

The Yosemite Project for Healthcare Information Interoperability

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9-Jul-2015

These slides: <http://tinyurl.com/YosemiteRoadmap20150709slides>

<http://YosemiteProject.org/>

Outline

- Mission of the Yosemite Project
- Foundation: RDF
- Roadmap for interoperability:
 - Standardize the Standards
 - Crowdsource Translations
 - Incentivize

Imagine a world

Imagine a world
in which **all healthcare systems**
speak the **same language**
with the **same meanings**
covering **all healthcare.**

Semantic interoperability:

*The ability of computer systems
to exchange data
with unambiguous, shared meaning.*

– [Wikipedia](#)

Healthcare today



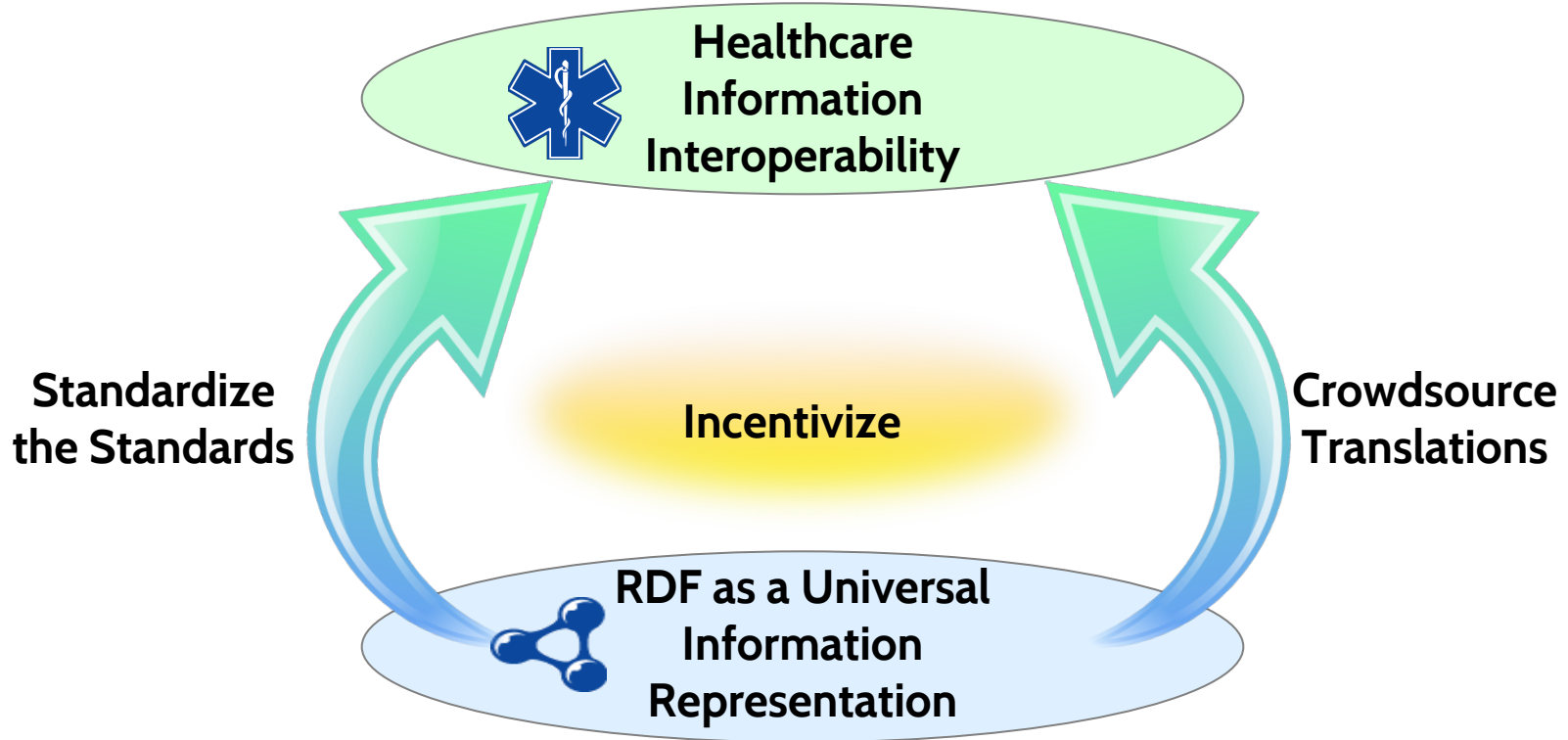
Tower of Babel, Abel Grimmer (1570-1619)

Yosemite Project

MISSION:

*Semantic interoperability
of
all structured healthcare information*

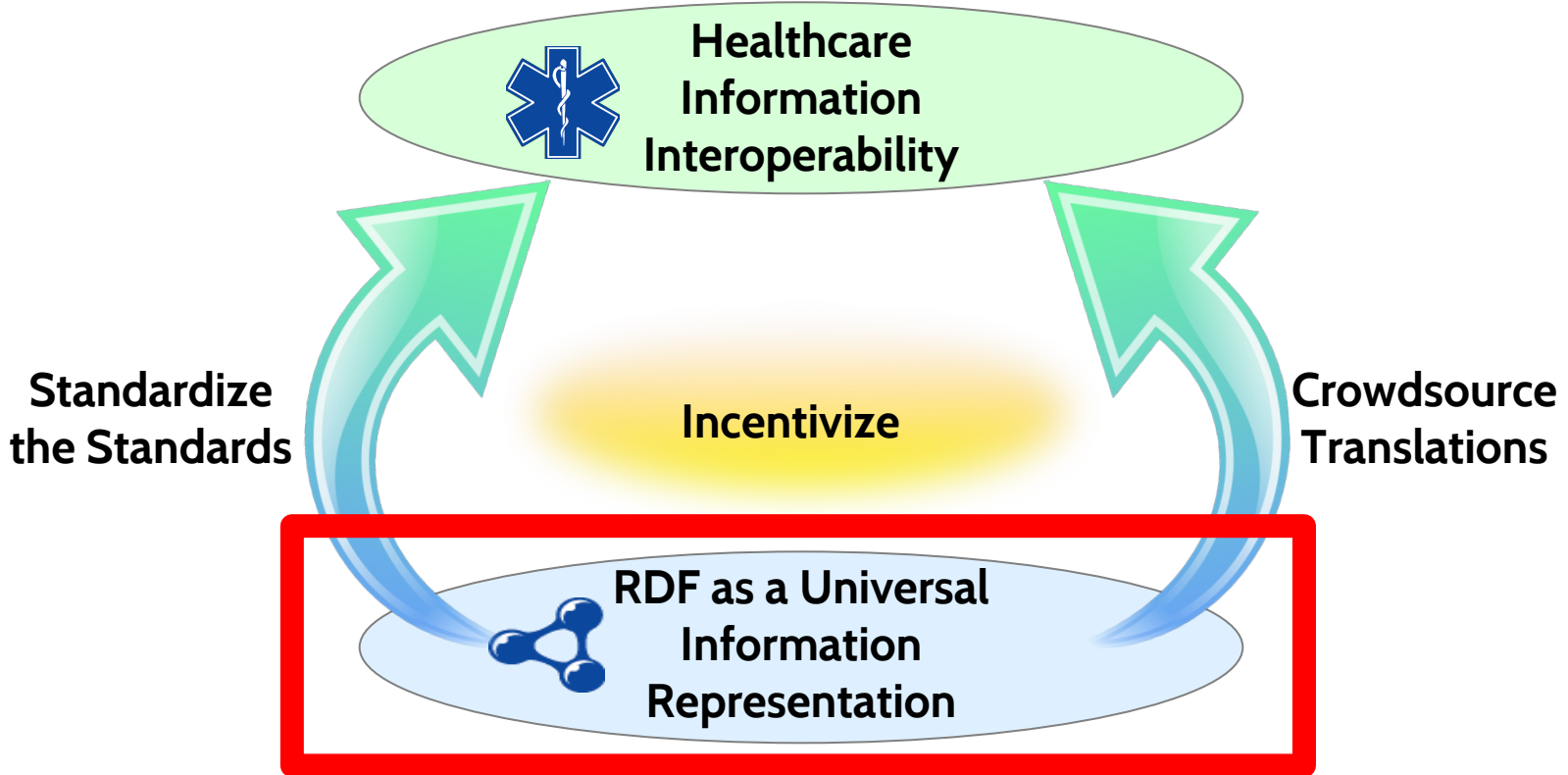
Interoperability Roadmap





RDF as a Universal Information Representation

Interoperability Roadmap



What is RDF?

- "Resource Description Framework"
 - *But think "Reusable Data Framework"*
 - Language for representing information
 - International standard by W3C
 - Mature – 10+ years
 - Used in many domains, including biomedical and pharma
- 11

RDF graph

English assertions:

Patient319 has name "John Doe".

Patient319 has systolic blood pressure observation Obs_001.

Obs_001 value was 120.

Obs_001 units was mmHg.

RDF* assertions ("triples"):

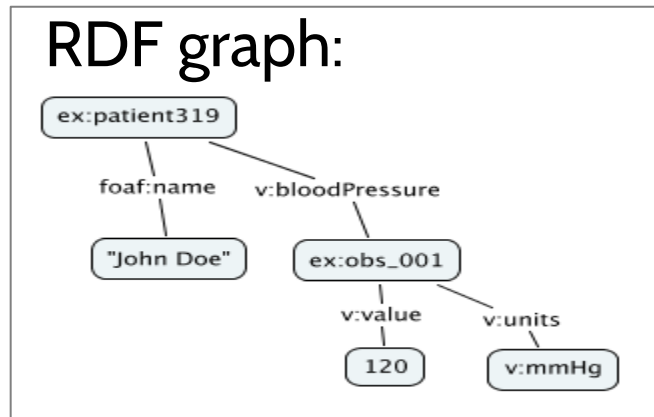
ex:patient319 foaf:name "John Doe" .

ex:patient319 v:systolicBP ex:obs_001 .

ex:obs_001 v:value 120 .

ex:obs_001 v:units v:mmHg .

RDF graph:



12

*Namespace definitions omitted

RDF captures information – not syntax

- RDF is format independent
- There are multiple RDF syntaxes: Turtle, N-Triples, JSON-LD, RDF/XML, etc.
- The same information can be written in different formats
- Any data format can be mapped to RDF

Different source formats, same RDF

HL7 v2.x

```
OBX|1|CE|3727-0^BPsystolic,  
sitting||120||mmHg|
```

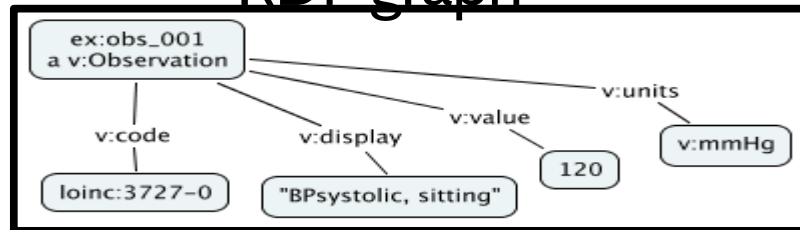
FHIR

```
<Observation  
  xmlns="http://hl7.org/fhir">  
  <system value="http://loinc.org"/>  
  <code value="3727-0"/>  
  <display value="BPsystolic, sitting"/>  
  <value value="120"/>  
  <units value="mmHg"/>  
</Observation>
```

Maps to

Maps to

RDF graph



Why does this matter?

- Emphasis is on the meaning (where it should be)
- RDF acts as a universal information representation
- Existing data formats can be used
 - Each one has an implicit RDF equivalent
 - No need for explicitly exchange RDF format

Why RDF?

"Captures information content, not syntax"

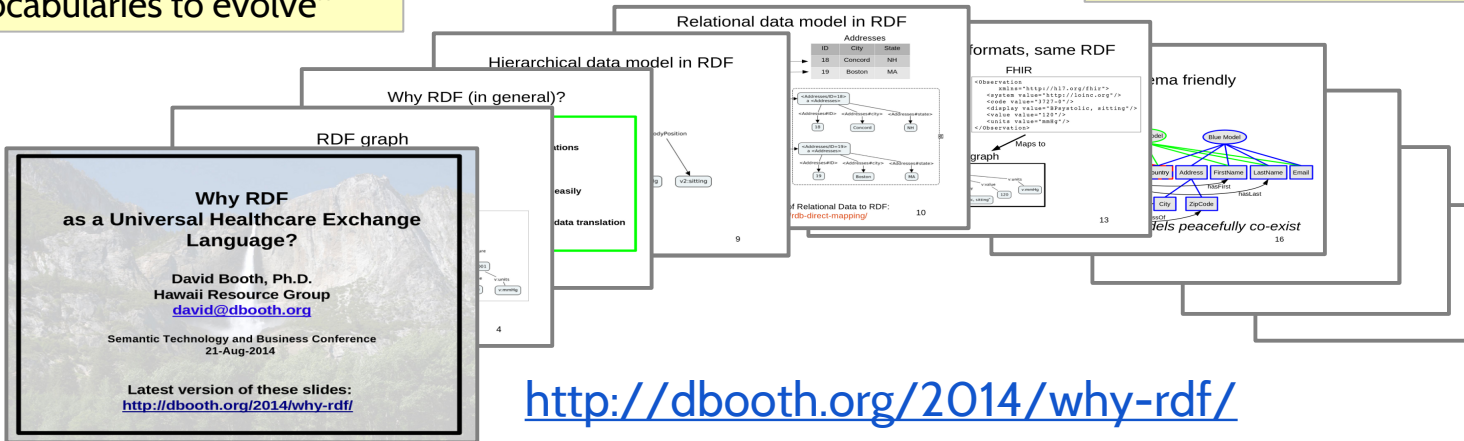
"Allows data models and vocabularies to evolve"

'Multi-schema friendly'

"Good for model transformation"

"Allows diverse data to be connected and harmonized"

"Supports inference"

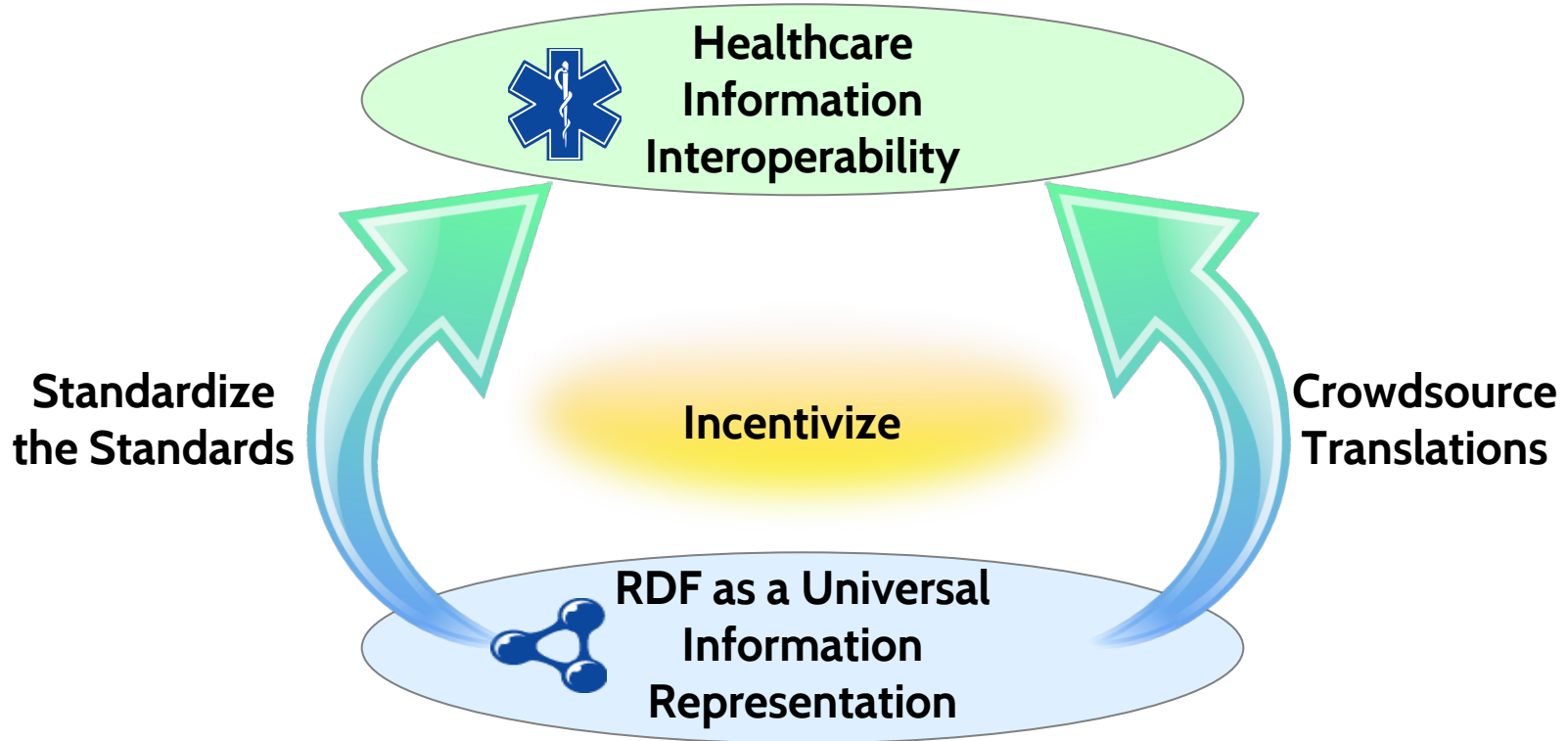


- Endorsed by over 100 thought leaders in healthcare and technology as the *best available candidate* for a universal healthcare exchange language
 - See <http://YosemiteManifesto.org/>

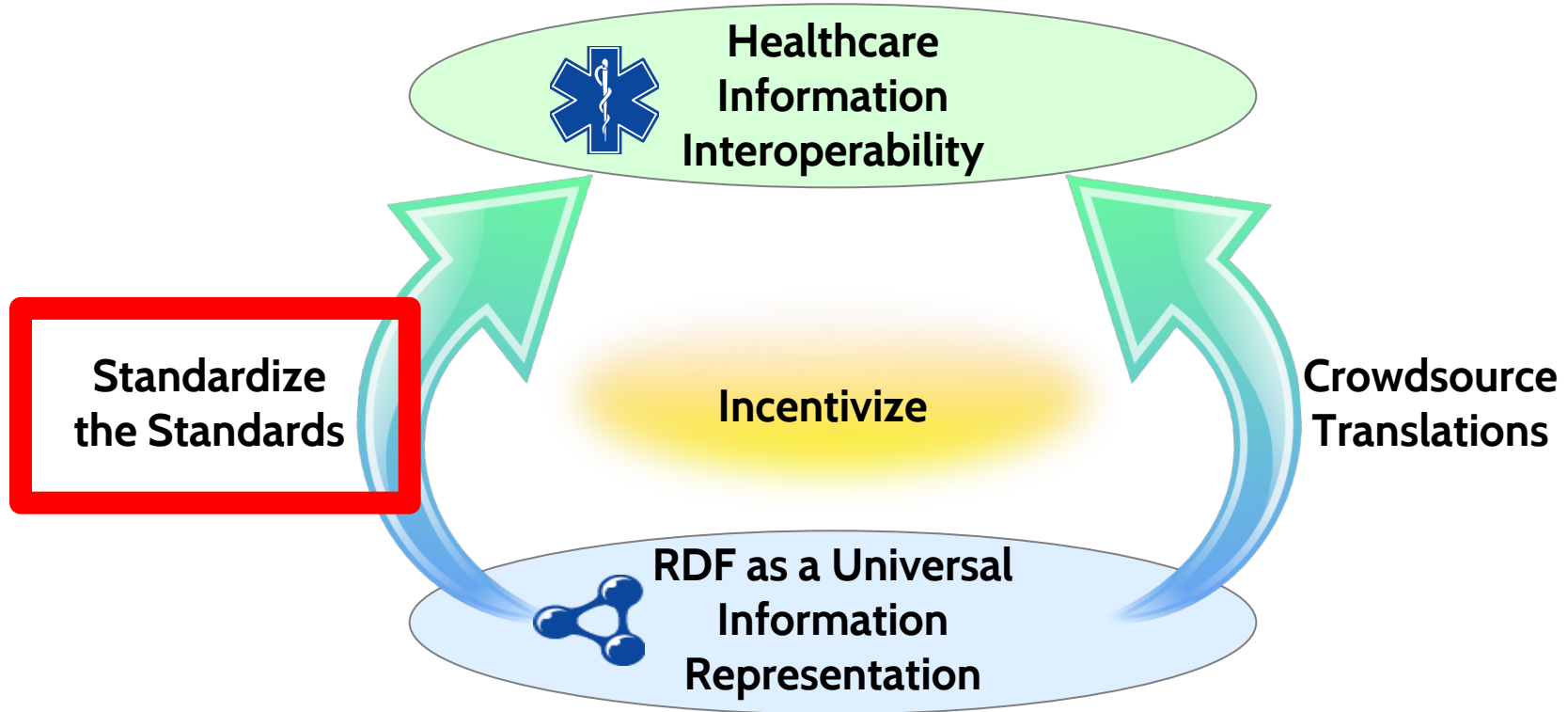


Standardize the Standards

Interoperability Roadmap



Interoperability Roadmap

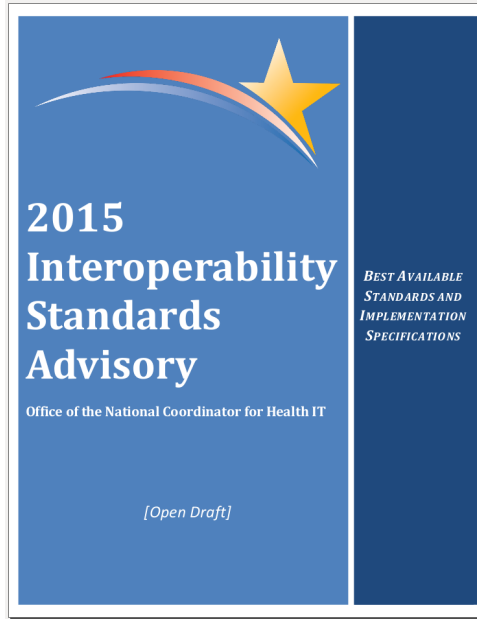


Standard Vocabularies in UMLS

AIR ALT AOD AOT BI CCC CCPSS CCS CDT CHV COSTAR CPM CPT CPTSP
CSP CST DDB DMDICD10 DMDUMD DSM3R DSM4 DXP FMA HCDT
HCPCS HCPT HL7V2.5 HL7V3.0 HLREL ICD10 ICD10AE ICD10AM
ICD10AMAE ICD10CM ICD10DUT ICD10PCS ICD9CM ICF ICF-CY ICPC
ICPC2EDUT ICPC2EENG ICPC2ICD10DUT ICPC2ICD10ENG ICPC2P
ICPCBA ICPCDAN ICPCDUT ICPCFIN ICPCFRE ICPCGER ICPCHEB
ICPCHIN ICPCITA ICPCJPN ICPCPOR ICPCSPA ICPCSWE JABL KCD5
LCH LIC LNC LNC-AD LNC-DS3 MCM MEDLINEPLUS MSHCZE MSHDUT
MSHFIN MSHFRE MSHGER MSHITA MSHJPN MSHLAV MSHNOR
MSHPOL MSHPOR MSHRUS MSHSCR MSHSPA MSHSWE MTH MTHCH
MTHHH MTHICD9 MTHICPC2EAE MTHICPC2ICD10AE MTHMST
MTHMSTFRE MTHMSTITA NAN NCISEER NIC NOC OMS PCDS PDQ
PNDS PPAC PSY QMR RAM RCD RCDAE RCDSA RCDSY SNM SNMI SOP
SPN SRC TKMT ULT UMD USPMG UWDA WHO WHOFRE WHOGER
WHOPOR WHOSPA

Over 100!

