# Developing Trust in Aggregated Government Data

*Provenance,*

*Interpretation Knowledge*

*and URI Design*

*for*

*Incremental Enhancement of Tabular Data*

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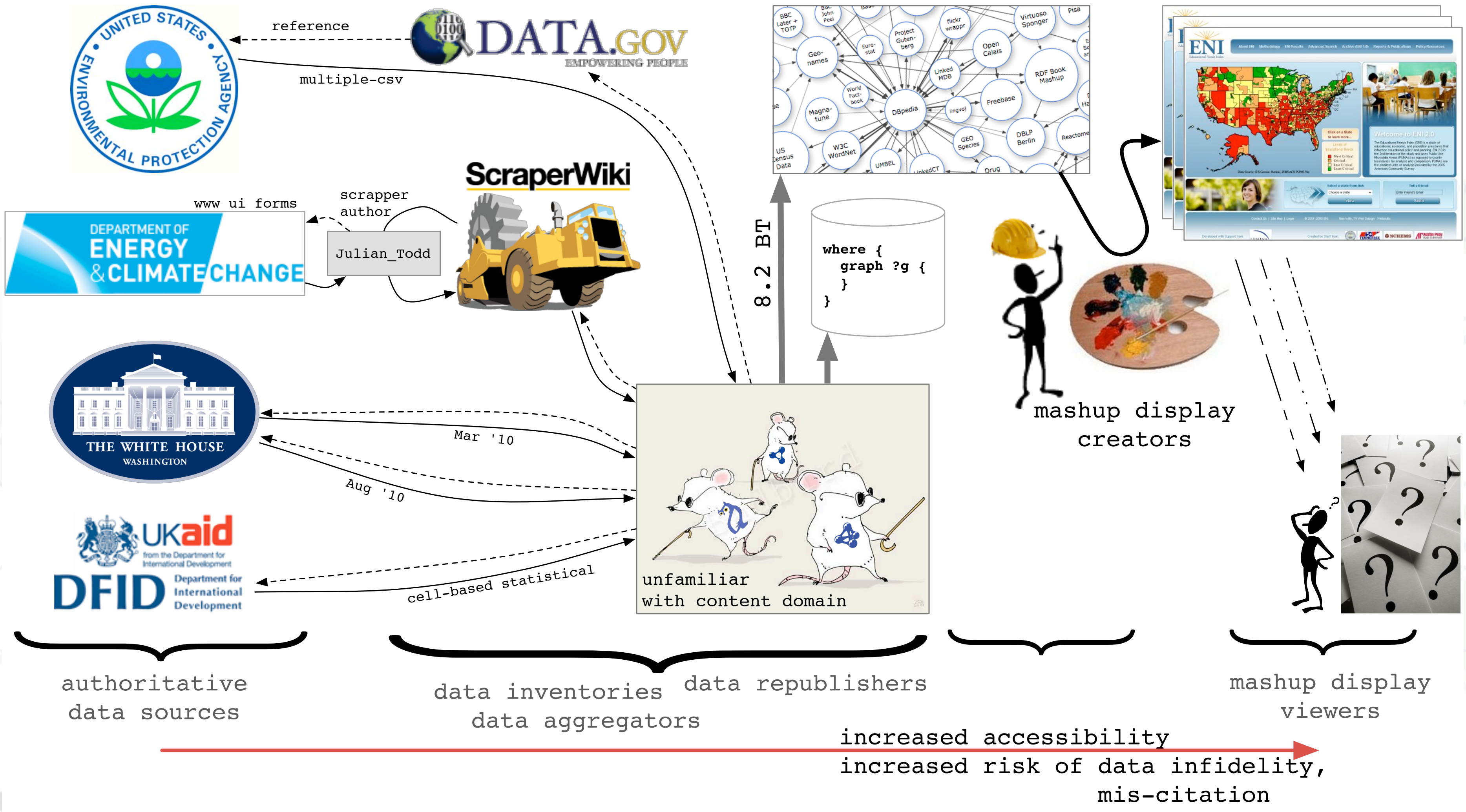
Tetherless World Constellation
Rensselaer Polytechnic Institute

# Challenges for Data Aggregators


UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
DATA.GOV
EMPOWERING PEOPLE
ScraperWiki
DEPARTMENT OF ENERGY & CLIMATE CHANGE
THE WHITE HOUSE
WASHINGTON
UKaid from the Department for International Development
DFID Department for International Development
DBpedia
Freebase

