- DRAFT -

Proving the Viability of RDF as a Universal Healthcare Exchange Language

David Booth, Ph.D.

Latest version of these slides:
http://dbooth.org/2014/proving/

See also associated paper

Imagine a world

in which **all healthcare systems**

speak the **same language**

with the **same meanings**

covering **all healthcare.**

Semantic interoperability

Definition:

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

– Wikipedia

Healthcare today

Tower of Babel, Abel Grimmer (1570-1619)

REPORT TO THE PRESIDENT REALIZING THE FULL POTENTIAL OF HEALTH INFORMATION TECHNOLOGY TO IMPROVE HEALTHCARE FOR AMERICANS: THE PATH FORWARD

Executive Office of the President

President's Council of Advisors
on Science and Technology

December 2010

PCAST report:

"It is crucial that the Federal Government facilitate the nationwide adoption of a ***universal exchange language*** *for healthcare information"*

Yosemite Manifesto
on RDF as a Universal Healthcare Exchange Language

1. **RDF is the best available candidate** for a universal healthcare exchange language.
2. Electronic healthcare information should be exchanged in a format that either: (a) is an RDF format directly; or (b) has a standard mapping to RDF.
3. Existing standard healthcare vocabularies, data models and exchange languages should be leveraged by defining standard mappings to RDF, and any new standards should have RDF representations.
4. Government agencies should mandate or incentivize the use of RDF as a universal healthcare exchange language.
5. Exchanged healthcare information should be self-describing, using Linked Data principles, so that each concept URI is de-referenceable to its free and open definition

See http://YosemiteManifesto.org/

What is RDF?

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

Why?

Key things you need to know about RDF

#1: RDF is unambiguously **self describing**

#2: RDF data is easy to meaningfully **merge**

#3: RDF is **easy to create** from other data formats

#4: RDF captures **data meaning** – not syntax

#5: RDF enables **multiple data models and vocabularies** to be readily **combined and interrelated**

#6: RDF facilitates **smarter queries**

#7: RDF facilitates **transformations** between data models and vocabularies

See: ***Key Things You Need to Know About RDF***
http://dbooth.org/2014/key/

See: ***Key Things You Need to Know About RDF***

http://dbooth.org/2014/key/

Why RDF as a Universal Healthcare Exchange Language?

All the preceding reasons, plus:

- Emphasis on meaning and precise semantics – not syntax
- Easy to map existing formats to RDF
- Excellent for semantically connecting diverse vocabularies and data models – Multi-schema friendly

Non-technical:

- Vendor-neutral international standard (W3C)
- Mature – 10+ years
- Supports standards and innovation

Why is this important?

- Healthcare involves many thousands of concepts
  - Over 120,000 in SNOMED alone
  - Nearly 3 million in UMLS
- New concepts continually being defined and re-defined
- Critical to easily find authoritative, shared definitions

Why is this important?

- Healthcare information exists in many locations, formats, data models and vocabularies
- Need to integrate information for:
  - Better patient care
  - Better quality measurement
  - Better research

The solution is **standards!**
(Isn't it?)

And yet, somehow standards do not seem to solve the problem . . . .

See: ***Why Standards are Not Enough to Solve Healthcare's Interoperability Problem (And How RDF Can Help)***

http://dbooth.org/2014/standards/

Why standards and innovation?

- Dilemma: Standards are necessary for semantic interoperability, BUT standards are a moving target
  - Medical science and technology are continually changing
  - Medicine is too big and diverse to suddenly adopt one monster standard
  - UMLS lists over 100 vocabularies!
- Change is the norm!

Embracing standards and innovation

A universal healthcare exchange language MUST:

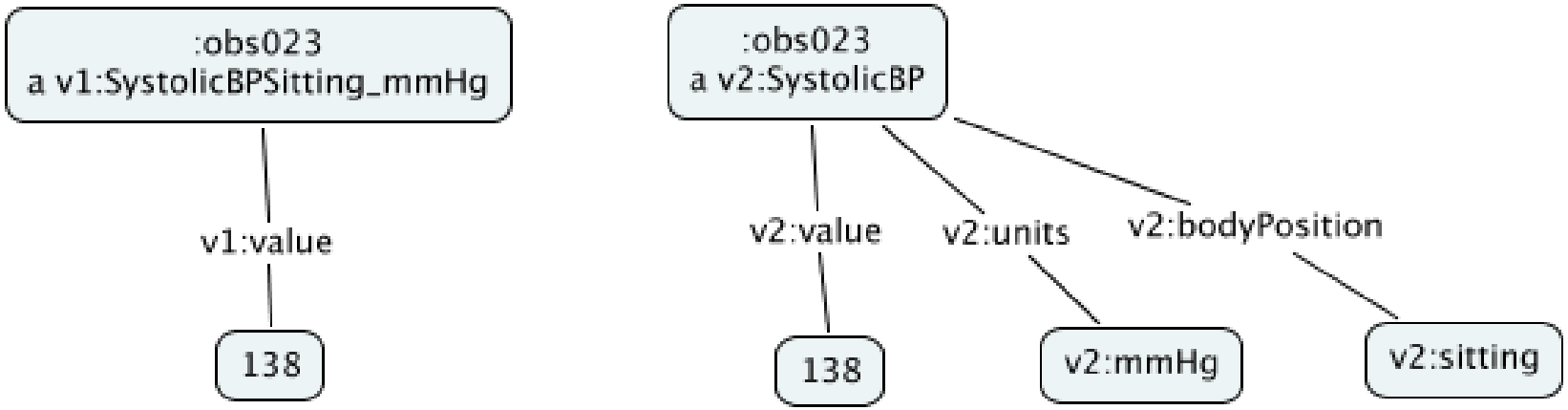
- Leverage existing and future standards – both de facto and de jure
- Support decentralized innovation – new terms, vocabularies and data models
- Allow continual incorporation of new standards
- Support a graceful transition from innovation to standard – without re-tooling

- *RDF is the best available candidate!*

Semantic alignment

- @@ Illustrate four cases in transforming model A to B: @@
- A and B hold the same information – Lossless
- A holds more information than B – Lossy
- B holds more information than A – Cannot transform
- A and B hold overlapping information – Go broader, then transform lossy

Pre-coordinated vs. post-coordinated



- @@ TODO: Get SNOMED example @@

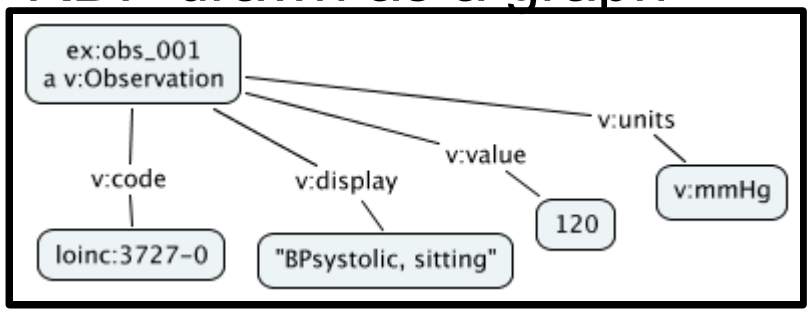
RDF example

RDF (Turtle)

```
@prefix ex: <http://example/ex/> .
@prefix loinc: <http://loinc.org/> .
@prefix v: <http://example/v/> .

ex:obs_001 a v:Observation ;
 v:code loinc:3727-0 ;
 v:display "BPsystolic, sitting" ;
 v:value 120 ;
 v:units v:mmHg .
```

RDF drawn as a graph



RDF (N-Triples)

```
<http://example/ex/obs_001> <http://www.w3.org/1999/02/22-rdf-syntax-ns#type> <http://example/v/Observation> .
<http://example/ex/obs_001> <http://example/v/code> <http://loinc.org/3727-0> .
<http://example/ex/obs_001> <http://example/v/display> "BPsystolic, sitting" .
<http://example/ex/obs_001> <http://example/v/value> "120"^^<http://www.w3.org/2001/XMLSchema#integer> .
<http://example/ex/obs_001> <http://example/v/units> <http://example/v/mmHg> .
```

- Same information

Same information, different formats

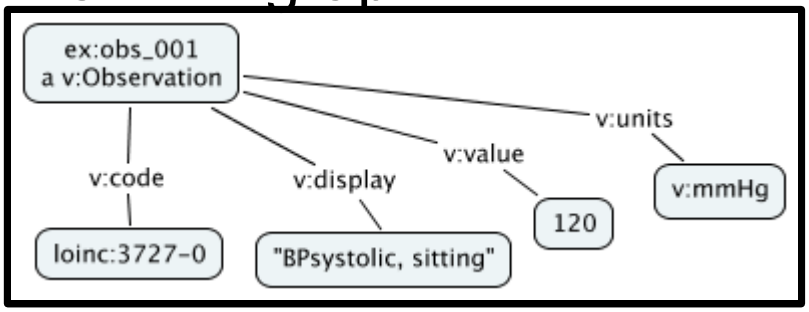
HL7 v2.x

```
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>
```

As RDF graph



- Can be represented as the same RDF!

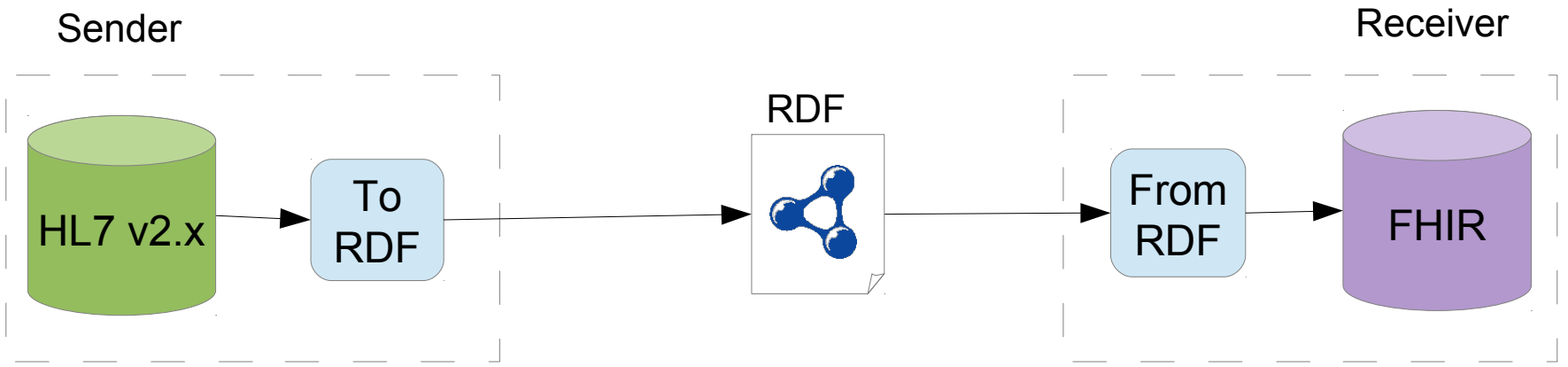
Why is this important?

- Multiple data models and vocabularies can be:
  - dynamically added
  - used together harmoniously
- This is critical in domains that involve many or changing data models/vocabularies
- Even standards are are not static!
  - Standards are continually revised or they become obsolete
- Example: Unified Medical Language System (UMLS) includes over 100 standard vocabularies and millions of concepts!

What would it mean to use RDF?

- Healthcare information is exchanged as RDF, using:
  - Standard models and vocabularies whenever possible
  - Other models and vocabularies when necessary
- Existing representations can still be used internally

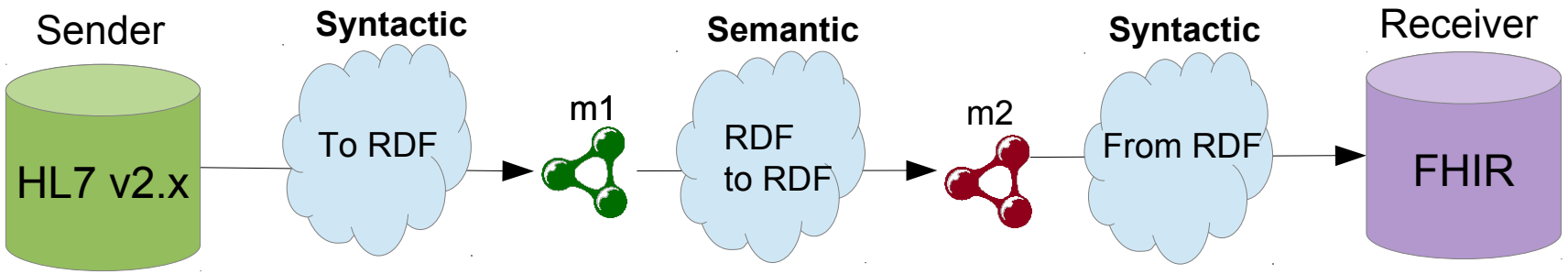
How would it work? (Naive view)



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

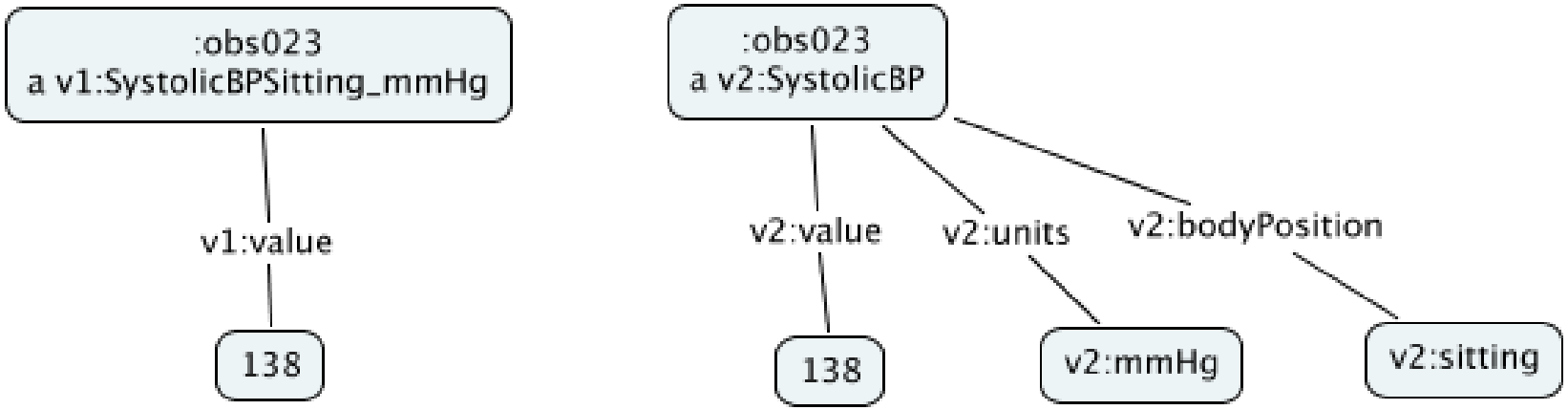
- Sender converts to RDF
- Receiver converts from RDF

Semantic alignment



- Often semantic alignment is required:
- RDF acts as a common substrate language

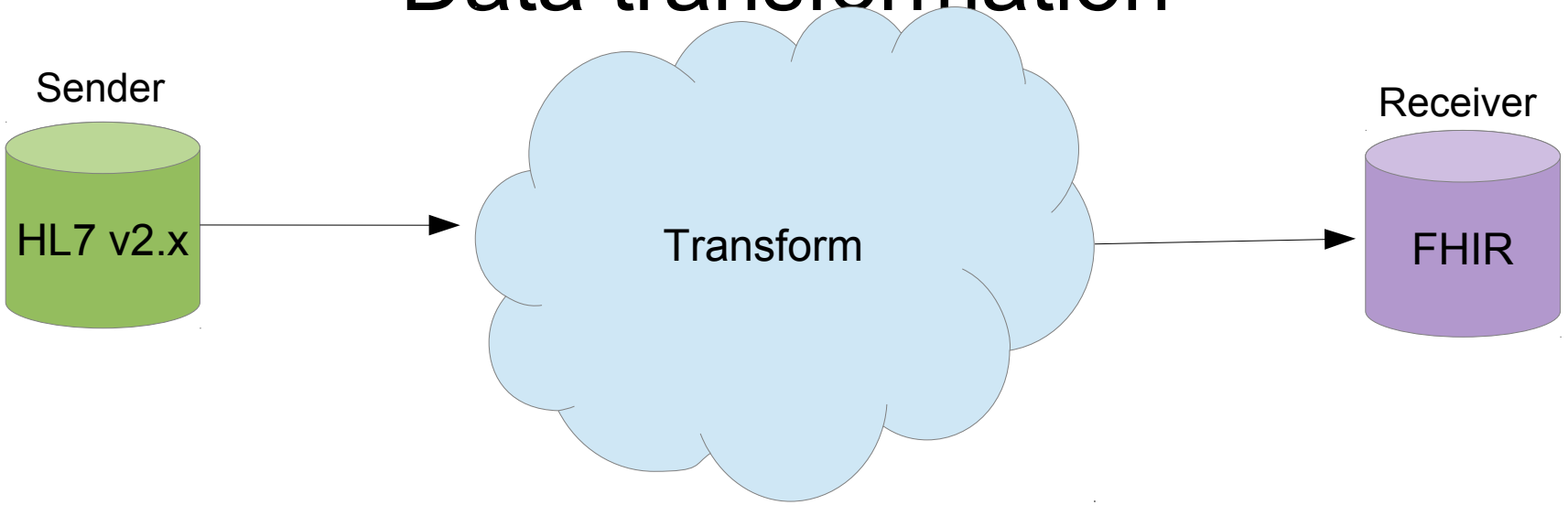
Same format, same information, but different vocabularies and data models



- Transformation or inference is needed to get from one to the other!

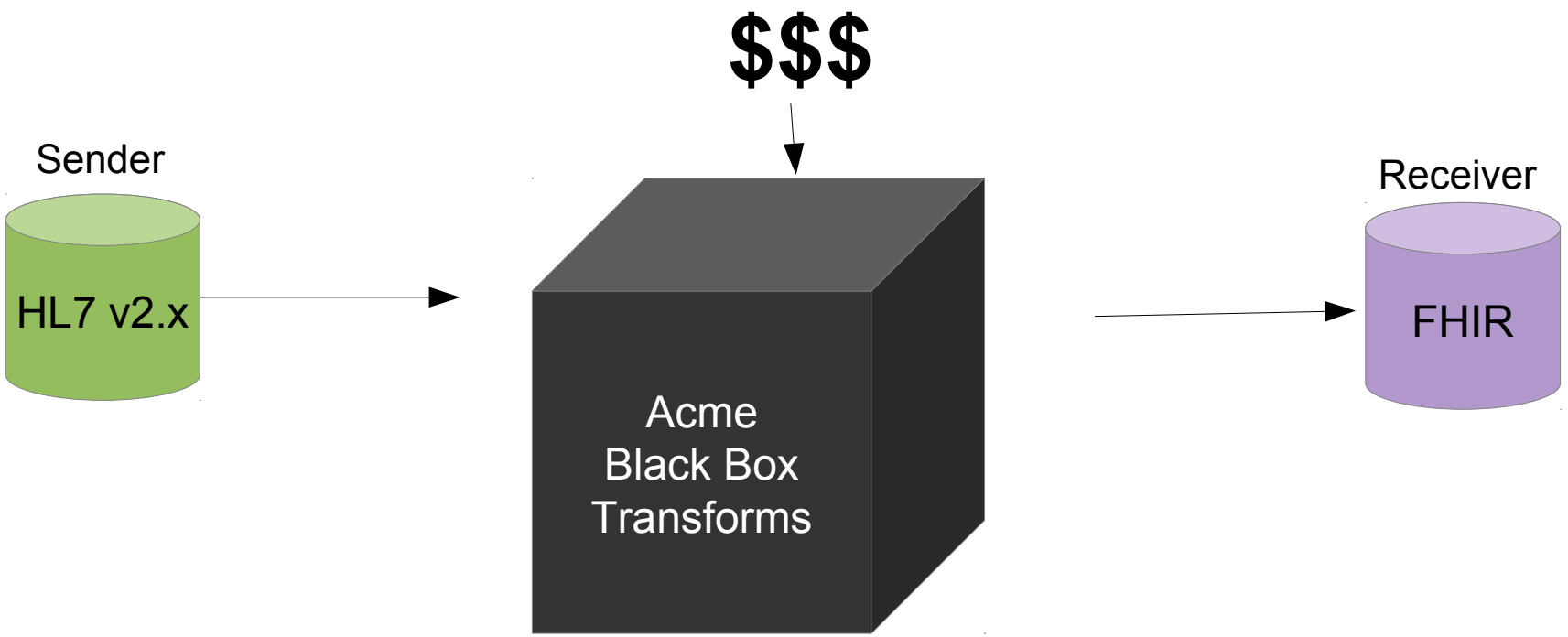
How can we achieve
semantic interoperability?

Data transformation

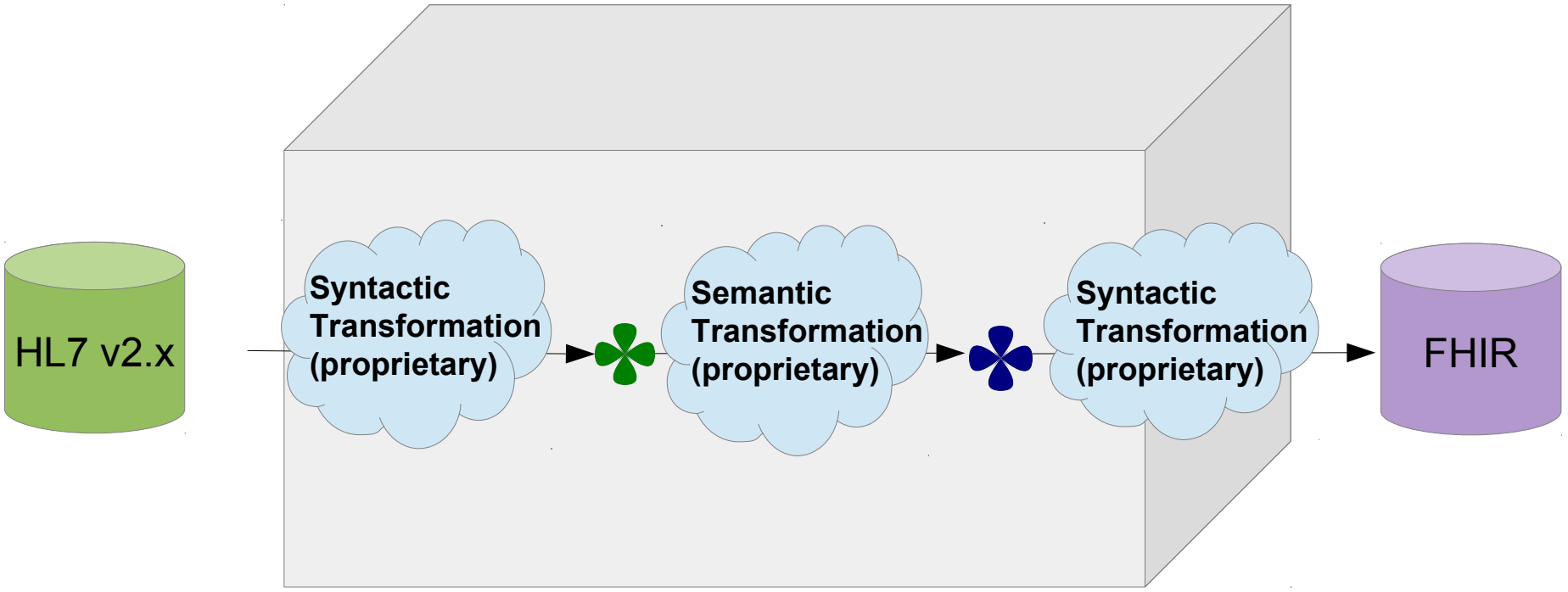


- Sometimes transformation cannot be avoided

Current interface engines

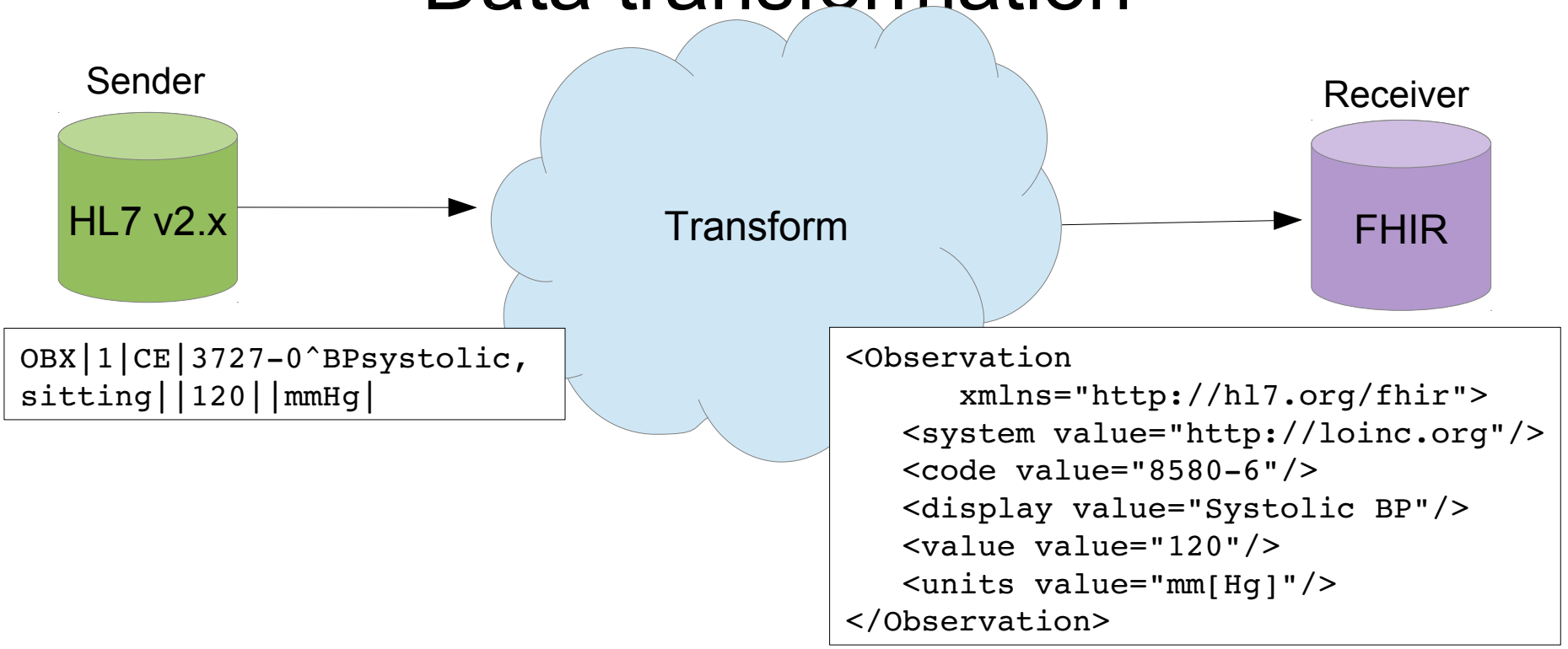


Inside the Black Box . . .

