The Synergy of Ontologies and HL7-FHIR

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Outline

- Some background concepts
  - What is an ontology?
  - What is FHIR?
  - Semantic Web
  - Why do we need any of them?
- Immediate rewards
- Longterm opportunities

What is an ontology?

- **on·tol·o·gy** */änˈtäləjē/*
    1. the branch of metaphysics dealing with the nature of being.
    2. a set of concepts and categories in a subject area or domain that shows their properties and the relations between them
- A way of formalizing human knowledge about an area of the world
- Consists of:
    - Taxonomy (classes and subclasses)
    - Individuals that are instances of a classes
    - Properties/relationships between classes and individuals
    - Expressions about classes and/or properties
- Ontologies are usually constructed with a particular application or goal

Data modeling

- a RDF triple says that *some relationship, indicated by the <u>predicate</u>, holds between the <u>resources</u> denoted by the <u>subject</u> and <u>object</u>.*

- Subject -> Predicate -> Object
  - Dr Smith treats Patient Brown

- Triplestore (RDF/XML)
  - <rdf:Description

    rdf:about="Dr Smith" >

    <treats> Patient Brown </treats>

    </rdf:Description>

- Graph   (Dr Smith)   treats   →   (Pt.Brown)

HL7 Fast Healthcare Interoperability Resources

- Health Level 7: international non-profit dedicated to designing standards for health data interoperability
- FHIR: A standard for health care data exchange
- Builds on older versions
  - Version 2: commonly used
  - Version 3: updated version with more robust definitions about healthcare domains
  - CDA: an XML-based markup standard intended to specify the encoding, structure and semantics of clinical documents for exchange
- Uses modern computer approaches, e.g. REST
- Includes conceptual framework of healthcare in a data-centric vision

FHIR modules

Level 1 Basic framework on which the specification is built

🏥 **Foundation**	Base Documentation, XML, JSON, Data Types, Extensions

Level 2 Supporting implementation and binding to external specifications

👥 **Implementer Support**	🔒 **Security & Privacy**	✅ **Conformance**	📚 **Terminology**	🔷 **Exchange**
Downloads, Version Mgmt, Use Cases, Testing	Security, Consent, Provenance, AuditEvent	StructureDefinition, CapabilityStatement, ImplementationGuide, Profiling	CodeSystem, ValueSet, ConceptMap, Terminology Svc	REST API + Search Documents Messaging Services Databases

Level 3 Linking to real world concepts in the healthcare system

👤 **Administration**	Patient, Practitioner, CareTeam, Device, Organization, Location, Healthcare Service

Level 4 Record-keeping and Data Exchange for the healthcare process

🩺 **Clinical**	🧪 **Diagnostics**	💊 **Medications**	🗂 **Workflow**	💲 **Financial**
Allergy, Problem, Procedure, CarePlan/Goal, ServiceRequest, Family History, RiskAssessment, etc.	Observation, Report, Specimen, ImagingStudy, Genomics, Specimen, ImagingStudy, etc.	Medication, Request, Dispense, Administration, Statement, Immunization, etc.	Introduction + Task, Appointment, Schedule, Referral, PlanDefinition, etc	Claim, Account, Invoice, ChargeItem, Coverage + Eligibility Request & Response, ExplanationOfBenefit, etc.

Level 5 Providing the ability to reason about the healthcare process

🧠 **Clinical Reasoning**	Library, PlanDefinition & GuidanceResponse, Measure/MeasureReport, etc.

Semantic Web

- Effort to develop standards that enable computers to access data throughout the Web and to be able to reason using that data

- World Wide Web Consortium (W3C)

- Establishes standards for both syntax and semantics

- Works on many different aspects of data representation and communication

- Involves how to model data (RDF), format data (XML), reason with data (OWL), search for data (SPARQL)

- Ultimate origin of ontology+FHIR synergy

Why do we need them?

- Ontologies represent our knowledge

- FHIR is one method of exchanging information about that knowledge

- DICOM is good example
    - On semantic level, it described what constitutes medical imaging
    - Made a connection between how we think of imaging and how it is represented in a computer
    - On syntactical level, it describes precisely how to encode and transmit the data that describe images
    - Users are free to use and transform data any way they want; DICOM standard allows common use of source and transformed data

Impediments to standardization*

1. Failure to initiate a standardization effort;

2. Failure to reach consensus leading to deadlock;

3. Failure to contain the scope of the effort, leading to "feature creep";

4. Failure of acceptance by the field (eg, because of standardization that is incompatible with current/evolving practice).

Final recommendation for prescription key elements:

   Treatment site, Delivery method, Dose per fraction, Fraction number, Total dose

* "Standardizing Dose Prescriptions: An ASTRO White Paper",
SB Evans et al, PRO, 2016.

Difficulty in defining concepts*:

Total Skin ElectronTherapy
IMRT
3D-CRT
Gamma Knife Radiosurgery
TomoTherapy
Photon radiotherapy
Proton therapy
Heavy Ion therapy
Brachytherapy
Orthovoltage
LDR
PDR
HDR
VMAT

External Beam Radiation Therapy
Neutron therapy
Stereotactic radiation therapy
Internal Radiation Therapy
(Brachytherapy)
Low Dose Rate Brachytherapy
High Dose Rate Brachytherapy
Interstitial brachytherapy
Intracavitary brachytherapy
Intraluminal radiation therapy
Stereotactic radiotherapy
Radiosurgery

How can they work together?

- In ontology, break down complex structures and define the basic concepts (classes)
  - Radiation therapy procedure: patient, physician, number of fractions, part of body irradiated, etc.
  - Radiation therapy device: produces some forms of radiation, measures amount of radiation, has some geometrical elements
- FHIR can easily communicate simple data elements and can group them as well if they match common paradigm (physician treats patient)
- Users of data can build whatever structures they want from the elements, e.g. treatment course—they are not constrained by arbitrary standards but can leverage standardization of uncontested concepts

Future developments

- Follow guidelines for ontology development (OBO Foundry) to reduce redundant definitions and insure interoperability between ontologies
- Develop graph databases in line with ontology
- Use SPARQL to extract desired data
- FHIR provides reliable means of communication between applications
- Semantic Web tools provides means for reasoning using data from multiple sources
- Synergy emerges as information from other biomedical databases (described by ontologies) can be merged