

A Semantic Foundation for Achieving HIE Interoperability



Introduction

Interoperability of health IT systems within and across organizational boundaries has long been the holy grail of healthcare technologists. This whitepaper discusses the critical importance of semantic interoperability to both realizing the potential of electronic health records (EHRs) across the care continuum and making care-delivery reform initiatives, such as accountable care organizations (ACOs), successful. It also describes the high-level framework for reference terminology services that a vendor must support to enable health information exchanges (HIEs) to achieve semantic interoperability.

To best appreciate what semantic interoperability is about and how technology is rapidly evolving to make it possible, it's useful to understand the different categories of interoperability.

Level 0: No interoperability

- No use of IT to share information
- Examples: Mail, fax, and telephone

Level 1: Machine-transportable (structural) interoperability

- Transmission of non-standardized information via basic IT; information within the document cannot be electronically manipulated.
- Examples: Computer-based exchange of scanned documents, pictures, or PDF files

Level 2: Machine-organizable (syntactic) interoperability

- Transmission of structured messages containing non-standardized data; requires interfaces that can translate incoming data from the sending organization's vocabulary to the receiving organization's vocabulary; usually results in imperfect translations because of vocabularies' incompatible levels of detail.
- Examples: Email of free text, PC-based exchange of files in incompatible/proprietary file formats, HL7 messages

Level 3: Machine-interpretable (semantic) interoperability

- Transmission of structured messages containing standardized and coded data; ideal state in which all systems exchange information using the same formats and vocabularies.
- Examples: Automated exchange of coded results from an external lab into a provider's EMR and automated exchange of a patient's "problem list"

In principle, both machine-transportable and machine-organizable interoperability enable aggregation of patient data from different sources in a longitudinal manner. They do not, however, support benefits promised by true semantic interoperability. For example, while machine-transportable interoperability allows a clinician to gather and view all the laboratory results for a patient across different source systems in a longitudinal manner, it is impossible to run computations on the results because they do not contain standardized and analogous information.

Semantic interoperability, on the other hand, creates coherence between systems that don't "speak the same language." Semantic interoperability establishes seamless exchange of data between two or more systems or healthcare networks, ensuring data content is not only understandable within its original context, but also capable of supporting clinical decision-making,

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care collaboration, public health reporting, clinical research, health service management, and more. It is these capabilities that are required by HIEs and ACOs.

Why Semantic Interoperability is Critical

From LOINC to SNOMED, ICD-9, ICD-10, NDC, and CPT – to name just a few – there are a multitude of code sets and terminologies semantic interoperability must make sense of. Add in the subtle nuances of clinician-friendly terminology and free text from physician dictation and you start to comprehend the semantic challenges of health information exchange.

Consider, for example, a simple description of the tympanic membrane as recorded in the chart of a patient with acute otitis media. The terms “erythematous,” “injected,” “inflamed,” or “reddened” tympanic membrane all describe essentially the same clinical finding. To realize consistent data-sharing across such variations in terminology, an effective terminology services platform uses sophisticated mapping processes to enable semantic interoperability. The result: a unified view of the patient from multiple data contributors, enabling decision support, trending, analytics, and effective care collaboration.

Another example of computational challenge is aggregated laboratory data across the HIE. An HIE receives test results from different laboratories with each laboratory having its own way of coding and ordering tests. Typically, for a CBC panel, each source system may have its own test names, units of measure, machine sensitivity, reference range and probably variation on panel grouping. It is not possible to make comparisons or

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run trending on aggregated lab data across the HIE unless the results are semantically interoperable.

Specifically, key drivers for semantic interoperability include:

- **Aggregation of clinical data from different sources.** The source systems in an HIE/HIO setting would typically use a variety of terminologies to represent the same information. These terminologies must be reconciled to meaningfully aggregate patient information.
- **Need for decision support system based on aggregated data.** As HIEs evolve to the point where they want to implement decision-support engines against the integrated data, patient content must be accurately merged into a common vocabulary representation.
- **Reporting and trending.** Semantic incompatibility needs to be reconciled before trending and reporting can be performed. In addition, population health reporting requires standardized datasets.

As these needs suggest, semantic interoperability is a critical factor in achieving the benefits promised by electronic health record systems across the continuum of care, particularly as the healthcare industry moves toward an accountable care model.

Key Features of Semantic Interoperability

Semantic interoperability across systems is enabled by clinical terminologies – sets of terms with a declared meaning – and coding schemes that define the meaning of data. Together, standard clinical terminologies and classifications represent a common medical language, allowing clinical data to be utilized effectively and shared between EHR systems.

A semantically interoperable electronic health record has the following characteristics:

- Interchanges and interprets data consistently, irrespective of setting or location of care.
- Represents information in a codified form that can be mapped with standard terminology and classification schemes. This includes support for terminology specific to each source system, allowing these systems to maintain their existing terminology representations.