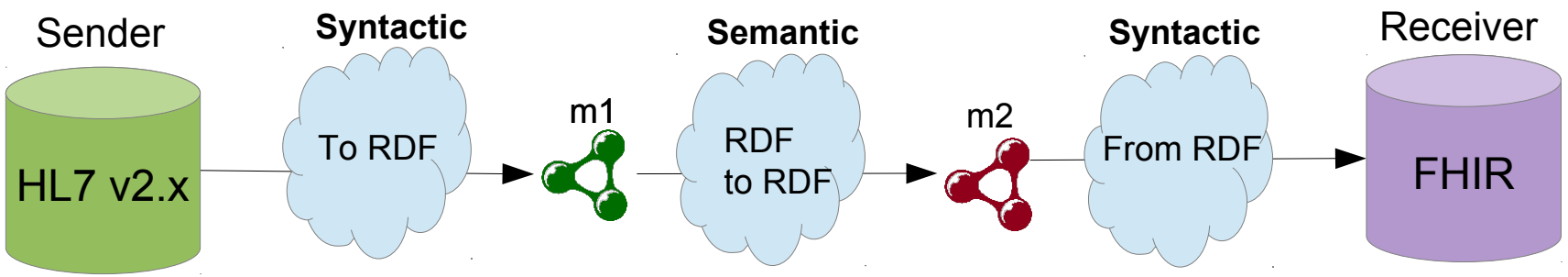


- Converts to/from required formats on output/input
- Typically uses proprietary schema-and-format-independent information representation for semantic transformations

Data transformation



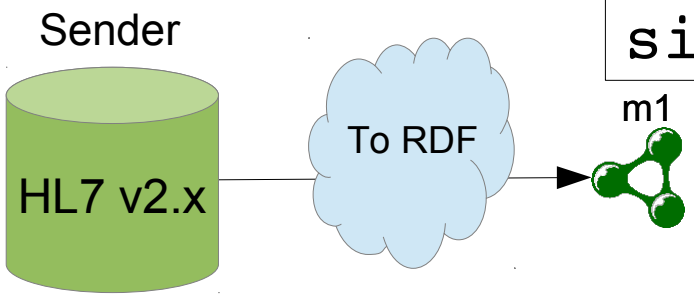
Syntactic and Semantic Transformations



- RDF acts as a common substrate language
- Based on URIs as universal identifiers

Syntactic transformation to RDF

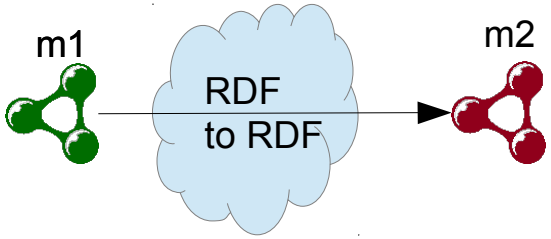
```
OBX|1|CE|3727-0^BPsystolic,
sitting||120||mmHg|
```



RDF

```
d1:obs042 a m1:PatientObservation ;
  m1:code "3727-0" ;
  m1:description "BPsystolic, sitting" ;
  m1:value 120 ;
  m1:units "mmHg" .
```

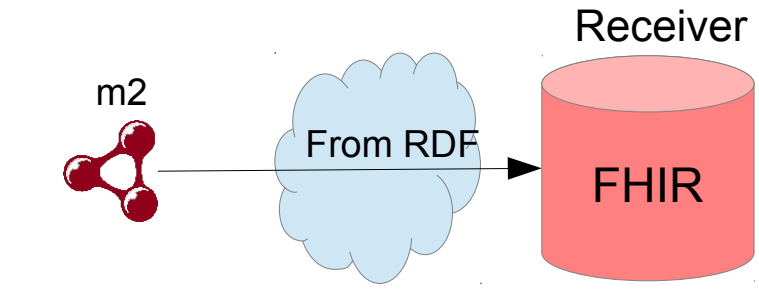
Semantic transformation RDF-to-RDF




```
CONSTRUCT {
  ?observation a m2:Observation ;
    a m2:BP_systolic ;
    m2:value ?value ;
    m2:units m3:mmHg ;
    m2:position m3:sitting .  }
WHERE {
  ?observation a m1:PatientObservation ;
    m1:code "3727-0" ;
    m1:value ?value ;
    m1:units "mmHg" . }
```

Syntactic transformation from RDF

```
d2:obs-091 a m2:Observation ;
  m2:system "http://loinc.org/" ;
  m2:code "8580-6" ;
  m2:display "Systolic BP" ;
  m2:value 107 ;
  m2:units "mm[Hg]" .
```



RDF

```
<Observation
      xmlns="http://hl7.org/fhir">
   <system value="http://loinc.org/"/>
   <code value="8580-6"/>
   <display value="Systolic BP"/>
   <value value="107"/>
   <units value="mm[Hg]"/>
</Observation>
```

Recipe for semantic interoperability

1. Capture structured information, to enable machine processing.
2. Use standard vocabularies whenever possible.
3. Continually expand and update the set of acceptable standards.
4. RDF-enable exchanged data.
5. Include *all* relevant data – even data that has not yet been standardized.
6. Map existing and new healthcare information standards to RDF.
7. Make all RDF data be self-describing (as Linked Data), using URIs that can be dereferenced to their definitions.
8. Use free and open vocabularies for data exchange.
9. Enact incentives for semantic interoperability.

How can we **represent** these **transformations?**

Many ways . . .

- Transformations can be any kind of rules or functions
- Declarative style
  - Ontologies

```
v:AorticValve rdfs:subClassOf v:HeartValve .
```

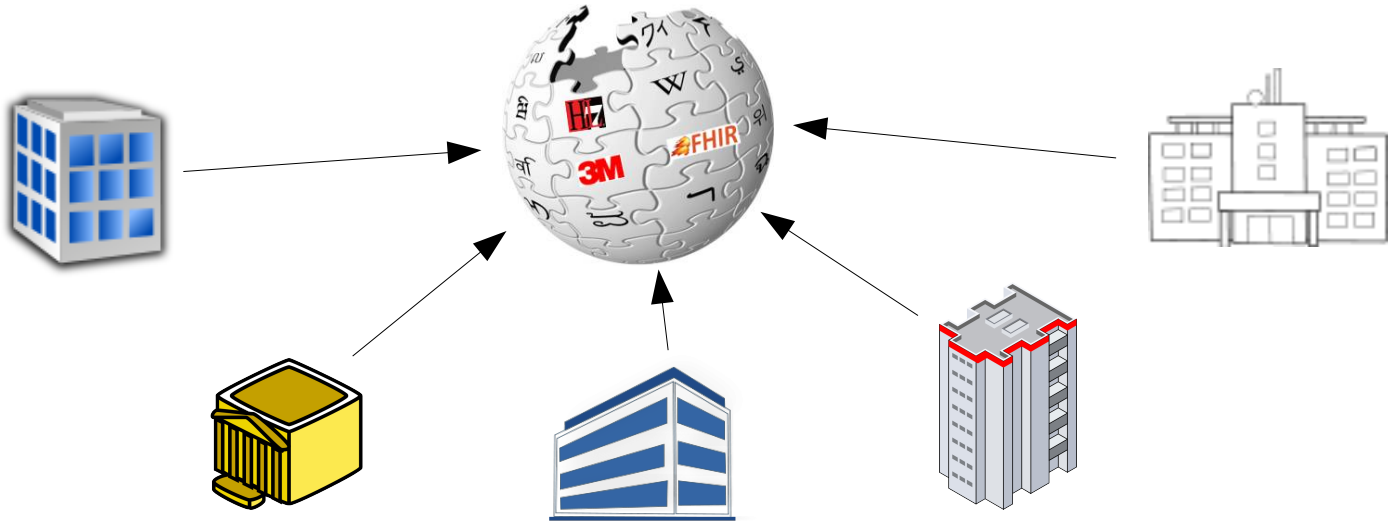
- Procedural style
  - Rules

```
{ ?x a v:AorticValve . }
  => { ?x a v:HeartValve . }
```

  - Programs, e.g., Python, Java, C, etc.

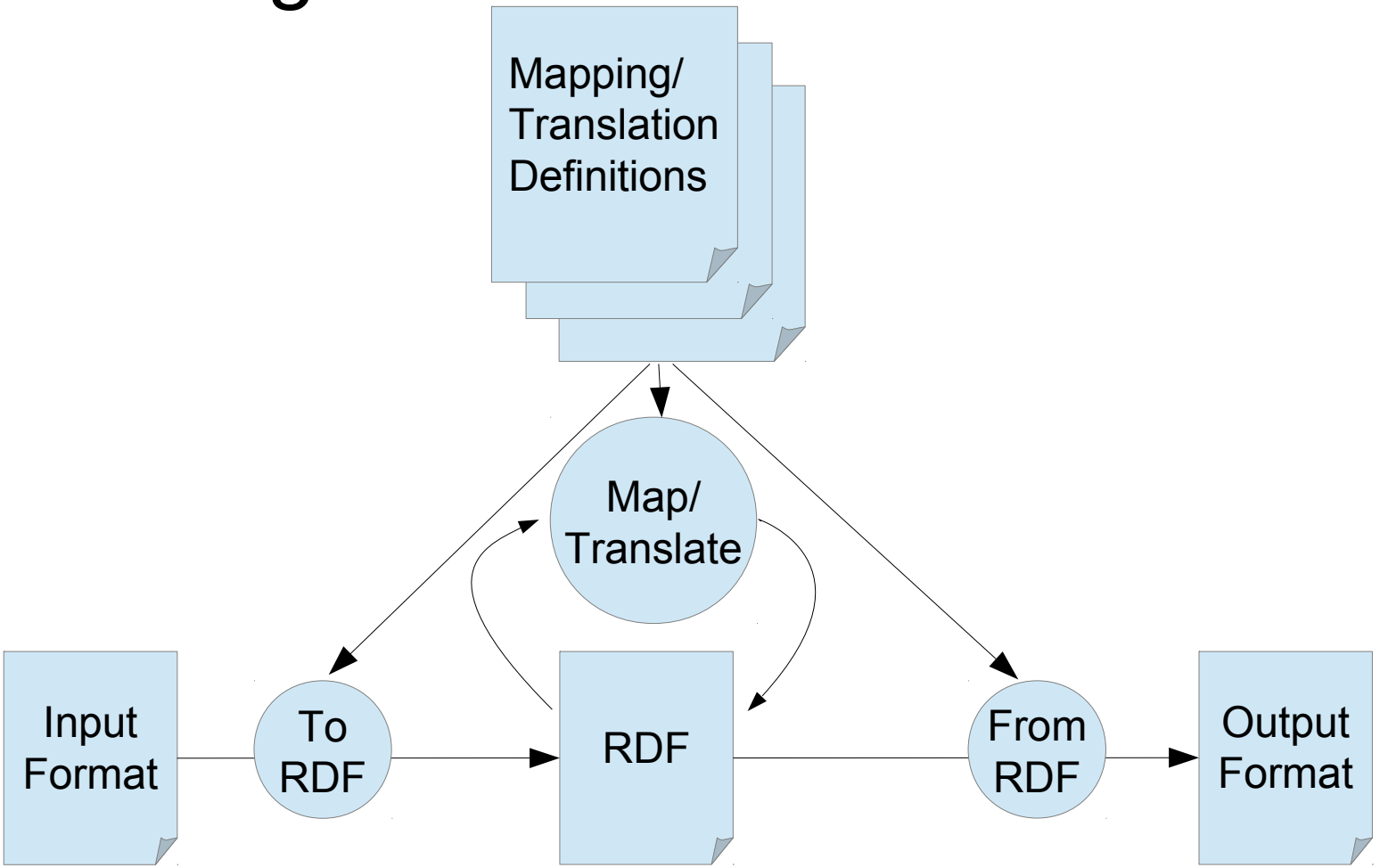
Where can we **get** these **transformations?**

Transformation Definition Repository

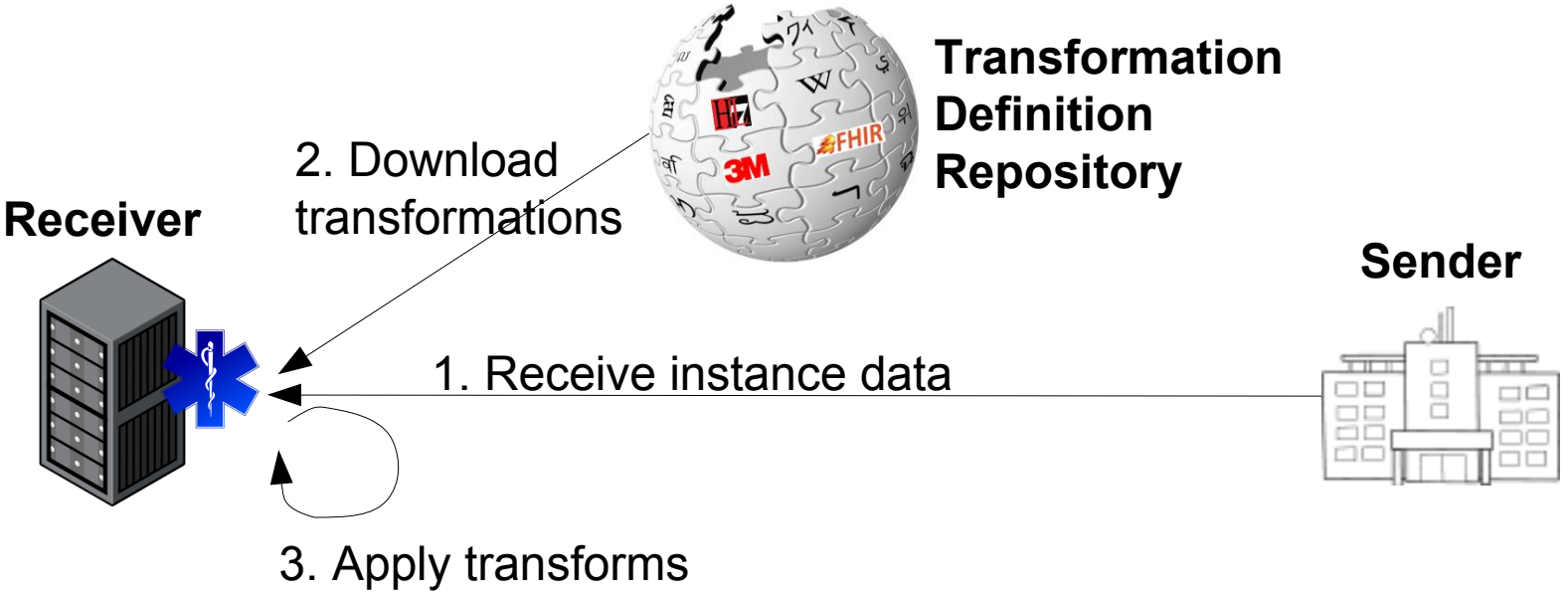


- **Transformations (rules & functions) can be upload & downloaded**
- **Collaborative – can be crowd sourced**
- **Repository keeps versions and metadata**
- **Could be used to lookup appropriate transformation both manually and automatically**

Using Transformation Definitions



Transformation Definition Repository



- **Instance data is transmitted peer-to-peer**
- **Recipient downloads transformations from hub for unknown data models and vocabularies**

Example scenario

- Sender:
  - Transforms internal format to RDF
  - Provides instance data in RDF
  - Class and property URIs indicate the vocabularies/data models used
  - Class and property URIs MUST be dereferenceable to definitions, i.e., as Linked Data
- Receiver:
  - Receives RDF data, and uses the wiki to lookup transformations for vocabularies / data models it does not understand
  - Downloads the desired transformations
  - Applies the transformations to the instance data
    - Instance data is now semantically aligned with receiver's ontology
  - Transforms from RDF to internal format

Transformation metadata

- Transformation identified by URIs
- Indicates:
  - Source vocabularies/data models
  - Target vocabularies/data models
- Includes usage measure/ratings, e.g.:
  - Objective: Number of downloads, Author, Date, etc.
  - Subjective: Who/how many like it, reviews, etc.
- License information? – TBD
  - E.g., allow commercial transformations?

Next steps

- RDF is the "Best available candidate":
  - Lots of uses, including in healthcare
  - Lots of believers: http://YosemiteManifesto.org/
- It is time to move forward *quickly*.

Questions?

BACKUP SLIDES

Why RDF? - Technical

- Semantics, not syntax
  - RDF is syntax independent
  - RDF captures the information content
- Multi-schema friendly
  - Multiple models, granularities and vocabularies can co-exist, semantically interrelated
  - Designed for web-scale data integration
- Self describing
  - Uses URIs as unique term and model identifiers
  - Term and model URIs can be dereferenceable to authoritative definitions

Why RDF? - Non-technical

- Supports standards and innovation
  - Leverage existing & future standards
  - Accommodate new models and vocabularies, with a graceful path toward standardization
- Vendor-neutral international standard (W3C)
- Mature
  - 10+ years
  - Used in a wide range of domains

Why not XML?

- XML places too much emphasis on syntax
  - But it's the information that matters
- Meaning is implicit
  - E.g., what does nesting mean?
- XML is schema centric – not multi-schema friendly:
  - Different schemas compete in XML – they do not co-exist well
- *Thought experiment: Integrate 5 different XML models. Good luck! :)*

Why not HL7?

- Meaning is implicit
- Too much emphasis on data transport and syntax

HOWEVER:

- HL7 can be leveraged by mapping to RDF

Why not JSON?

- Meaning is implicit
- JSON is not self-describing
  - The same term may have different meaning in different contexts
  - (Compare RDF's use of unambiguous URIs)
- JSON is schema-centric (not multi-schema friendly)

HOWEVER:

- JSON is a very convenient syntax, and can be used as an RDF serialization (JSON-LD)
- *Thought experiment: Integrate 5 JSON data models. It's easier than in XML, but still harder than in RDF.*

Why is it so difficult to standardize?

- Healthcare information is complex
- Lack of incentive
- Standardization takes time
  - Progress goes toward zero as committee size grows
- Moving target: medical science and technology continually changing

Issues

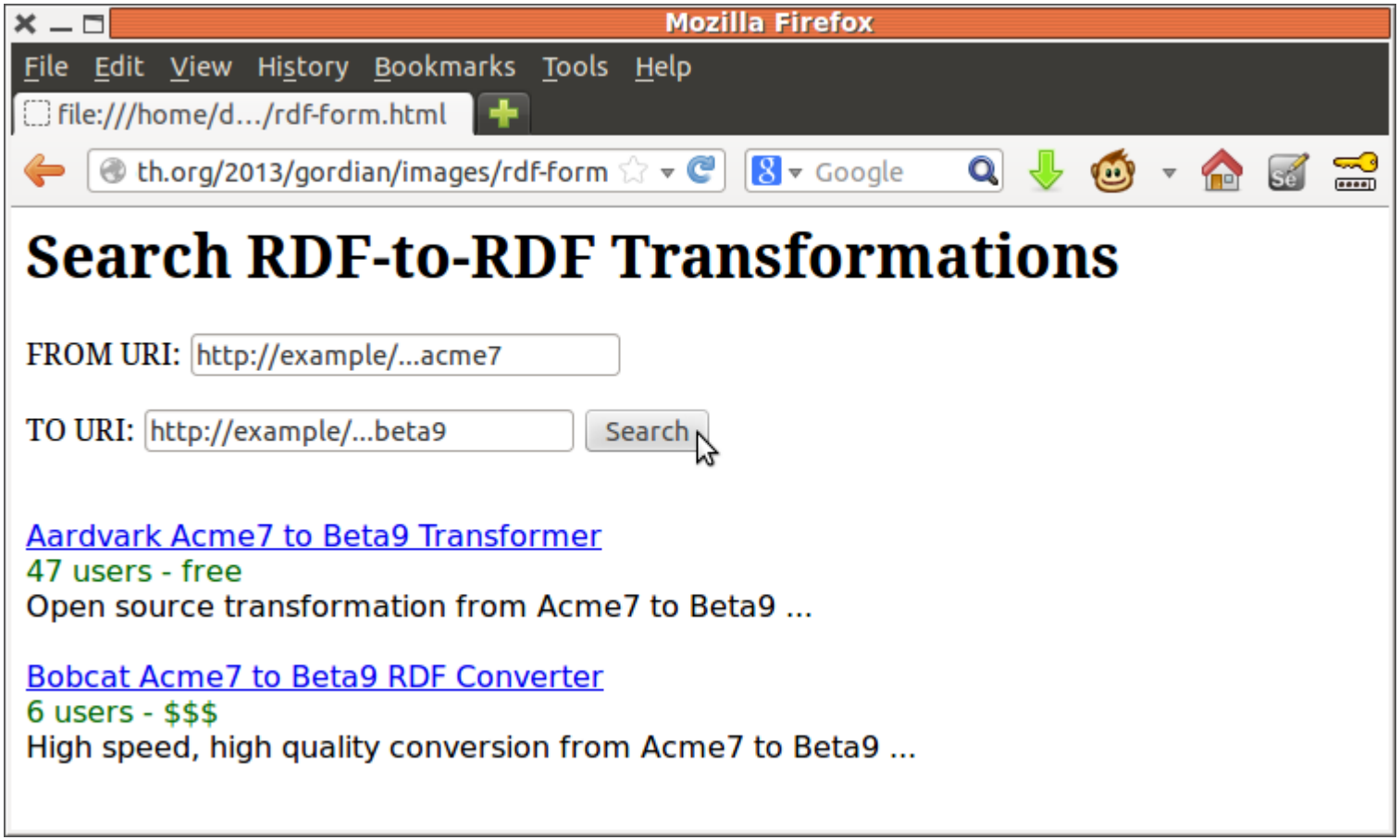
- How to incent contributions of transformations?
- How to provide objective measures of quality? E.g., number of downloads, who is using which transforms, etc.
- Licensing: Allow commercial transformations too?