ONC recommended standards



- Patchwork of ~30 standards + clarifications
- Different data formats, data models and vocabularies
- Defined in different ways - not in a uniform, computable form

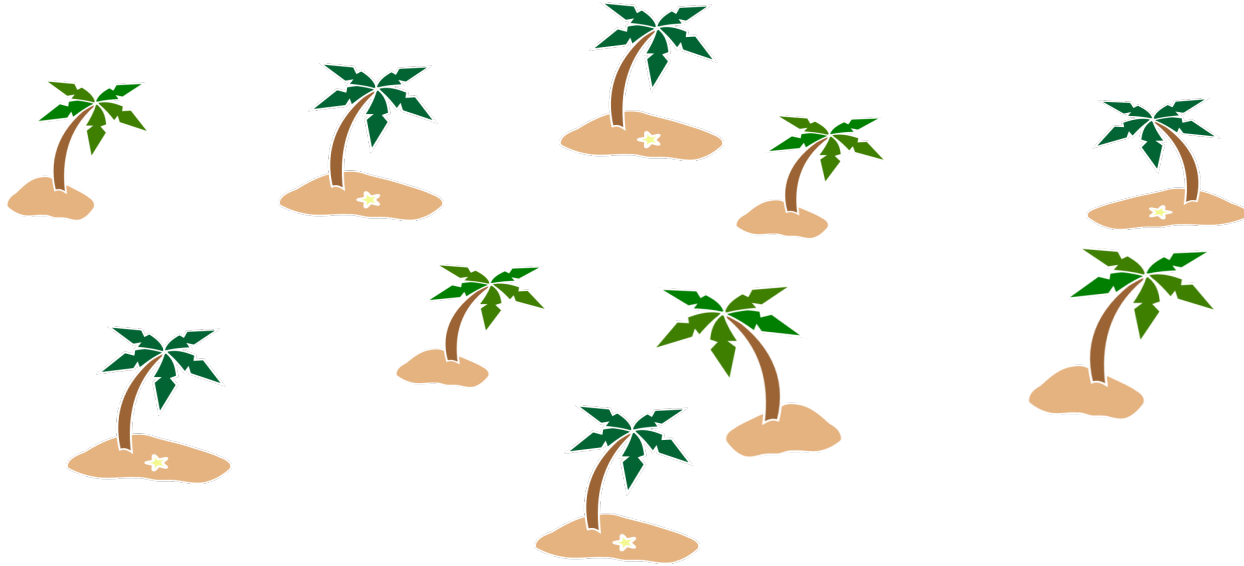
HOW STANDARDS PROLIFERATE:

(SEE: A/C CHARGERS, CHARACTER ENCODINGS, INSTANT MESSAGING, ETC.)



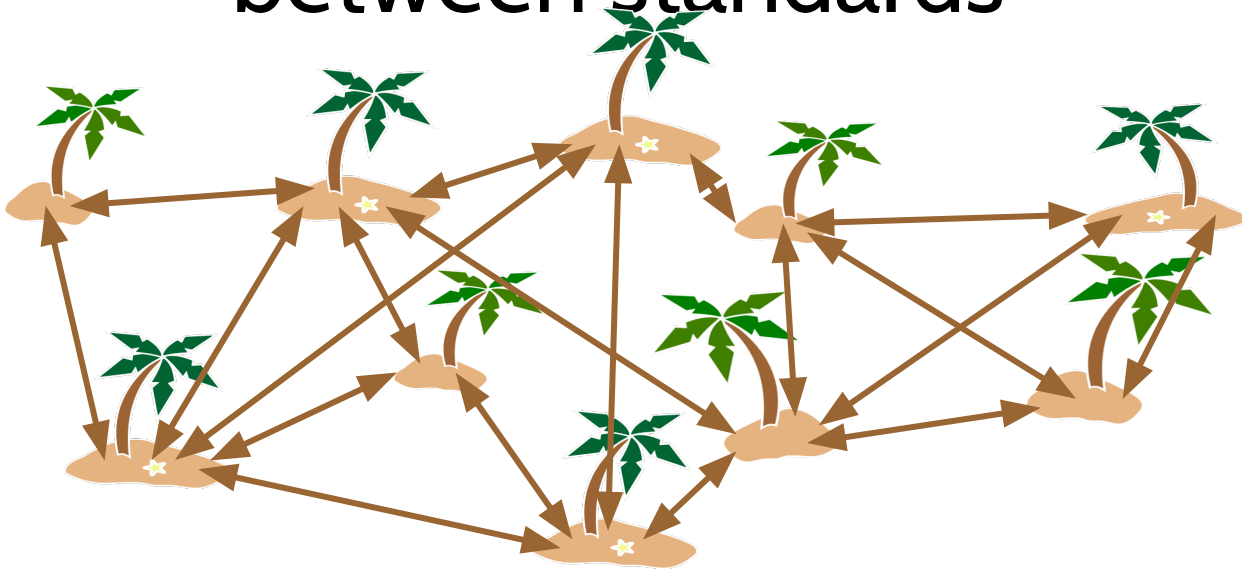
<http://xkcd.com/927/>

Each standard is an island



- Each has its "sweet spot" of use
- Lots of duplication

RDF and OWL enable semantic bridges between standards

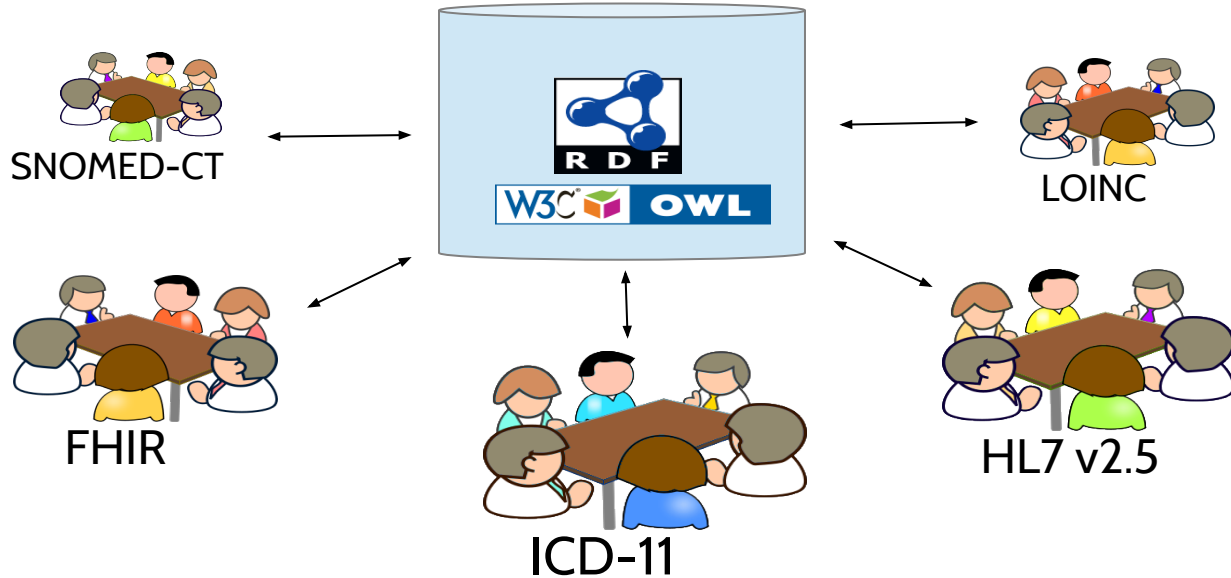


- Goal: a cohesive mesh of standards that act as a single comprehensive standard

Standardize the standards

- Use RDF & family as a common, computable definition language
- Semantically link standards
- Converge on common definitions

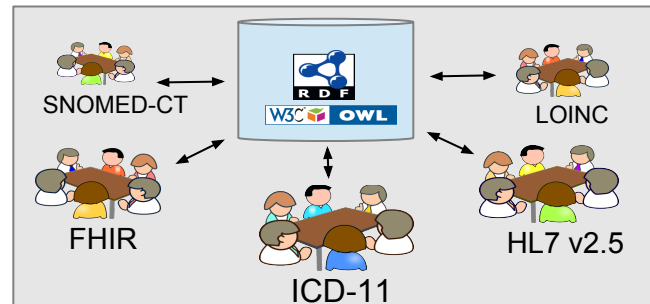
Needed: Collaborative Standards Hub



- Cross between BioPortal, GitHub, WikiData, Web Protege, CIMI repository, HL7 model forge, UMLS Semantic Network and Metathesaurus
 - Next generation BioPortal?

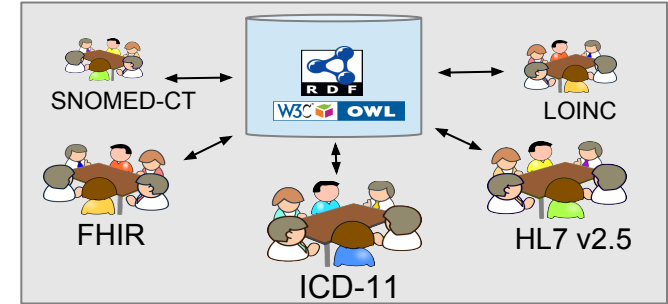
Collaborative Standards Hub

- Repository of healthcare information standards
- Supports standards groups and implementers
- Holds RDF/OWL definitions of data models, vocabularies and terms
- Encourages:
 - Semantic linkage
 - Standards convergence



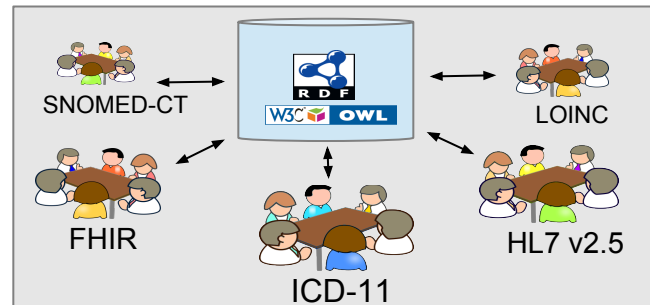
Collaborative Standards Hub

- Suggests related concepts
- Checks and notifies of inconsistencies – within and across standards
- Can be accessed by browser or RESTful API



Collaborative Standards Hub

- Can scrape or reference definitions held elsewhere
- Provides metrics:
 - Objective (e.g., size, number of views, linkage degree)
 - Subjective (ratings)
- Uses RDF and OWL under the hood
 - Users should not need to know RDF or OWL



iCat: Web Protege tool for ICD-11

CAT ICD Collaborative Authoring Tool Csongor Nyulas | [Sign Out](#) | [Options](#) ▾

My ICD | **ICD Content** | Category Notes and Discussions | Reviews | Change History | Manage Hierarchy | Export and Import

ICD Categories

Create Watch Branch Search: '29E' 'Roseola infantum'

- 07 VII Diseases of the eye and adnexa 9 2773
- 08 VIII Diseases of the ear and mastoid process 7
- 09 IX Diseases of the circulatory system 4 2285
- 10 X Diseases of the respiratory system 3 1385
- 11 XI Diseases of the digestive system 4 4381
- 12 XII Diseases of the skin 10 6775
- LA Infections and infestations affecting the skin
- LA0 Viral infections affecting the skin 2 2
- LA00 Pox virus infections of the skin 2
- LA01 Herpes virus infection of skin and mucous membranes
- 29A0 Herpes simplex infection of skin and mucous membranes
- LA011 Varicella zoster infection of skin
- LA018 Other human herpes virus infections
- 29E Roseola infantum 4**
- LA02 Human papilloma virus infection of skin
- LA05 Skin disorders related to HIV and other immunodeficiencies
- LA07 Viral exanthems 1 17
- LA08 Miscellaneous skin disorders resulting from infections
- LA09 Miscellaneous dermatoses with suspected infectious etiology

Details for 29E Roseola infantum

Title & Definition	Classification Properties	Terms	Clinical Description
Manifestation Properties	Causal Properties	Temporal Properties	Severity Properties
Functioning Properties	Specific Condition Properties	Treatment	Diagnostic Criteria
ICD-10 Notes and Hints	ICD-10 Linearizations	Editorial Information	

ICD-10 Code ? B08.2

Sorting label 29E

ICD Title ? Roseola infantum

Short Definition ?

Text
An acute, short-lived, viral disease of infants and young children characterized by a high fever at onset that drops to normal after 3-4 days and the concomitant appearance of a macular or maculopapular rash that appears first on the trunk

External Definitions ?

Definition	Source
An acute, short-lived, viral disease of infants and young children characterized by a high fever at onset that drops to normal after 3-4 days and the concomitant	UMLS/MSH 2008_2008_02_04

[Add new value](#)

icat.stanford.edu/#

iCat development of ICD-11

In three years:

- 270 domain experts around the world
- 45,000+ classes
- 260,000+ changes
- 17,000 links to external terminologies

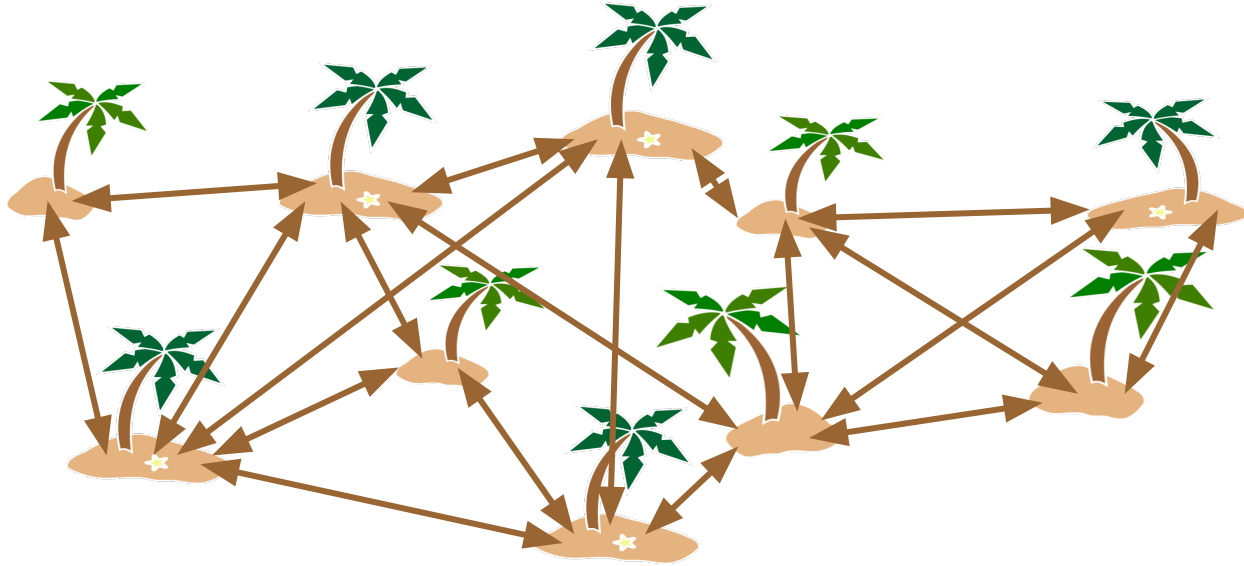


Similar Effort in Financial Industry: FIBO



- Standards in RDF
- Similar concept but narrower scope than Yosemite Project
- For financial reporting and policy enforcement
- Using github and other tools to help collaboration

RDF helps avoid the bike shed effect



- Each group can use its favorite data format, syntax and names
- RDF can uniformly capture the information content

Bike shed effect

a/k/a Parkinson's Law of Triviality

Organizations spend disproportionate time on trivial issues. -- C.N. Parkinson, 1957

1. Nuclear Plant

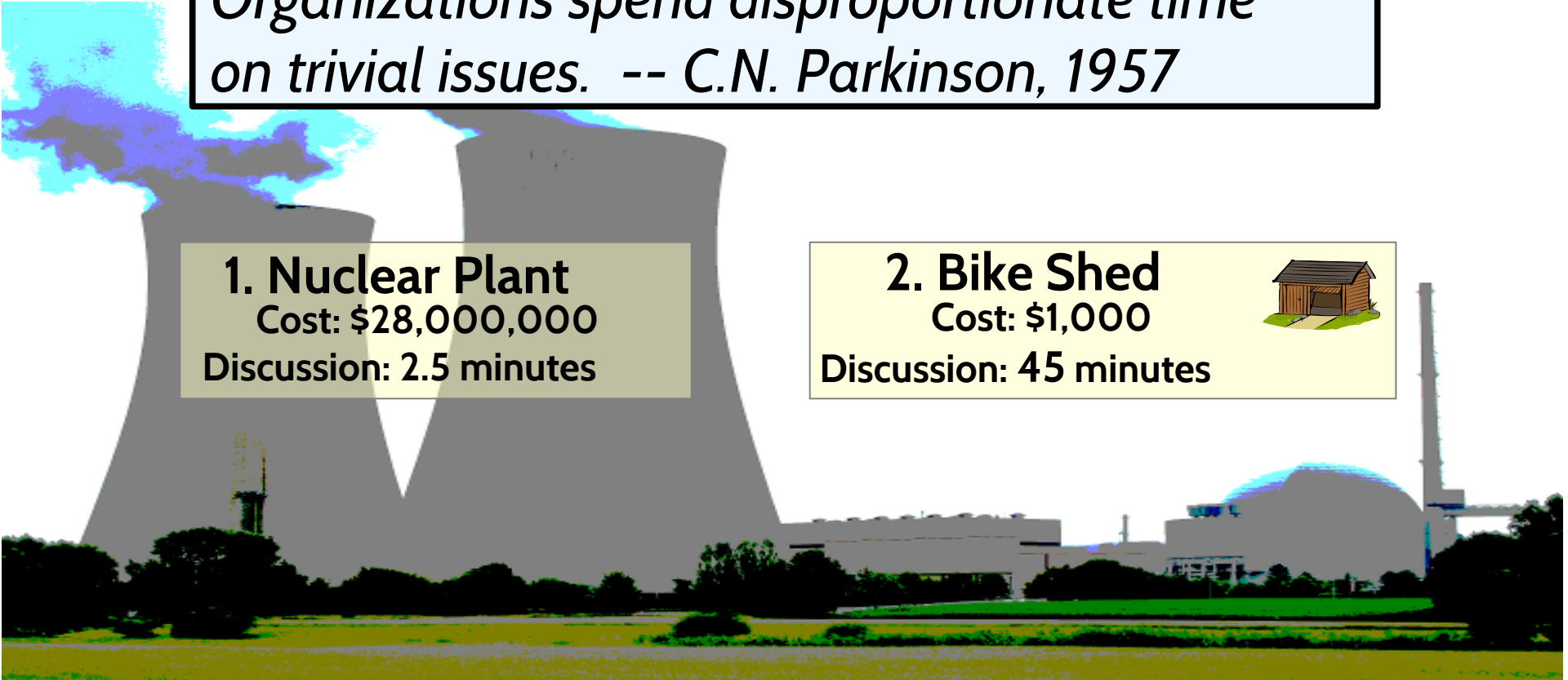
Cost: \$28,000,000

Discussion: 2.5 minutes

2. Bike Shed

Cost: \$1,000

Discussion: 45 minutes



Standards committees and the bike shed effect

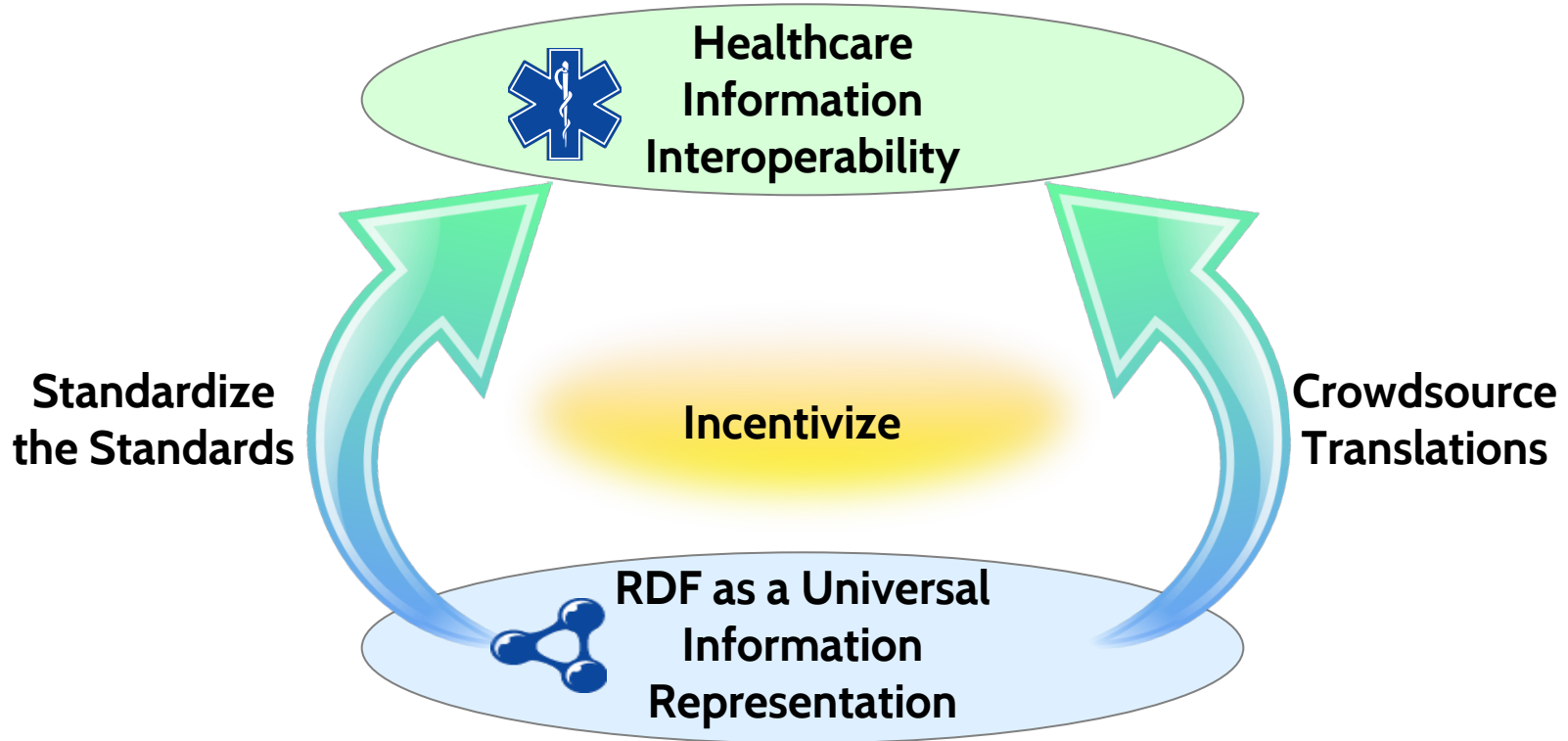


- Committees spend hours deciding on data formats, syntax and naming
 - Irrelevant to the computable information content