Semantic interoperability requires common or mapped clinical terminologies and enabling services that make those terminologies available on a shared infrastructure.

- Standardizes data so the same set of codes is used to encode data throughout a system.
- Aggregates data represented in the end-user application using consistent vocabulary, vocabulary versions, and reference ranges for trending and comparison.
- Enables decision support systems.

Semantic Interoperability and Terminology Services Requirements

To achieve semantic interoperability, you need a sophisticated terminology services framework designed to tie together disparate systems from the perspective of content, structure, and nomenclature standards. In selecting an HIE vendor, the quality and scope of the reference terminology services are critical. This section outlines the high-level framework for reference terminology services that a vendor must support to enable HIEs to achieve semantic interoperability.

I. Reference Terminology Services

A reference terminology service (RTS) is a standards-based solution that supports the creation and maintenance of terminology codesets, a data dictionary, mapping between other coding systems, versioning, and related attributes. The RTS provides key functions to address a variety of use cases relating to remediation of medical terminologies between different coding systems. All data entering a data repository must be “washed” through the RTS for terminology reconciliation. In addition to terminology remediation, the RTS also supports normalization of content and structure.

At the core of an RTS is a clinical terminology server, which supports a number of standards-based application program interfaces (APIs) and modules that can be leveraged for seamless integration with third-party terminology servers. The clinical terminology server supports message-layer and application-layer run-time queries of different terminologies in a consistent, well-defined fashion.

II. Map Development

Semantic interoperability requires common or mapped clinical terminologies and enabling services that make those terminologies available on a shared infrastructure. In a health information exchange scenario, where different contributing systems are using different terminology schemes, it is important to provide a “map” between various terminology representations. A map essentially provides a cross-walk from one system to another, which is used by a terminology service, such as the clinical terminology server, for creating a semantically interoperable health information infrastructure that may span multiple organizational entities and source systems.

III. Support for Non-standard Terminologies

A successful RTS must be agnostic to content providers and allow content to be plugged in whether it is created in-house or licensed from third-party vendors in this space. For example, the RTS loads LOINC codeset mapping in proprietary-to-proprietary and proprietary-to-standard maps in the data repository for application purposes while loading many-to-many maps in the cloud services offering. Using these maps, the clinical terminology server ties together diverse clinical terminologies and classifications to represent a common medical language, allowing clinical data to be effectively utilized and shared between EHR systems and achieve compliance with meaningful use objectives.

The mapping process employs a standard method in which the terminology context or classification description principles are interpreted between systems.



IV. Map Development Principles

Because there are no broadly accepted map development standards in the industry, Medicity recommends adhering to the following mapping best practices:

- Understandable
 - Mappings define source and target domain scope for the map.
 - Map documentation is complete, clear, and unambiguous.
 - All mappings have a stated purpose and audience.
- Reproducible
 - Mappings uniformly employ authoritative reference sources.
 - Documentation defines all assumptions, heuristics, and procedures required to manage context and create maps.
- Useful
 - Use cases are defined for all mappings.
 - Publication cycle is timely and linked to version change for source and target vocabularies.
 - Agreement is reached for standards of knowledge representation in mapping.

Medicity and Semantic Interoperability Processes

Medicity offers the technology framework to help organizations achieve semantic interoperability and also be compliant with meaningful use requirements relating to codified data representation. While we support the industry standards required for semantic interoperability, we are in no way limited to using only these standards and codesets.

Based on our experience achieving semantic interoperability at numerous HIE implementations, Medicity recommends a policy of incremental steps and a focused, consensus- based approach to terminology reconciliation in an open, collaborative environment. Medicity uses the following process for establishing semantic interoperability for its clients.

I. Establish the Least Common Denominator

Whether it is a multi-stakeholder HIE deployment or an intra-enterprise scenario, establishing the “least common

denominator” involves creating semantically sound and focused subsets of terminology needs that have immediate relevance to the priorities of participating entities. Medicity uses work groups with representation from participating HIE entities to gain consensus on the least common denominator.