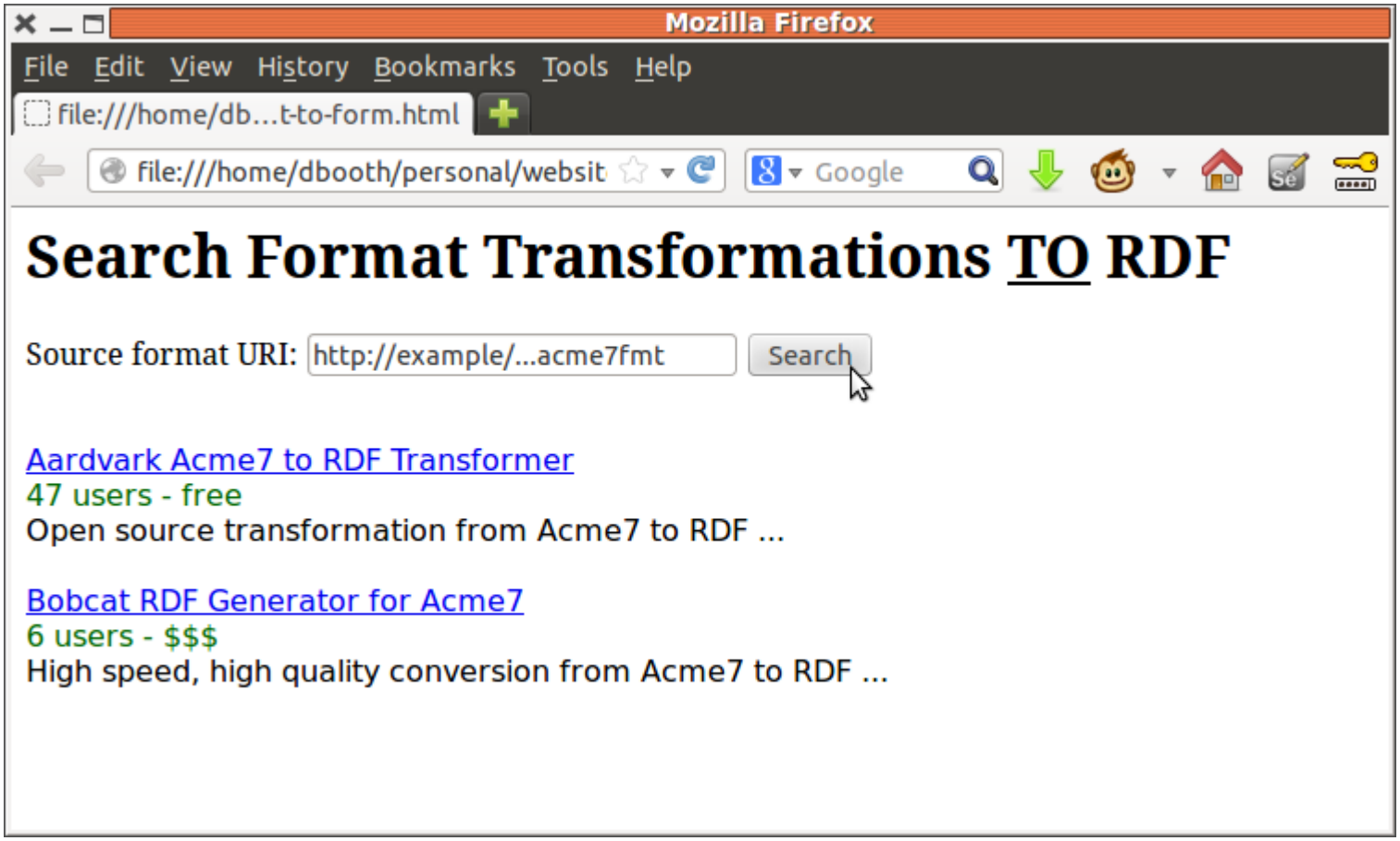
Modeling steps

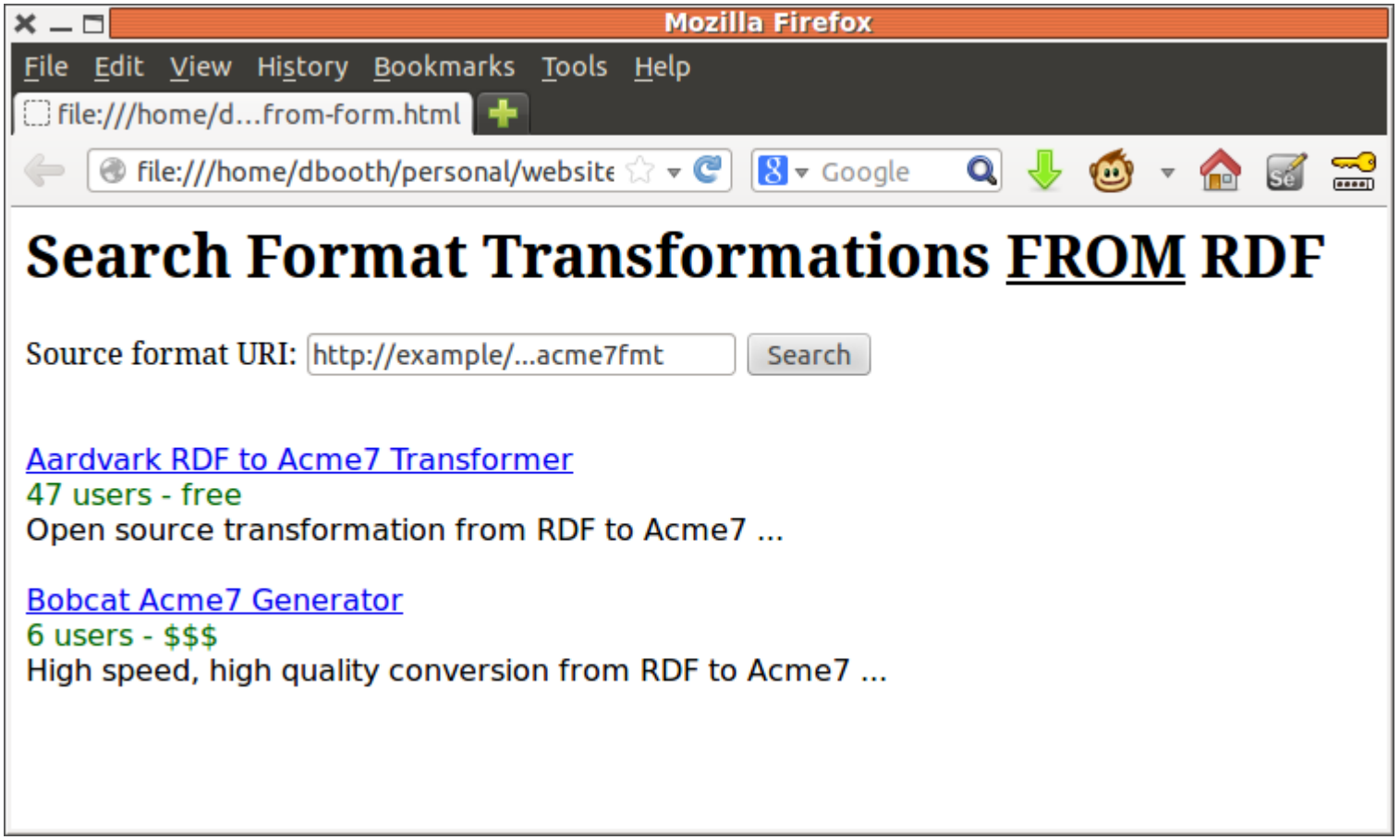
1. Model existing data – as it is
   - Start with the data you know you need
2. Model desired data or queries – as they are
   - Start with what you know you need
3. Choose mappings or bridge models
   - Rules, hub ontologies, etc.
4. Iterate

Issue: How to know if unrecognized data is needed?

- Party B receives data from party A. Part of that data is in an unknown model
  - Solution: Metadata?
- Party A needs to indicate what data is available
  - Solution: Data summary?
  - E.g. # triples of each predicate, class, MB, etc.
  - MB might be helpful for images


Mozilla Firefox
File Edit View History Bookmarks Tools Help
file:///home/d.../rdf-form.html
th.org/2013/gordian/images/rdf-form
Google
Search RDF-to-RDF Transformations
FROM URI: http://example/...acme7
TO URI: http://example/...beta9
Search
Aardvark Acme7 to Beta9 Transformer
47 users - free
Open source transformation from Acme7 to Beta9 ...
Bobcat Acme7 to Beta9 RDF Converter
6 users - $$$
High speed, high quality conversion from Acme7 to Beta9 ...


Mozilla Firefox
File Edit View History Bookmarks Tools Help
file:///home/db…t-to-form.html
file:///home/dbooth/personal/websit
Google
Search Format Transformations TO RDF
Source format URI: http://example/...acme7fmt
Search
Aardvark Acme7 to RDF Transformer
47 users - free
Open source transformation from Acme7 to RDF ...
Bobcat RDF Generator for Acme7
6 users - $$$
High speed, high quality conversion from Acme7 to RDF ...


Mozilla Firefox
File Edit View History Bookmarks Tools Help
file:///home/d...from-form.html
file:///home/dbooth/personal/website
Google
Search Format Transformations FROM RDF
Source format URI: http://example/...acme7fmt
Search
Aardvark RDF to Acme7 Transformer
47 users - free
Open source transformation from RDF to Acme7 ...
Bobcat Acme7 Generator
6 users - $$$
High speed, high quality conversion from RDF to Acme7 ...

Negotiating natural language

I speak:

- English
- French
- German

I understand:

- English
- French
- German
- Mandarin

Negotiating healthcare language

I speak:

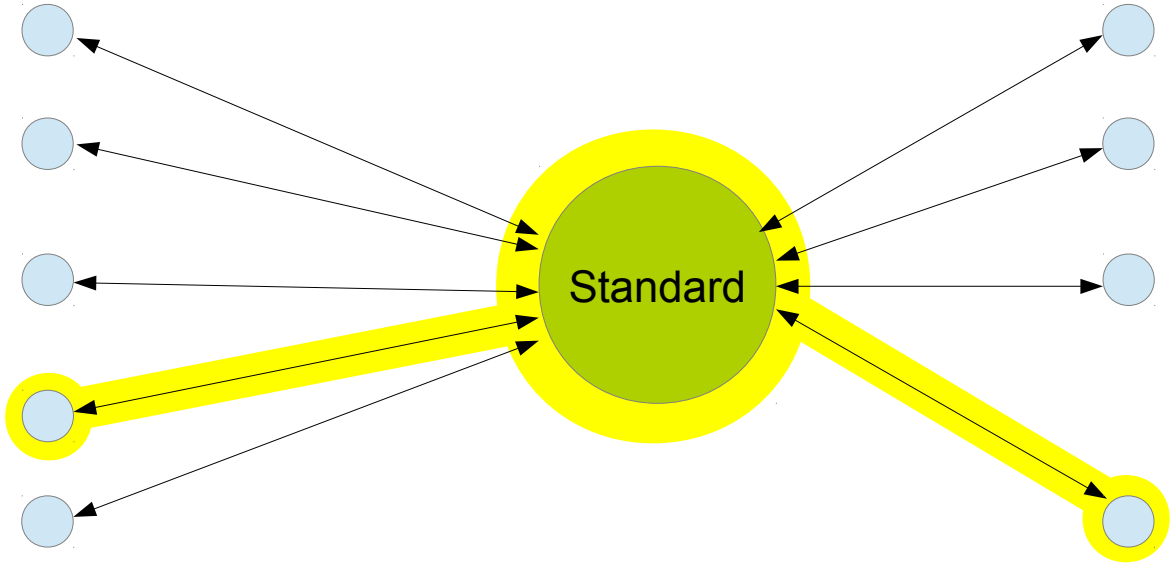
- http://...SNOMED
- http://...LOINC
- http://...ICD9
- http://...3MHDD
- http://...ACME7

I understand:

- http://...SNOMED
- http://...ACME7

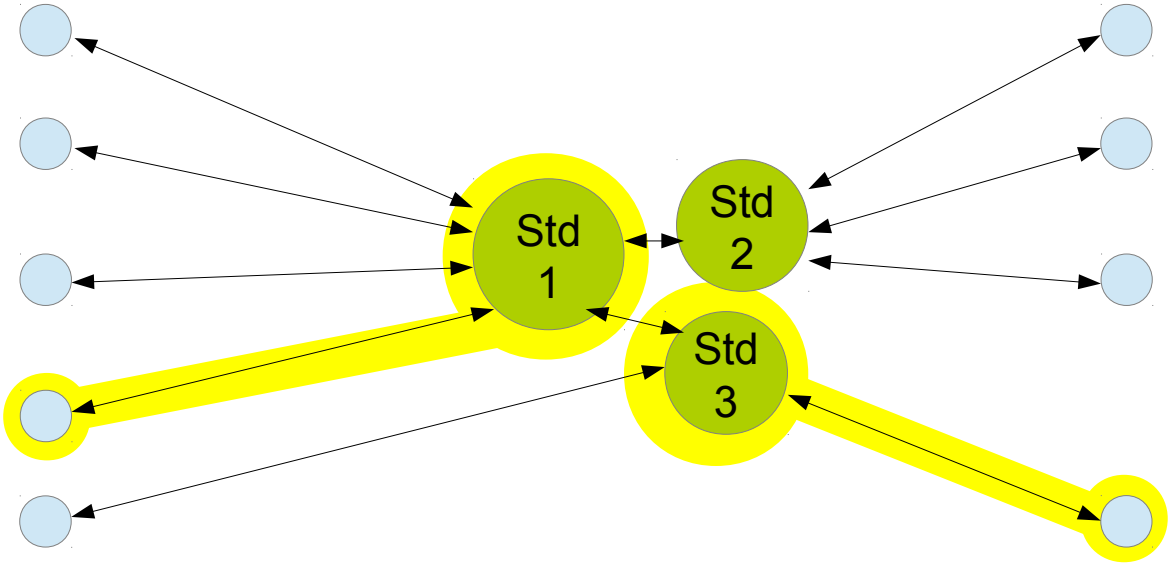
- Identified by URI
- Represented in RDF

Standardization



- PROS: Most efficient; desirable whenever possible
  - Only need *n* transformations instead of *(n-1)*(n-1)*
- CONS: Infeasible when committee/standard gets too big

Standards and diversity



- *Cannot stop the world to wait for standardization!*

Key requirements

- Continually incorporate new vocabularies and data models
- Support existing and future healthcare standards
- Support decentralized innovation

Why include non-standard concepts?

- Important to send *all* requested information in machine-processable form
- Receiver may be able to use it
- Helps bootstrap standardization

Additional requirements for graceful adoption of new concepts

- Enable new concepts to be semantically linked to existing ones
- Enable authoritative definitions of new concepts to be obtained automatically

Best available candidate: RDF

Why RDF?

Why RDF?

1. **Semantics, not syntax**

Why RDF?

1. Semantics, not syntax
2. **Self describing – derefenceable URIs**

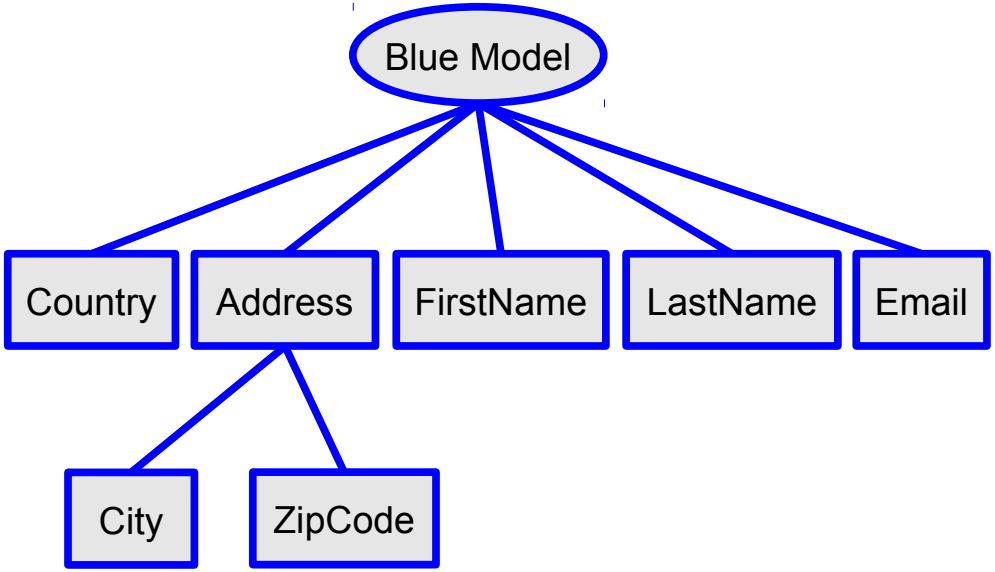
Why RDF?

1. Semantics, not syntax
2. Self describing
3. **Schema promiscuous**

Why RDF?

Schema promiscuous

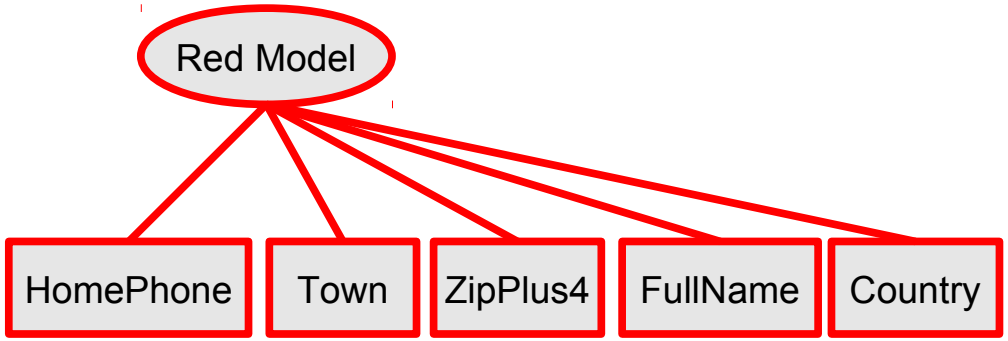
- Blue App has model



Why RDF?

Schema promiscuous

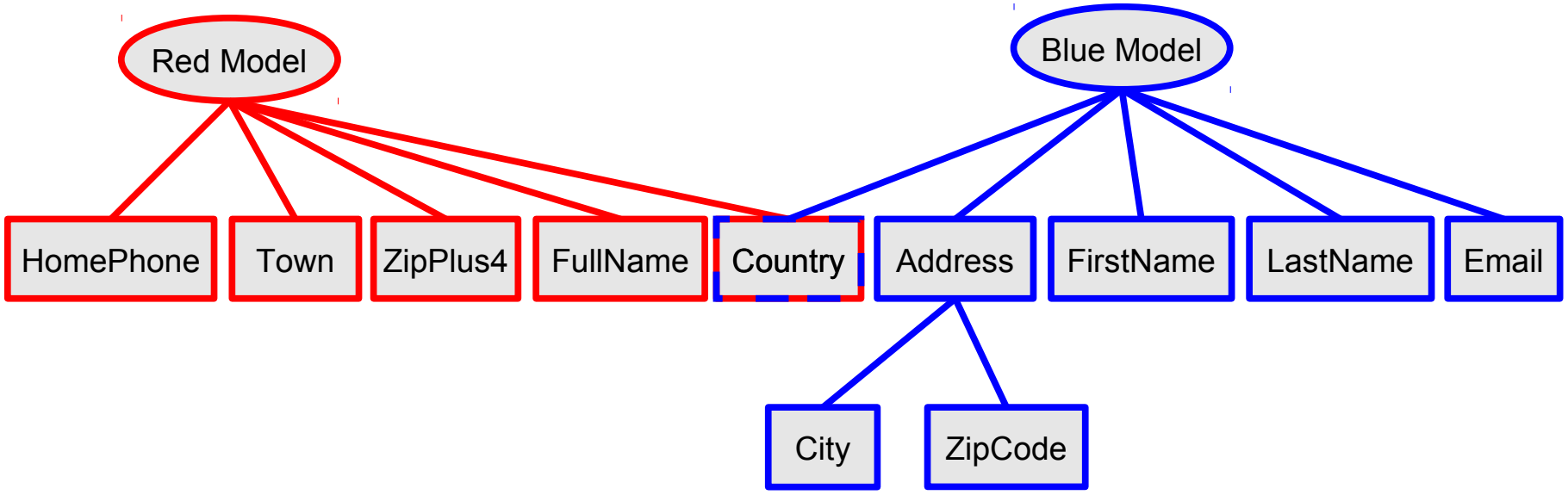
- Red App has model



Why RDF?

Schema promiscuous

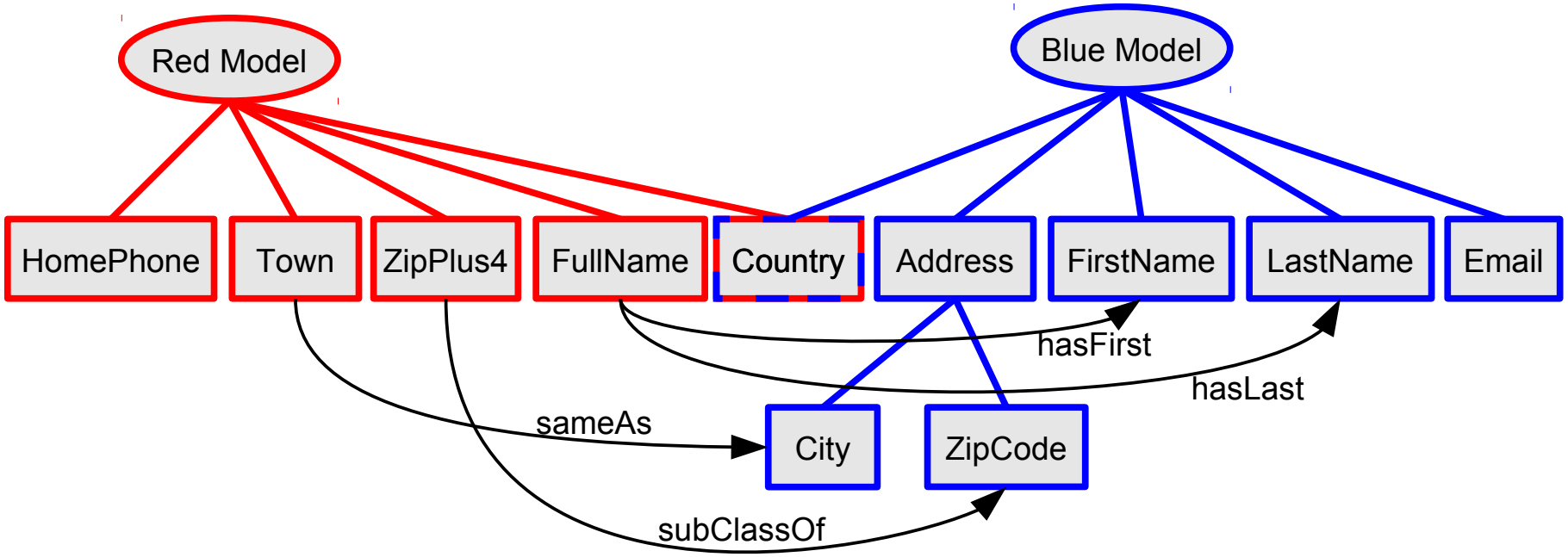
- Merge RDF data
- Same nodes (URIs) join automatically



Why RDF?

Schema promiscuous

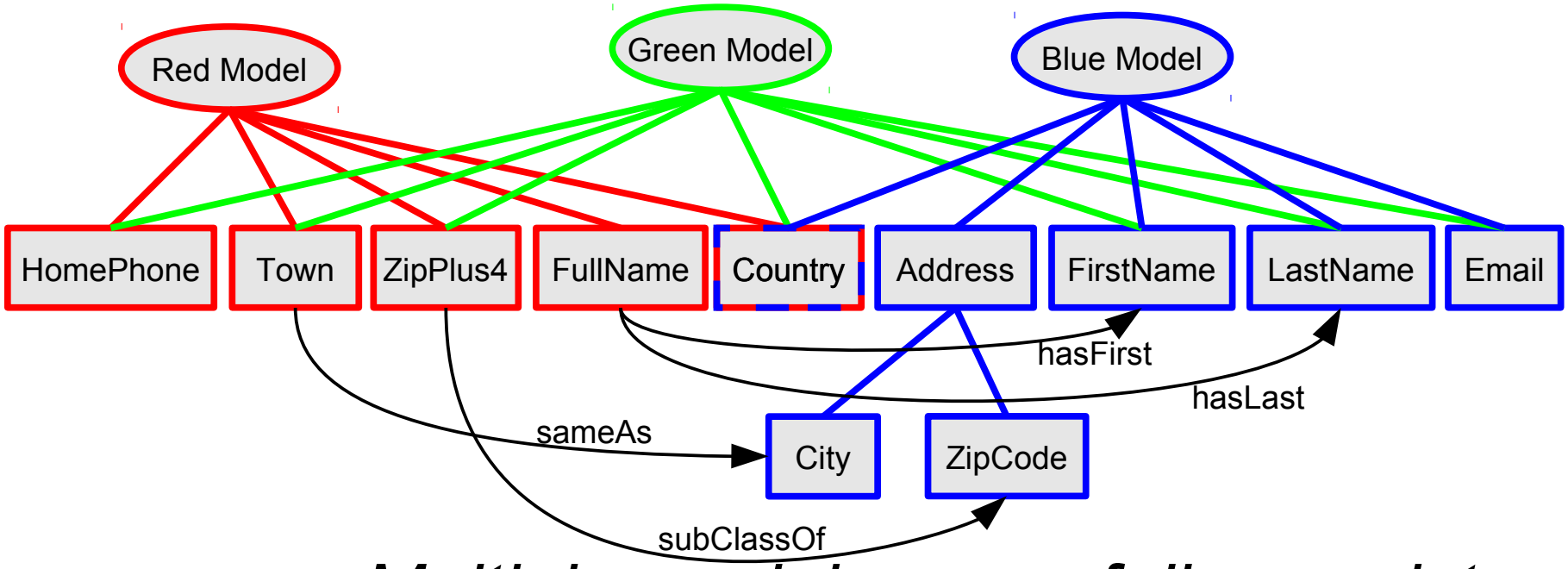
- Add relationships and rules
- (Relationships are also RDF)



Why RDF?