reference

multiple-csv

www ui forms

scrapper author

Julian_Todd

8.2 BT

```
where {
  graph ?g {
  }
}
```

Mar '10

Aug '10

cell-based statistical

unfamiliar with content domain

mashup display creators

authoritative data sources

data inventories data aggregators

data republishers

mashup display viewers

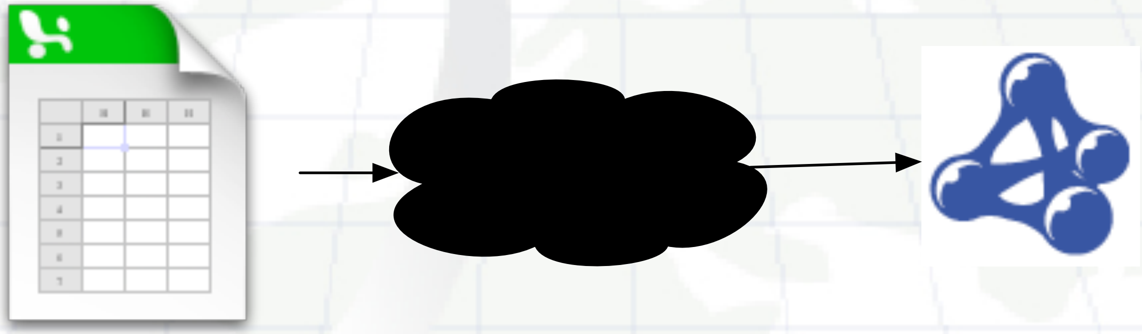
increased accessibility

increased risk of data infidelity, mis-citation

# Challenges for Data Aggregators

Disconnected, Not on Semantic Web

On Semantic Web

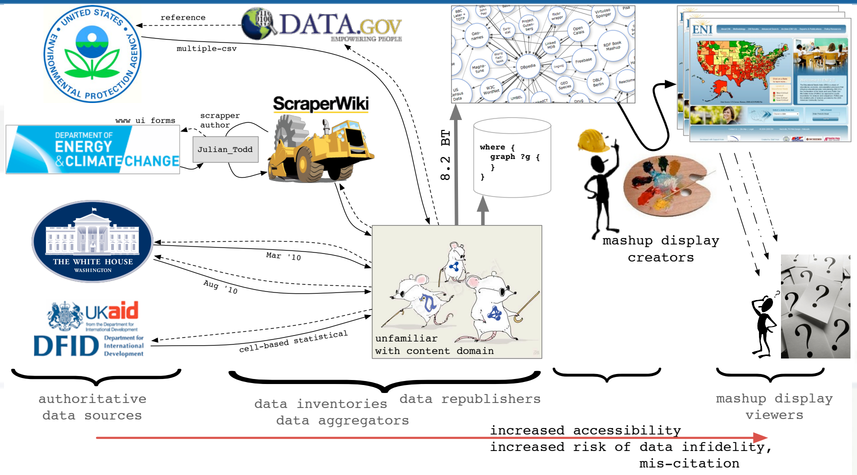


http://www.whitehouse.gov/files/disclosures/visitors/WhiteHouse-WAVES-Released-0910.csv