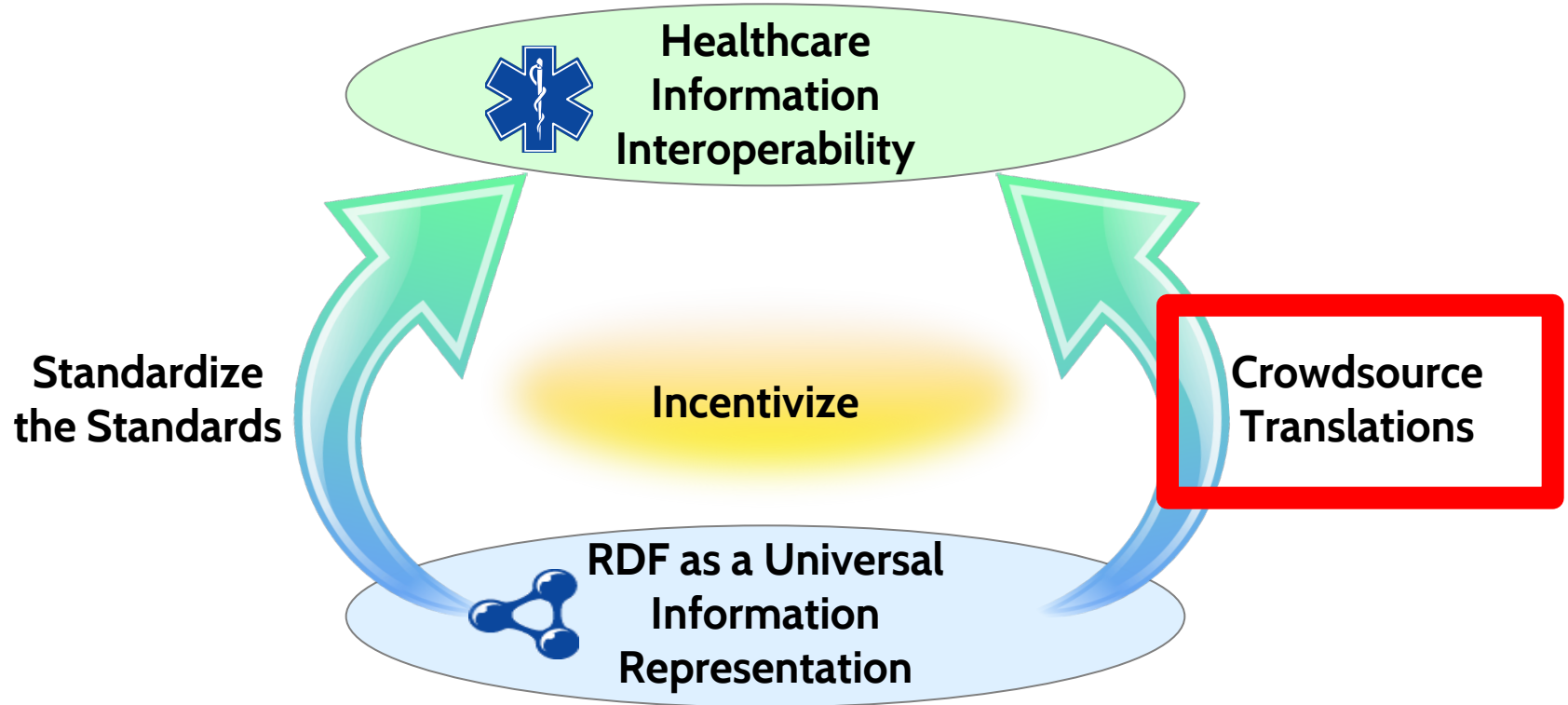


Crowdsource Translations

Interoperability Roadmap



Interoperability Roadmap



Two ways to achieve interoperability

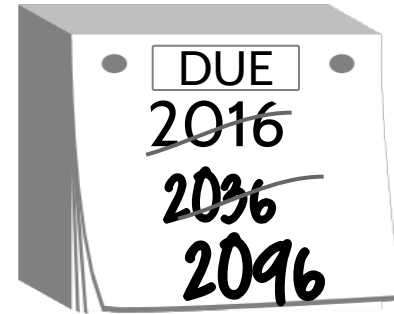
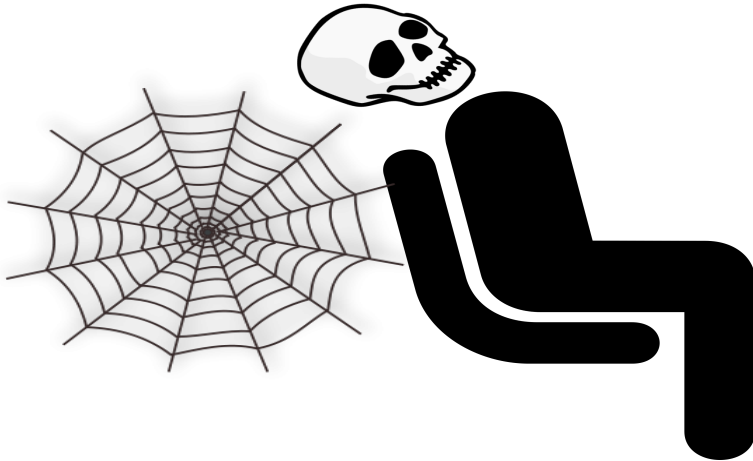
- Standards:
 - Make everyone speak the same language
 - I.e., same data models and vocabularies
- Translations:
 - Translate between languages
 - I.e., translate between data models and vocabularies

Obviously we prefer
standards.

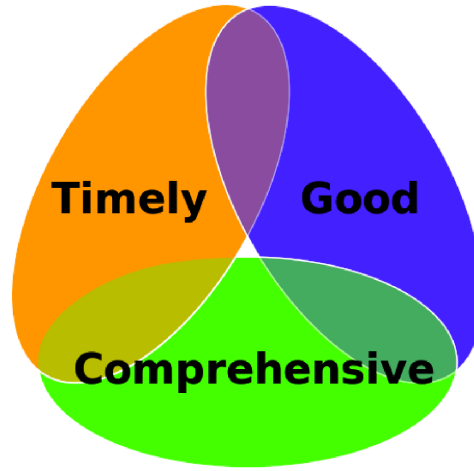
But

Standardization takes time

COMING SOON!
**COMPREHENSIVE
STANDARD**

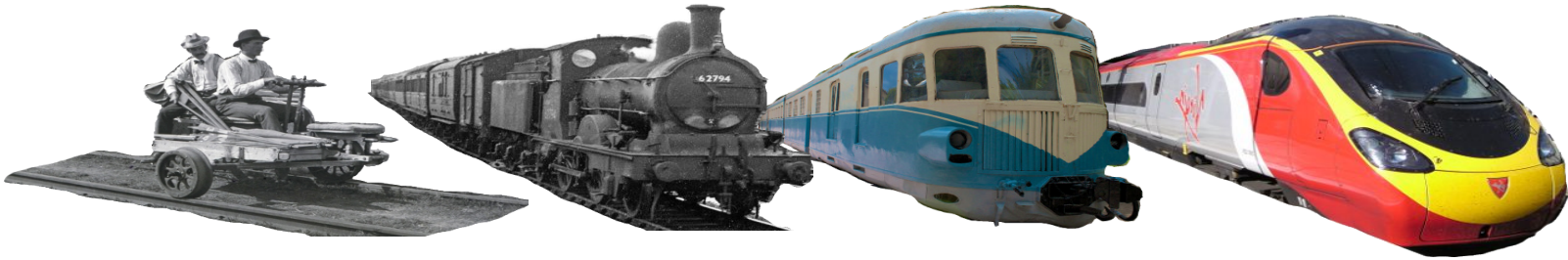


Standards trilemma: Pick any two



- **Timely:** Completed quickly
- **Good:** High quality
- **Comprehensive:** Handles all use cases

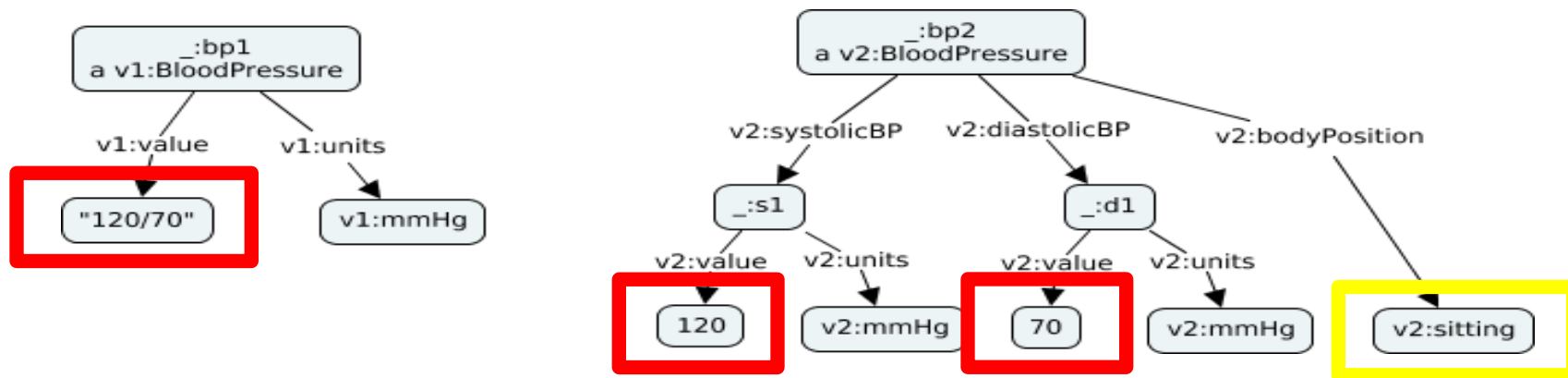
Modernization takes time



- Existing systems cannot be updated all at once

Diverse use cases

- Different use cases need different data, granularity and representations



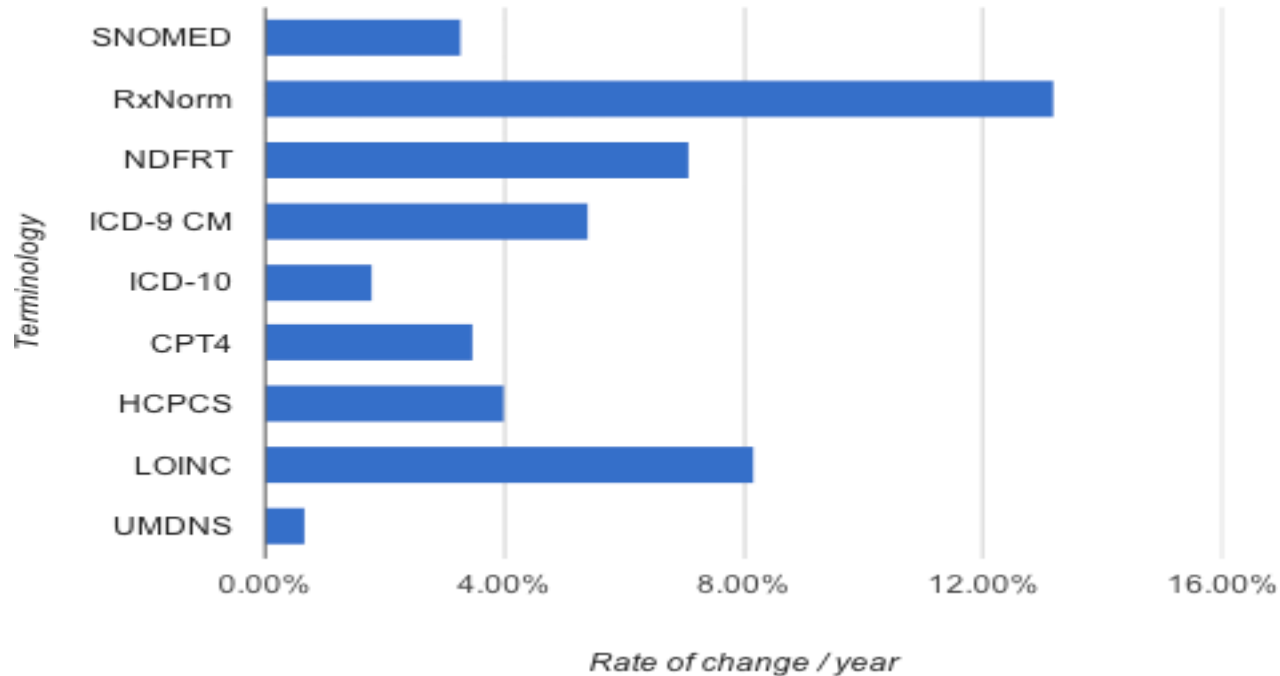
*One standard does **not** fit all!*

Standards evolve

- Version $n+1$ improves on version n



Healthcare terminologies rate of change



Slide credit: Rafael Richards (VA)

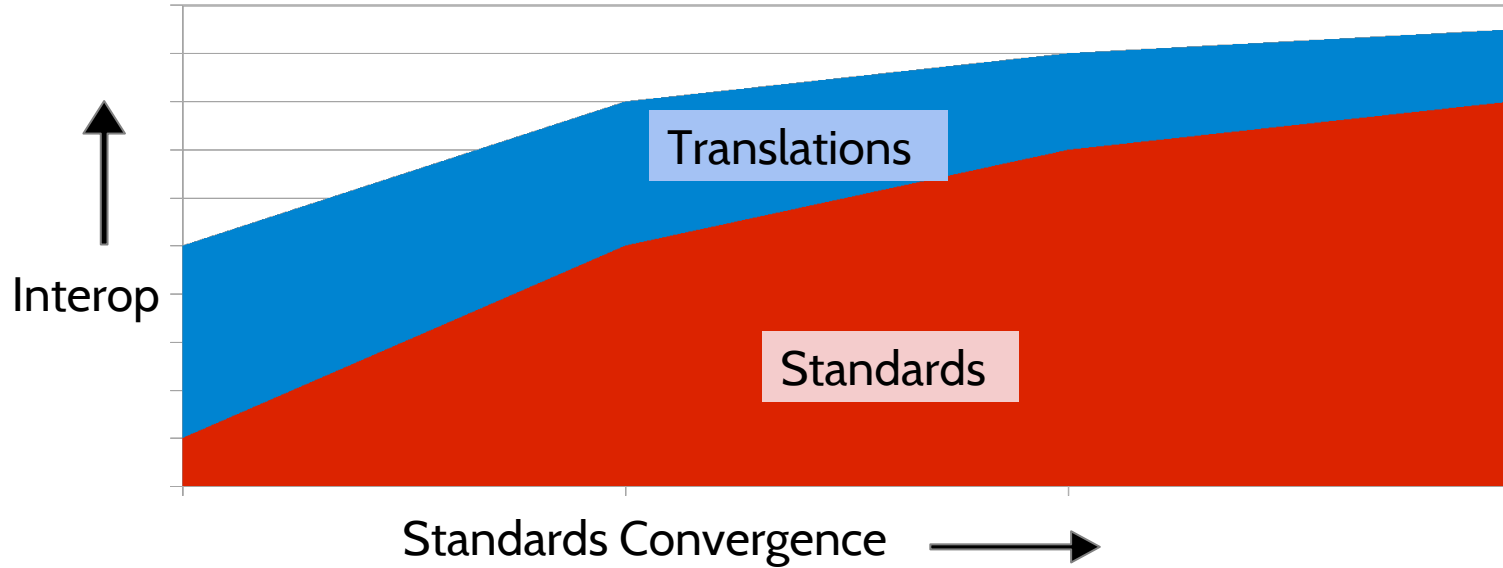
Translation is unavoidable!

Translation allows:

- Newer systems to interoperate with older systems
- Different use cases to use different data models
- Standards to evolve

A realistic strategy for semantic interoperability
must address both
standards and translations.

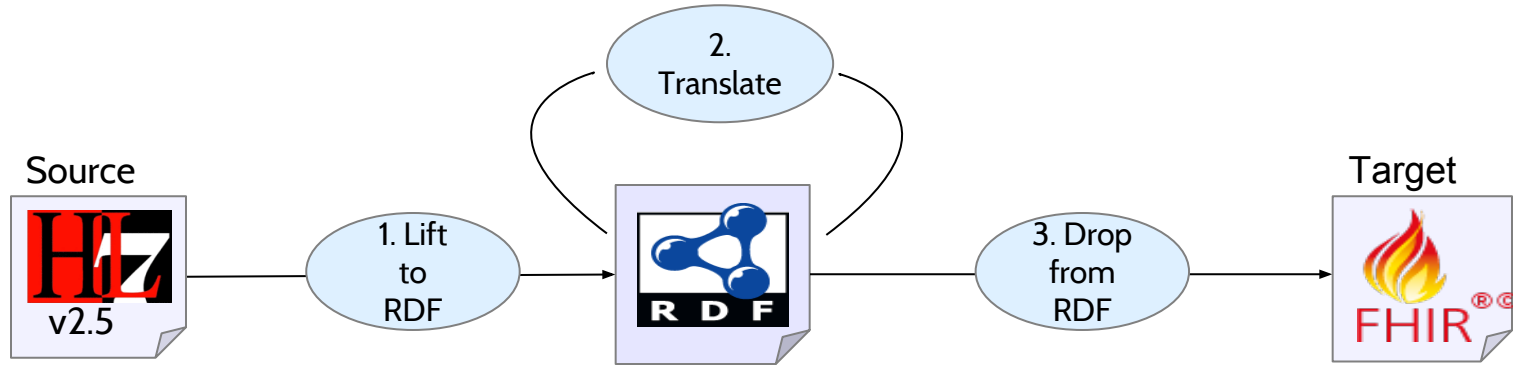
Interoperability achieved by standards vs. translations



How RDF helps translation

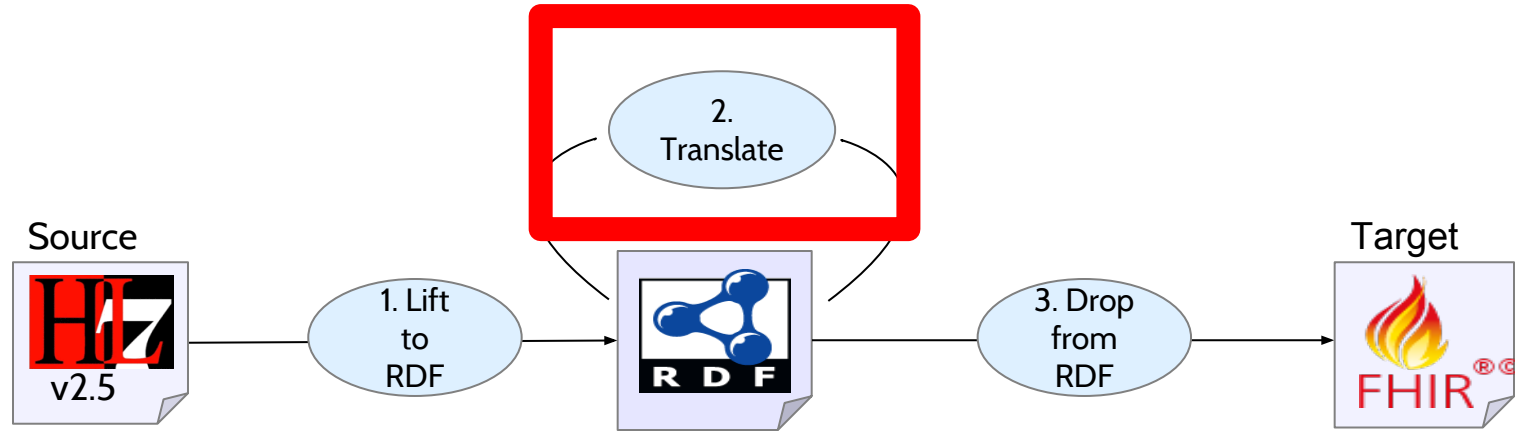
- RDF supports **inference**
 - Can be used for translation
- RDF acts as a **universal information representation**
- Enables data model and vocabulary translations to be **shared**

Translating patient data



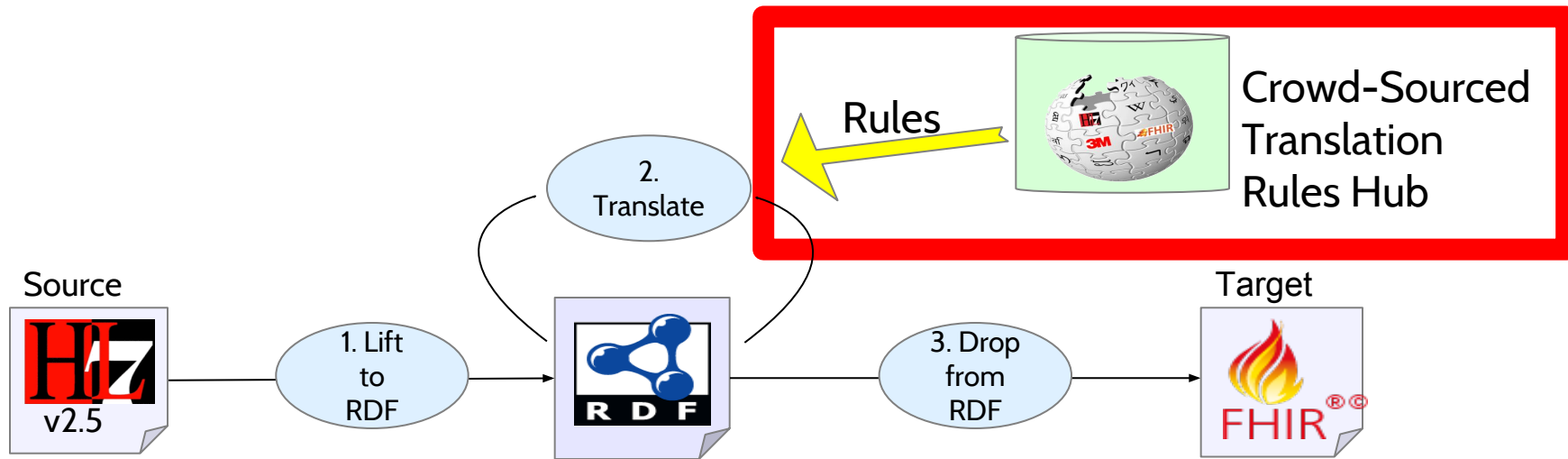
- Steps 1 & 3 map between source/target syntax and RDF
- Step 2 translates instance data between data models and vocabularies (RDF-to-RDF)
 - A/k/a semantic alignment, model alignment

How should this translation be done?