Schema promiscuous

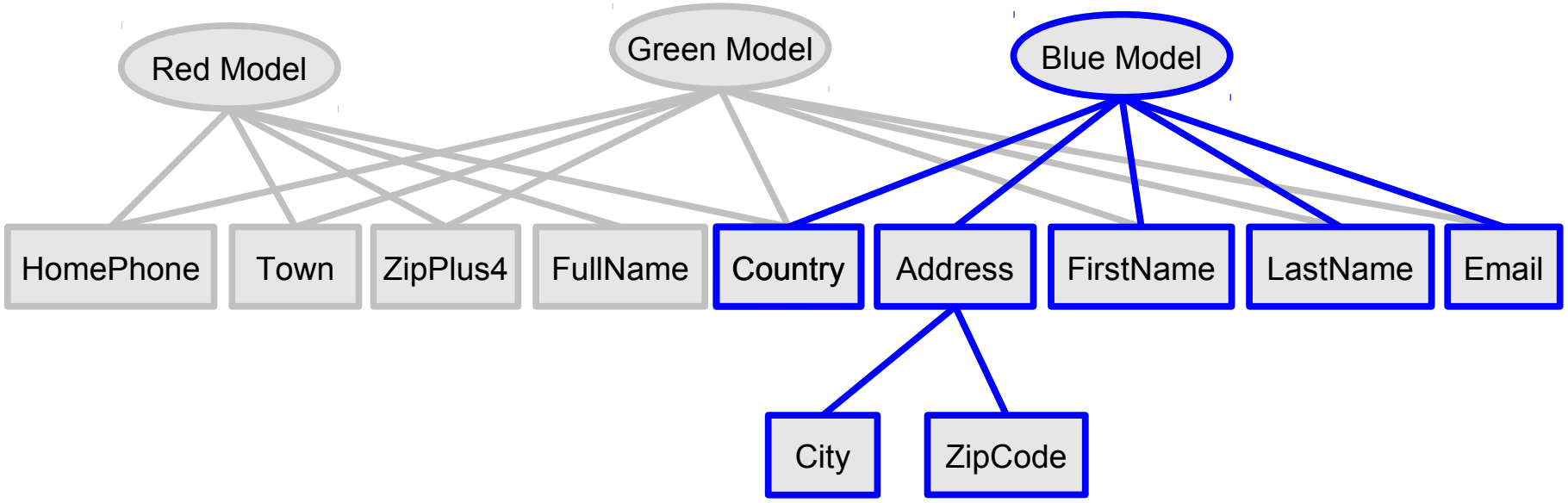
- Later add Green model
  (Using Red & Blue models)



Multiple models peacefully coexist

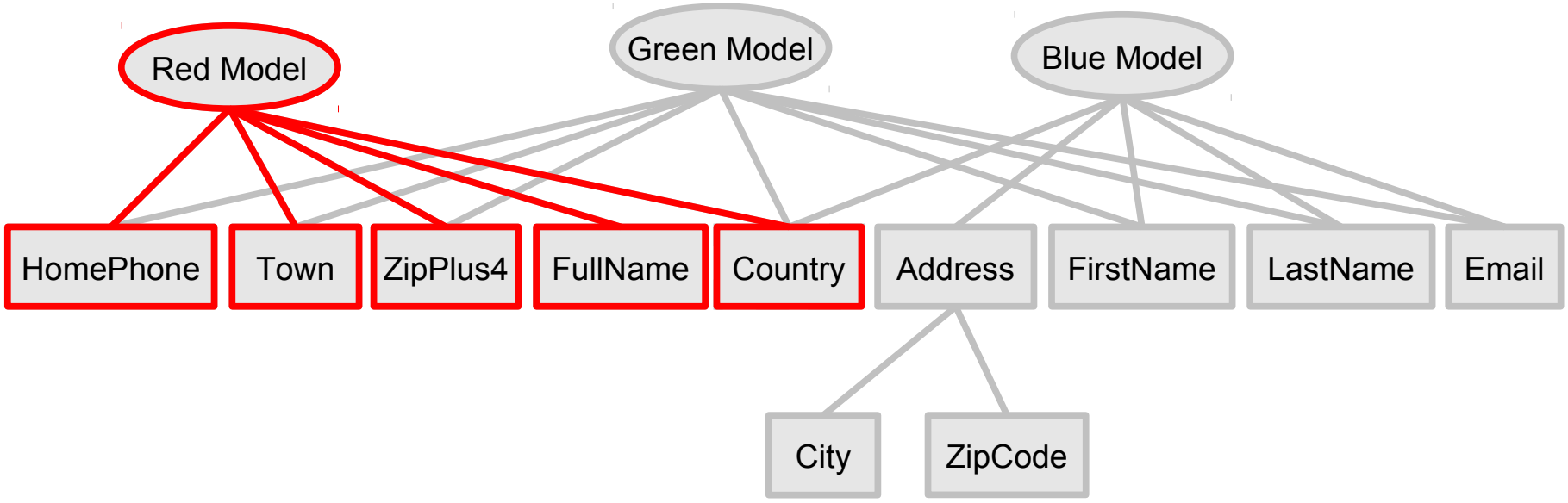
Why RDF?
Schema promiscuous

- What the Blue app sees:
  - No difference!



Why RDF?
Schema promiscuous

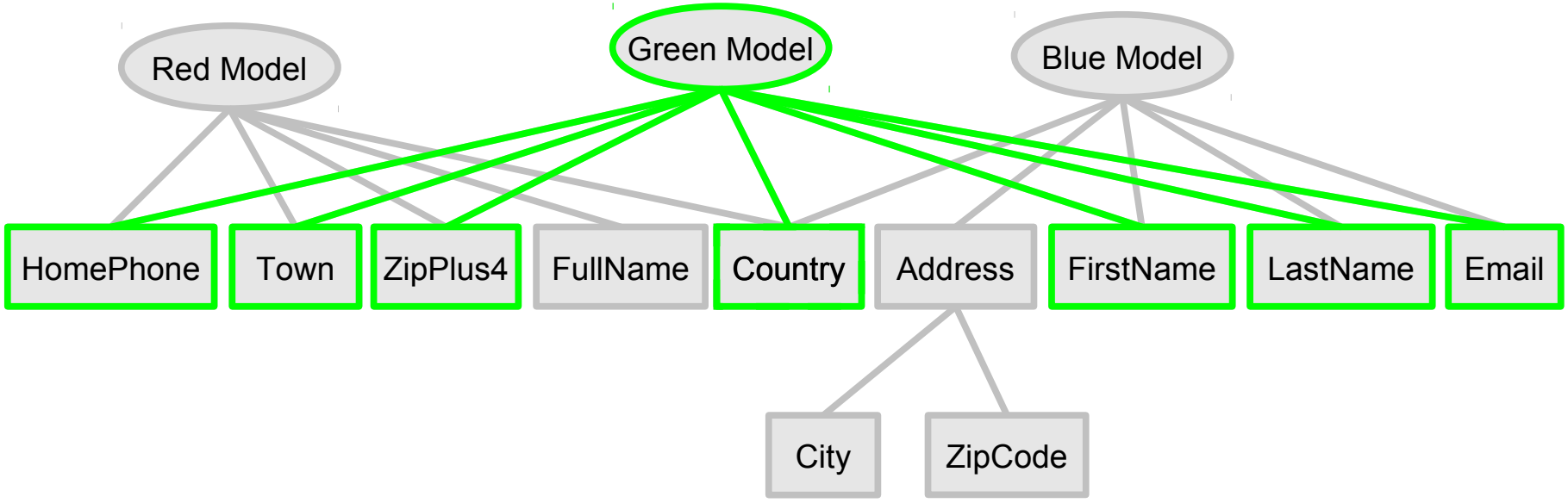
- What the Red app sees
  - No difference!



Why RDF?

Schema promiscuous

- What the Green app sees
  - No difference!



Why RDF?

1. Semantics, not syntax
2. Self describing
3. Schema promiscuous
4. **Neutral, mature, international standard**

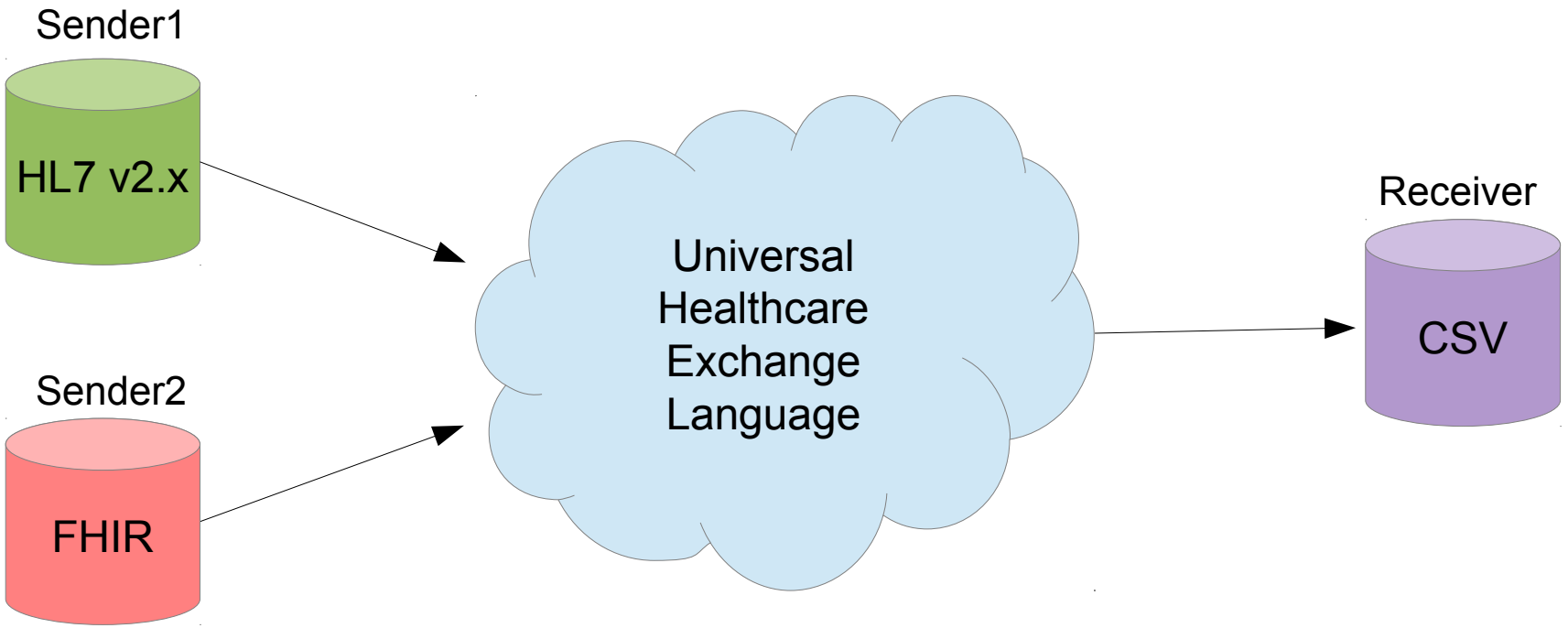
Why RDF?

1. Semantics, not syntax
2. Self describing
3. Schema promiscuous
4. Neutral, mature, international standard

Best available candidate for a universal healthcare exchange language!

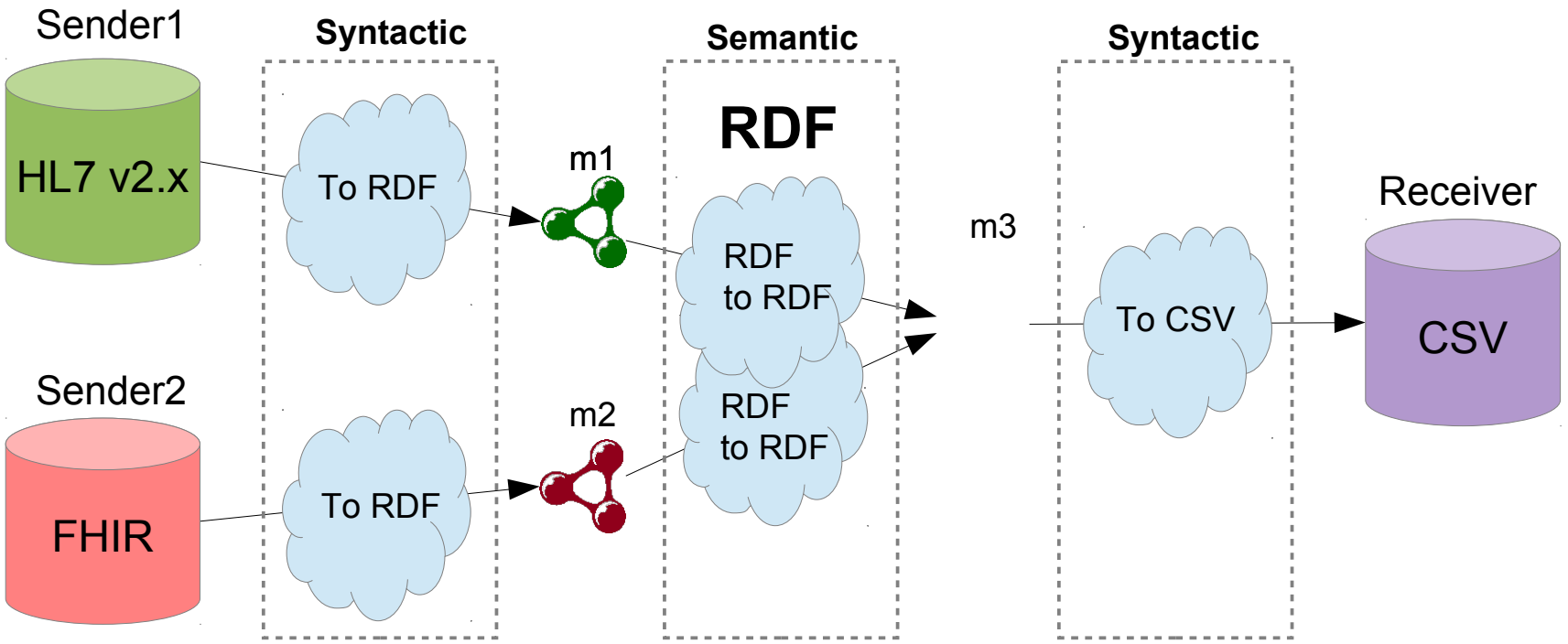
How?

Semantic interoperability involves data transformations

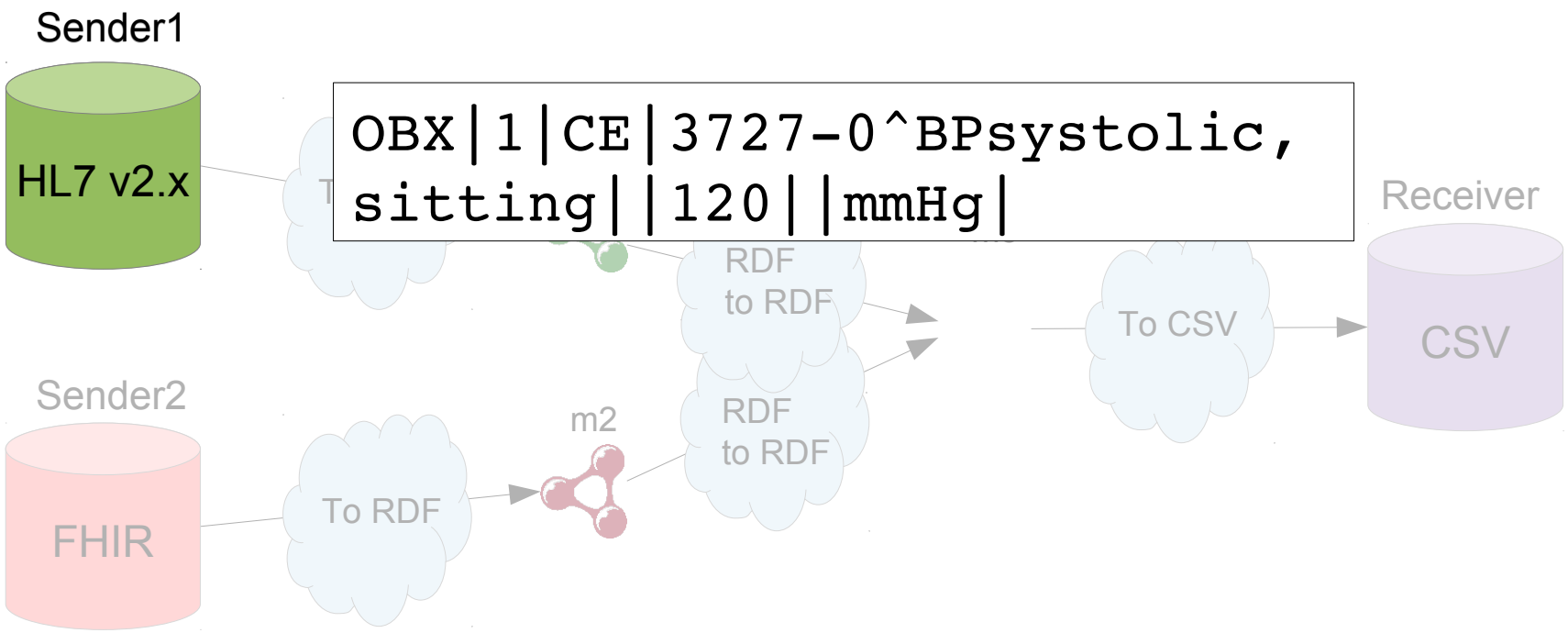


How?

Syntactic and Semantic Transformations



Sender1 data: HL7 v2.x



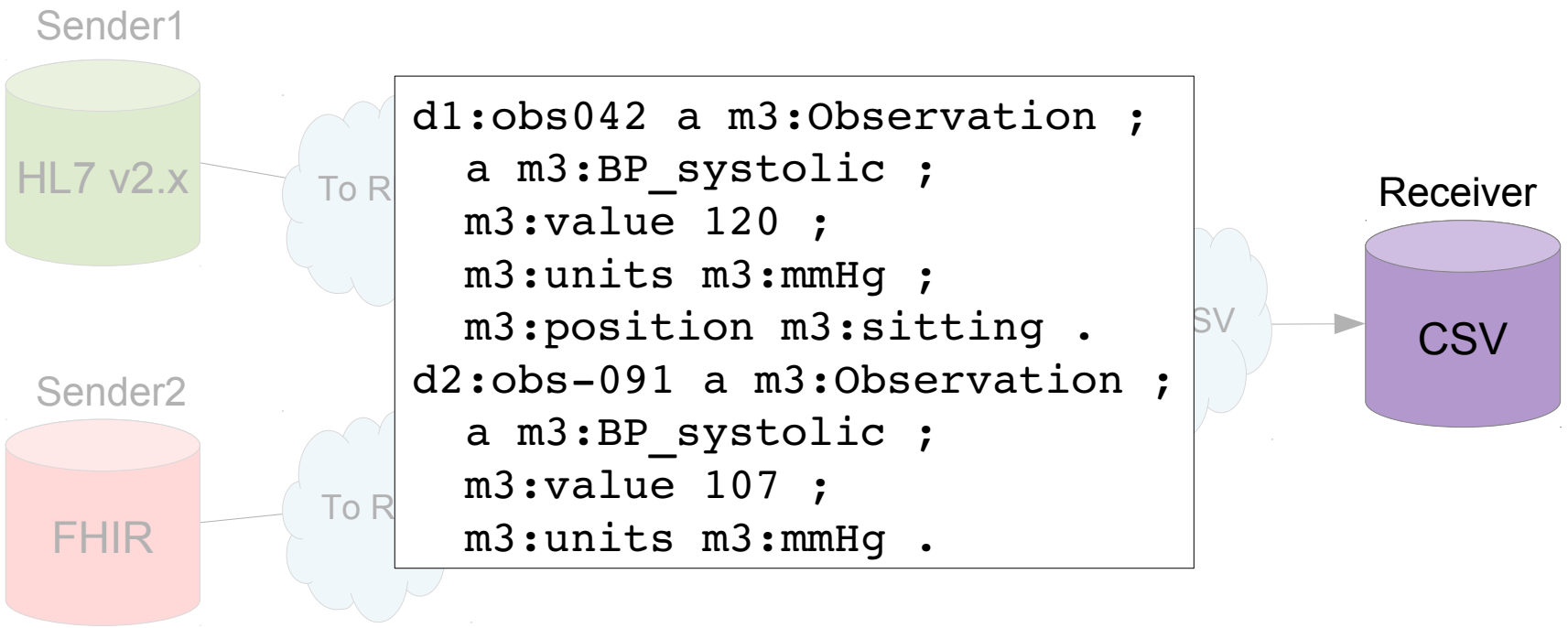
(Fictitious examples for illustration)

Sender2 data: FHIR

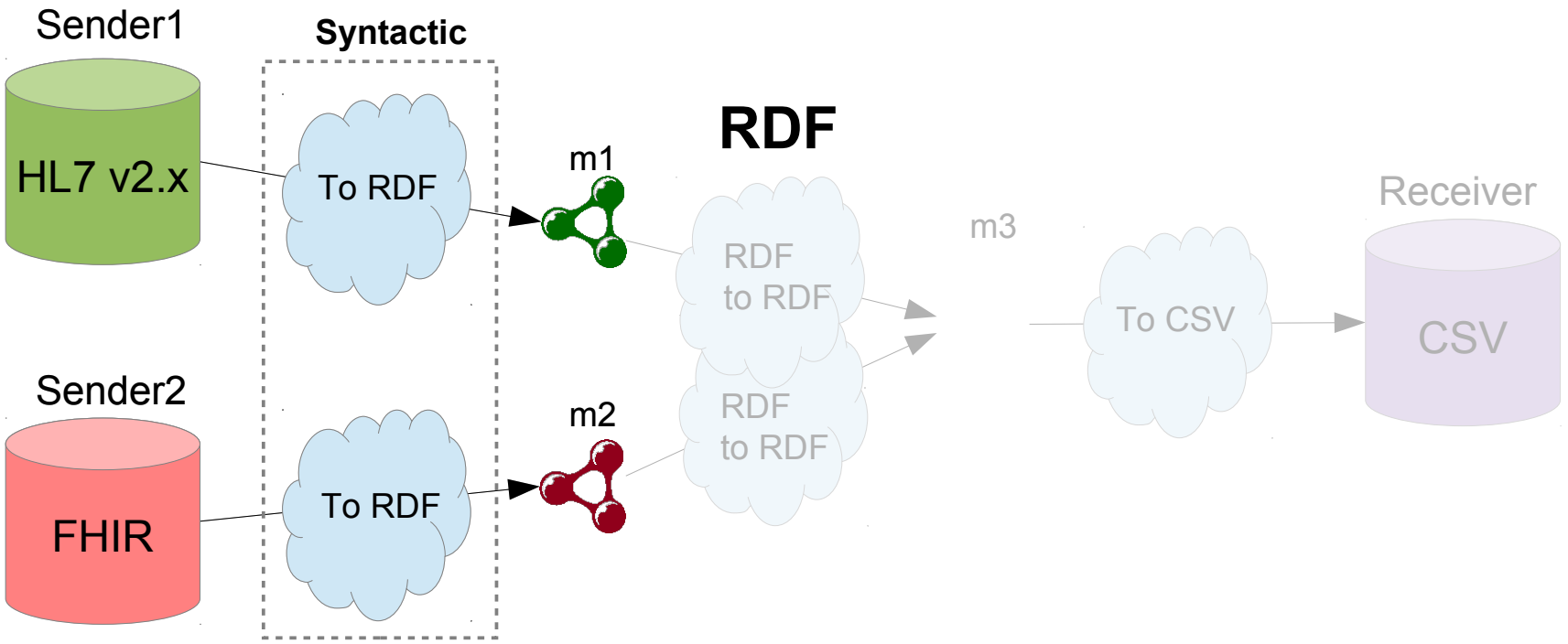

```
<Observation
      xmlns="http://hl7.org/fhir">
   <system value="http://loinc.org"/>
   <code value="8580-6"/>
   <display value="Systolic BP"/>
   <value value="107"/>
   <units value="mm[Hg]"/>
</Observation>
```

(Fictitious example for illustration)

Receiver data expected: RDF

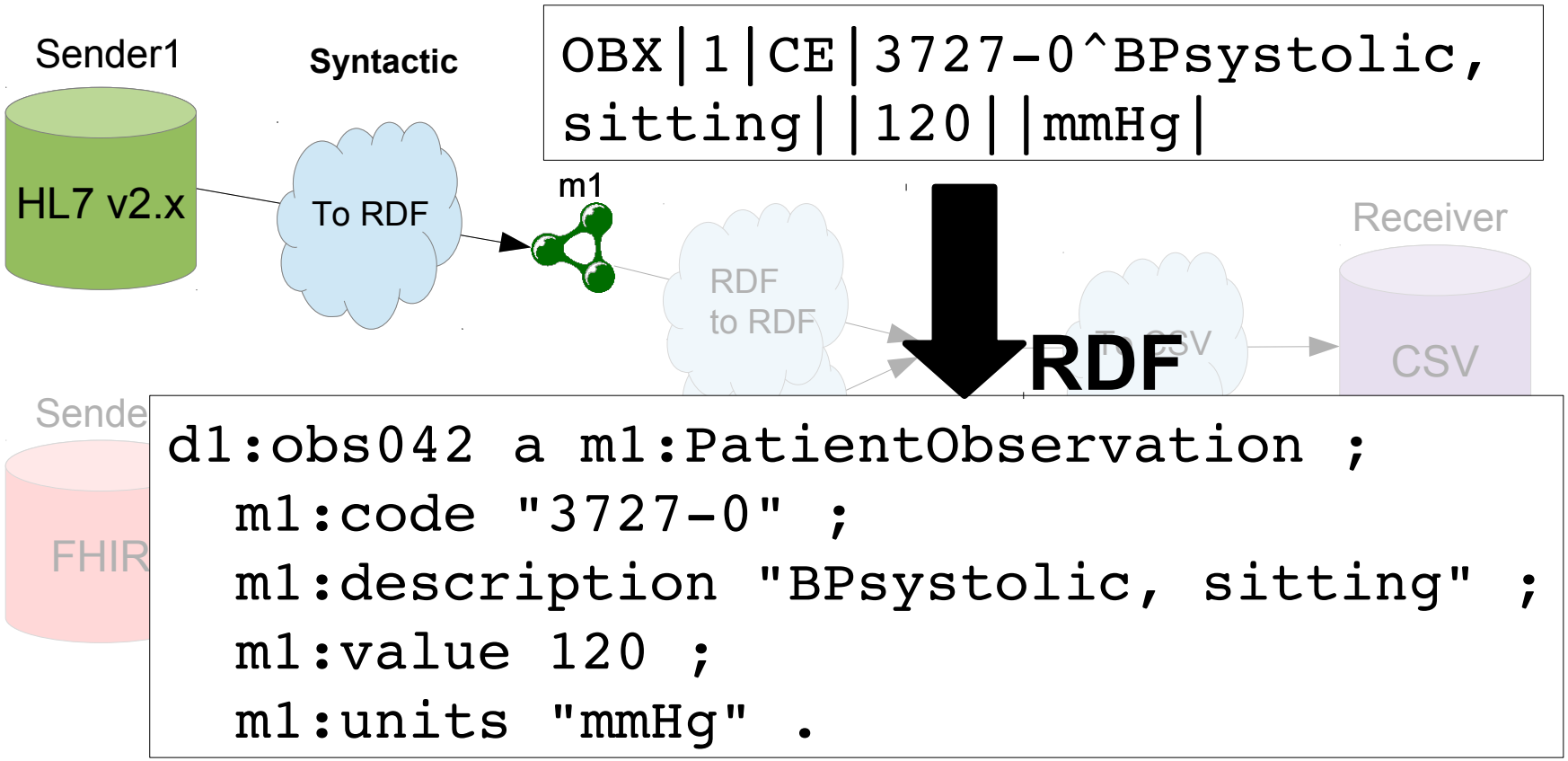


Step 1: Syntactic transformation

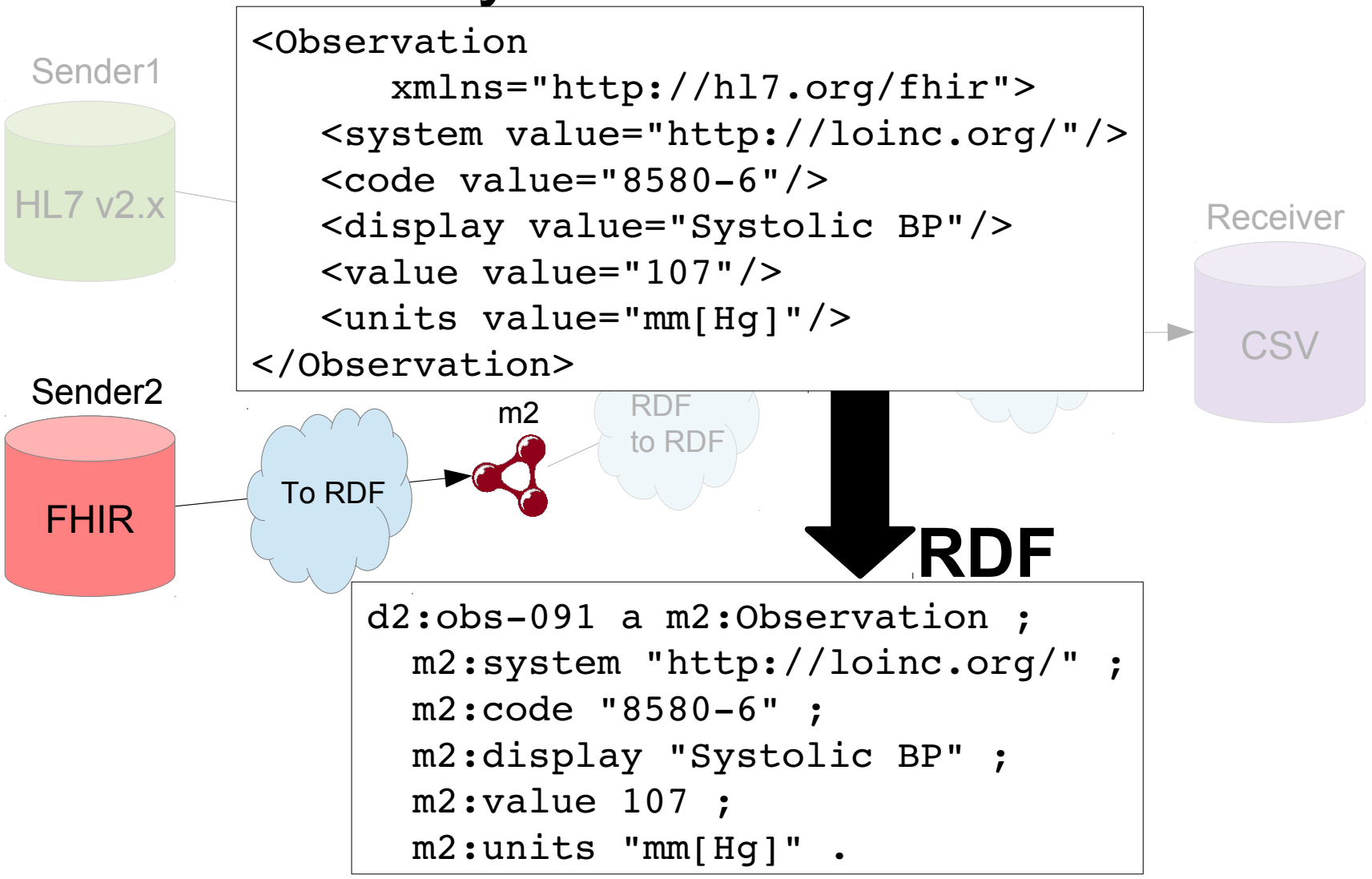


- Transform from source format to substrate model (RDF)
- Allows data to be merged
- Data may not join semantically due to differing vocabularies

