the development process objectives, content and presentation style used in other foundational standards such as ISO/IEC 10746, however addressing the business domain missed in ISO/IEC 10746. This way it qualifies for a potential ISO/IEC 10746-6.

• ISOPWI 23903 “works” like a system integrator.
ISO/NWI ISO 23903 Normative References

• The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

• ISO/IEC 10746 Information technology - Open distributed processing - Reference model: Part 1-4

• OMG Ontology Definition Metamodel V1.1


• ISO 22600 Health informatics – Privilege management and access control: Part 1-3

• ISO 21298 Health informatics – Functional and structural roles
Short History of the Interoperability Reference Architecture

• Mid-nineties: OMG proposed a methodology for analyzing and systematizing legacy and newly developed systems with respect to their distribution, scalability, and cooperation from the system's point of view instead from a software perspective.

• 1997: The Generic Component Model (GCM) was first internationally published.

• 2003: ISO 22600 ‘Health informatics – Privilege management and access control’ for managing multiple policies was approved. The GCM approach provides the basis for its formal modelling.

• The approach served as basis for ISO 21298 ‘Health informatics – Structural and functional roles’ as well as for most of the HL7 security and privacy specifications.

• 2015: Decision at ISO/TC215 Meeting in Bern to include the Interoperability Reference Architecture in all interoperability specifications of ISO/TC215 and CEN/TC251.

• 2016: Confirmation of that decision at the ISO/TC215 Meeting in Amsterdam.

• 2018: Decision to establish a foundational standard on Interoperability and Integration Reference Architecture, balloted and approved in 2019.
Modeling Challenges of Advanced Interoperability
Universal Type Theory Basis of the GCM – Barendregt Cube with Parameters ➔ Meta Reference Architecture

After Kamareddine et al.
Context-Free vs. Context-Aware Grammars

Any business system can be represented using ICT ontologies. However, the justification of correctness and completeness of structure and behavior of the represented ecosystem can only be provided at the business ecosystem’s view using the involved domains’ ontologies. Justification of structure and behavior representation includes the representational components, their underlying concepts, their relations, but also the related constraints.
Generic Reference Architecture

Domain Perspective
Domain n
Domain 2
Domain 1

System Concepts
Relations Networks
Basic Services / Functions
Basic Concepts

Development Process Perspective

System’s Architectural Perspective
View 1
View 2
View m
Extending ISO/IEC 10746

Represented by ICT ontology

Represented by domain ontology

Enterprise View
Information View
Computational View
Engineering View
Technology View

Business View
Enterprise View
Information View
Computational View
Engineering View
Technology View

a)
b)

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ISO Interoperability Reference Architecture Model

- Business Concepts
  - Domain n
  - Domain ...
  - Domain 1

- Relations Networks
  - Sub-Domain 1
  - Sub-Domain 2

- Aggregations
  - Service 1,1
  - Service 1,2

- Details
  - Task 1,1,1
  - Task 1,1,2

Business Viewpoint
ISO Interoperability Reference Architecture Model

![Diagram of ISO Interoperability Reference Architecture Model]

- Business Concepts
- Relations Networks
- Aggregations
- Details

- Domain n
- Domain 2
- Domain 1

- System Component Composition
- System Domain
- System Viewpoint

- Business VP
- Enterprise VP
- Information VP
- Computational VP
- Engineering VP
- Technology VP

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Interoperability Mediated by the ISO Interoperability Reference Architecture Model

- Patient Representations
- Health Professional Representations
- Human Resources Representations
- Biomed. Technologies Representations
- Biology Representations
- ICT Specs.
- Reference Architecture Model
- Business Admin. Representations
- Medicine Representations
- Legal/Regulatory Affairs Representations
- Ethics Representations

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Development Process Perspective

System-theoretical, ontology-based, policy-driven abstract Interoperability Reference Architecture model and framework representing any system's components, their functions and interrelations

Existing domain-specific models, specifications and solutions

Harmonization and transformation using logics, meta-languages, etc., at the level needed

Formalized components, missing existing components, their functions and interrelations, re-engineered in the use-case-specific Interoperability Reference Architecture instance

Mapping of instances
## Comparing Data Model Levels, Dimensions of Modeling, and the ISO Interoperability Reference Architecture Model

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Examples based on the ISO/TC215 and CEN/TC251 Interoperability Reference Architecture
Security Services Represented Using GCM

Domain Perspective

System's Architectural Perspective

System Component Composition

Development Process Perspective

Domain Perspective

Enterprise View
Information View
Computational View
Engineering View
Technology View

Business Concepts
Relations Networks
Aggregations (Basic Services / Functions)
Details (Basic Concepts)

Information security management,
directory services, ID management, certification management, naming services
identification, authentication, integrity check, non-repudiation, security logging, digital signature
enabling/disabling access, delegation, encoding/decoding

System Domain
System Viewpoint

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Policy Ontology (ISO 22600-2)
ISO 22600-2,3
ISO 21298
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ISO 13606 Reference Architecture
Conclusions 1

• Interoperability is not first a matter of the ICT domain, but a user domains’ one.
• Interoperability is a challenge to meeting business objectives by sharing knowledge and skills, which should be built on a hierarchical system of ontologies.
• Interoperability must go beyond simplification and abstraction for data integration at ICT ontology level towards concept and rule harmonization and integration at business domains’ ontologies level.
• The modeling process is an iterative one where the first iteration is performed in a top-down manner to guarantee the conceptual integrity of the model.
• The view on the model as well as the way of structuring and naming the concepts of the problem space have to be defined by the relevant stakeholders.
• Multi-disciplinary interoperability solutions (life sciences, natural sciences, technology, legal and social sciences, etc.) require an architecture-centric systems approach to the domains of discourse represented by their ontologies, so enabling the formalization of systems representation and integration including ontology mapping, supported by appropriate tools.
• Flexible, scalable, business-controlled, adaptive, knowledge-based, intelligent systems must follow a systems-oriented, architecture-centric, ontology-based and policy-driven approach.
• Such approach requires ISO/PWI 23903 Health informatics – Interoperability Reference Architecture.
Conclusions 2

• ISO/PWI 23903 provides a model and framework for integrating different standards as well as systems based on those specifications by supporting the use case specific identification and consistent, formal representation including constraints of the necessary components and their relationships within the different viewpoint of the extended ISO/IEC 10746 RM-ODP without the need for revising those specifications.

• This implies the appropriate reuse of existing components for representing those viewpoints.
Thank You Very Much For Your Attention!

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