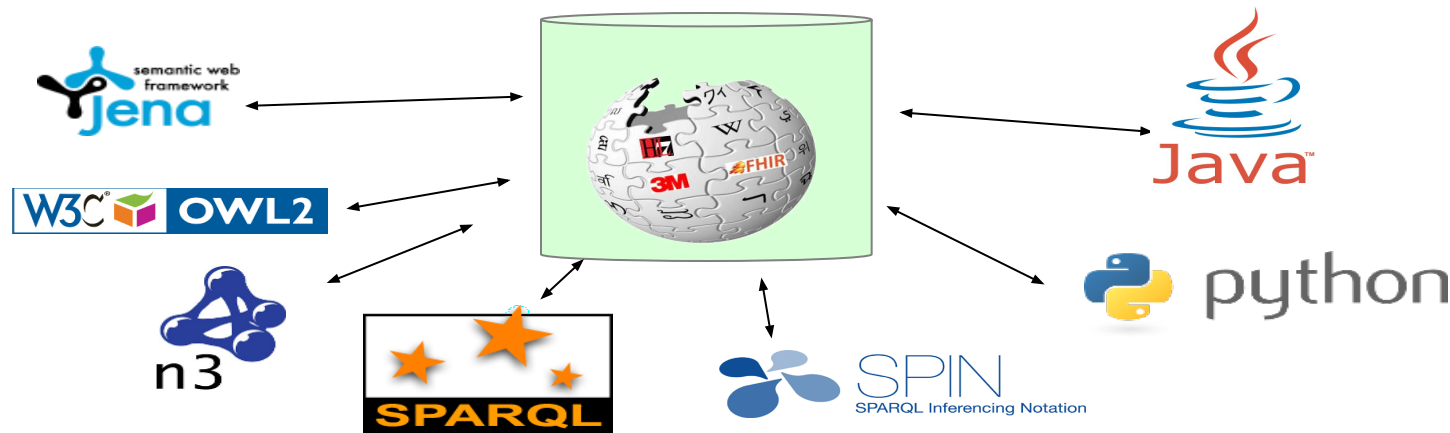
- Translation is hard!
- Many different models and vocabularies
- Currently done in proprietary, black-box integration engines

Where are these translation rules?



- By manipulating RDF data, rules can be mixed, matched and shared

Needed: Crowd-Sourced Translation Rules Hub

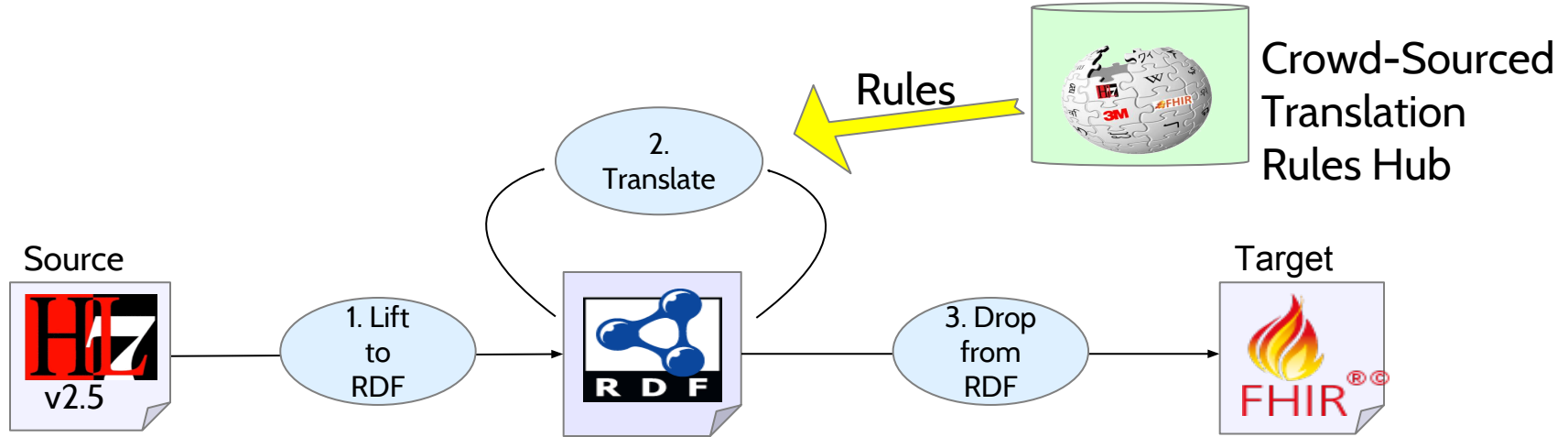


- Based on GitHub, WikiData, BioPortal, Web Protege or other
- Hosts translation rules
- Agnostic about "rules" language:
 - Any executable language that translates RDF-to-RDF (or between RDF and source/target syntax)

Translation rules metadata

- Source and target language / class
- Rules language
 - E.g. SPARQL/SPIN, N3, JenaRules, Java, Shell, etc.
- Dependencies
- Test data / validation
- License (free and open source)
- Maintainer
- Usage metrics/ratings
 - Objective: Number of downloads, Author, Date, etc.
 - Subjective: Who/how many like it, reviews, etc.
 - Digital signatures of endorsers?

Patient data privacy

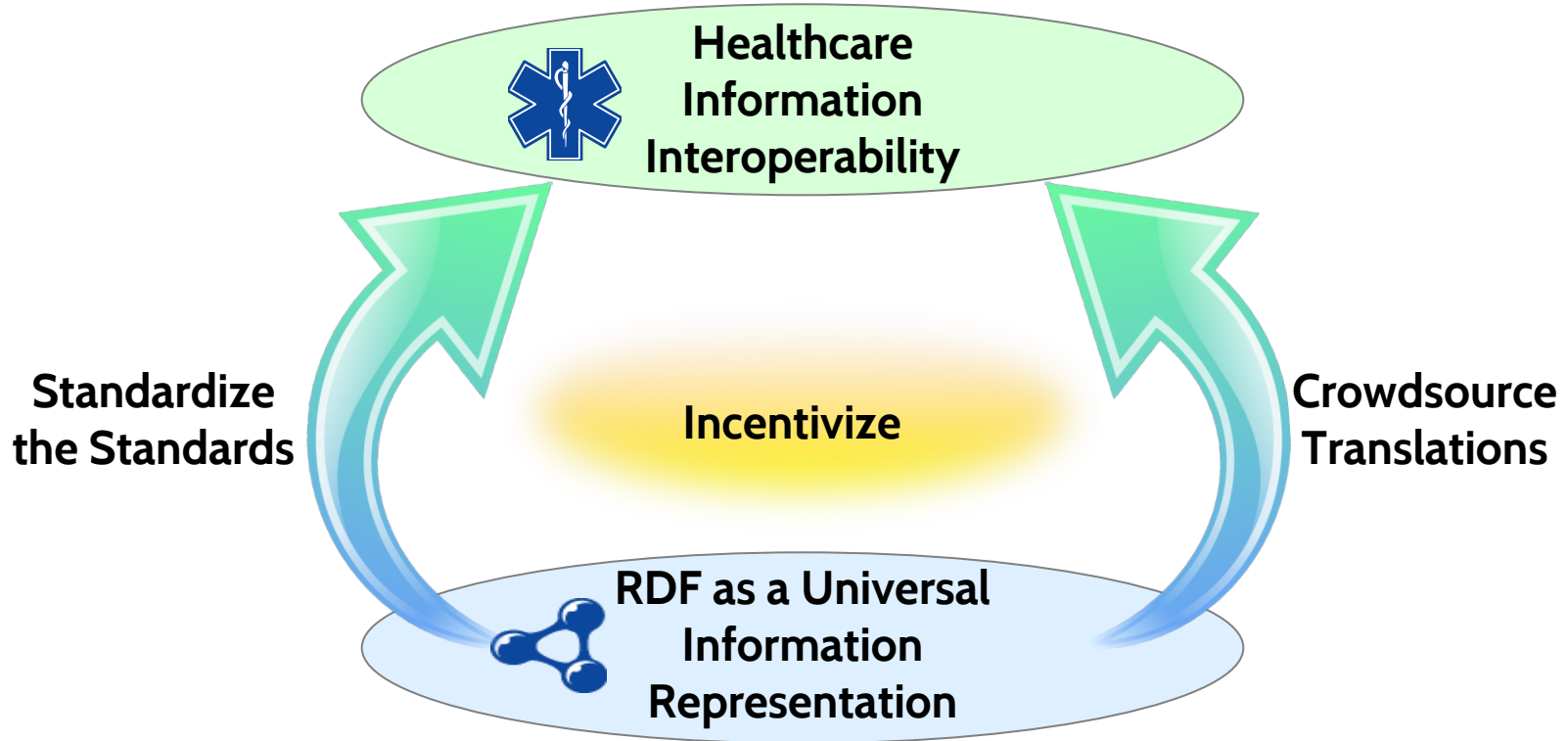


- Download translation rules as needed – plug-and-play
- Run rules locally
 - Patient data is not sent to the rules hub

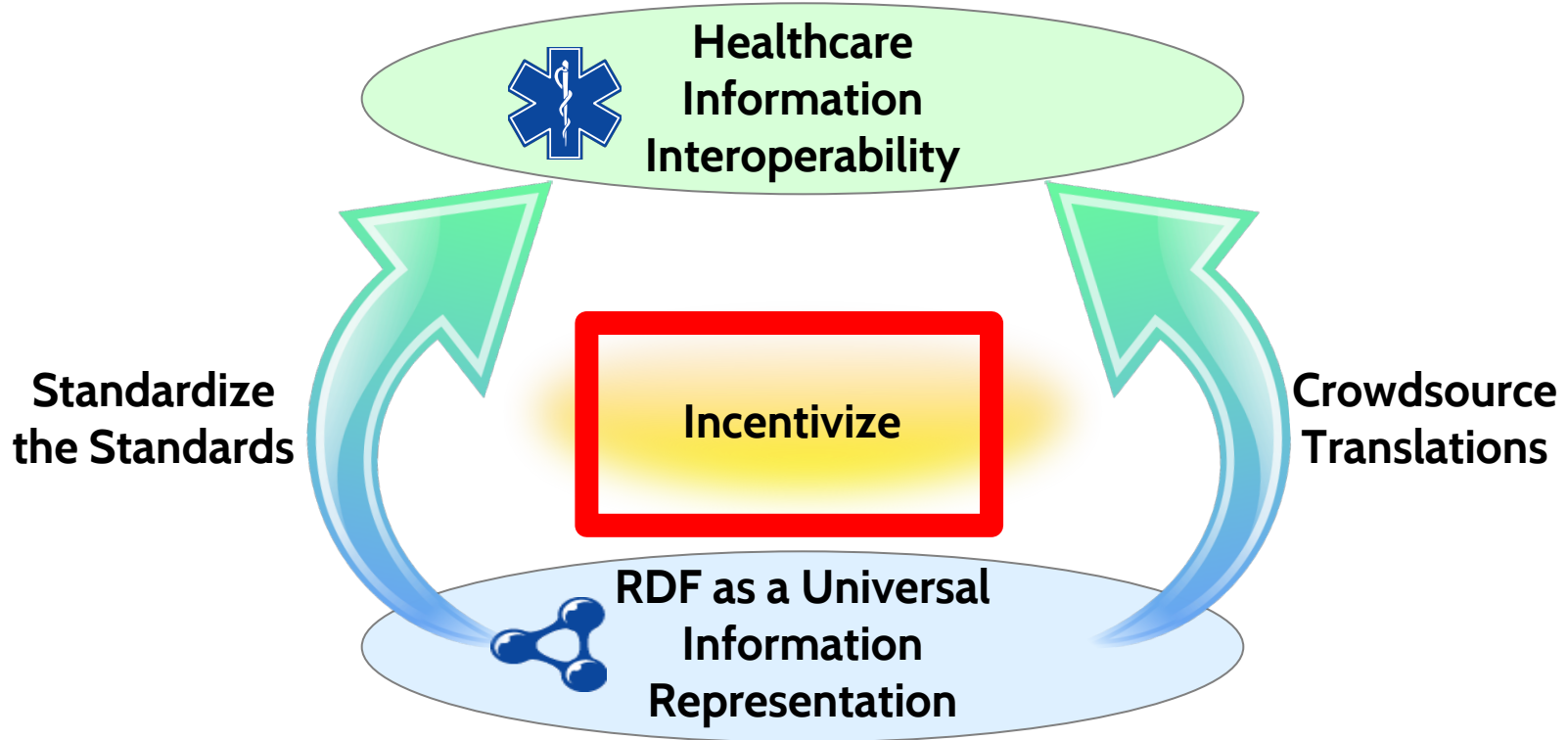


Incentivize

Interoperability Roadmap



Interoperability Roadmap



Incentivize

- There is no natural business incentive for a healthcare provider to make its data interoperable with its competitors
- Carrot / stick policies are needed
- Not the focus of the Yosemite Project, but essential for policy makers to address

What will semantic interoperability cost?

My SWAG . . .

	Initial	Ongoing
Standards	\$40-500M	+ \$30-400M / year
Translations	\$30-400M	+ \$20-300M / year
Total	\$60-900M	+ \$50-700M / year

What is yours?

?

Opportunity cost

Non-interoperability



Interoperability



**\$700 Million
per year?**

*Source: <http://www.calgaryscientific.com/blog/bid/284224/Interoperability-Could-Reduce-U-S-Healthcare-Costs-by-Thirty-Billion>

Upcoming Webinars

- **July 23, 2015** - Why RDF for Healthcare - David Booth, HRG
- **Aug 6, 2015** - drugdocs: Using RDF to produce one coherent, definitive dataset about drugs, Conor Dowling, Caregraf
- **Sept 3, 2015** - Linked VistA: VA Linked Data Approach to Semantic Interoperability, Rafael Richards, Veterans Affairs
- **Sept 17, 2015** - Clinical data in FHIR RDF: Intro and Representation, Josh Mandel, Children's Hospital Informatics Program at Harvard-MIT, and David Booth, HRG
- *Others to be announced*

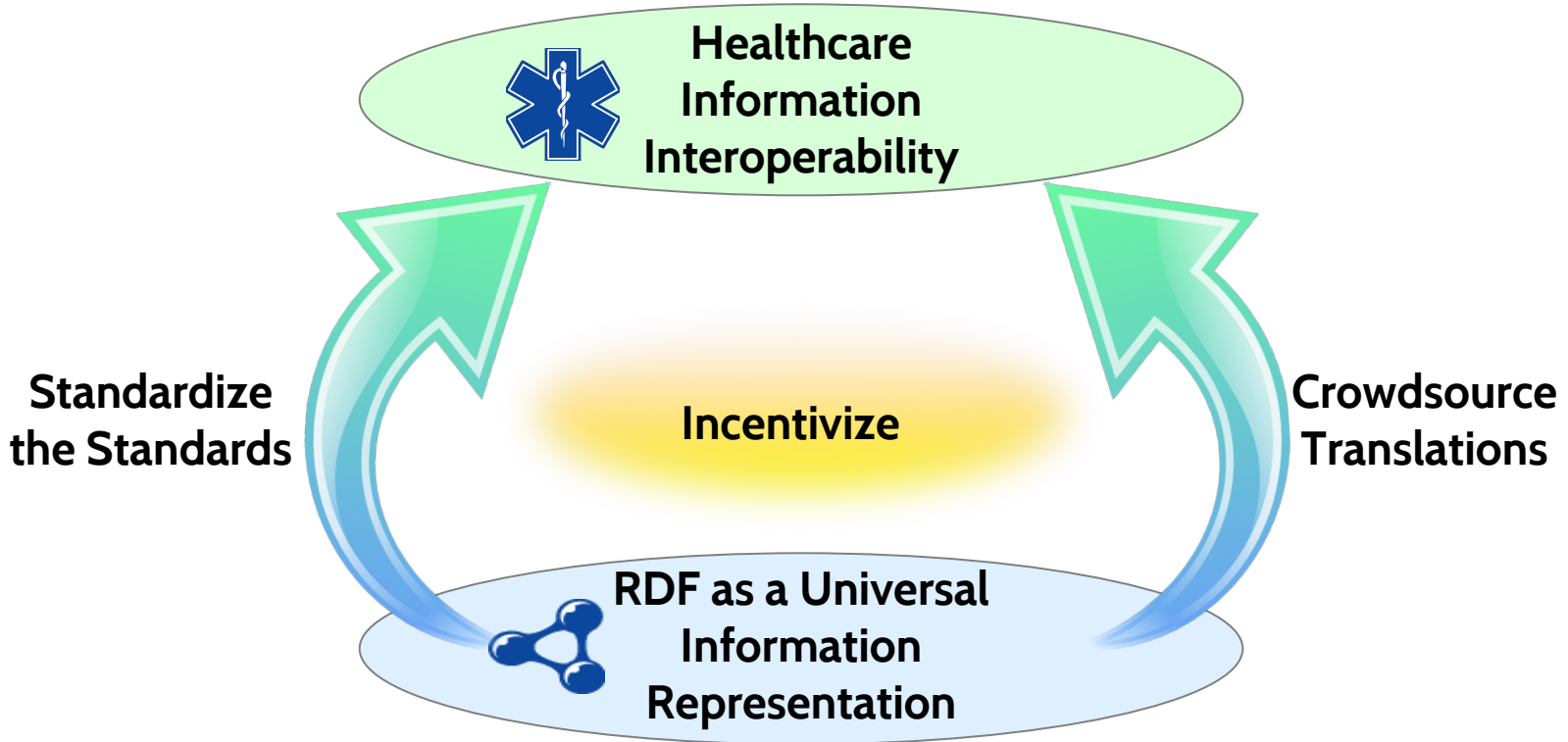
Questions?