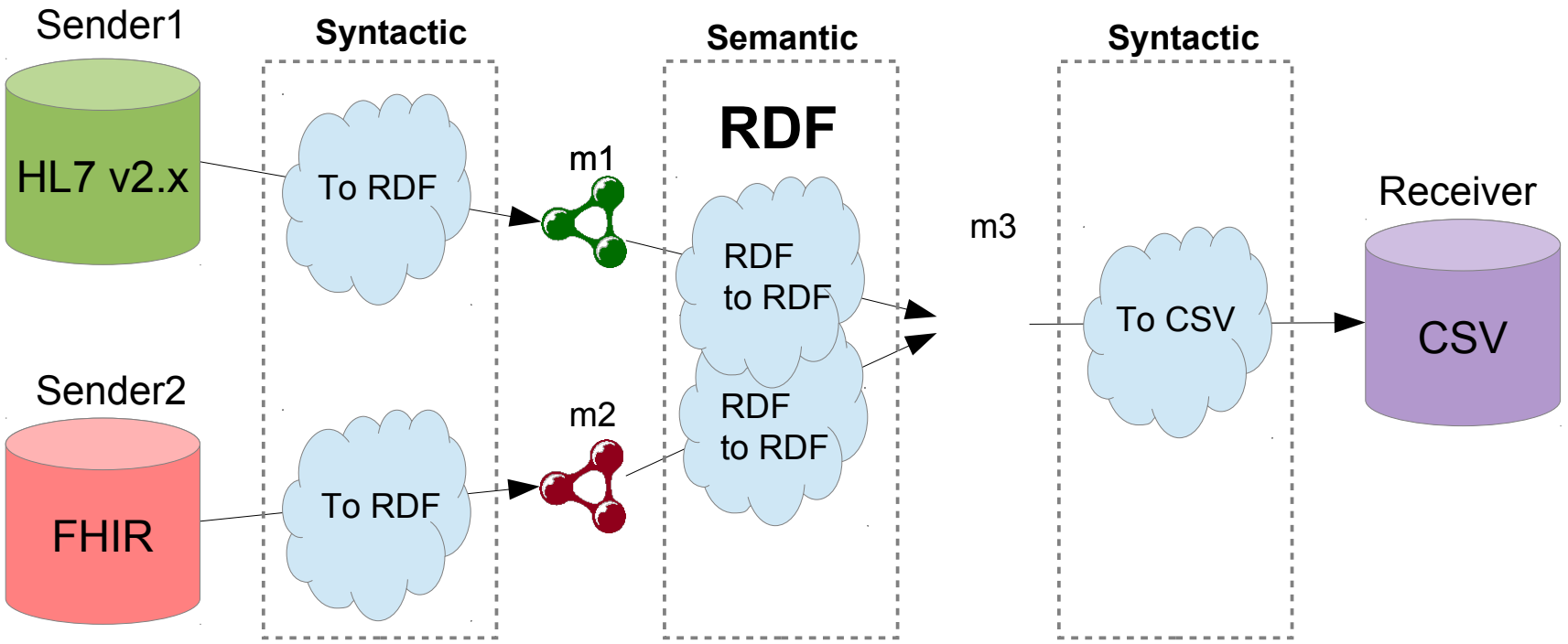
Sender1 syntactic transformation



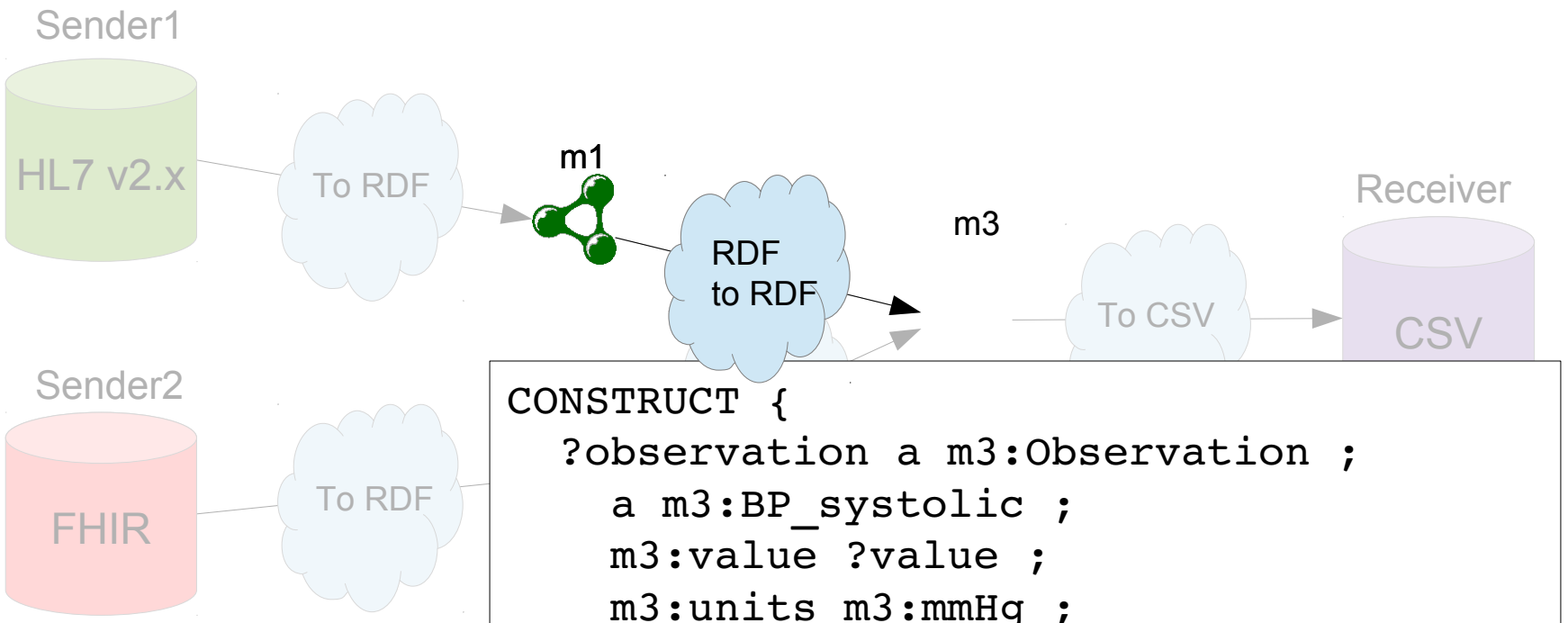
Sender2 syntactic transformation



Step 2: Semantic Transformations



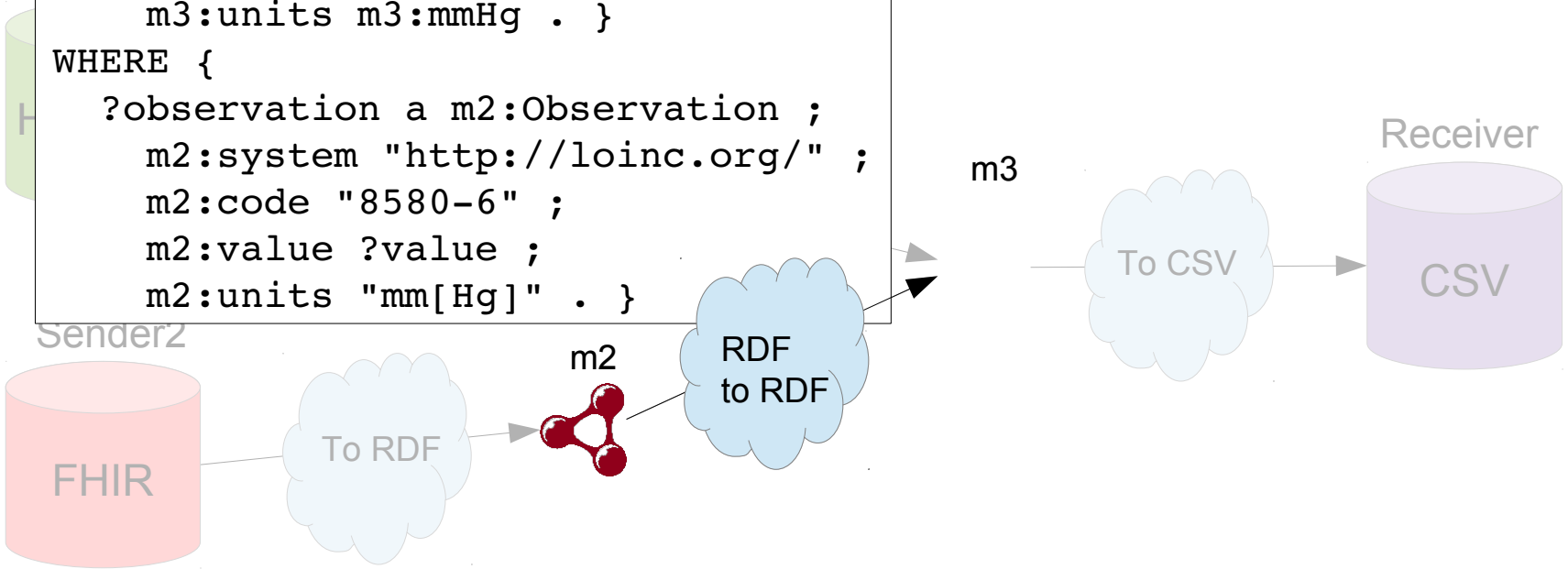
Sender1 semantic transformation



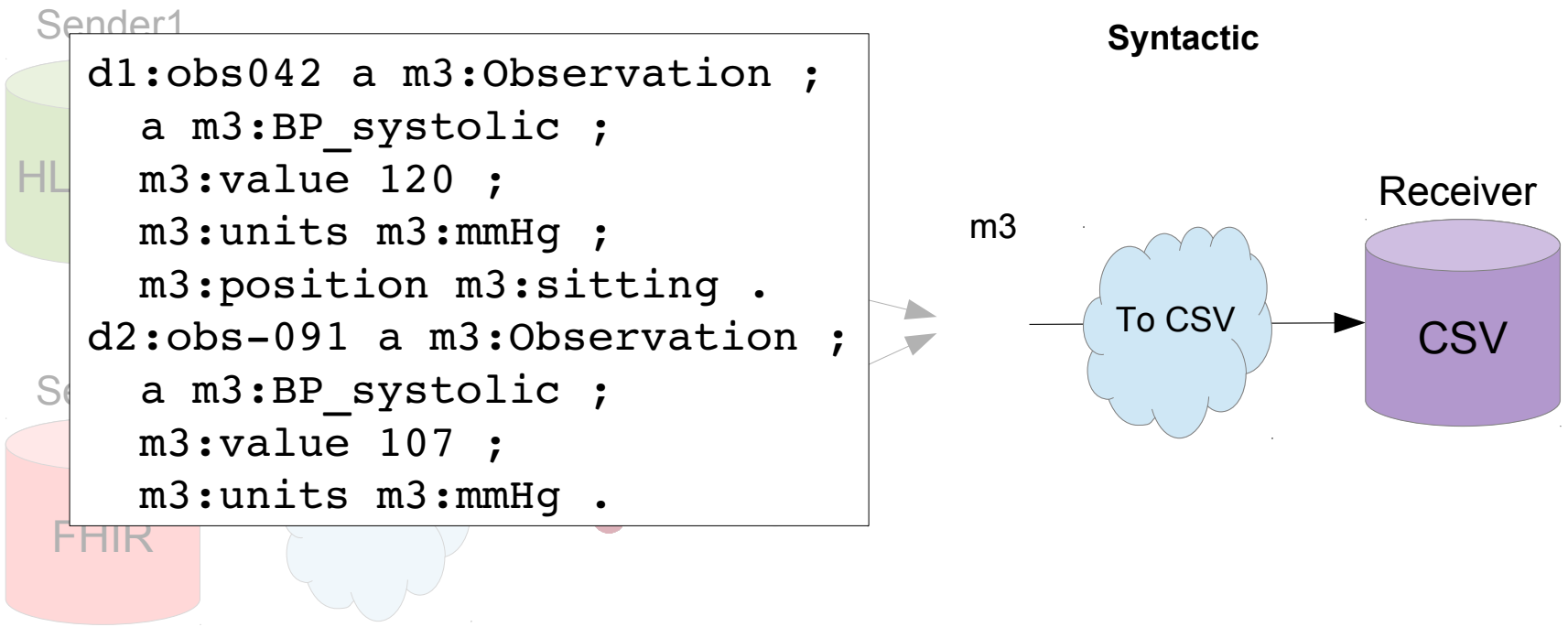

```
CONSTRUCT {
  ?observation a m3:Observation ;
    a m3:BP_systolic ;
    m3:value ?value ;
    m3:units m3:mmHg ;
    m3:position m3:sitting .  }
WHERE {
  ?observation a m1:PatientObservation ;
    m1:code "3727-0" ;
    m1:value ?value ;
    m1:units "mmHg" . }
```

Sender2 semantic transformation

```
CONSTRUCT {
  ?observation a m3:Observation ;
    a m3:BP_systolic ;
    m3:value ?value ;
    m3:units m3:mmHg . }
WHERE {
  ?observation a m2:Observation ;
    m2:system "http://loinc.org/" ;
    m2:code "8580-6" ;
    m2:value ?value ;
    m2:units "mm[Hg]" . }
```

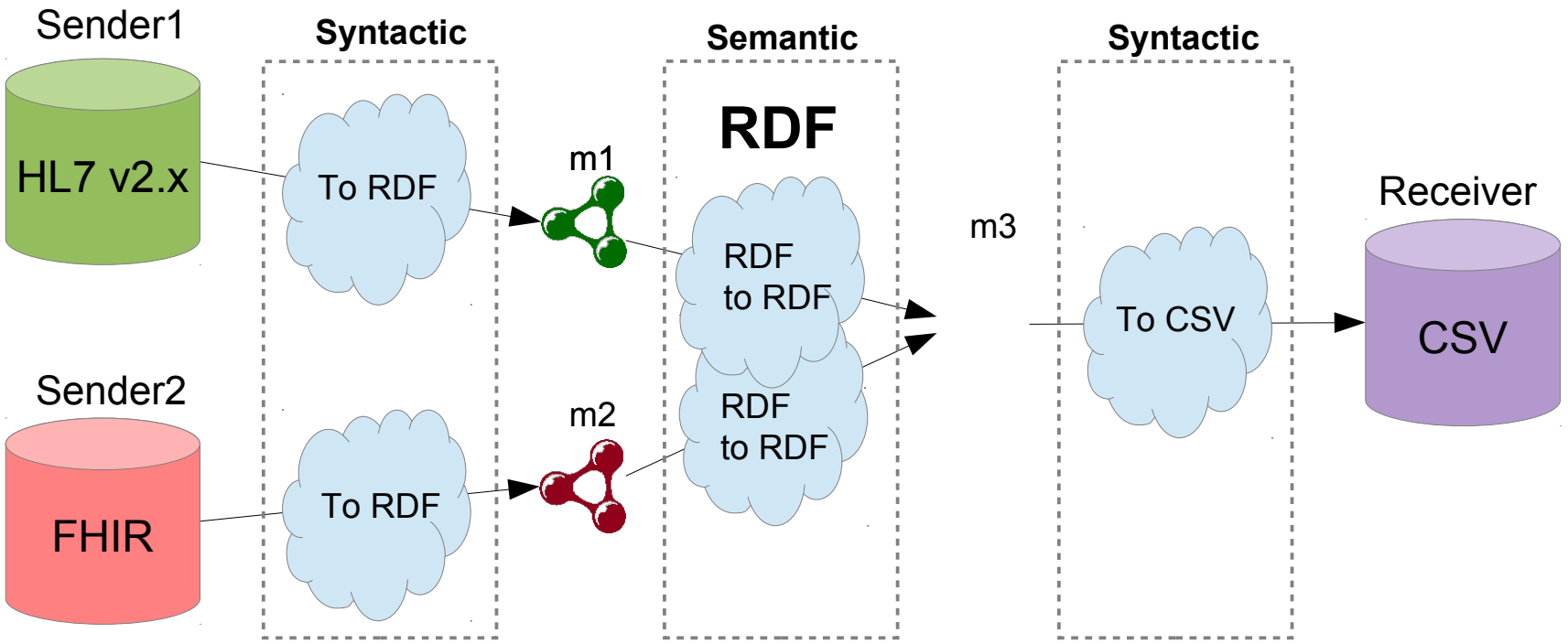


Merged RDF



- m3 can be understood by Receiver
- Ready for syntactic transform to CSV

Summary of transformations



Ideally, transformations should be standardized

Proprietary vocabularies

- Impede semantic interoperability
- Exchanged healthcare information should be based on **free and open vocabularies**
  - But proprietary can be used internally

Yosemite Manifesto
on RDF as a Universal Healthcare Exchange Language

1. RDF is the best available candidate for a universal healthcare exchange language.

2. Electronic healthcare information should be exchanged in a format that either: (a) is an RDF format directly; or (b) has a standard mapping to RDF.

3. Existing standard healthcare vocabularies, data models and exchange languages should be leveraged by defining standard mappings to RDF, and any new standards should have RDF representations.

4. Government agencies should mandate or incentivize the use of RDF as a universal healthcare exchange language.

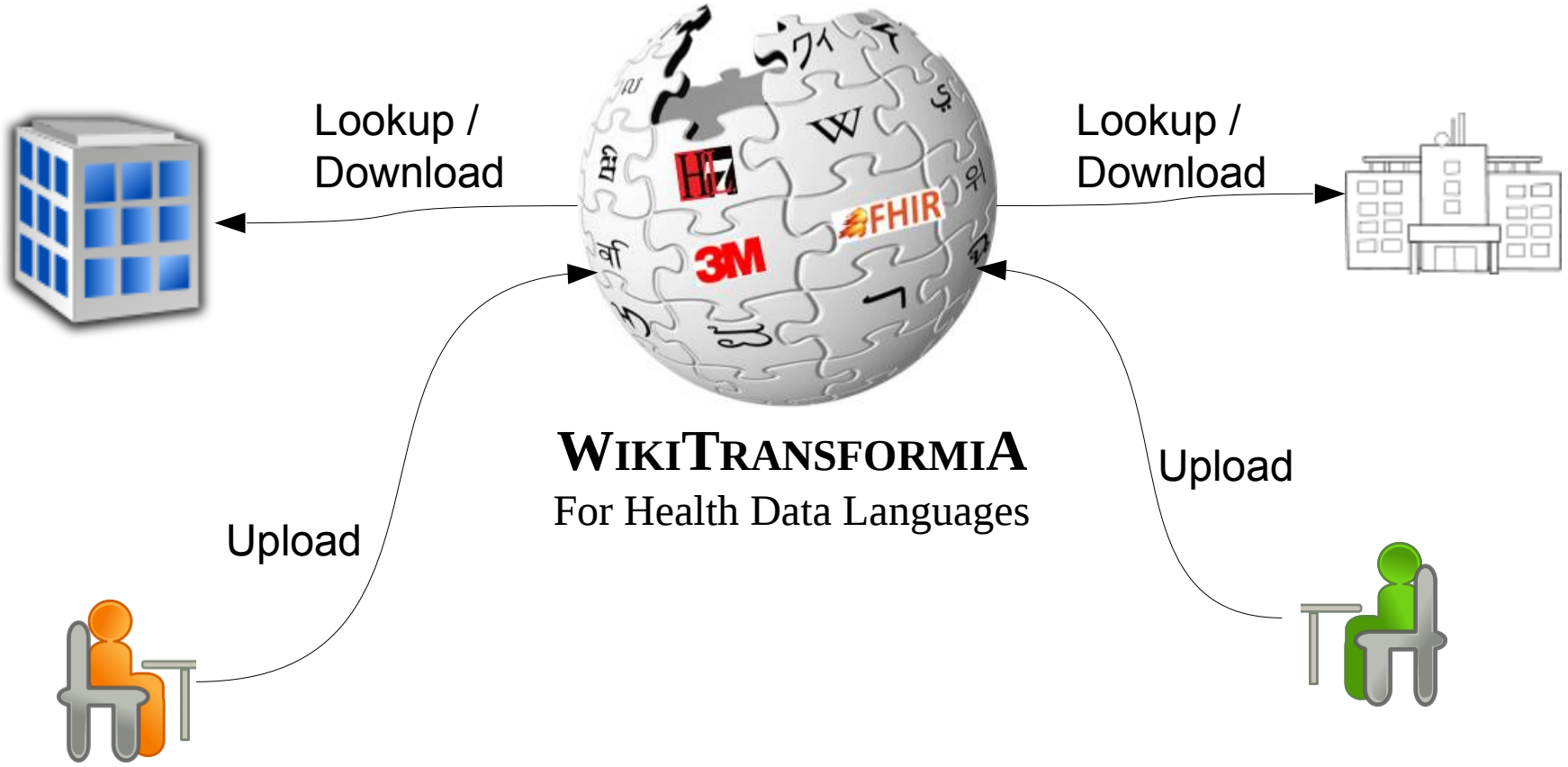
5. Exchanged healthcare information should be self-describing, using Linked Data principles, so that each concept URI is de-referenceable to its free and open definition.

Sign at http://YosemiteManifesto.org/

Research needed to prove feasibility

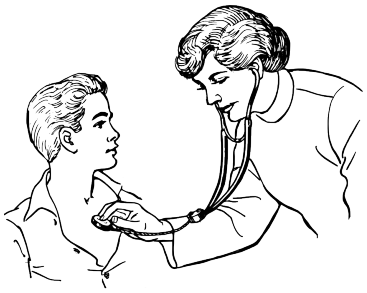
- Build and demonstrate a reference implementation
  - At least two senders and one receiver
- Demonstrate all important features:
  - Syntactic & semantic transformations
  - Selecting and applying transformations
  - Incorporate new vocabularies & deprecate old
  - Privacy & security
  - Hosting concept definitions
- Run stress tests to simulate scaling to nationwide adoption
- Recommend conventions

Data Transformation Wiki



What would it be like?