To illustrate, let’s look at a real-world scenario:

A statewide HIE deployment has five different laboratory information systems (LIS) that utilize proprietary lab order and result codes. A common vocabulary was implemented to provide the HIE physician community with a lab result trending functionality. To get there, a workgroup called the Laboratory Standardization Committee was formed at the HIE level, consisting of lab directors and LIS analysts. After analyzing the needs of all participating stakeholders, the workgroup elected to use LOINC as the least common denominator. A terminology mapping vendor was contracted to evaluate the test compendiums of each of the five data providers and recommend the proper mapping of LIS result codes to a common LOINC value. The HIE elected not to limit the number of result codes to be used in the mapping effort. The process entailed the following:

- *Extraction of test compendiums from the various source LIS systems in a predetermined format.*
- *Evaluation of each data provider’s compendium and subsequent recommendations for the proper LOINC code mapping for each test code.*
- *Examination of the mapping by the Laboratory Standardization Committee*
- *Validation and approval of the mappings.*
- *Consolidation of the individual mapping specification in a HIE-wide master mapping table.*

II. Validate Maps

All maps are subject to quality controls and validation during the creation and updating processes. A prime data integrity issue is the potential for clinical and policy errors resulting from decisions based on poorly mapped data. All organizations creating and updating maps are provided guidance on putting processes in place to ensure the quality of the map. Once a map has been created and validated, it needs to be tested to determine if it is “fit for purpose.” This

testing is crucial for ensuring the map meets the needs for which it was created. End users of the data must be involved in this process. Once a map is used within other software applications, processes external to the map can affect the data, particularly if the software uses the information in an interpretive way (such as the ICD-9-CM codes translated into risk-of-mortality or severity-of-illness groupings).

III. Institute Change Management and Versioning Across the HIE

Once a map is created, it is not valid forever. The map must be maintained and updated on a continual basis as data-reporting requirements, standards, and terminology and classification systems routinely change. An inadequately maintained map can be worse than no map because it has the potential to transmit the wrong data, introducing error. Medicity provides toolkits and processes based upon industry best practices to effectively manage codeset upgrades, maintenance, and versioning.

IV. Generate a Semantically Interoperable Health Record

A semantically interoperable health record is generated based on the following two concepts:

- **Interoperable structure** – Information within the health record is structured in a predefined format for content, such as problem list, medications, labs, vitals, radiology reports, etc. Medicity supports creation of CCR, CCD, and CDA R2 documents that are recognized as the standard for interoperability.
- **Interoperable terminology representation** – The content of health records generated by Medicity's interoperability platform are represented using the standard vocabulary defined by meaningful use regulations. Terminology standards supported by Medicity's reference terminology service include the following:

Problem List: ICD-9 and SNOMED CT in addition to ICD-10.

Allergies: While the meaningful use requirements allow usage of free text or local vocabularies, our solution also supports the usage of Unique Ingredient Identifier (UNII) to represent the ingredient allergy information.

Semantic interoperability is a critical factor in achieving the benefits promised by electronic health record systems across the continuum of care and making care-delivery reform initiatives, such as accountable care organizations (ACOs), successful.

Procedures: ICD-9-CM, (ICD-10 as candidate), SNOMED CT, LOINC, and CPT-4.

Lab Orders & Results: Medicity's reference terminology service supports LOINC codes, as well as cross-mapping proprietary lab codes to LOINC codes.

Medications: In addition to RxNorm, we support a wide range of other medication vocabularies, such as Multum MediSource Lexicon, Micromedex Drugdex, First Databank NDDF, FDA NDC, FDA MTHSL (FDA Standard Product Labels), Medi-Span Master Drug Database, GS- Gold Standard Alchemy. In addition, we support mapping of proprietary-to-RxNorm to promote the use of the coding standards as recommended by the meaningful use requirements.

Vital Signs: Meaningful use requirements allow free text or local vocabularies. Medicity can also support CDA templates.

Units of Measure: In addition to free text or local vocabularies, we support support UCUM.

Summary

Semantic interoperability is a critical factor in achieving the benefits promised by electronic health record systems across the continuum of care and making care-delivery reform initiatives, such as accountable care organizations (ACOs), successful. Since ACOs will require clinical integration across the continuum of care, the information generated by different applications will need to be reconciled to mean the same thing. To enhance

communication along the continuum of care, the participating EHR applications will need to speak the same language either by adopting the same terminologies (which is not practical) or semantic mapping of heterogeneous nomenclatures used by various participating applications. There will be a need for data standardization and mapping of terminologies so that medical concepts are represented uniformly for medical decision-making. Also, analytics and reporting on aggregated data cannot be performed without semantic reconciliation.

To achieve semantic interoperability, you need a sophisticated terminology services framework designed to tie together disparate systems from the perspective of content, structure, and nomenclature standards. Medicity's interoperability platform provides robust features to generate longitudinal patient records

that are semantically interoperable and portable. Based on our experience achieving semantic interoperability at numerous HIE implementations, Medicity recommends a policy of incremental steps and a focused, consensus-based approach to terminology reconciliation in an open, collaborative environment. By following the process we created for establishing semantic interoperability – selecting the least common denominator, validating maps, instituting change management and versioning across the HIE, and generating a semantically interoperable health record – our clients are successfully exchanging clinical data from different sources and working as true care collaborators, with everyone involved sharing a unified view of the patient.