BACKUP SLIDES

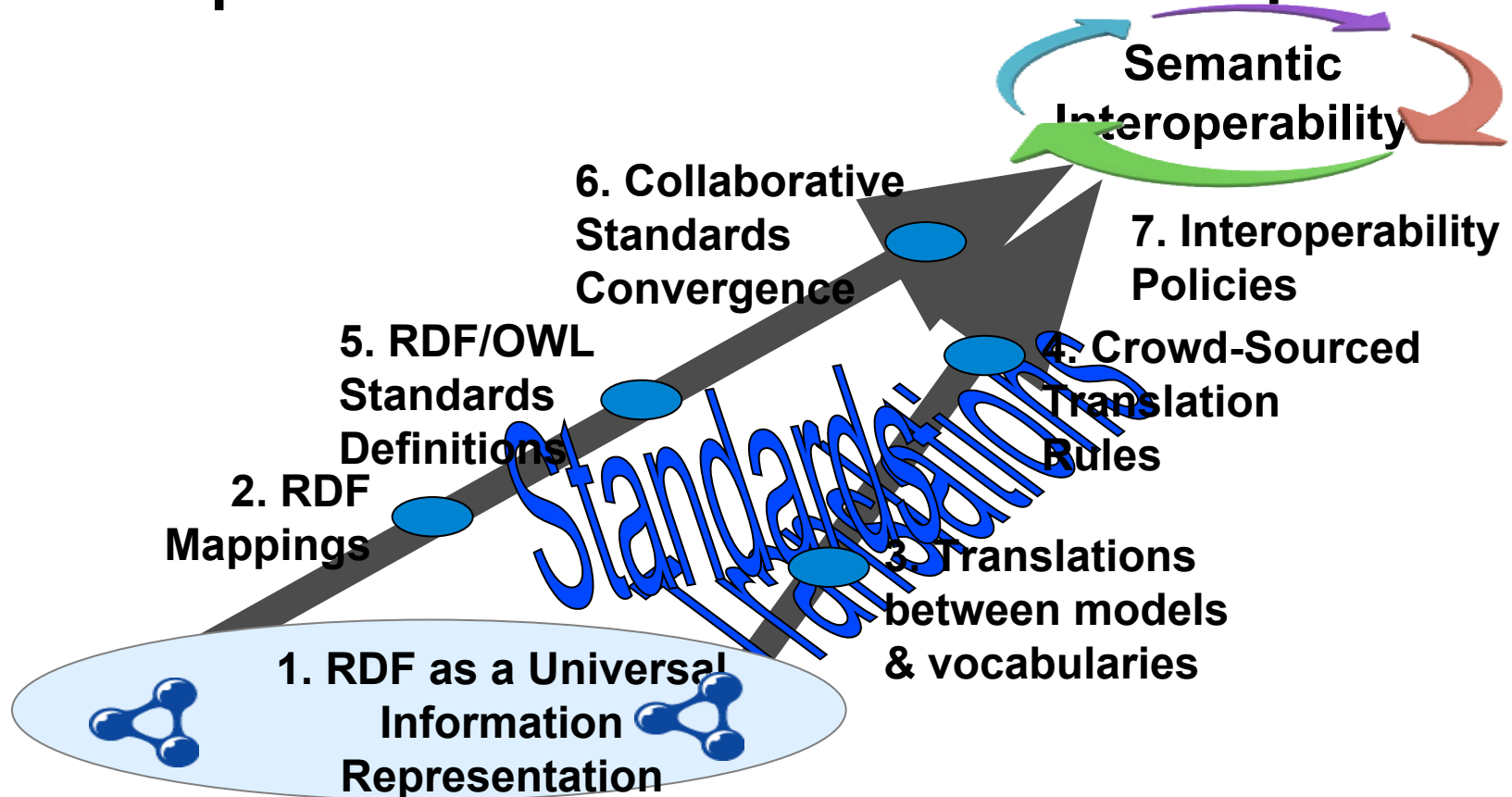
Related Activities

- Joint HL7/W3C subgroup on "RDF for Semantic Interoperability":
http://wiki.hl7.org/index.php?title=ITS_RDF_ConCall_Agenda
- ONC's "Interoperability Roadmap" (draft):
<http://tinyurl.com/mgtwwr8>

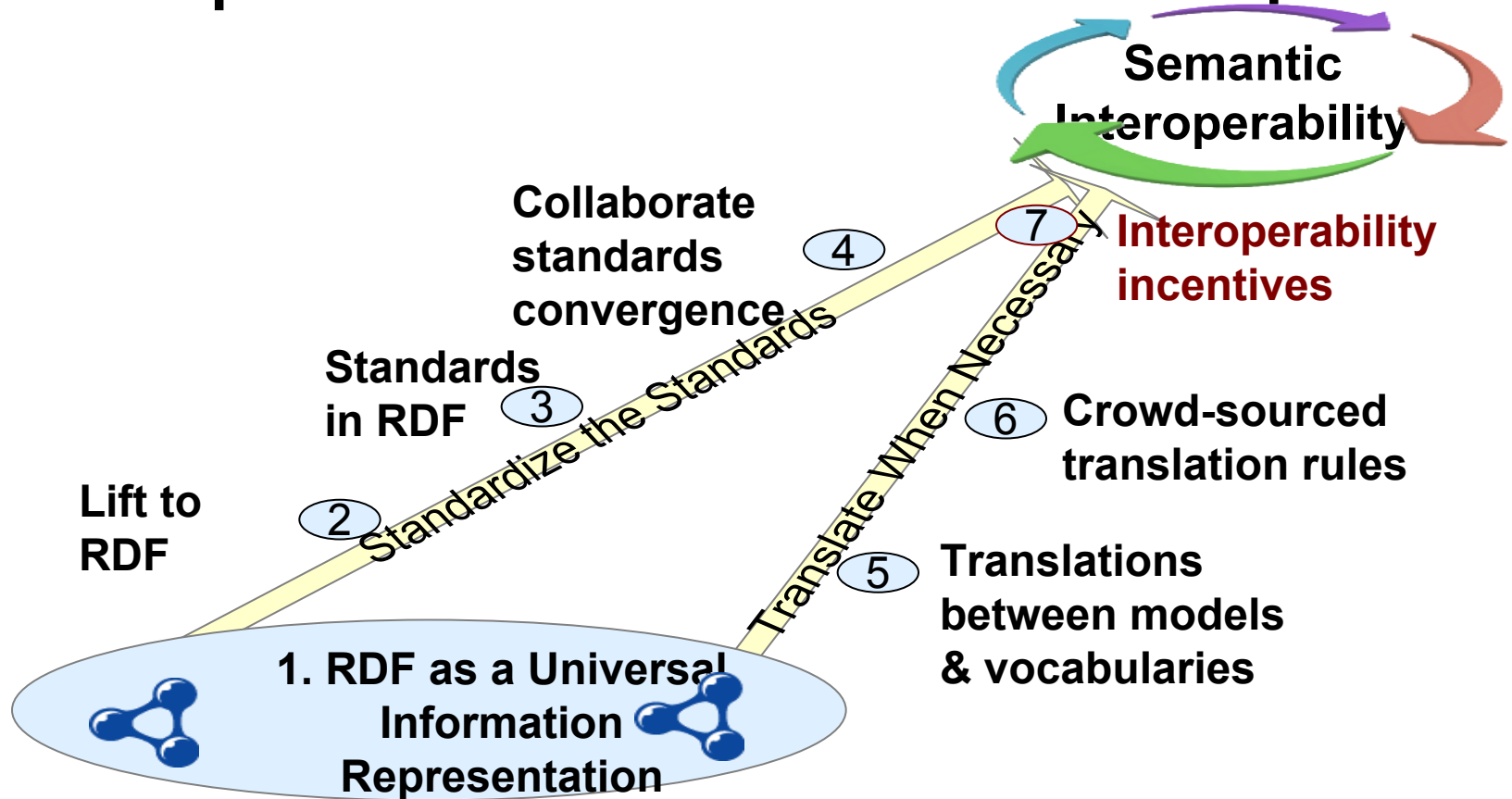
Interoperability Roadmap



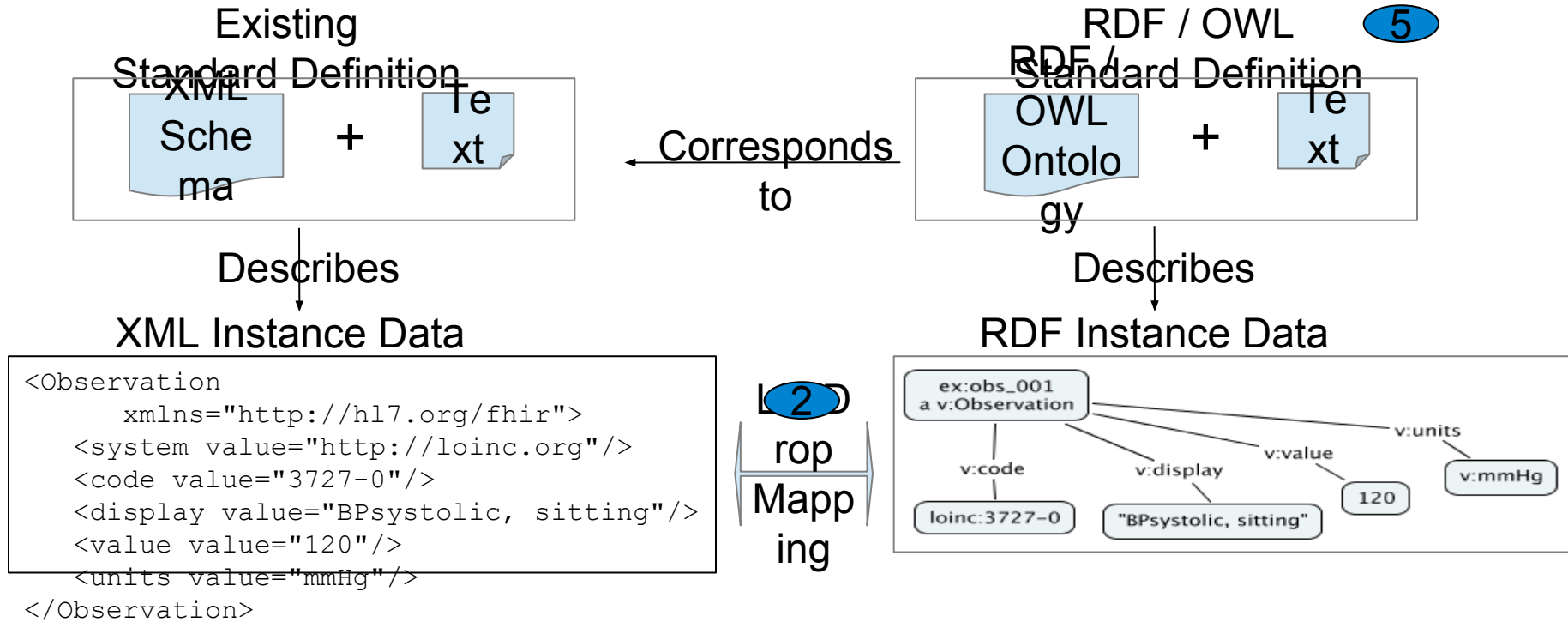
A Roadmap for Healthcare Information Interoperability



A Roadmap for Healthcare Information Interoperability



Steps 2 and 5



UNFINISHED SLIDE IDEAS

semantic interoperability

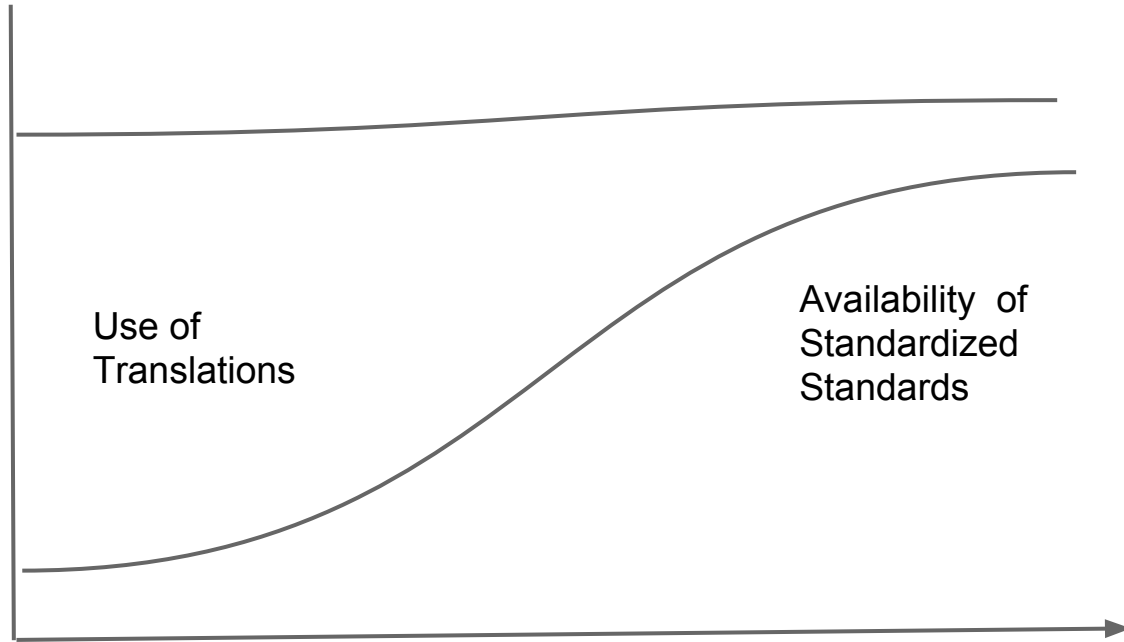
ability of computer systems to exchange
information with unambiguous shared meaning

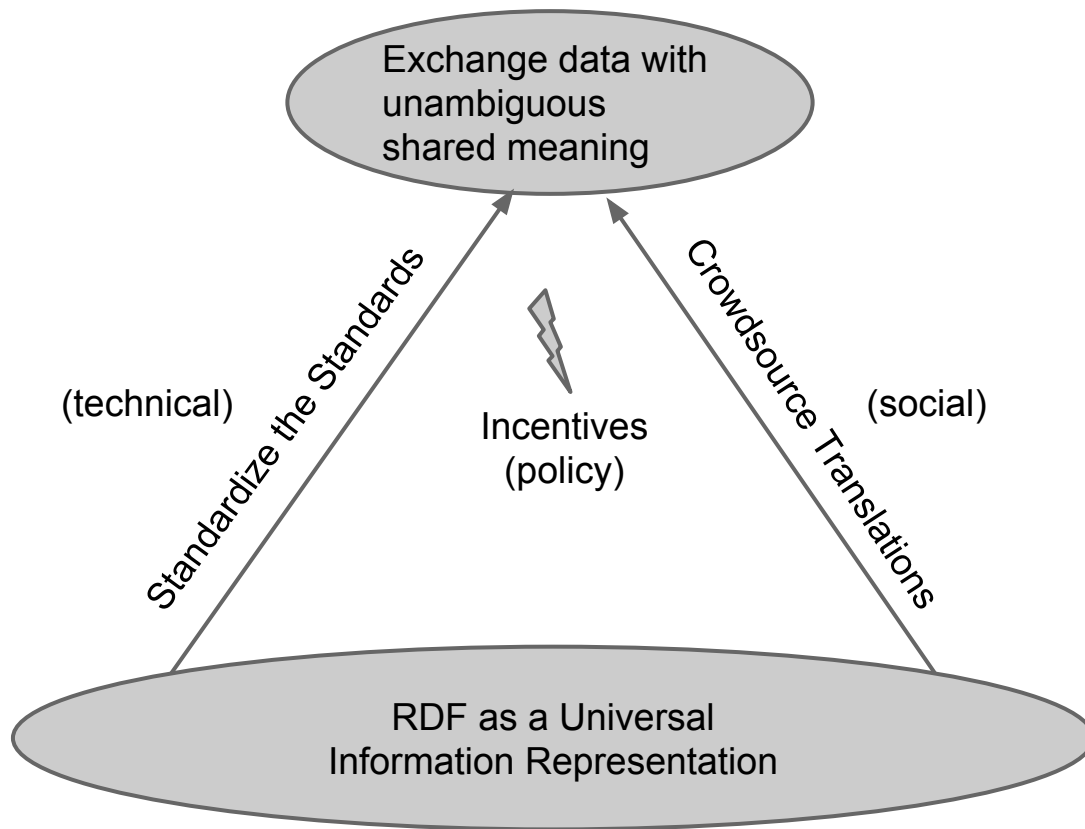
-Wikipedia

Key enablers for semantic interoperability

1. Standardize the standards (technical)
2. Crowdsource translations (social)
3. Incentivize (policy)

Evolution of need for Translations vs Standardization in support Semantic Interoperability







Healthcare
Information
Interoperability

Standardize the Standards

Crowdsource Translations

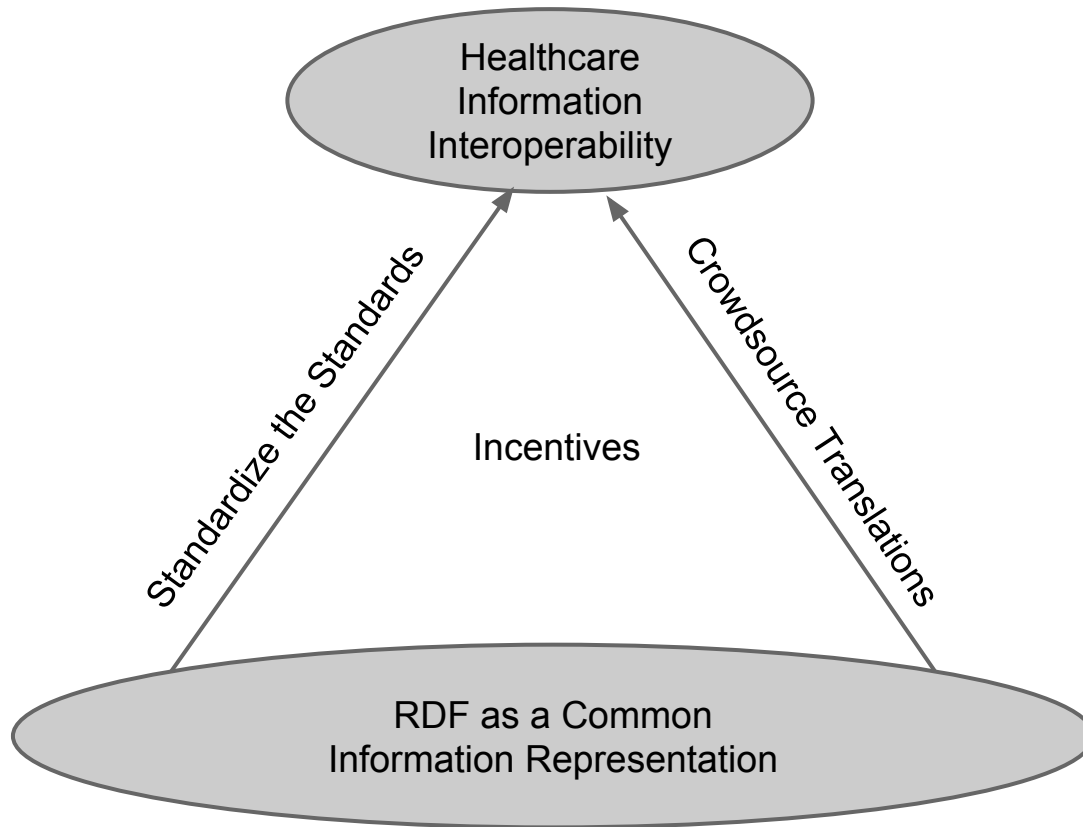
Incentivize

RDF as a Universal
Information Representation

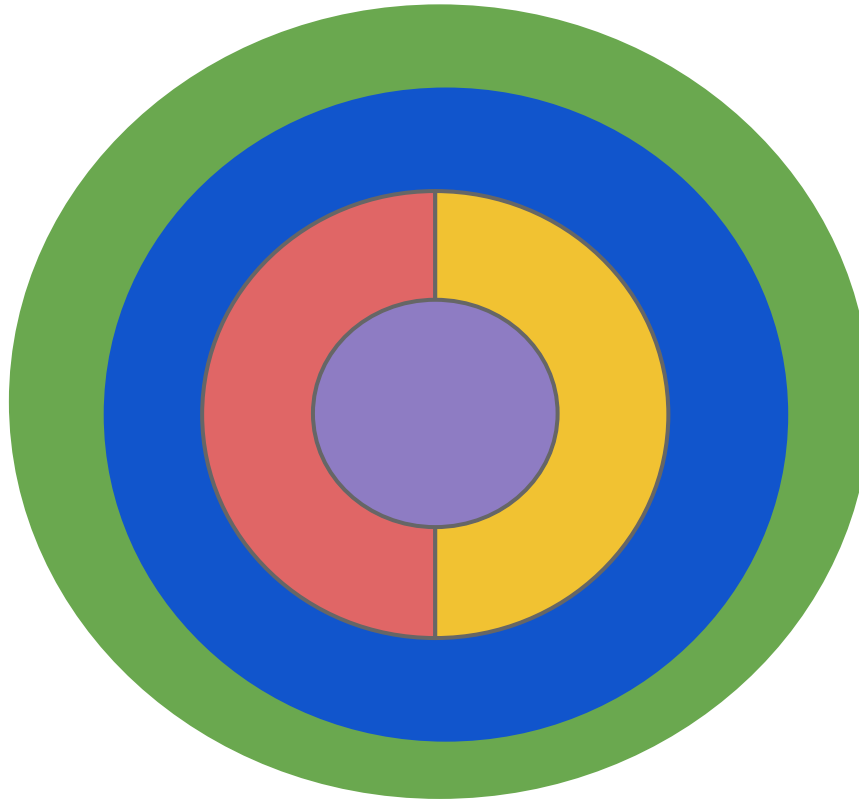
Objective
(interop)

Evolution
(social)


Foundation
(technical)





The Interoperability Onion





Overarching drivers/enablers:

 overarching incentives
(green for go forward,
greenbacks)


 RDF as shared representation
(blue for the W3C RDF logo )

Yin/Yang: two halves of the semantic data alignment coin

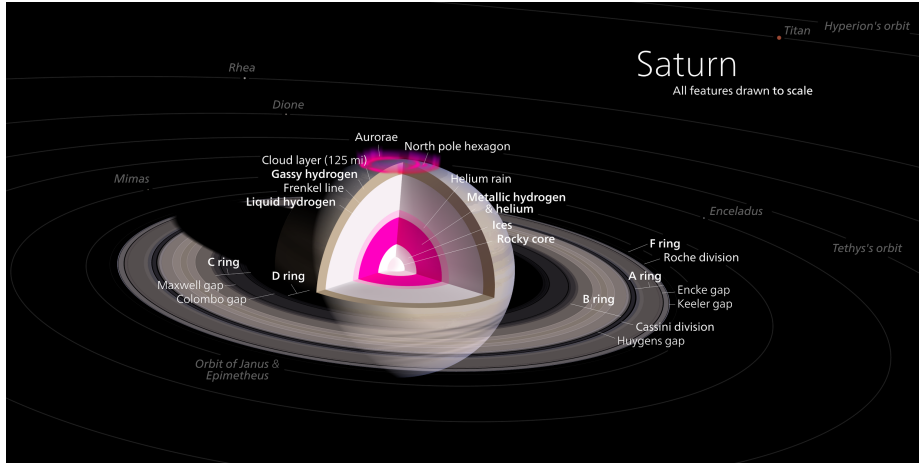
 standardize the standards

 crowdsource translations
(yellow: in the open = in the sunlight)

Bullseye: Semantic alignment

 healthcare interoperability
(royal purple; royal flush)

The Interoperability Galaxy



Overarching drivers/enablers:



overarching incentives
(green for go forward,
greenbacks)