- Better treatment
- Better research
- Lower cost



Goal: True semantic interoperability

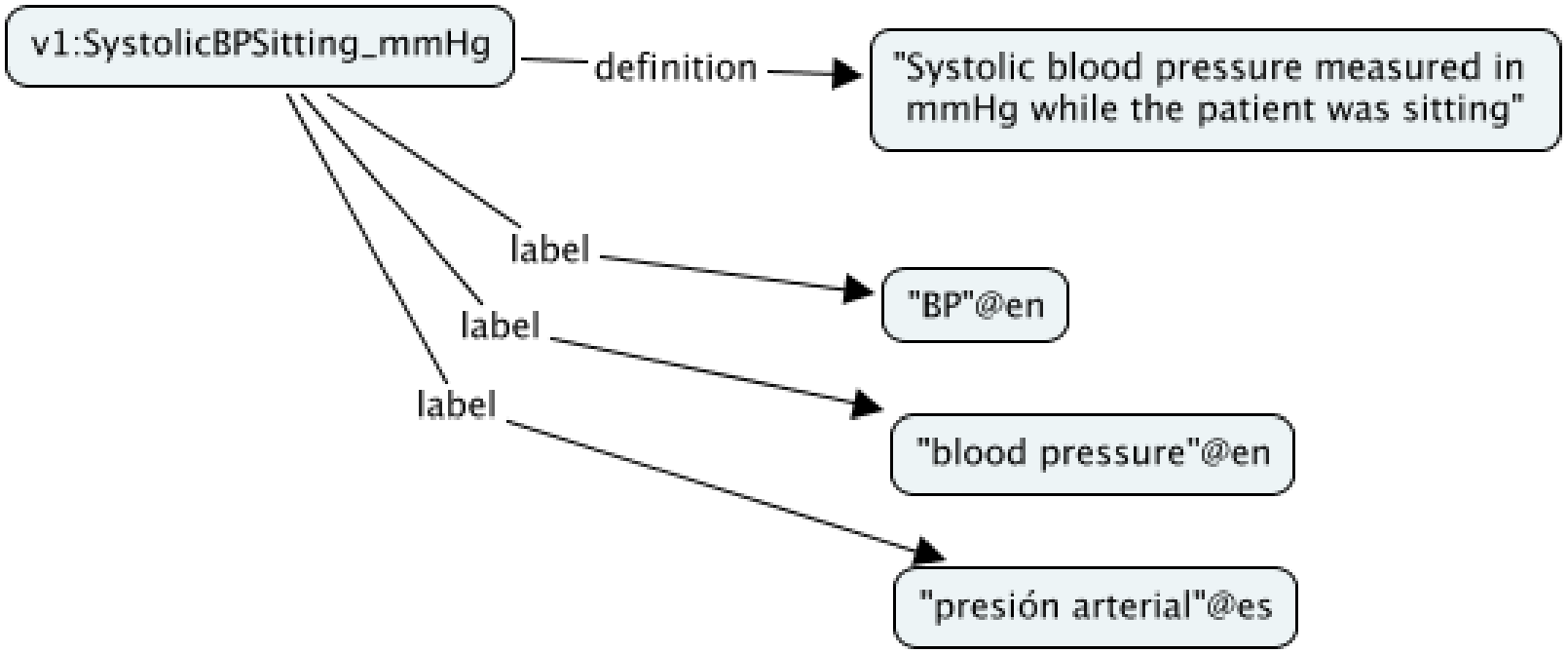
What does semantic interoperability involve?

- Machine processable information
- Common vocabularies
- Unambiguous concepts

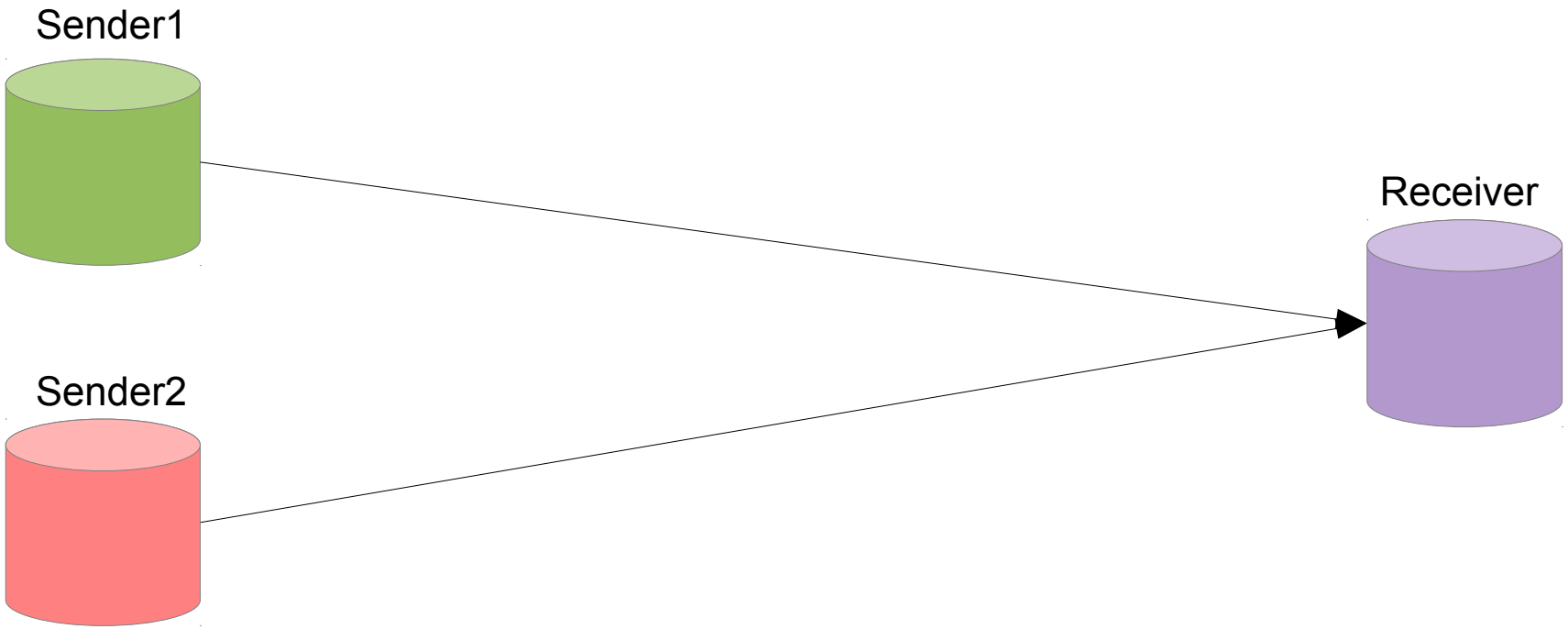
Why is this so difficult to standardize?

- Healthcare is complex: thousands of interrelated concepts, many domains
- Standardization progress diminishes toward zero as committee size grows
- Moving target: medical science and technology continually changing

Unambiguous concepts



Semantic interoperability

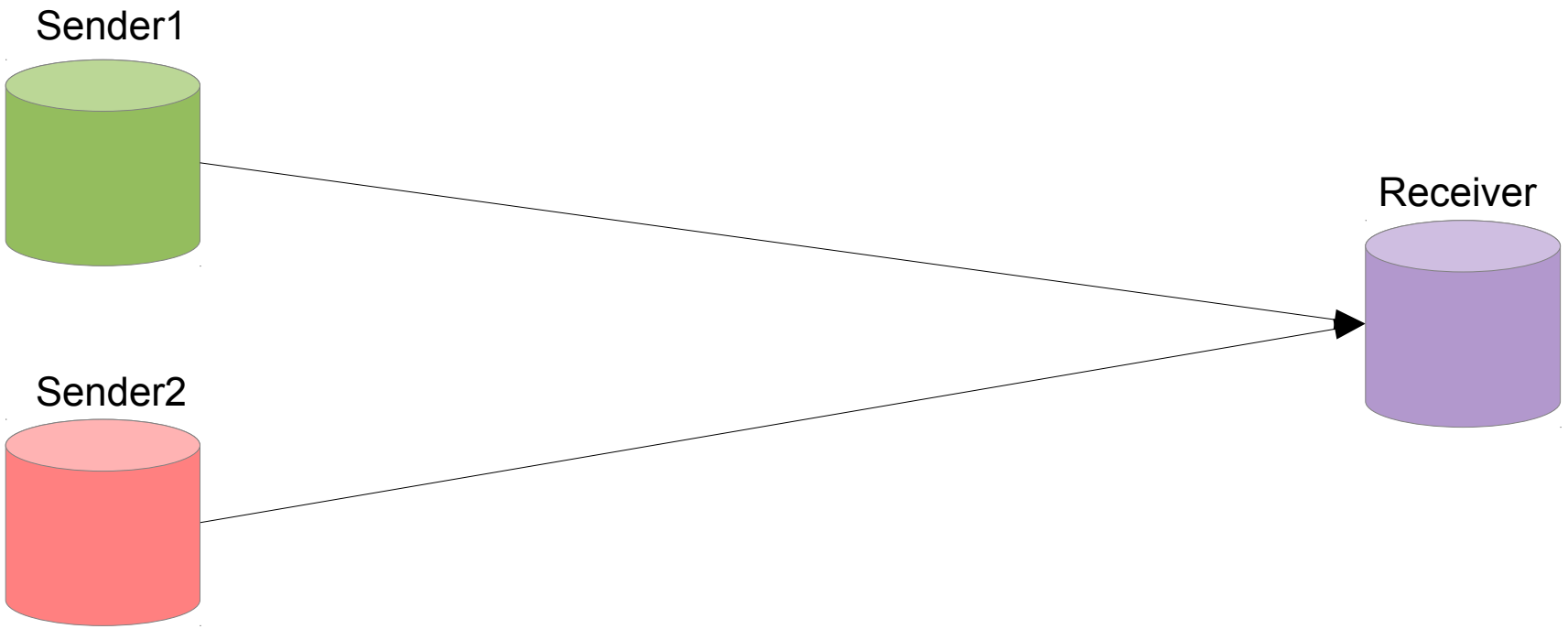


- Requires standardization

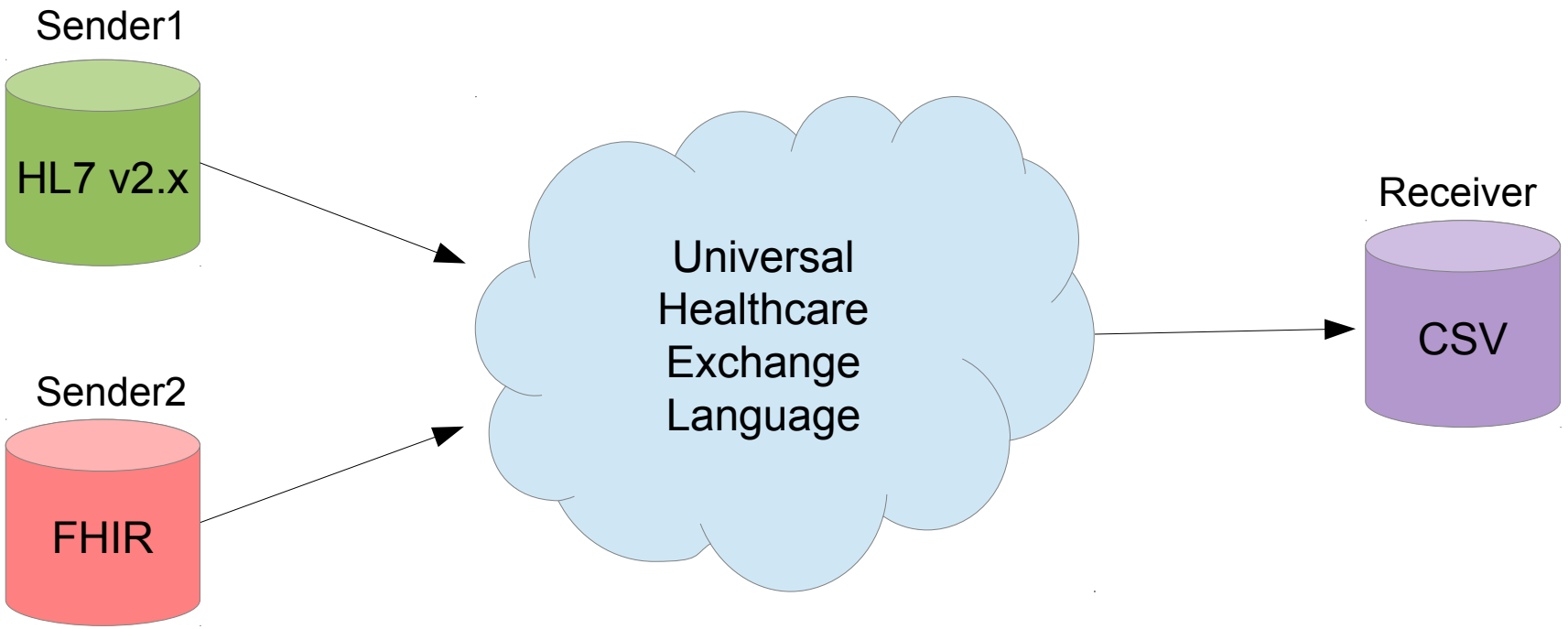
Assumption: Not standardizing internal systems

- Not politically feasible
- Too costly
- Unwise: would inhibit innovation

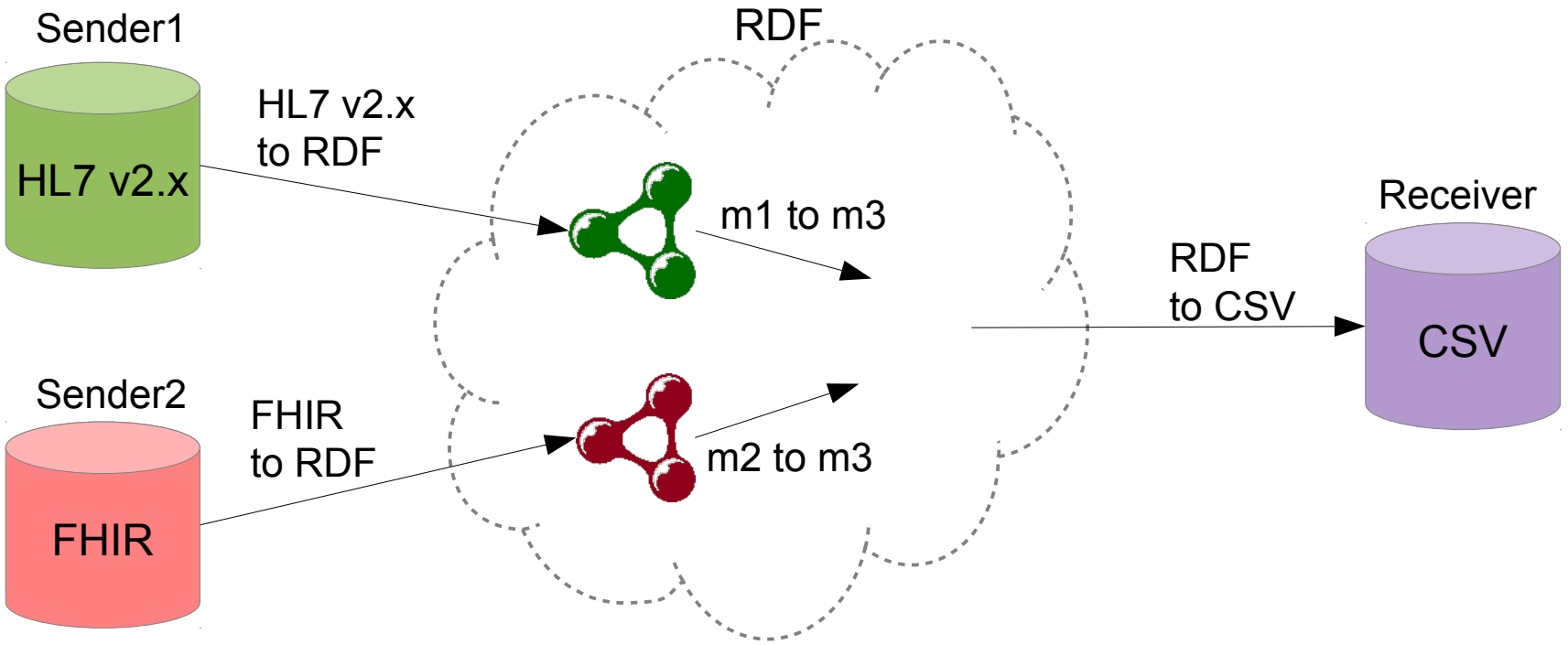
Semantic interoperability



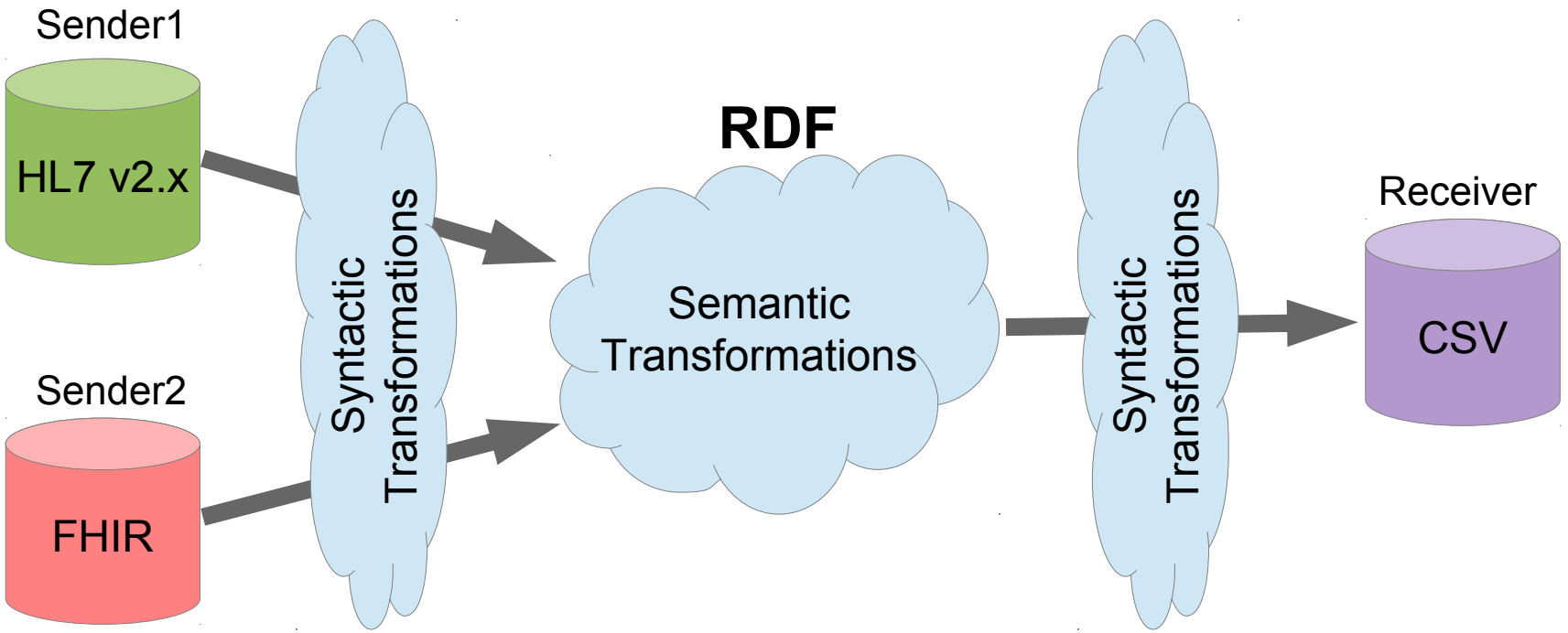
Semantic interoperability-2



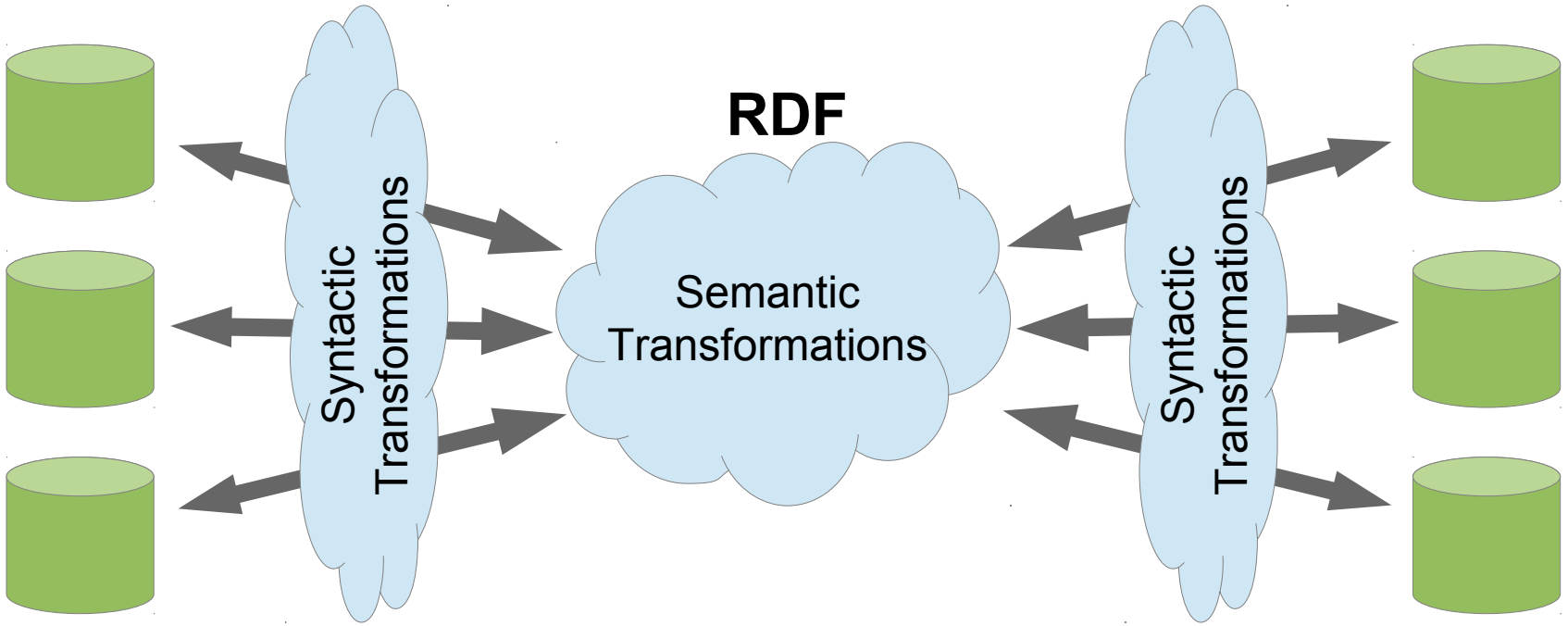
Step 2: Semantic transformation



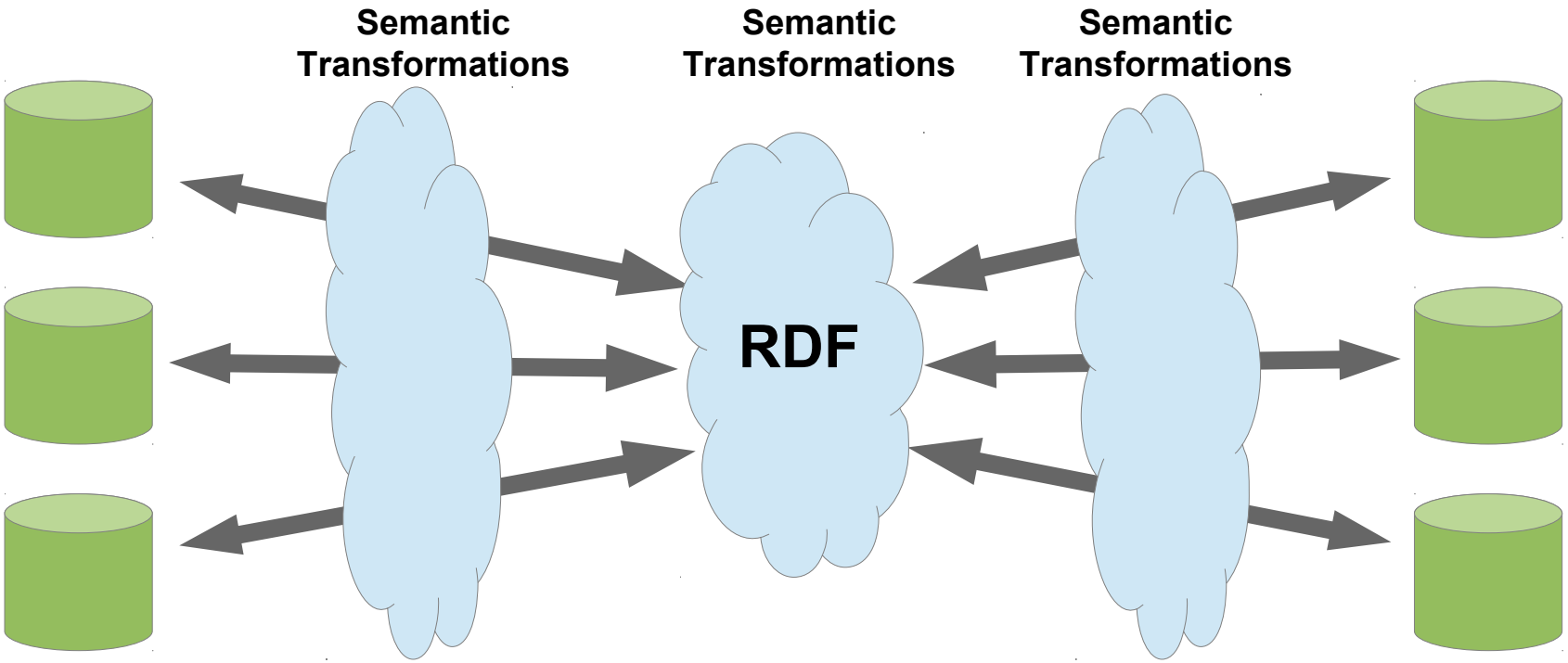
Data transformations



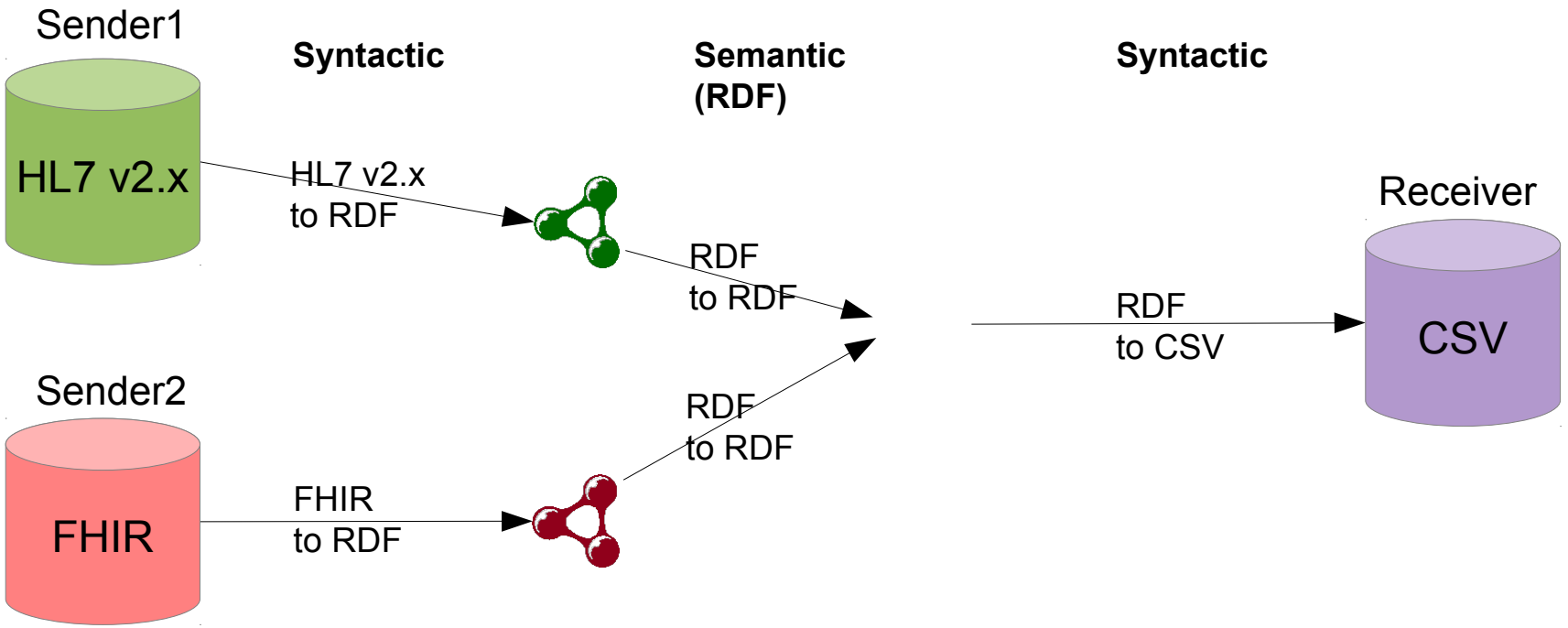
Data transformations



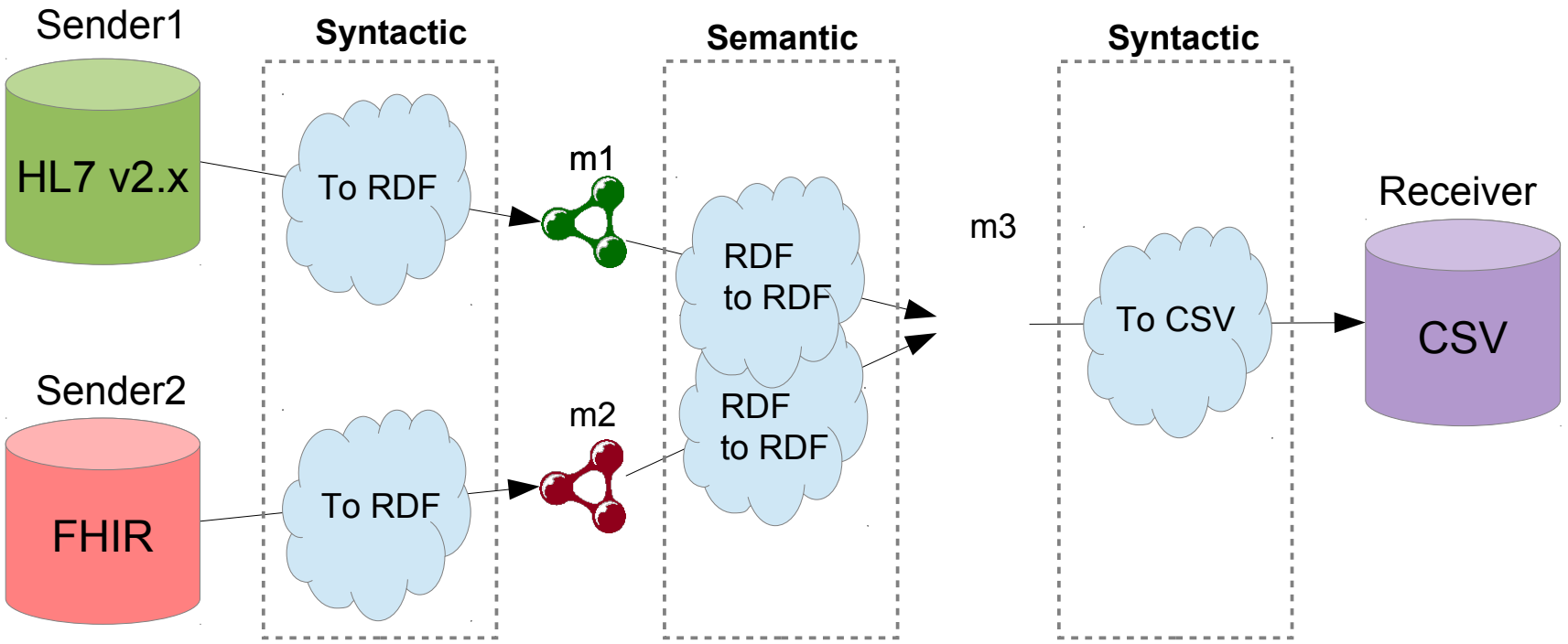
Step 2: Semantic transformation



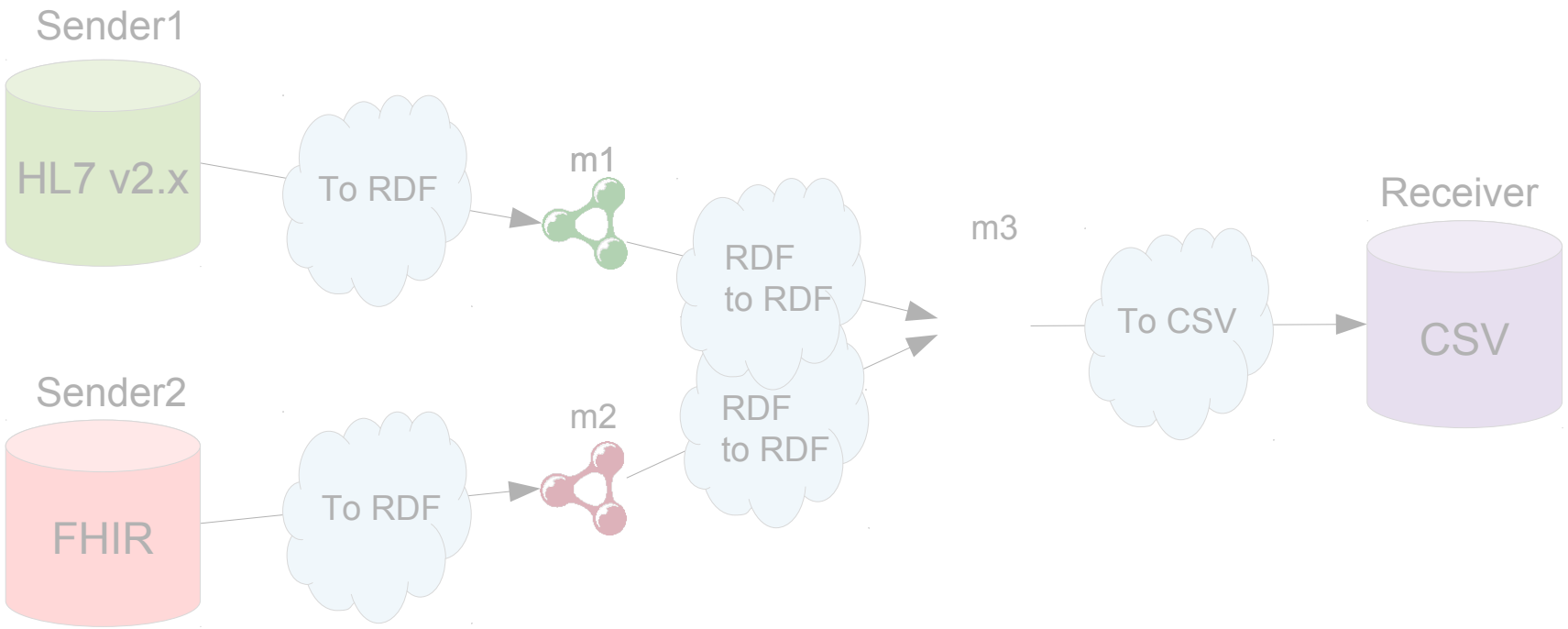
Syntactic and Semantic Transforms



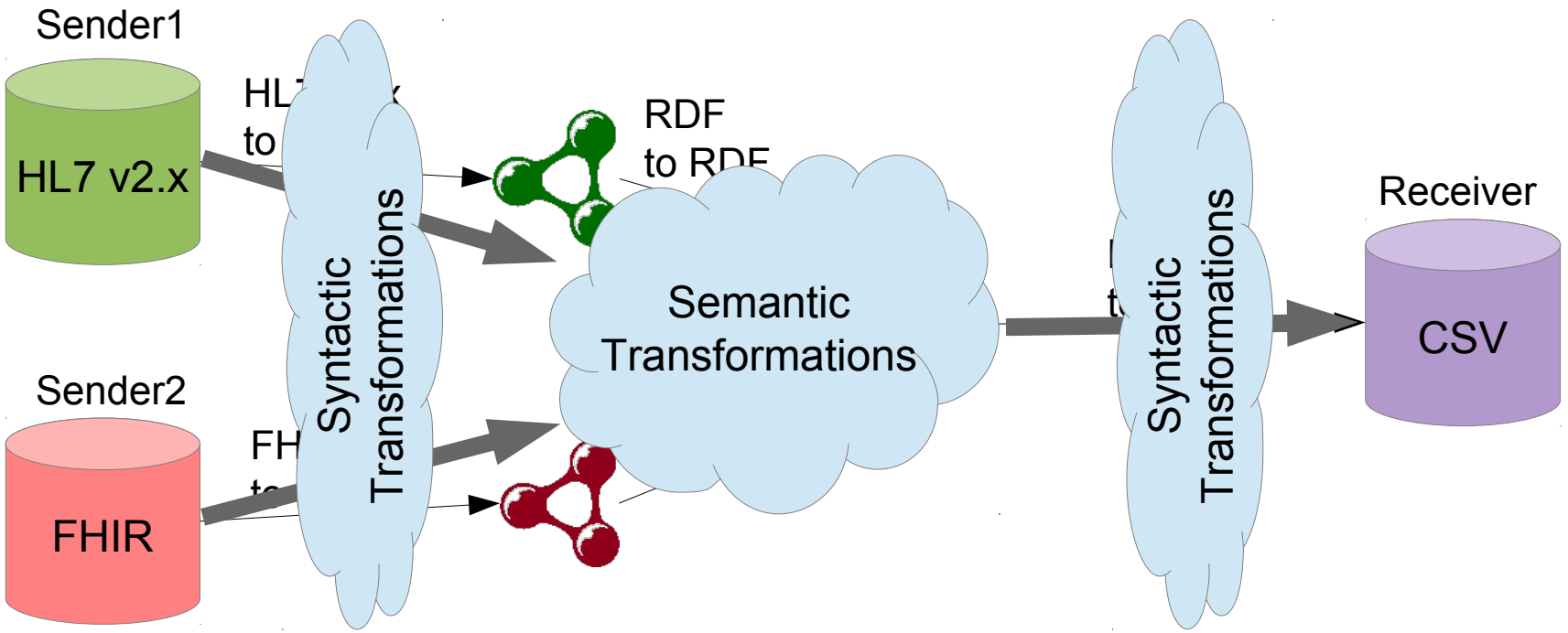
Syntactic and Semantic Transforms



Syntactic and Semantic Transforms

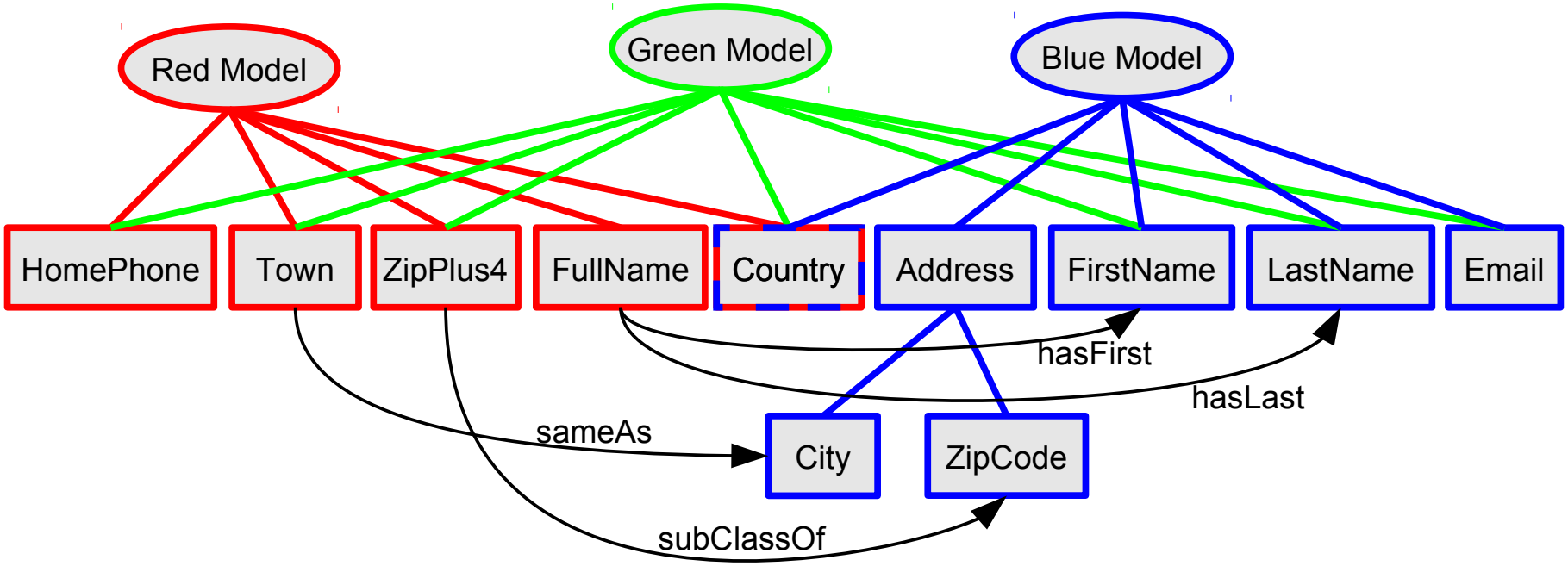


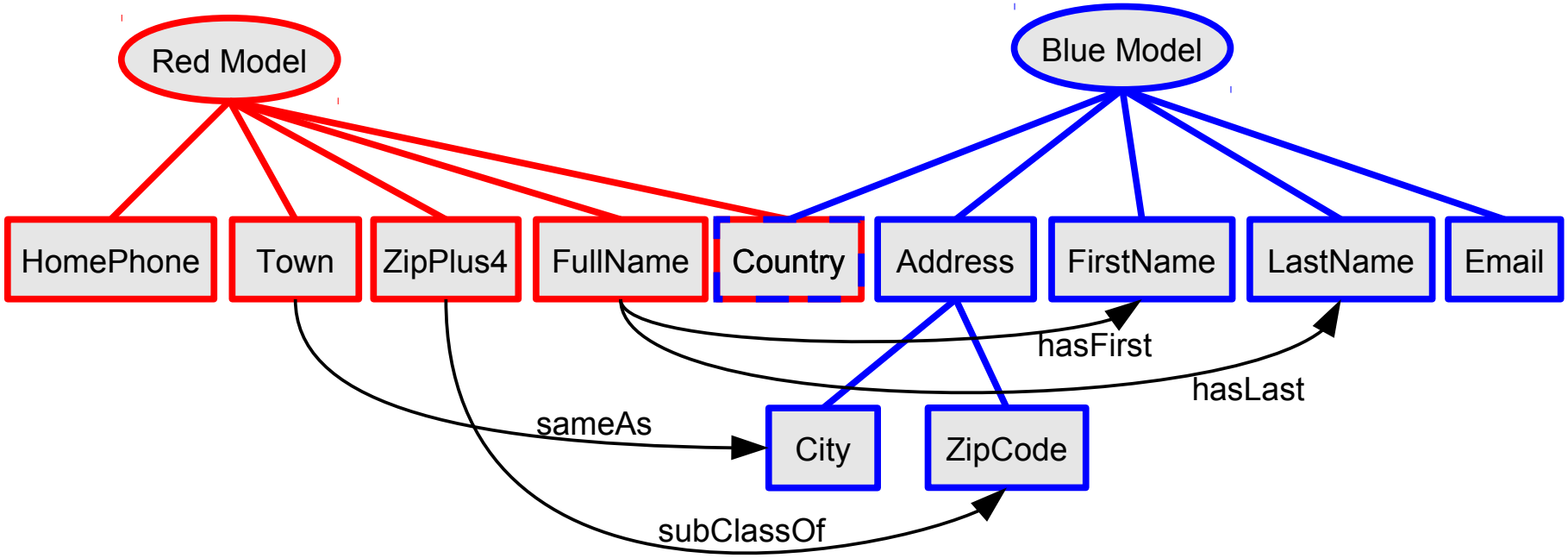
Step 2: Semantic transformation

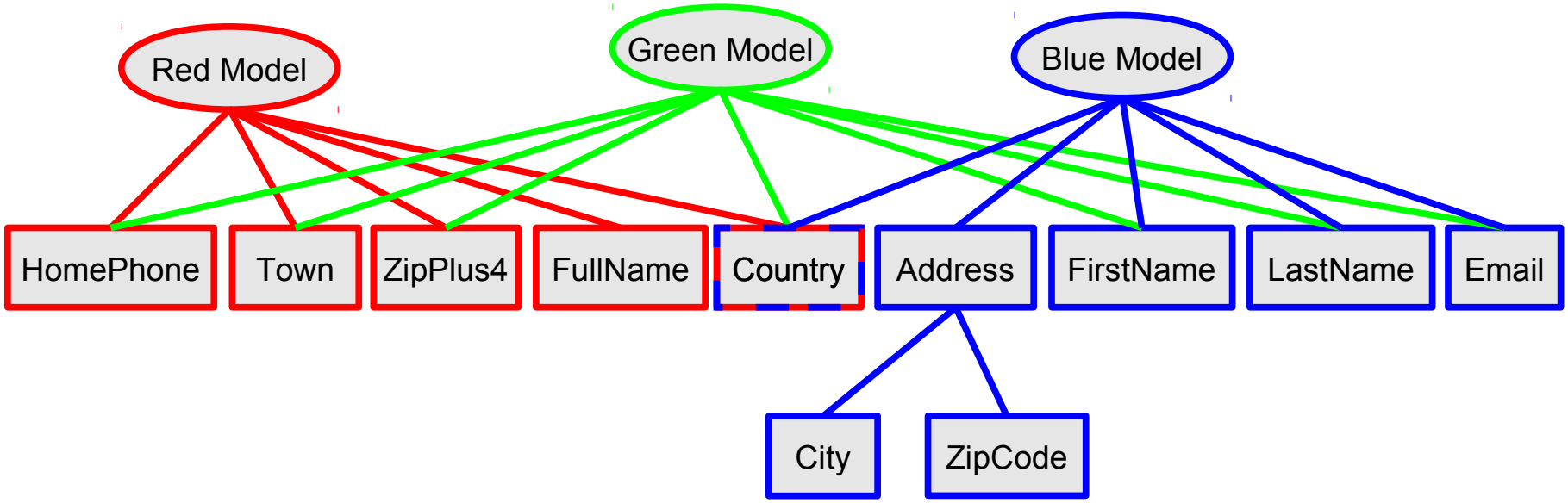


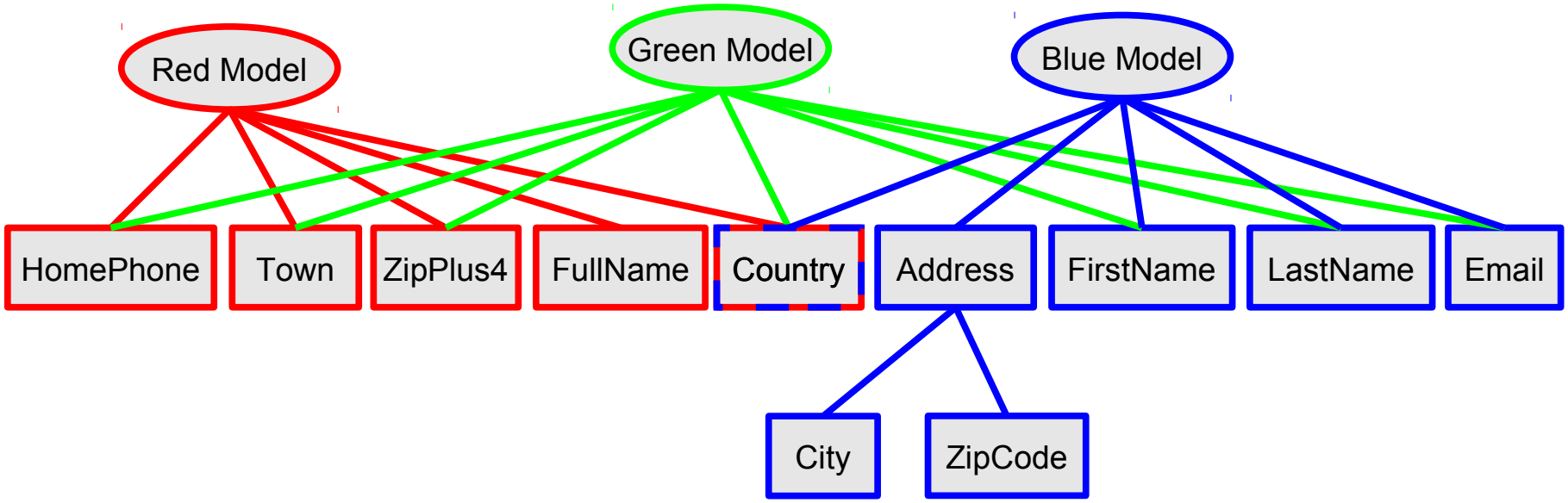
Why RDF?