RDF as shared representation
(blue for the W3C RDF logo)



Yin/Yang: two halves of the semantic data alignment coin



standardize the
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Bullseye: Semantic alignment



healthcare interoperability
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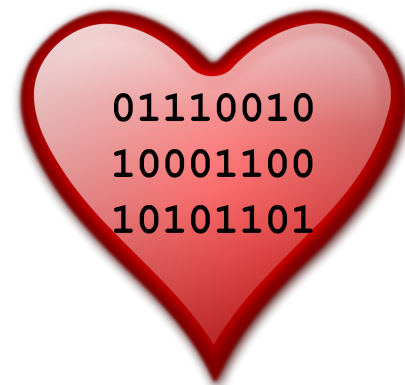
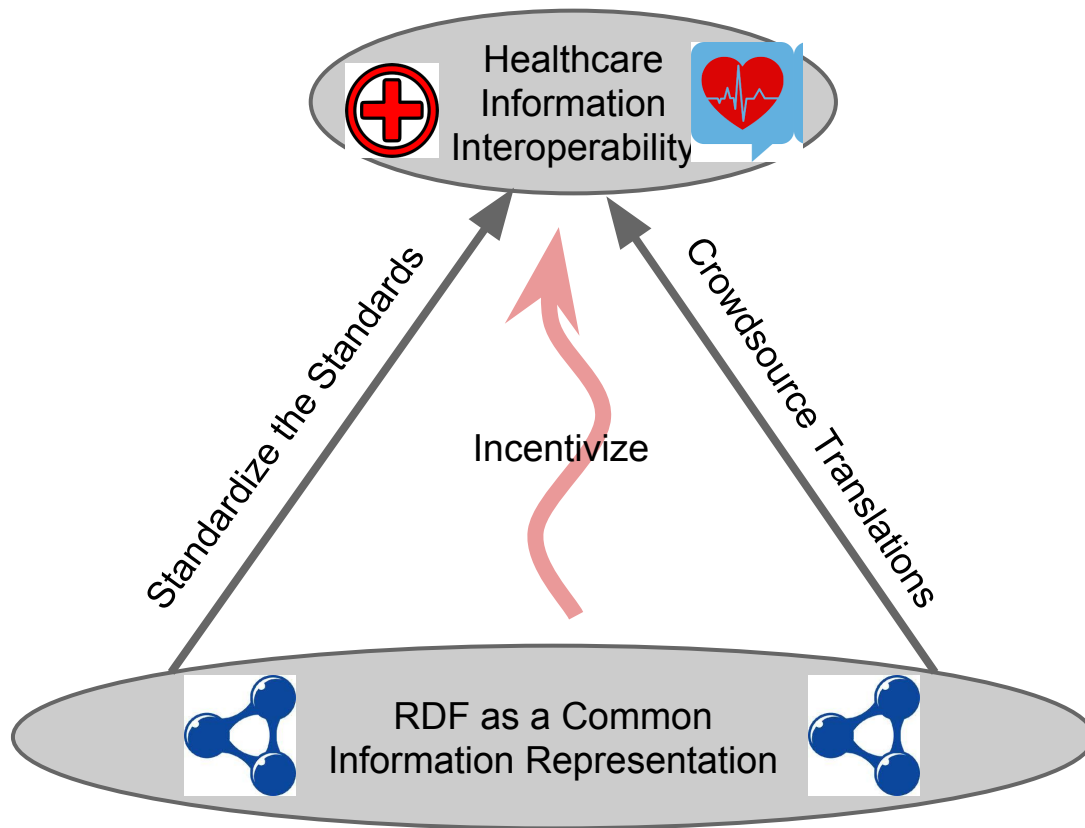
Magic quadrant of interoperability

Figure 1. Magic Quadrant for Business Intelligence and Analytics Platforms

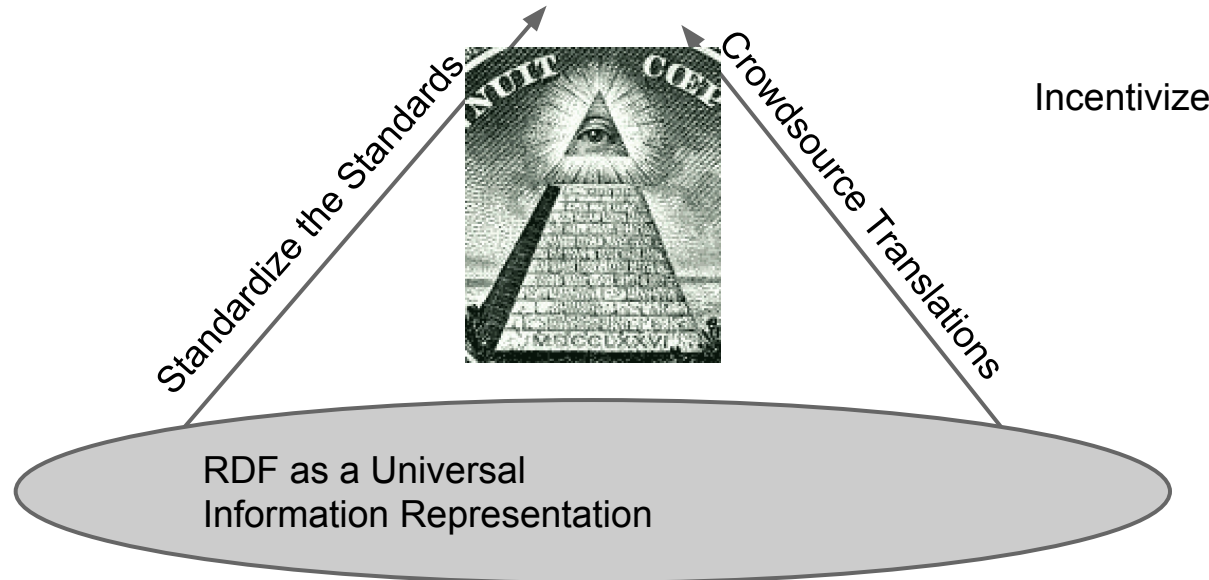


Crowdsource Translations

Standardize the Standards



Semantic
Interoperability



1. Standardize the standards:

Motivation and goal

MOTIVATION:

- Patchwork of inconsistent, overlapping standards
 - Different definitions, data formats, data models and vocabularies
- Hard to integrate and exchange data with fidelity and computability

GOAL:

- Share a common, computable information representation with coordinated, consistent meanings.

1. Standardize the standards

1. **Use RDF as a common information representation.** For each standard:
 - a. Define a standard mapping to/from RDF ("lift" and "drop")
 - b. Define a standard ontology for that RDF
2. **Facilitate collaboration.** Build a collaborative ecosystem. Facilitate standards convergence. I.e., modify standards to reconcile overlaps and differences that impair or impede interoperability.
 - a. Provide a **collaborative standards hub** and user-friendly tools to help domain experts (need cross-vocabulary capability; most generic foundation is GitHub)
 - b. Create and manage any standard (using RDF as a common information representation)
 - c. Define correspondences between standards (as RDF relationships and rules)
3. **Encourage participation and convergence.**
 - a. Encourage SDOs to participate
 - b. Make sure the standards hub and tools accommodate their needs
 - c. Actively seek out each SDO's requirements
 - d. Define metrics for consistency and overlap

2. Crowdsource Translation: Motivation and Goal

MOTIVATION:

- Healthcare is too diverse and dynamic to have a single, static monolithic standard
- Mapping (a/k/a translation) is inevitable

GOAL:

- Incorporate all structured healthcare data with best possible fidelity while minimizing the total mapping burden

2. Crowdsource Translation

1. Use RDF as a common information representation
2. Create a crowdsourcing translation rules hub
3. Bootstrap it with enough useful translation rules
4. Map proprietary/industry data models & vocabularies

3. Incentivize Interoperability:

Motivation and Goal

MOTIVATION:

- In a fee-for-service economy, there is no natural business incentive for interoperability
- Egregious example: information blocking

GOAL:

- Have providers offer interoperable goods and services

3. Incentivize Interoperability

- Many potential solutions
 - Carrots, sticks, different business models, etc.
 - ACOs, quality measurement, single payer, etc.
- **Policymakers *must* address this problem!**
- No technical solution can succeed if providers have a disincentive
- involvement of policymakers, insurance representatives, patient advocacy groups, application developers, healthcare standard developers

Incentivize Interoperability:

Other thoughts

1. New business models
2. Federally allowed charges per unit of information (5c/digital page rather than 99c physical page)
3. Affordable for patients and providers to get full disclosure of their record in convenient, processable form
4. Must be patient-focused (not to third parties); Much better version of BlueButton

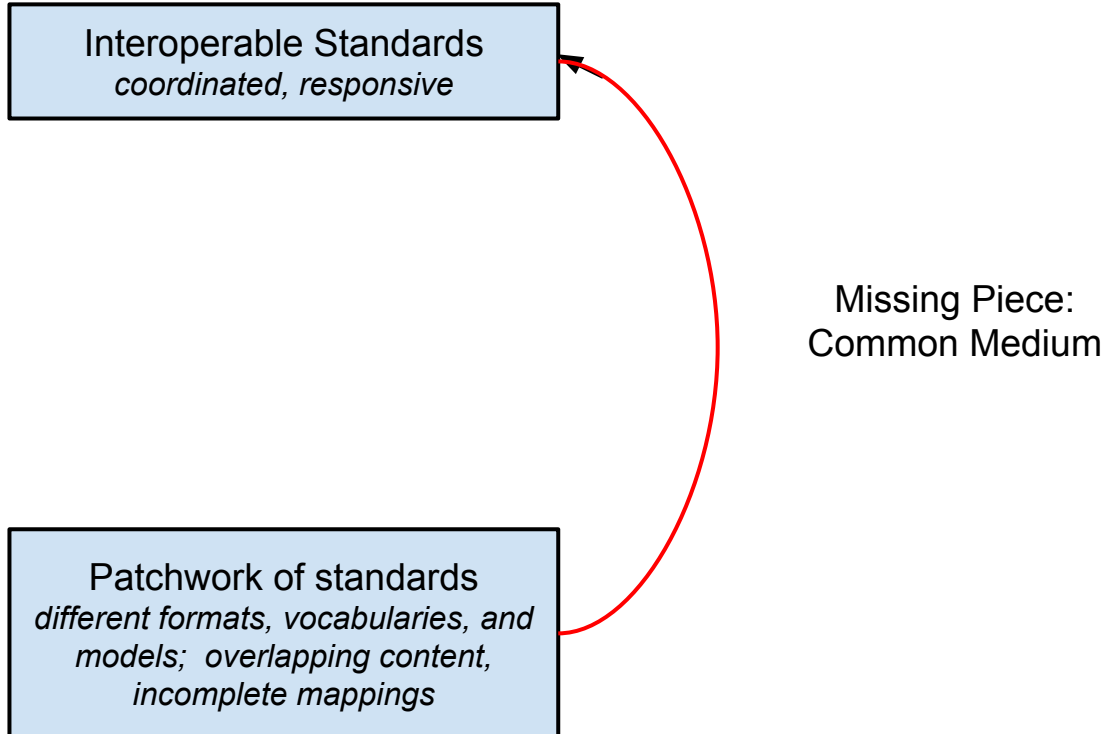
How to achieve semantic interoperability? (three areas)

1. Standardize the standards (technical)
 - a. common representation
2. Crowdsourcing mappings (social)
 - a. bring more people to process
 - i. who is in the crowd? Kaiser, VA, NLM
 - ii. bring them to the water
3. Incentivize interoperability (policy)
 - a. remove excuses:
 - i. licensing, privacy, security

Diagrams

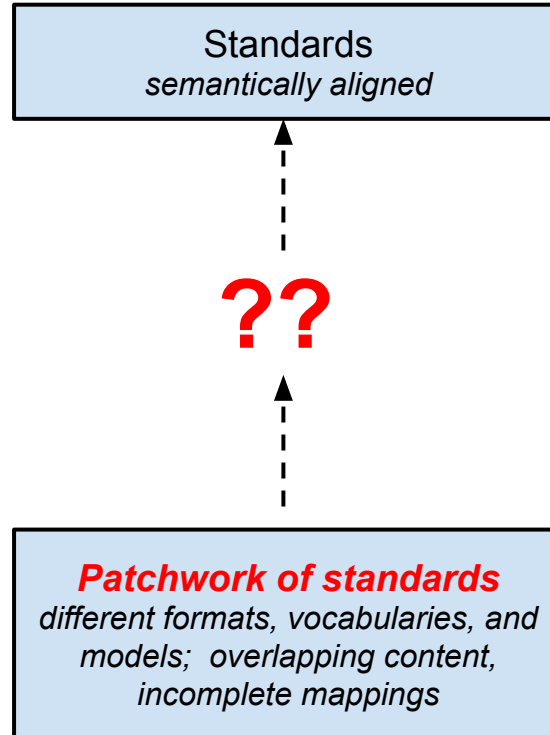
Standards Today

Providing a common information representation



Current Standards (“As-Is”)

How do we semantically align our standards?

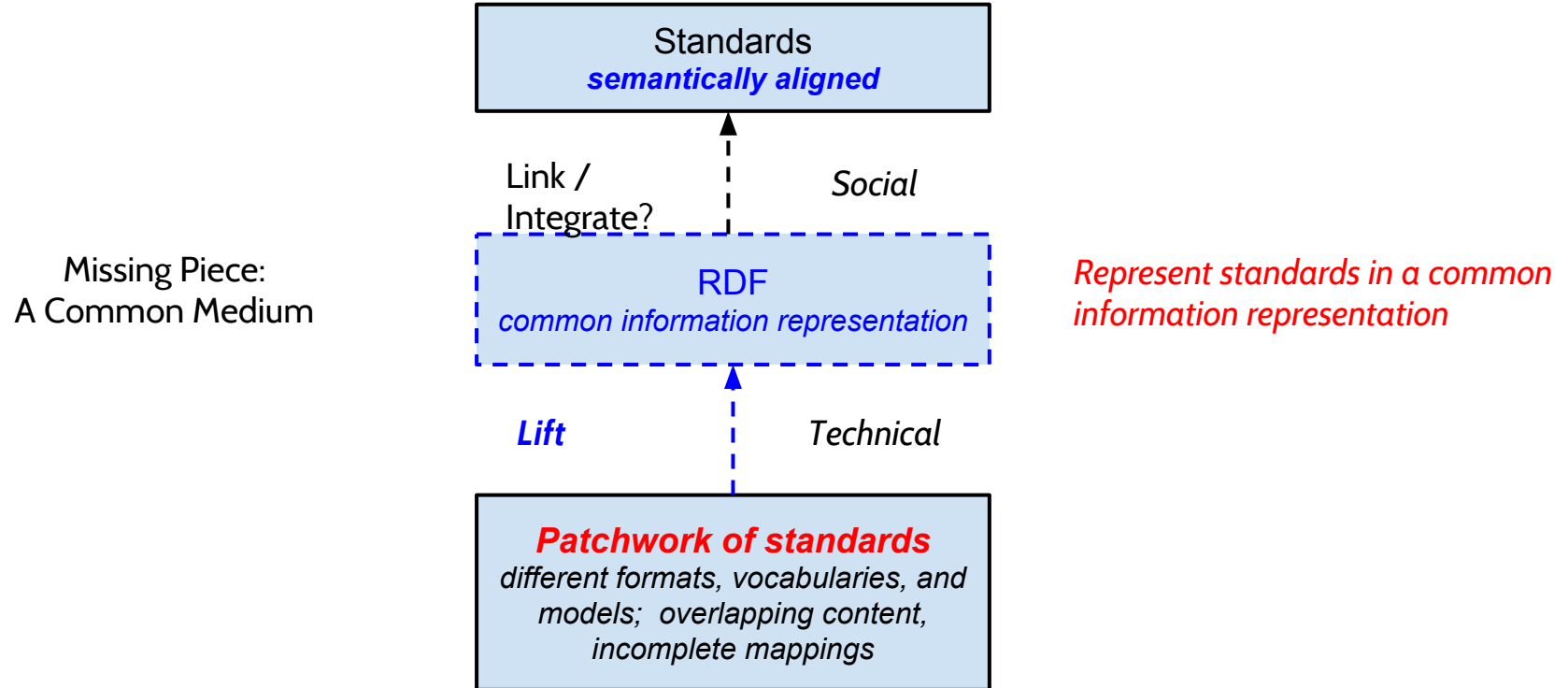


How do we semantically align our standards? our data?

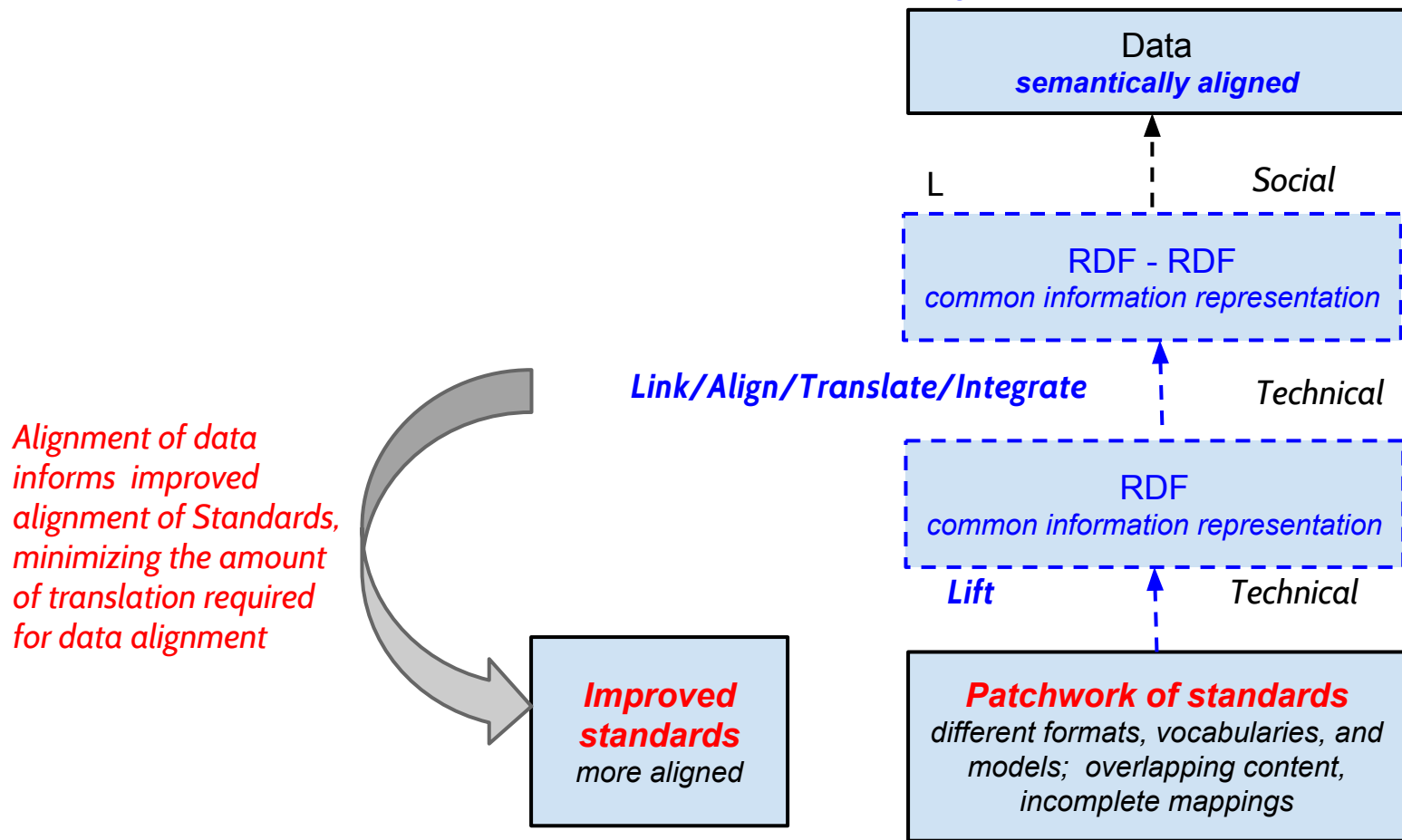
*Rate of change 2-8% /year
(and will never stop changing)*

Standardize the Standards:

Providing a common information representation



Standardize the Standards: *Providing a common information representation*



Standardize the Standards:

Providing a common information representation

This results in both
(1) less work to align
data and (2) more
data that can be
aligned

Data
semantically aligned

Align

*common
information
representation*

Lift

Patchwork of standards
*different formats, vocabularies, and
models; overlapping content,
incomplete mappings*