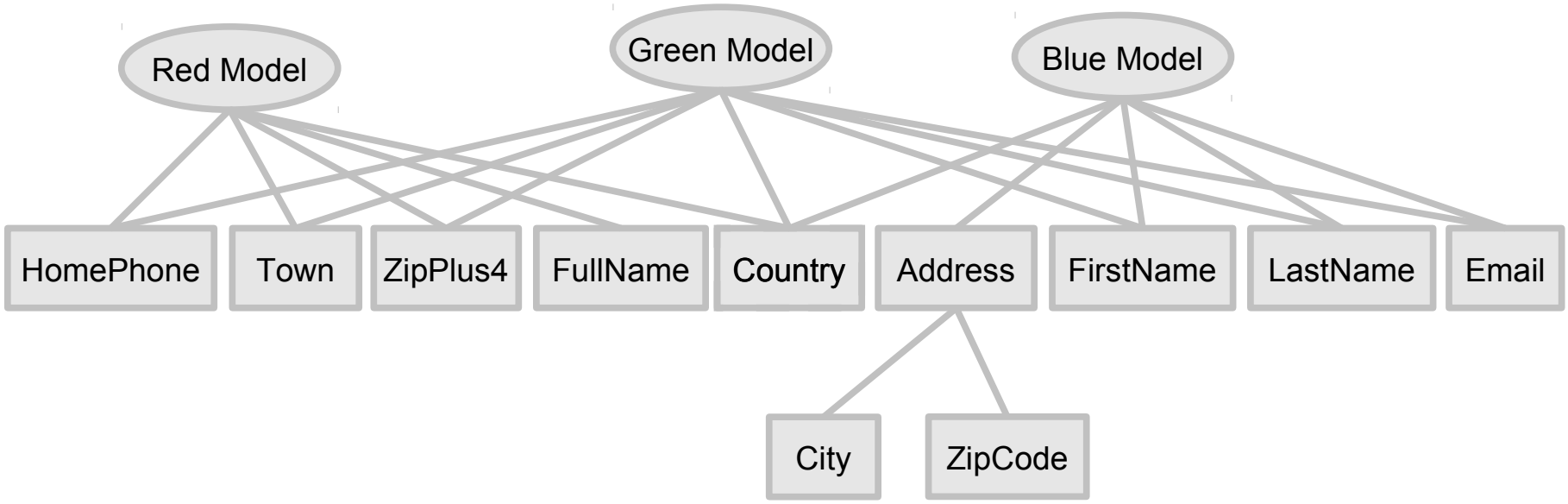
Schema promiscuous



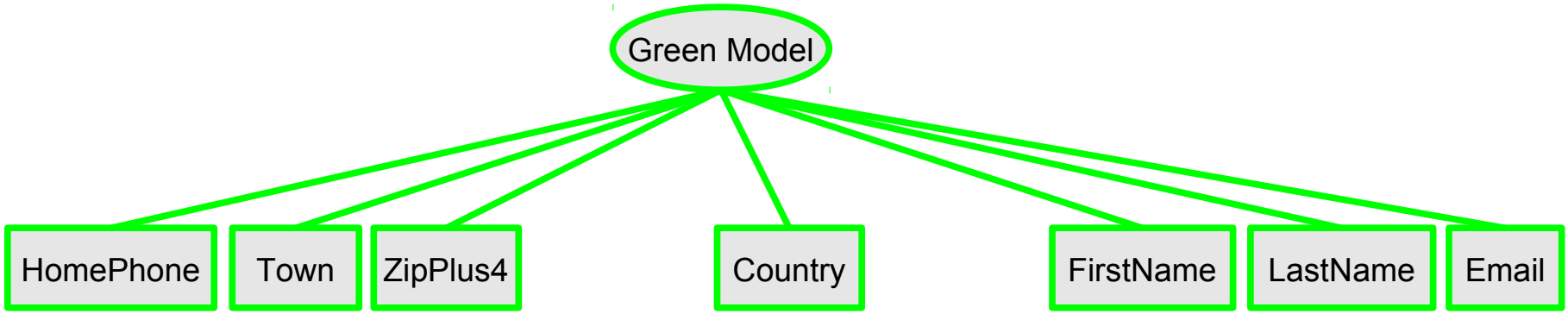

Red Model
Blue Model
HomePhone
Town
ZipPlus4
FullName
Country
Address
FirstName
LastName
Email
hasFirst
hasLast
sameAs
City
ZipCode
subClassOf


Red Model
Green Model
Blue Model
HomePhone
Town
ZipPlus4
FullName
Country
Address
FirstName
LastName
Email
City
ZipCode

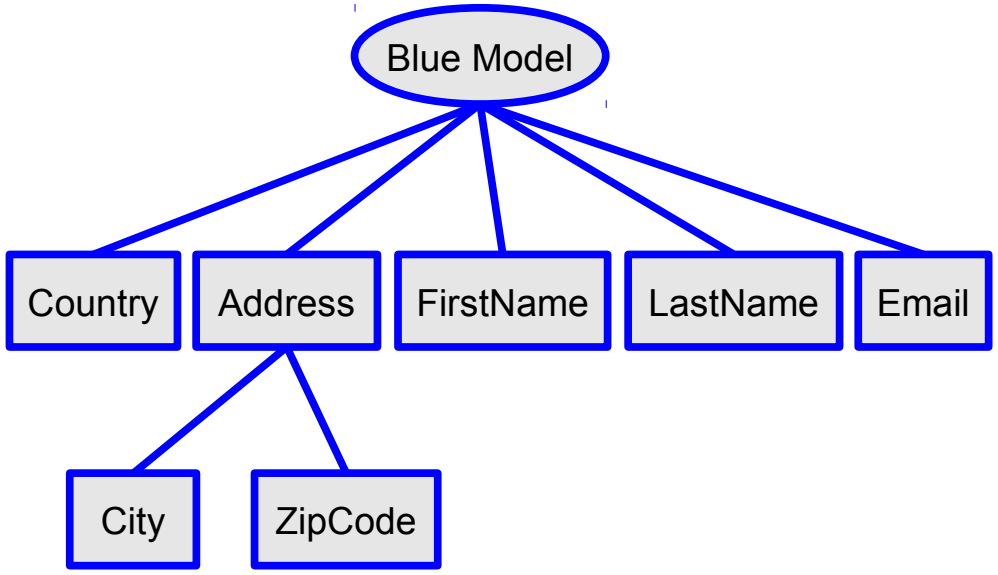

Red Model
Green Model
Blue Model
HomePhone
Town
ZipPlus4
FullName
Country
Address
FirstName
LastName
Email
City
ZipCode


Red Model
Green Model
Blue Model
HomePhone
Town
ZipPlus4
FullName
Country
Address
FirstName
LastName
Email
City
ZipCode

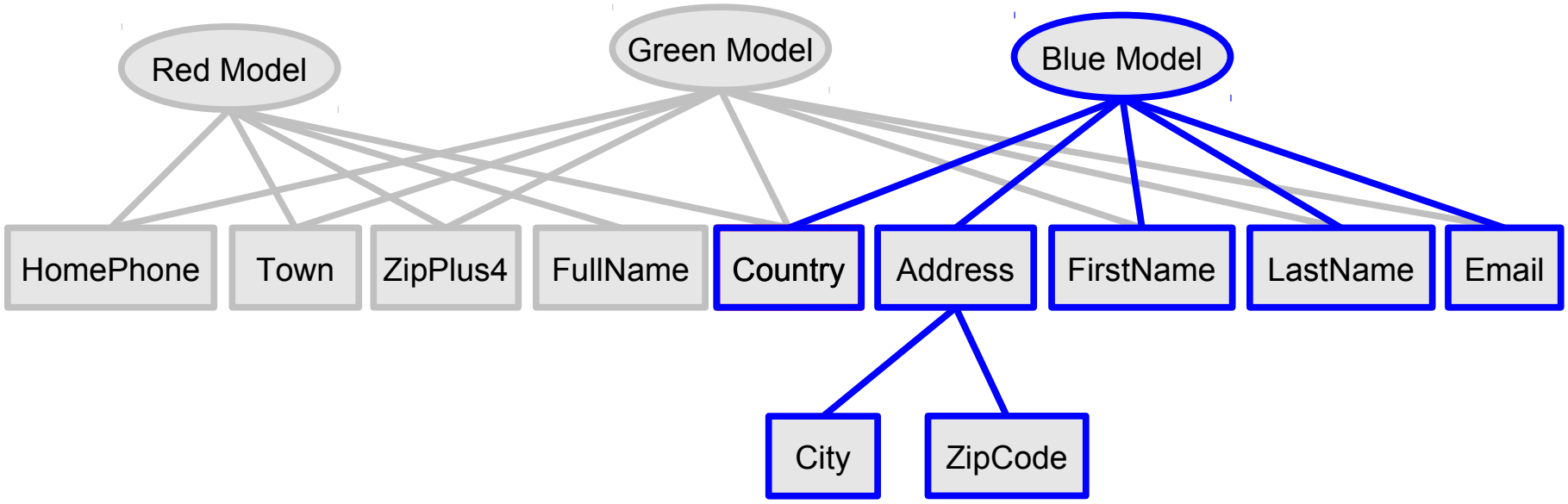
Green model


Green Model
HomePhone
Town
ZipPlus4
Country
FirstName
LastName
Email

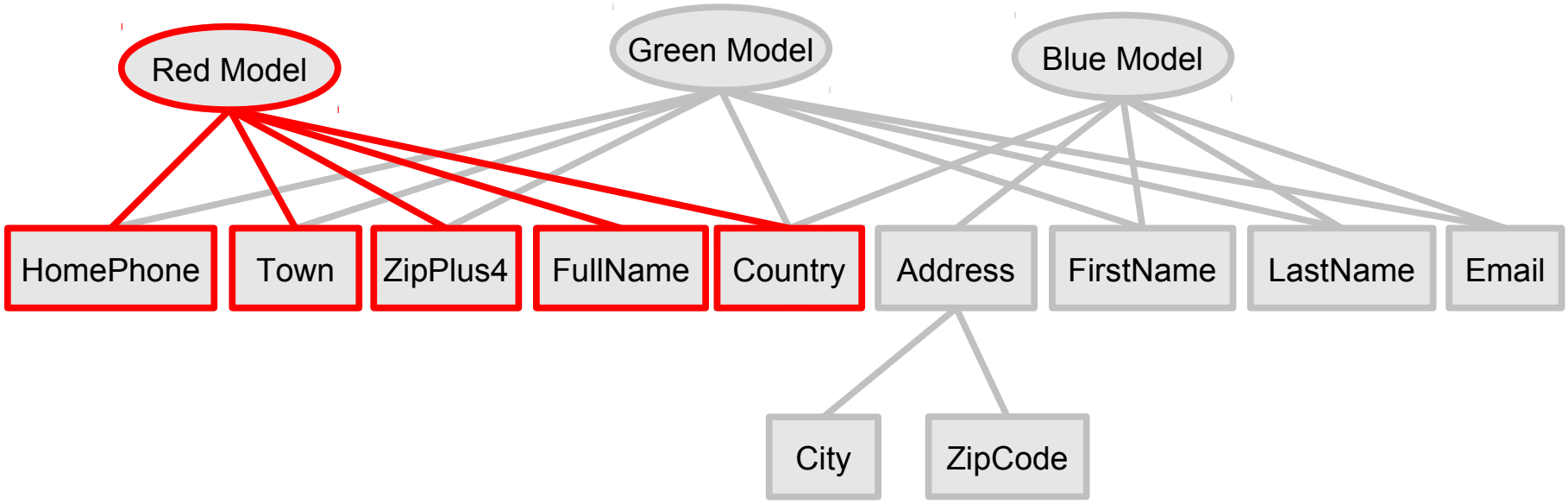
Blue view


Blue Model
Country
Address
FirstName
LastName
Email
City
ZipCode

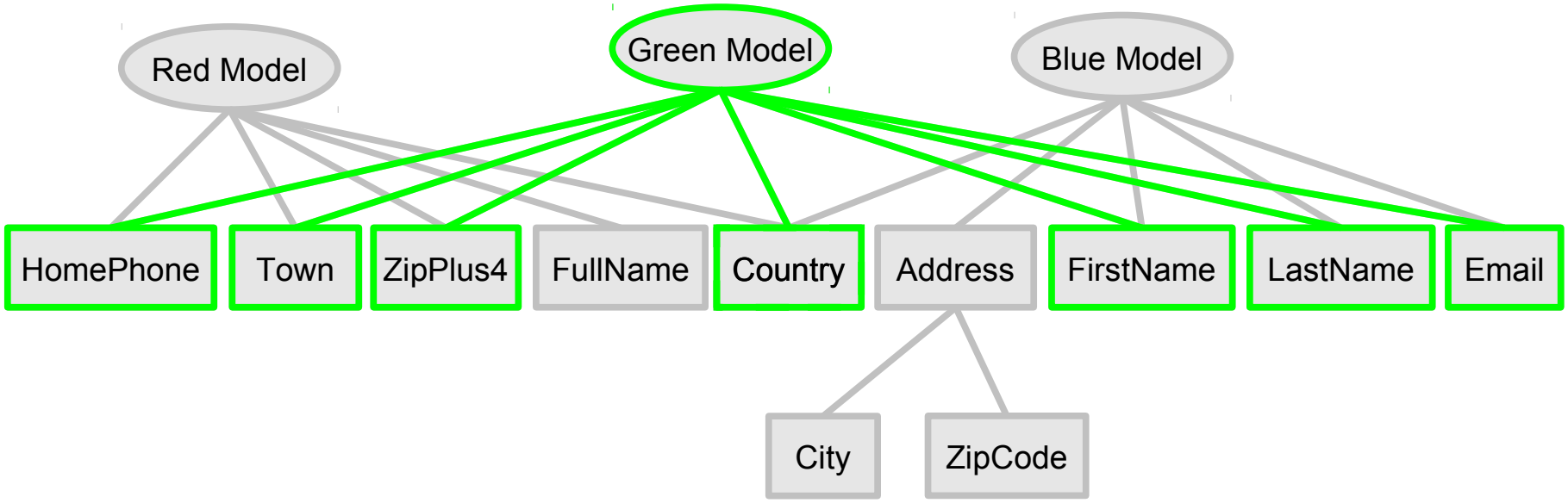
Blue view

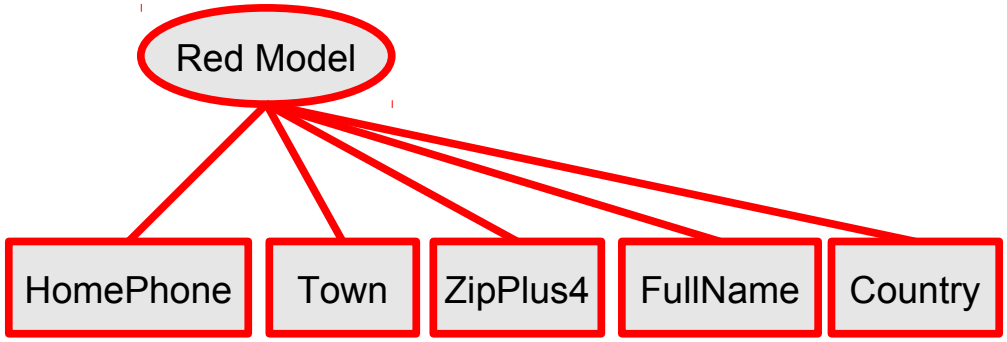

Red Model
Green Model
Blue Model
HomePhone
Town
ZipPlus4
FullName
Country
Address
FirstName
LastName
Email
City
ZipCode

Red view


Red Model
Green Model
Blue Model
HomePhone
Town
ZipPlus4
FullName
Country
Address
FirstName
LastName
Email
City
ZipCode

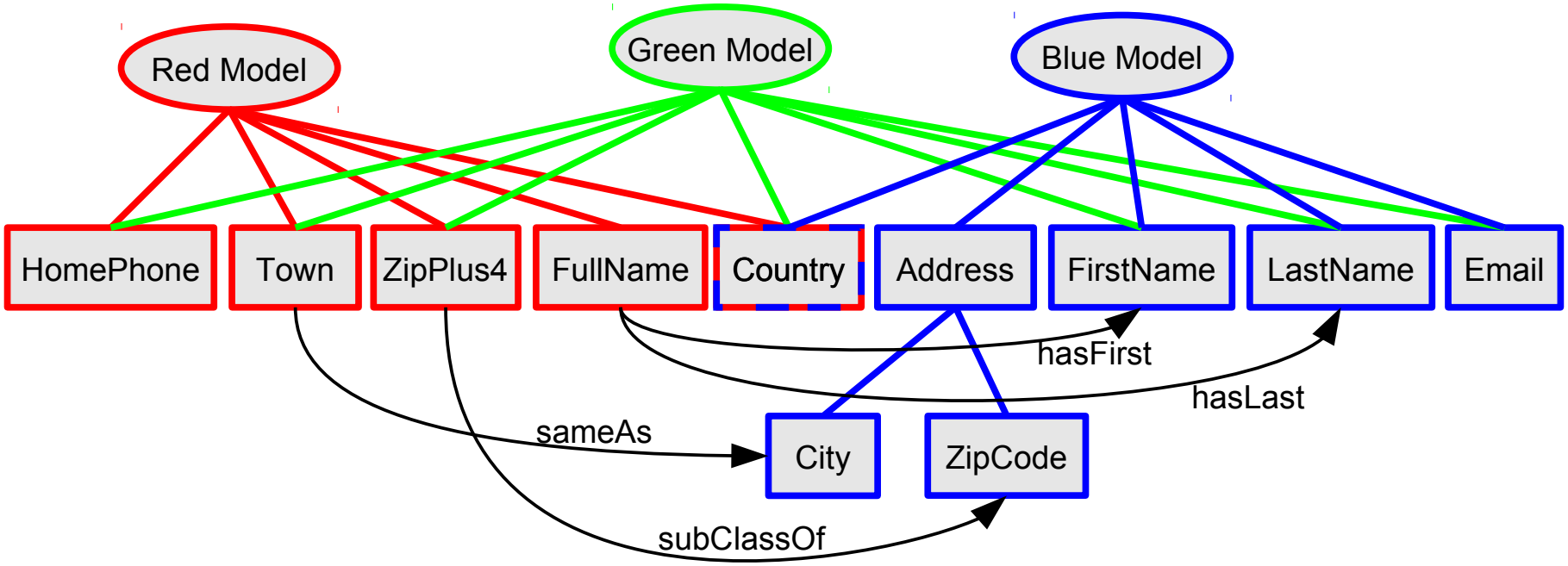
Green view


Red Model
Green Model
Blue Model
HomePhone
Town
ZipPlus4
FullName
Country
Address
FirstName
LastName
Email
City
ZipCode

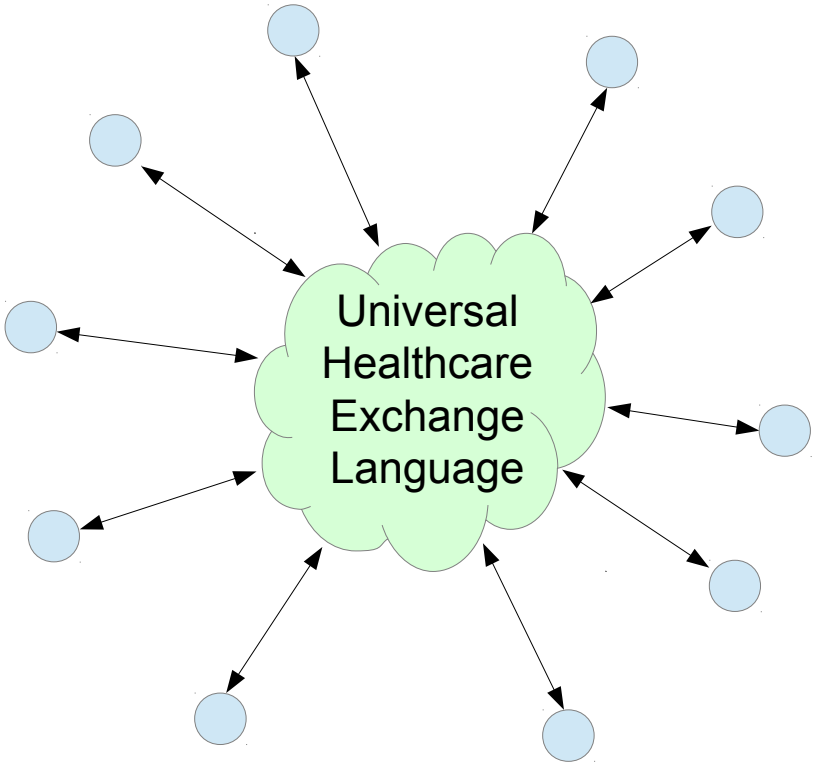

Red Model
HomePhone
Town
ZipPlus4
FullName
Country

Why RDF?

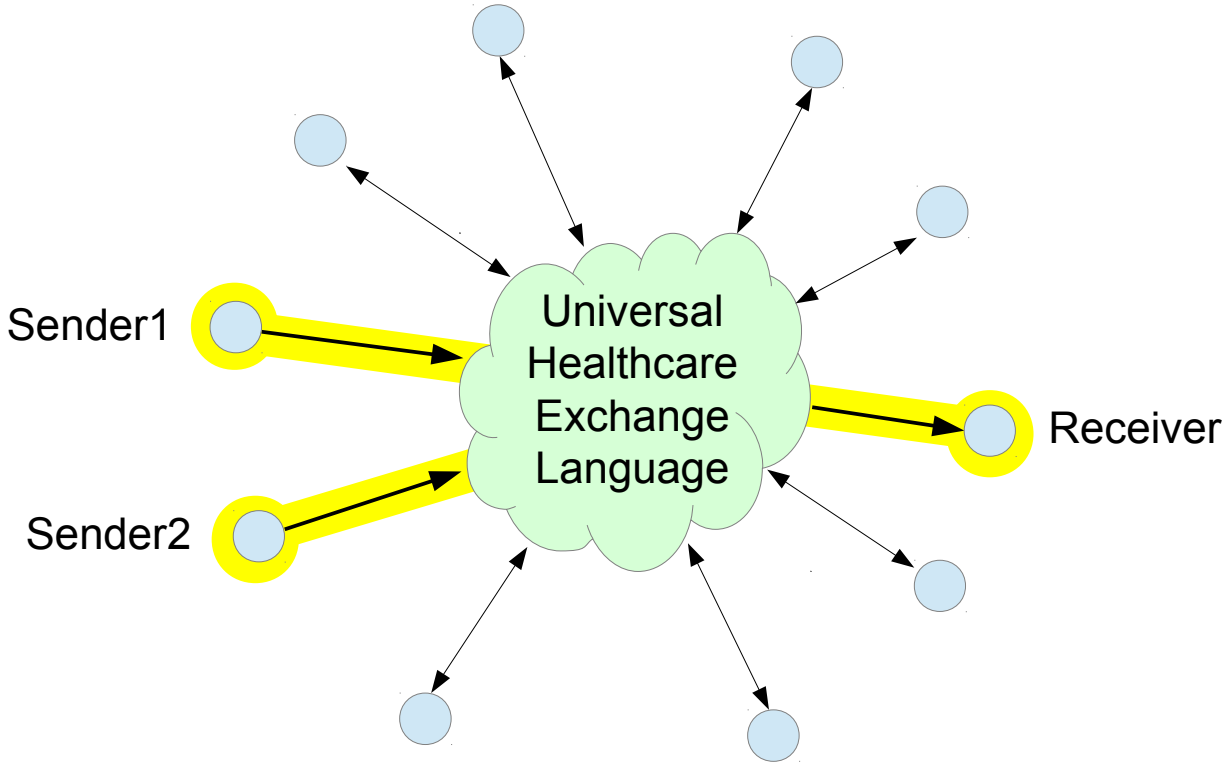
Schema promiscuous



Role of a common language



Role of a common language



Semantic relevance is relative

- Blood Pressure measurement:
  - Sitting versus Standing
- Is the difference semantically relevant?
- Depends on the application!
- v:BP_Machine rdfs:subClassOf v:BP .
- v:BP_Manual rdfs:subClassOf v:BP .
- { ?bp a v:BP_Machine . }
  => { ?bp a v:BP . } .

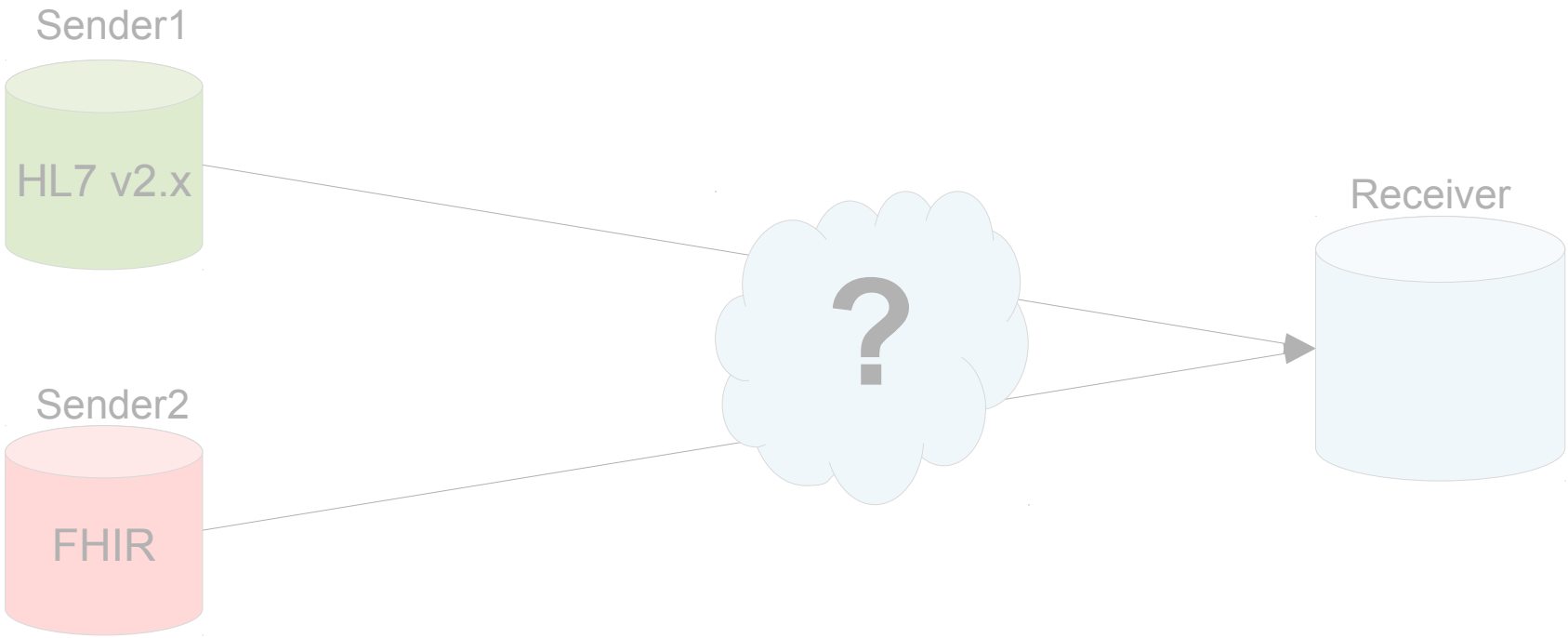
Merged RDF

Sender1
HL7 v2.x
HL7 v2.x
to RDF
RDF
to RDF
Receiver
Sender2
FHIR
FHIR
to RDF
RDF
to RDF

Step 1: Syntactic transformation

- Transform from source format to substrate model
- Allows data to be merged
- Data may not link semantically due to differing vocabularies

Sender1 data: HL7 v2.x



(Fictitious examples for illustration)

Yosemite Manifesto
on RDF as a Universal Healthcare Exchange Language

1. RDF is the best available candidate for a universal healthcare exchange language.

Yosemite Manifesto
on RDF as a Universal Healthcare Exchange Language

2. Electronic healthcare information should be exchanged in a format that either: (a) is an RDF format directly; or (b) has a standard mapping to RDF.

Yosemite Manifesto
on RDF as a Universal Healthcare Exchange Language

3. Existing standard healthcare vocabularies, data models and exchange languages should be leveraged by defining standard mappings to RDF, and any new standards should have RDF representations.

Yosemite Manifesto
on RDF as a Universal Healthcare Exchange Language

4. Government agencies should mandate or incentivize the use of RDF as a universal healthcare exchange language.

Yosemite Manifesto
on RDF as a Universal Healthcare Exchange Language

5. Exchanged healthcare information should be self-describing, using Linked Data principles, so that each concept URI is de-referenceable to its free and open definition.

Using Transformation Definitions