Improvement

Align

Data
semantically aligned

Align

*common
information
representation*

Lift

Aligned standards
aligned content, aligned mappings

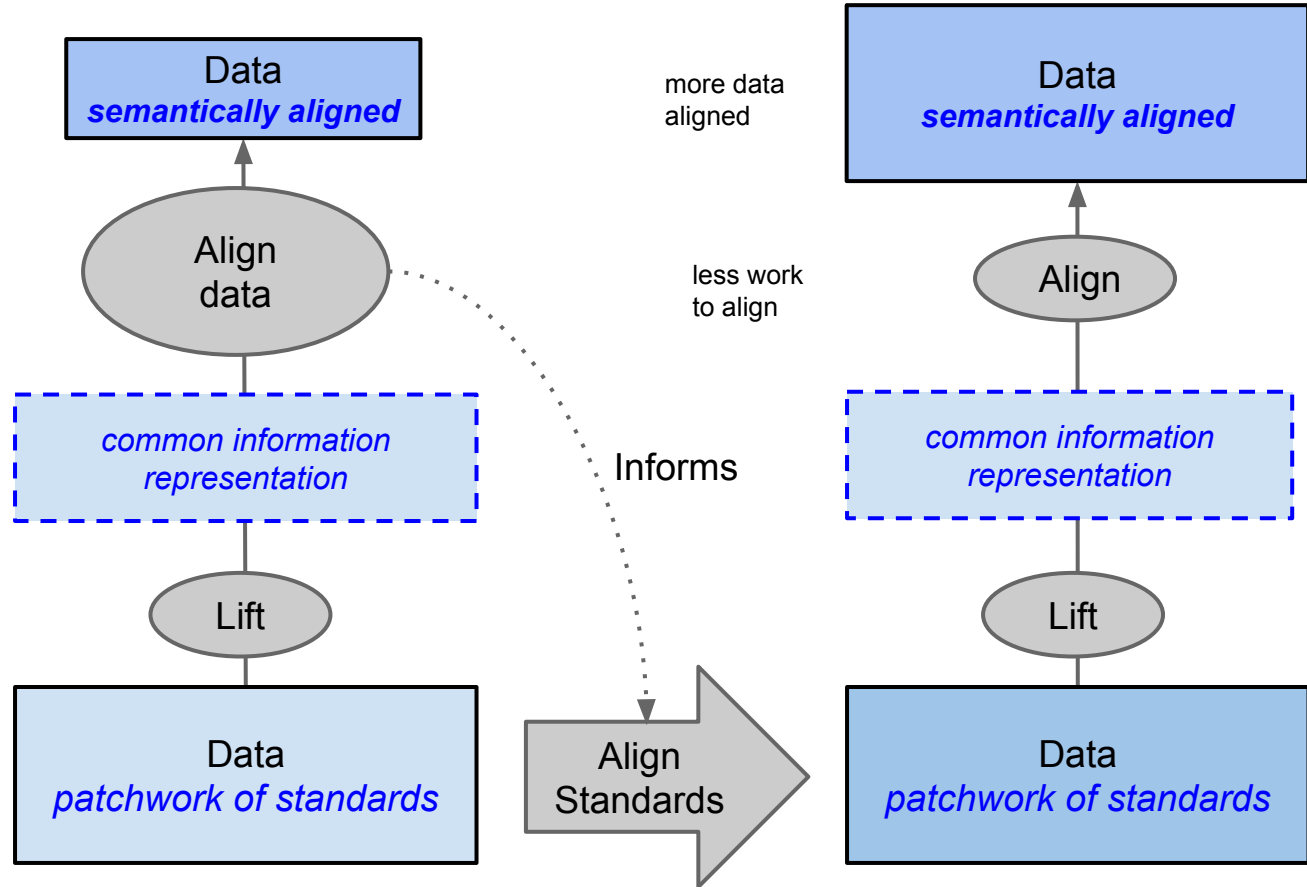
*RDF as common information
representation facilitates both:
(1) alignment of data; and (2)
alignment of standards.*

Standardize the Standards:

Providing a common information representation

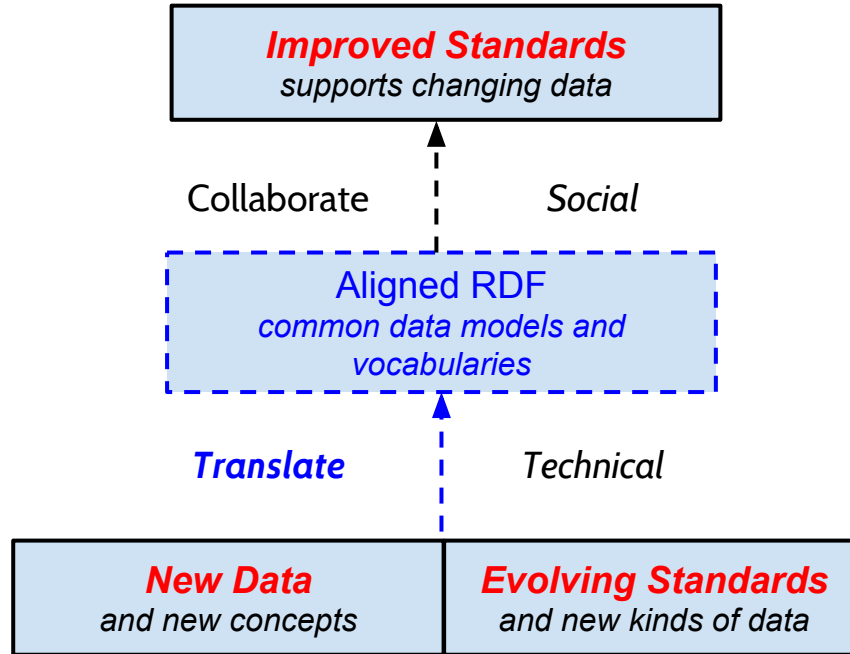
RDF as common information representation facilitates both: (1) alignment of data; and (2) alignment of standards.

This results in both (1) less work to align data and (2) more data that can be aligned



Innovating on top of the Standards:

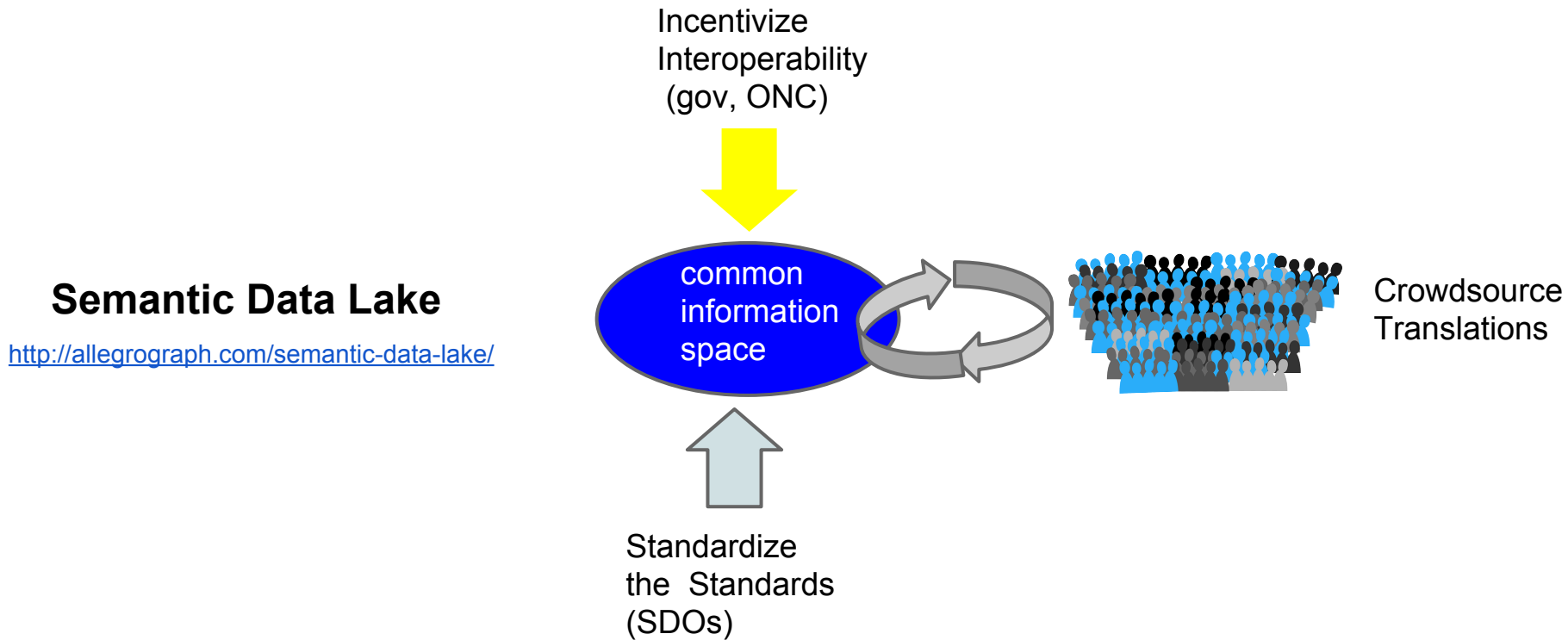
**Accommodating local innovation
and change**



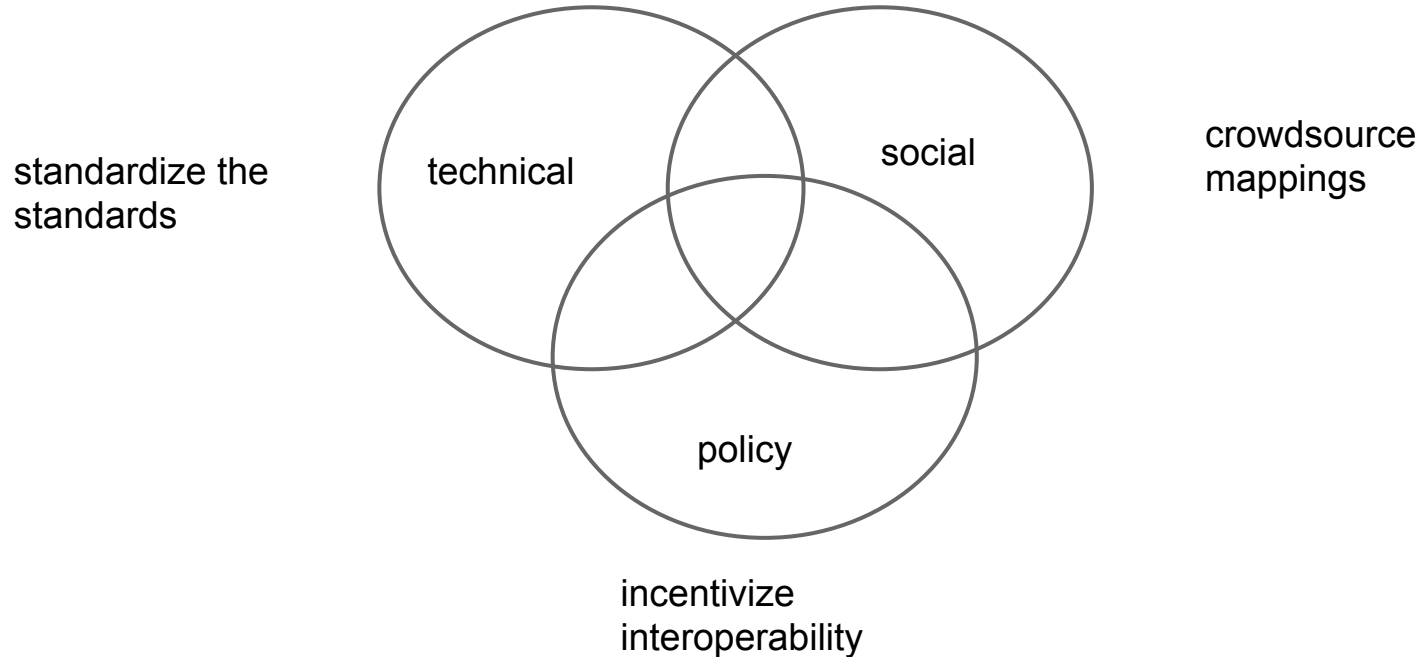
*Improved standards with better
coverage for new kinds of data.*

*Standards do not provide coverage for
the new kinds of data.
Rate of change 2-8% /year
(and will never stop changing)*

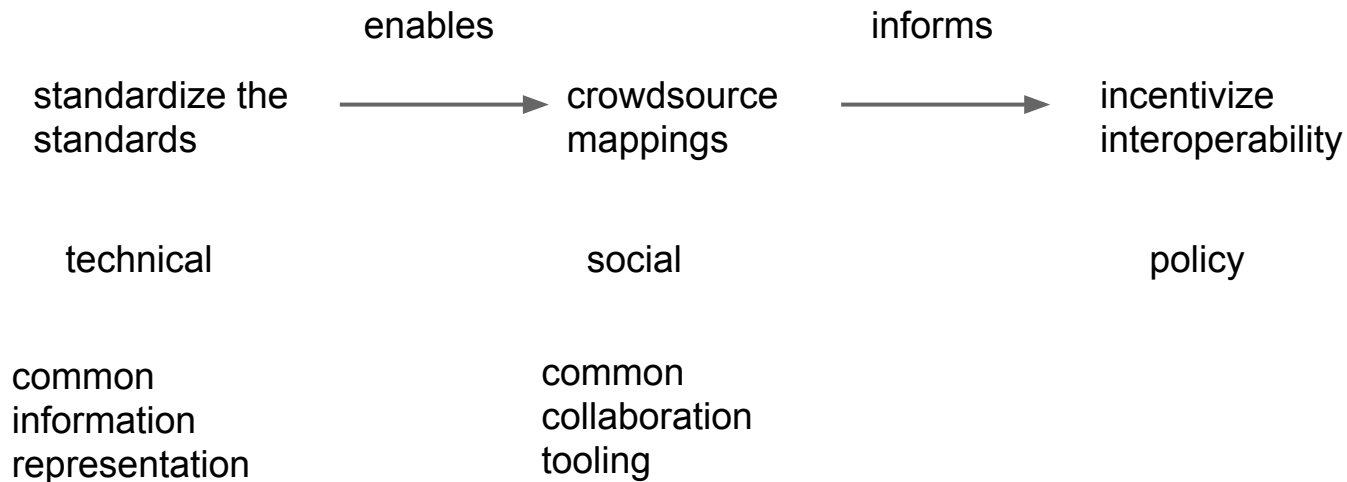
Semantic Interop: Overview



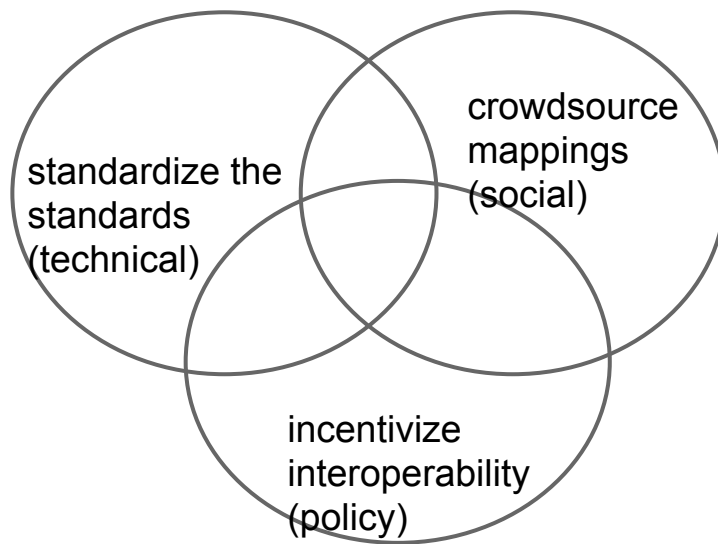
Semantic Interop: Components

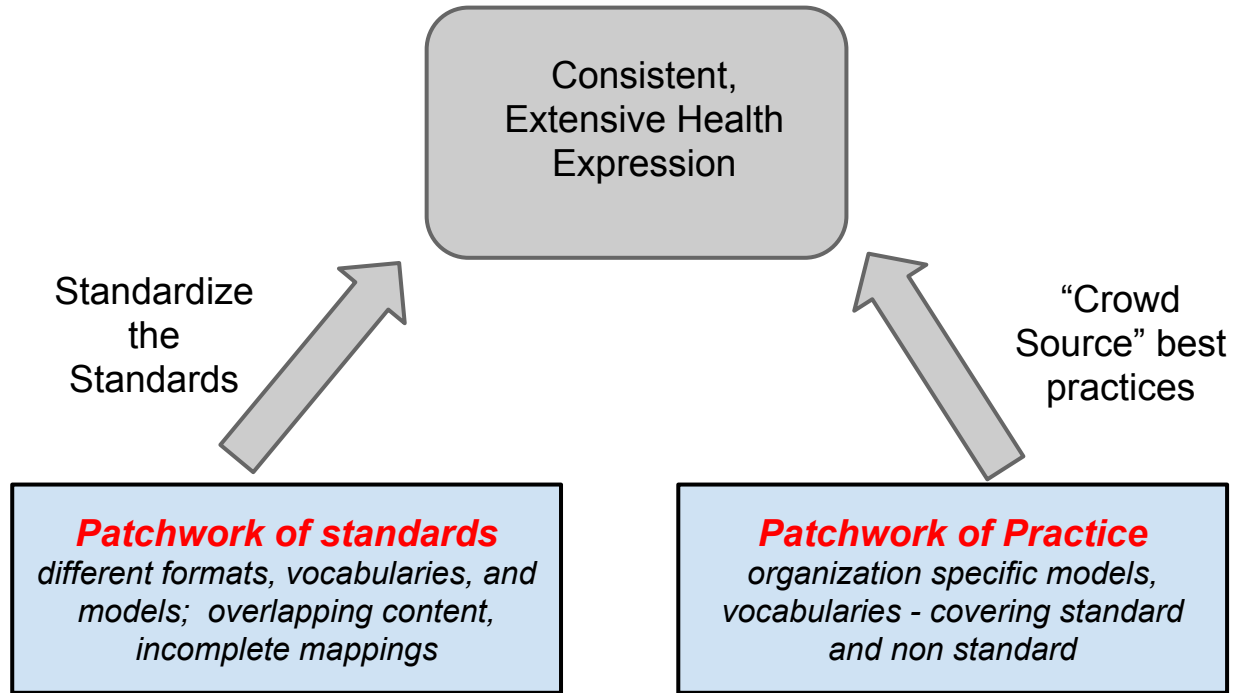


Semantic Interop: Dependencies

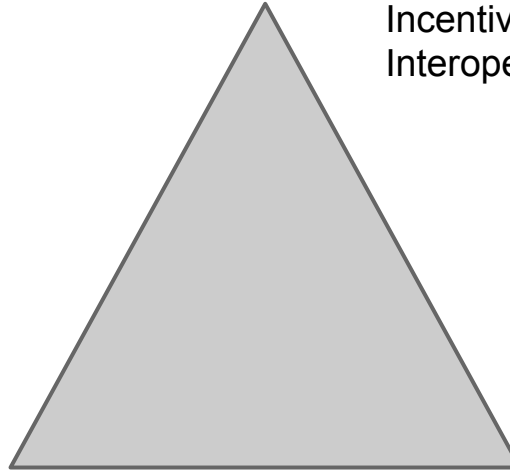


How to achieve semantic interoperability? (three tracks)



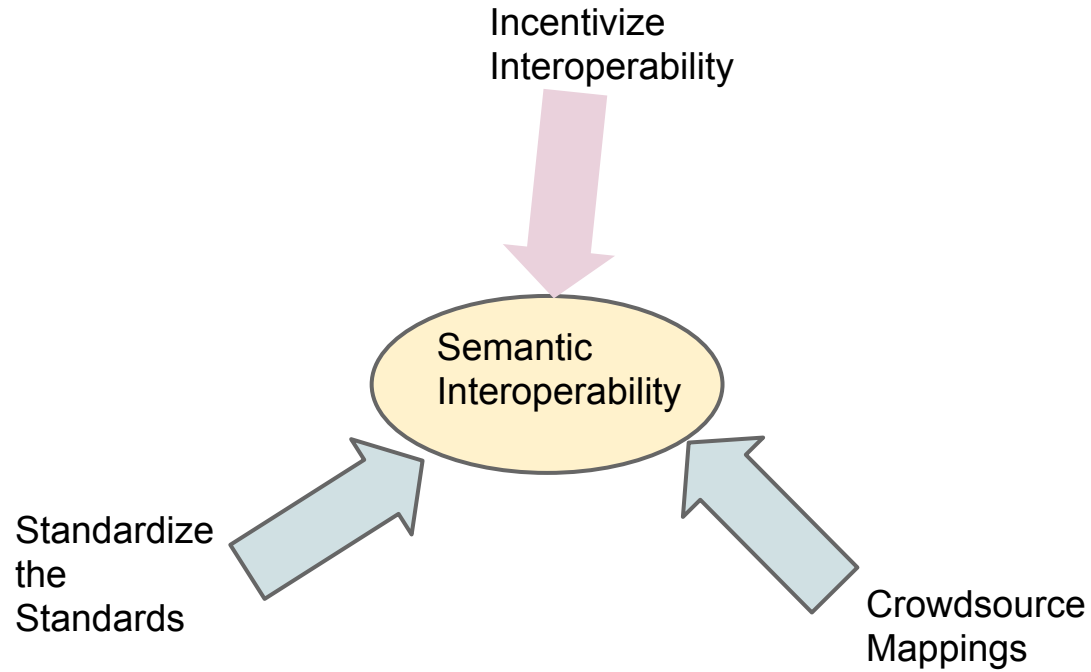


Standardize
the
Standards



Incentivize
Interoperability

Crowdsource
Mappings



HealthIT.gov: Best Available Vocabulary/Code Set/Terminology Standards and Implementation Specifications

<http://healthit.gov/policy-researchers-implementers/section-i-best-available-vocabularycode-setterminology-standards-and>

<http://healthit.gov/policy-researchers-implementers/meaningful-use-stage-2-0/standards-hub>

Standardizing the Standards (Community process)

1. **Lift.** (Four-star Linked Data). Define an RDF representation for each standard
 - a. Lift the information content out (directly) to RDF using native model and vocabulary of source (no translation). E.g., HL7 v2.x to RDF
2. **Link.** (Five Star Linked Data). Define mappings to / from the most comprehensive, precise fine-grained atomic concepts in the implementation community (i.e. to/from from all the 'as-is', end-user, specialized systems in a bottom-up decentralized fashion). Catch-22: this comprehensive, granular concept scheme (with 100% coverage) does not exist. This will require creating new definitions, as well as linking across overlapping definitions.
 - a. Translations (RDF-to-RDF)
 - b. Define new atomic concepts as needed, with translations to/from old concepts
3. **Converge.** Change standards to use shared concepts. (SOCIAL)

http://www.w3.org/2011/gld/wiki/5_Star_Linked_Data

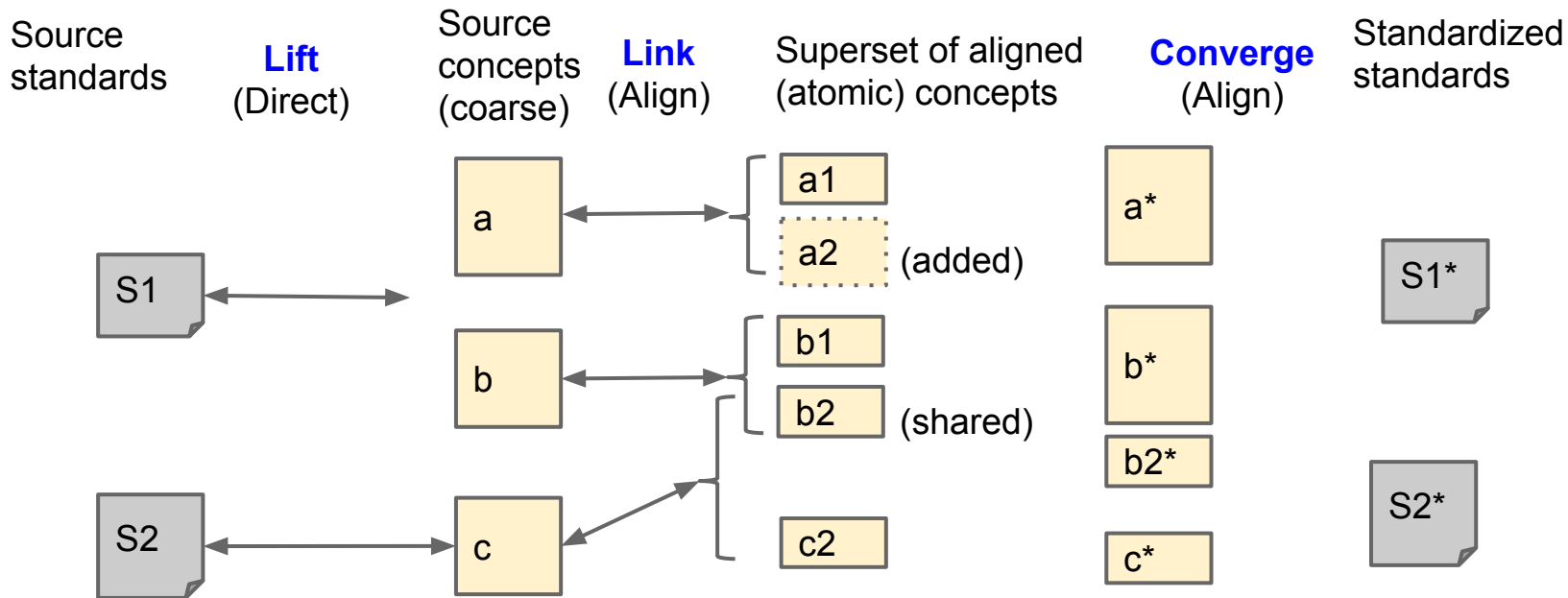
RDF = information representation

atomic concept = finest grained concept required for any use case (example: supine left brachial noninvasive systolic blood pressure)

standard = frequently used or ONC-endorsed information representation (data format, data model, vocabulary), defined by an SDO (such as HL7, AMA, IHTSDO, WHO, etc.). Usually healthcare-specific.

drop / dump = direct, nontranslated, automated conversion (RDFizer)

Standardizing the Standards (Community process)



Different source standards with different granularities can map into a superset concept scheme that retains the full granularity of all source systems bidirectionally;

$a \geq a1 + a2$: concepts are broken into their smallest meaningful exchangeable concept; a2 is added because

Translating between concepts

Case	Translation	Assessment
A same as B acetaminophen = paracetamol	Lossless: Can translate A to B and B to A	Good
A narrower than B Tylenol is narrower than acetaminophen	Lossy: Can translate A to B, but translating B to A requires extra information	Okay if there is significant utility in differentiating them. Otherwise bad.
A partially overlaps B	Cannot translate either direction without extra information	Bad. Concepts should be refactored.
A does not overlap B	N/A	Good. Different concepts: no translation needed.

Instance Data Use Case (source to target):

1. **Lift.** (Source -> RDF)
 - a. Direct conversion of source data, model and vocabulary to RDF (no semantic alignment)
2. **Align (RDF-RDF).** Semantic alignment: translate source data models and vocabularies to target data models and vocabularies via common atomic concepts
3. **Drop (RDF-> target).** Output to target format, model, and vocabulary

- a. *Further standardization*
- b. *Translations between them*

Form of the instance data:
models, vocabs, ontologies

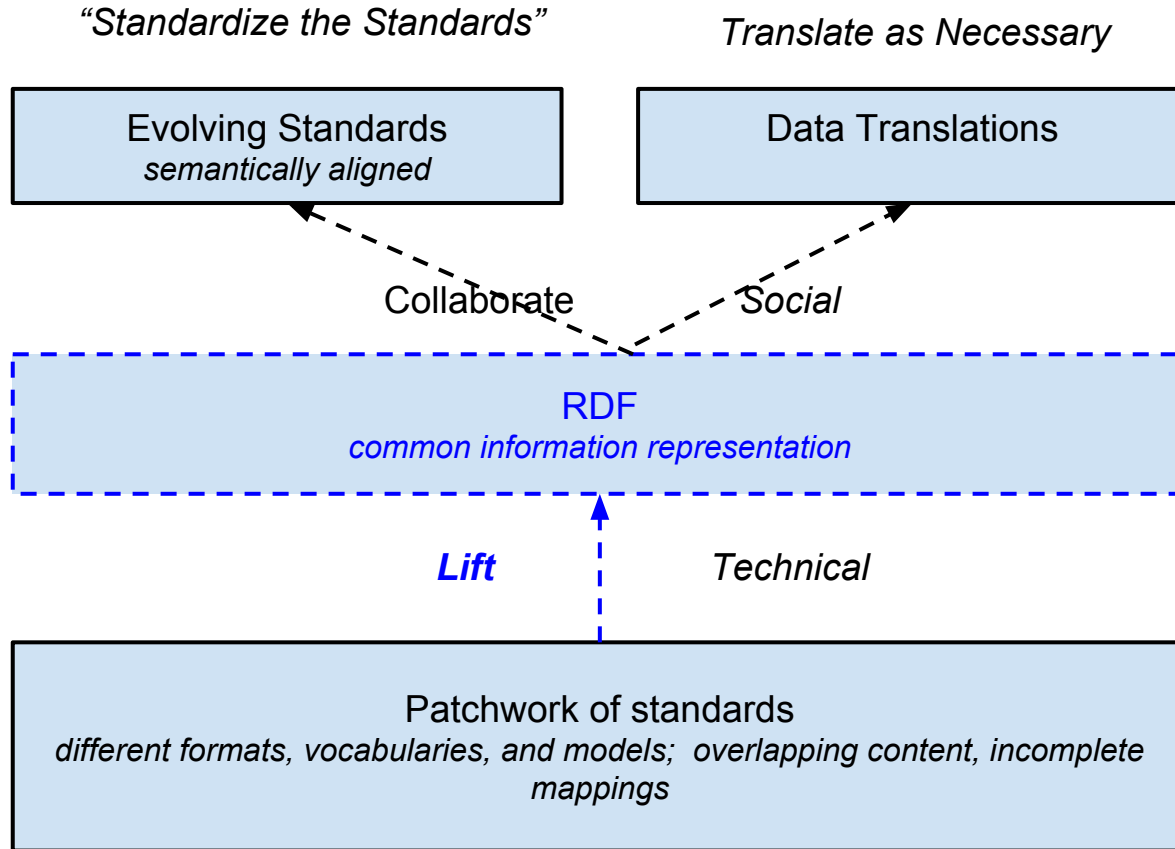
Collaboration Hub

Instance data

Data in RDF
common syntax, shared semantics

Diverse Data Systems
*different formats, overlapping
content, incomplete mappings*

**Beyond the standards:
Accommodating local innovation,
extensibility and change**



Standards are a constantly moving target. Therefore need to have capability for publishing both standard and nonstandard data in the same medium.

Enables:

- Publish ALL information NOW -- no loss of detail.
- Evolve from nonstandard to standard
- Translate between data models and vocabularies

New kinds of data for

Interoperability: Two Alternatives

1. Standardization:
 - a. Are never complete or perfect
 - b. Constantly changing
2. Translation: Beyond the standards

data standards:
constantly changing

data producers:
constantly changing

Parking Lot - Scratch Notes / Figures

Missing Piece:
Common Medium

(rate of change 2-8% /year)

- a. *Further standardization*
- b. *Translations between them*

*Triple Aim: Lower cost,
improve quality*

Collaboration Hub

Data in RDF

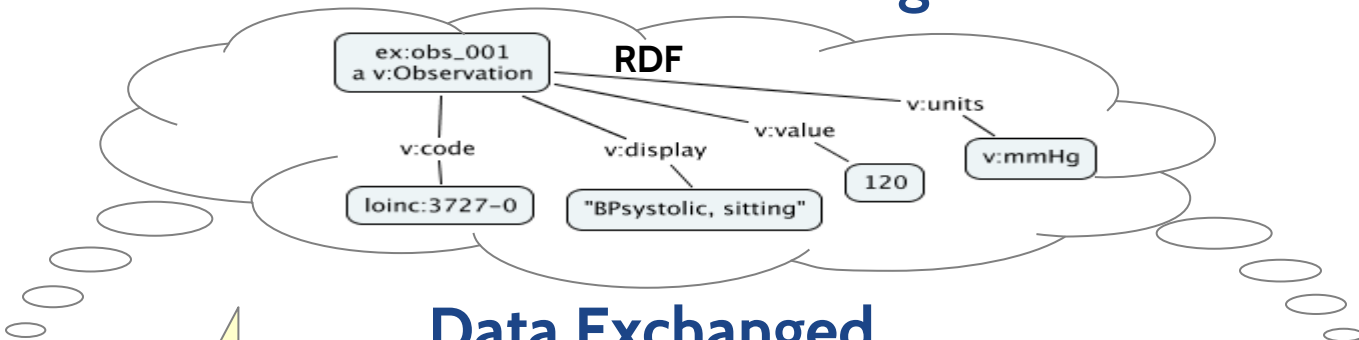
common syntax, shared semantics

Diverse Data Systems

different formats, overlapping

RDF as a universal information representation

Shared Meaning



Data Exchanged

FHIR

```
<Observation ...>
  <system value="http://loinc.org"/>
  <code value="3727-0"/>
  ...
</Observation>
```

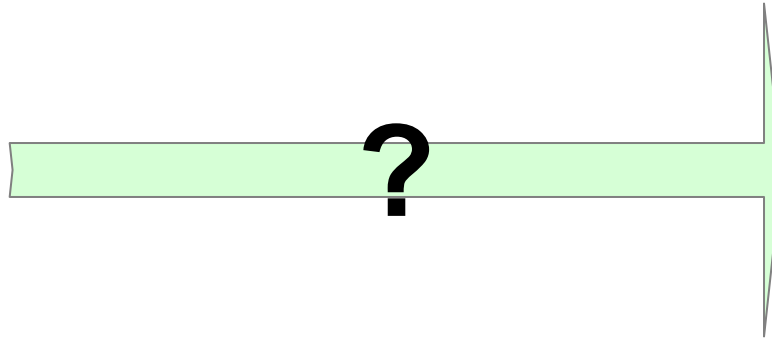
HL7 v2.x

```
OBX|1|CE|3727-0^BPsystolic,
sitting||120||mmHg|
```

If sender and receiver speak different format or semantics . . .

I have
HL7 v2.x

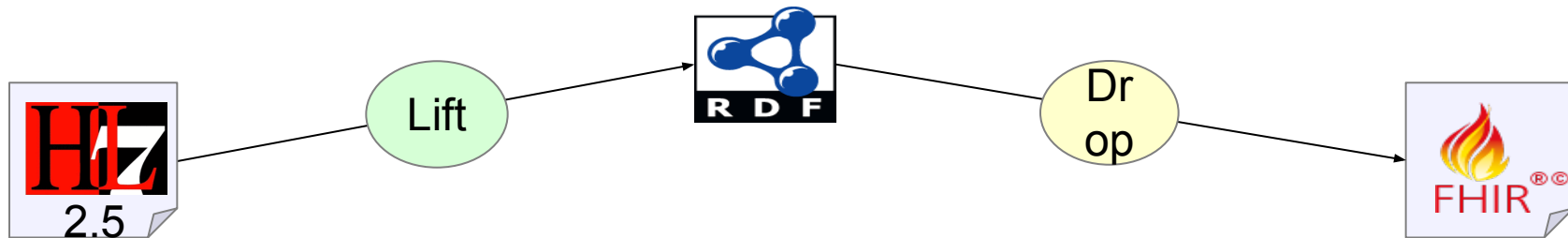
I want
FHIR!



116

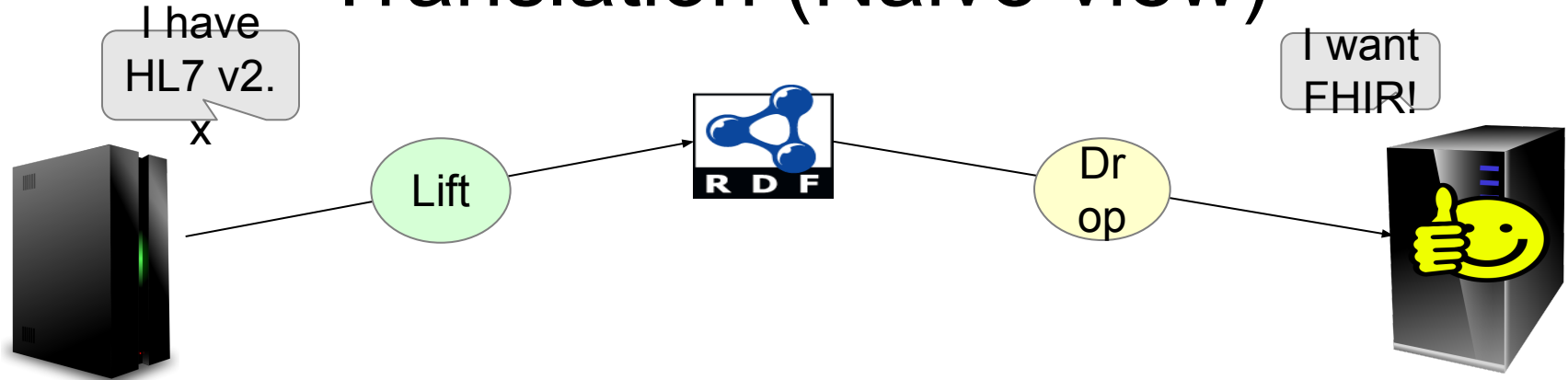
Translation needed!

Lift and Drop



- Lift: Maps to RDF
- Drop: Maps from RDF
- Simple syntactic translation
- Retains data models and vocabularies

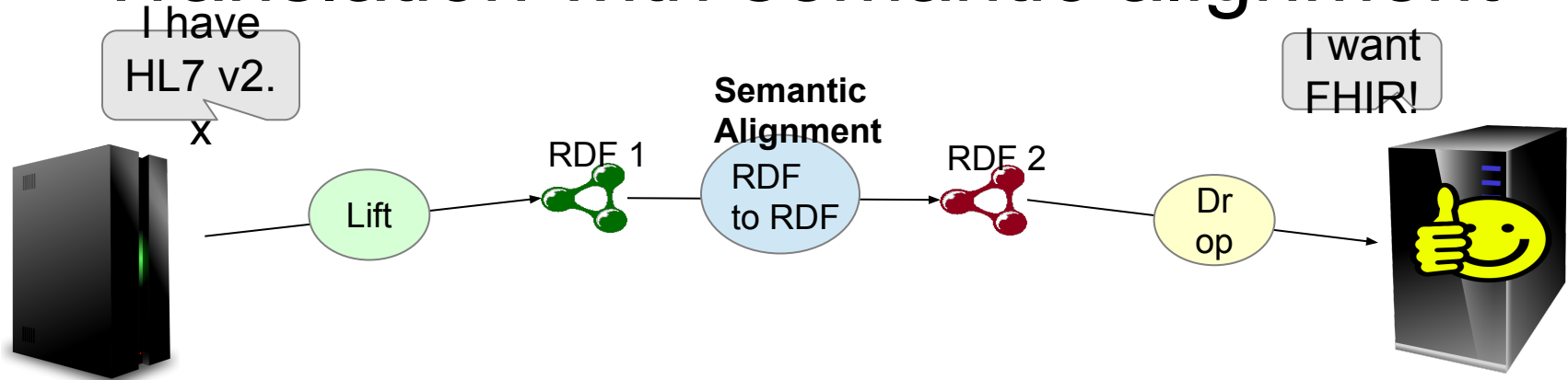
Translation (Naive view)



If Sender and Receiver use the same data model and vocabularies:

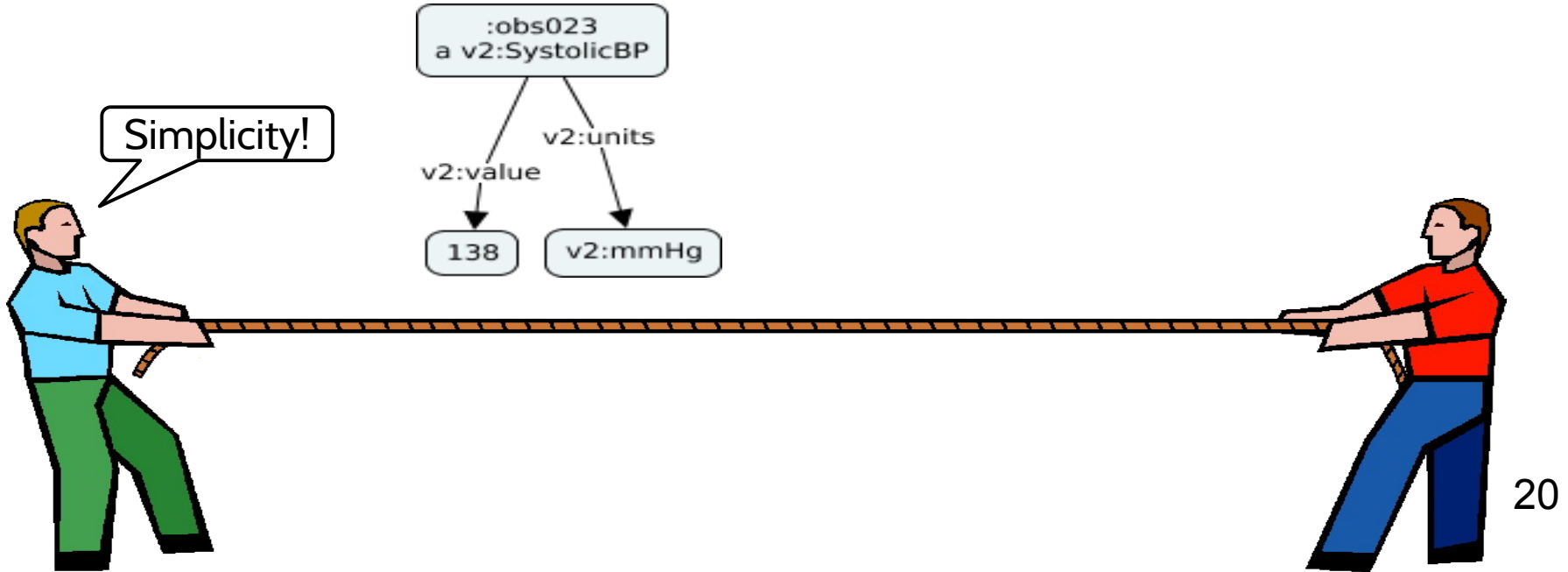
- Translate HL7 v2.x to RDF
- Translate RDF to FHIR

Translation with semantic alignment



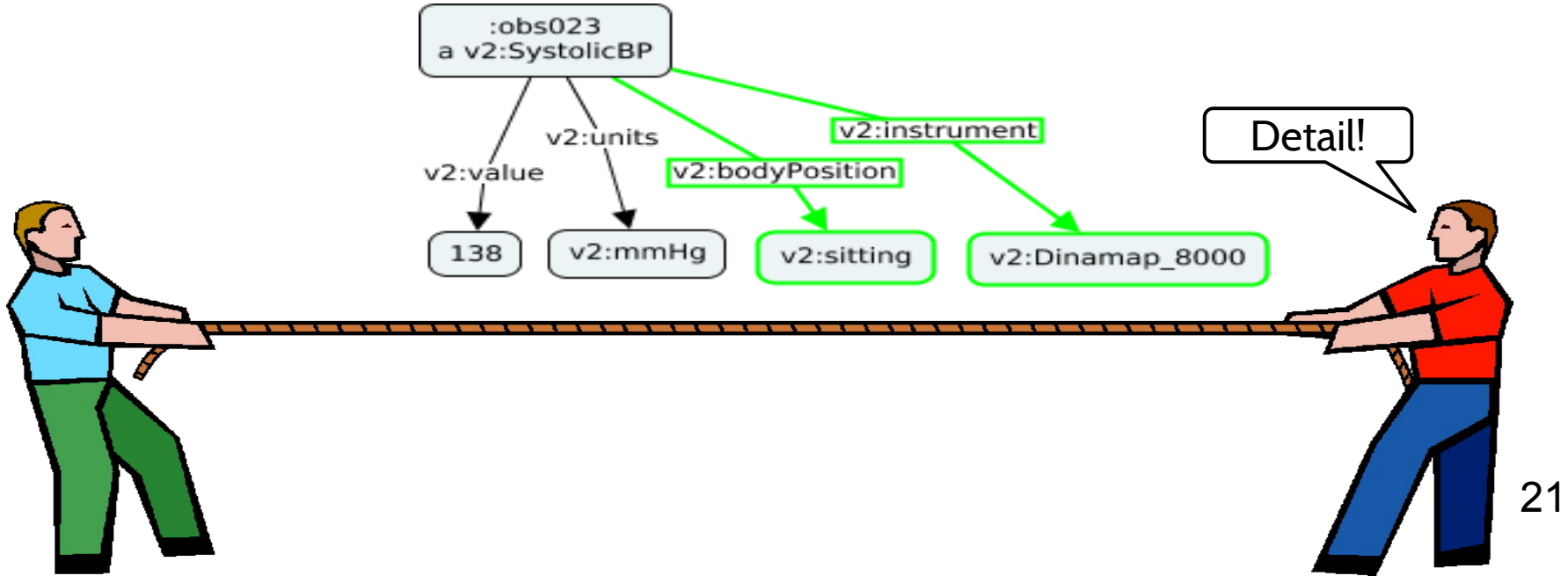
- Usually semantic alignment is required
 - RDF-to-RDF translation
 - Done with SPARQL rules or other methods
- RDF acts as a universal information representation

The granularity dilemma



Different uses want different granularities!

The granularity dilemma



Different uses need different granularities!