Trust

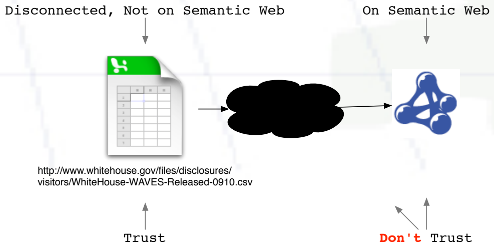
Don't Trust

# Assumptions



```
where {
  graph ?g {
  }
}
```

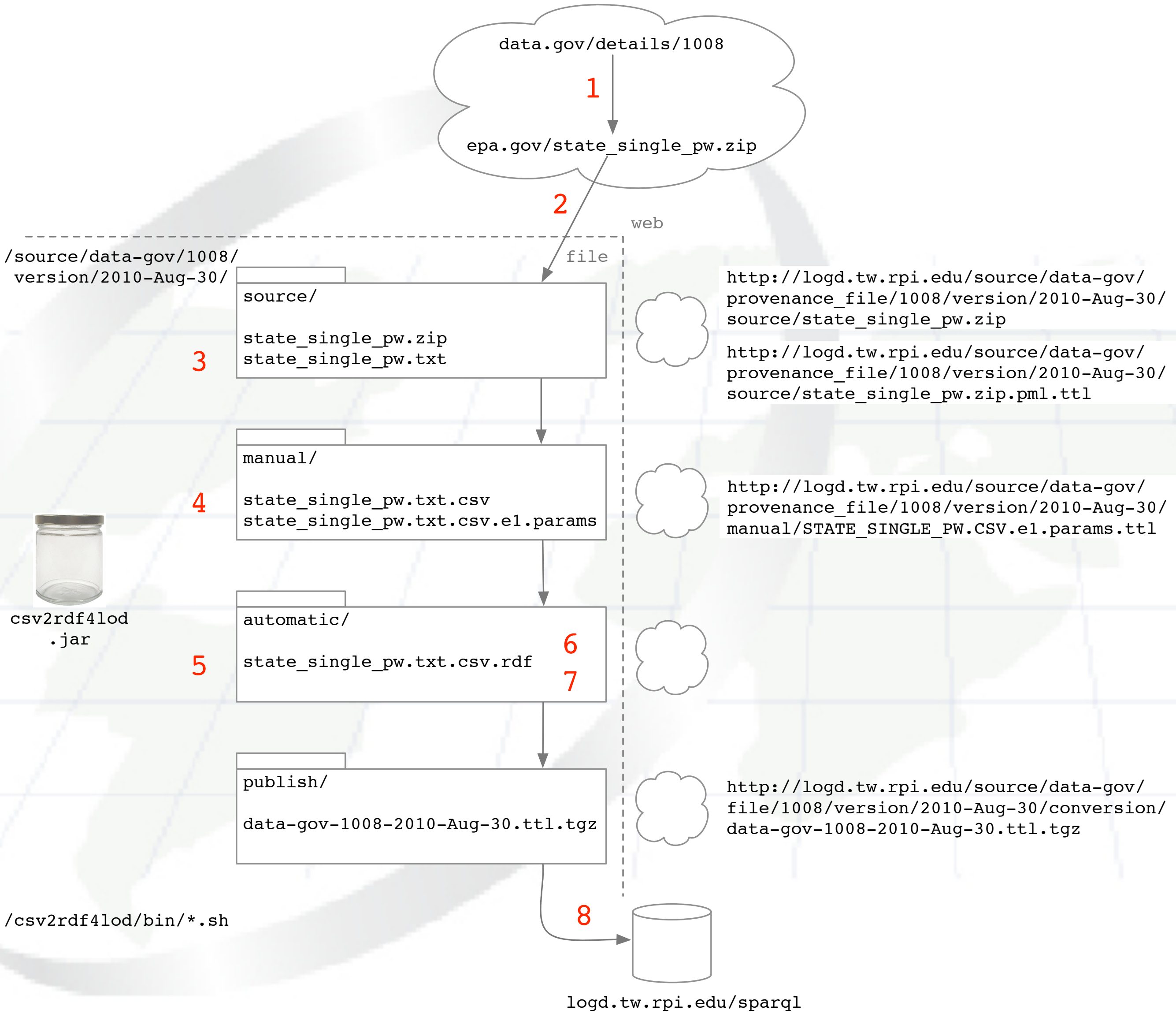
- Most data are from third-party sources
- Data are updated regularly and irregularly
- Complete interpretation is not immediately possible
- Subsequent interpretations should be backward-compatible
- Provenance is essential
  - Distinguishing among sources
  - Minimizing manual modifications during conversion
  - Tracing to source data
  - Attribution


Disconnected, Not on Semantic Web
On Semantic Web
http://www.whitehouse.gov/files/disclosures/visitors/WhiteHouse-WAVES-Released-0910.csv
Trust
Don't Trust

# Outline

- Challenges for Data Aggregators
- Trust in aggregated product
  - Provenance capture
  - Parameterized interpretations
  - Intuitively-structured RDF
- Interpretation knowledge vocabulary
  - Naming a Dataset
  - Naïve CSV conversion
  - Specifying an enhancement
  - A few simple examples
- URIs designed for dataset maintenance
  - Predicate Layering
  - Subject Versioning
  - VoID subset Hierarchy
  - Hierarchical Integration

# Capturing Conversion Provenance



data.gov/details/1008

epa.gov/state_single_pw.zip

/source/data-gov/1008/
version/2010-Aug-30/

source/
state_single_pw.zip
state_single_pw.txt

manual/
state_single_pw.txt.csv
state_single_pw.txt.csv.e1.params

automatic/
state_single_pw.txt.csv.rdf

publish/
data-gov-1008-2010-Aug-30.ttl.tgz

csv2rdf4lod
.jar

/csv2rdf4lod/bin/*.sh

logd.tw.rpi.edu/sparql

http://logd.tw.rpi.edu/source/data-gov/
provenance_file/1008/version/2010-Aug-30/
source/state_single_pw.zip

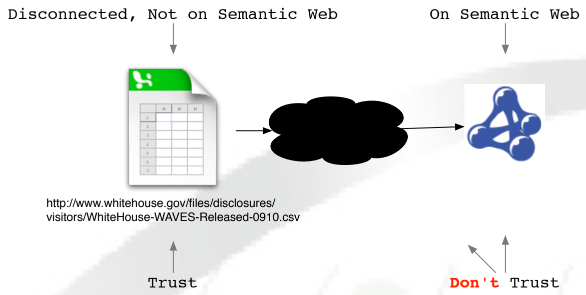
http://logd.tw.rpi.edu/source/data-gov/
provenance_file/1008/version/2010-Aug-30/
source/state_single_pw.zip.pml.ttl

http://logd.tw.rpi.edu/source/data-gov/
provenance_file/1008/version/2010-Aug-30/
manual/STATE_SINGLE_PW.CSV.e1.params.ttl

http://logd.tw.rpi.edu/source/data-gov/
file/1008/version/2010-Aug-30/conversion/
data-gov-1008-2010-Aug-30.ttl.tgz

1 – Following redirects
2 – Retrieving data file
3 – Unzipping
4 – Manual tweaks
5 – Converter invocation
6 – Predicate lineage
7 – Tracing triple to cell
8 – Populating endpoint

# Parameterized Interpretations



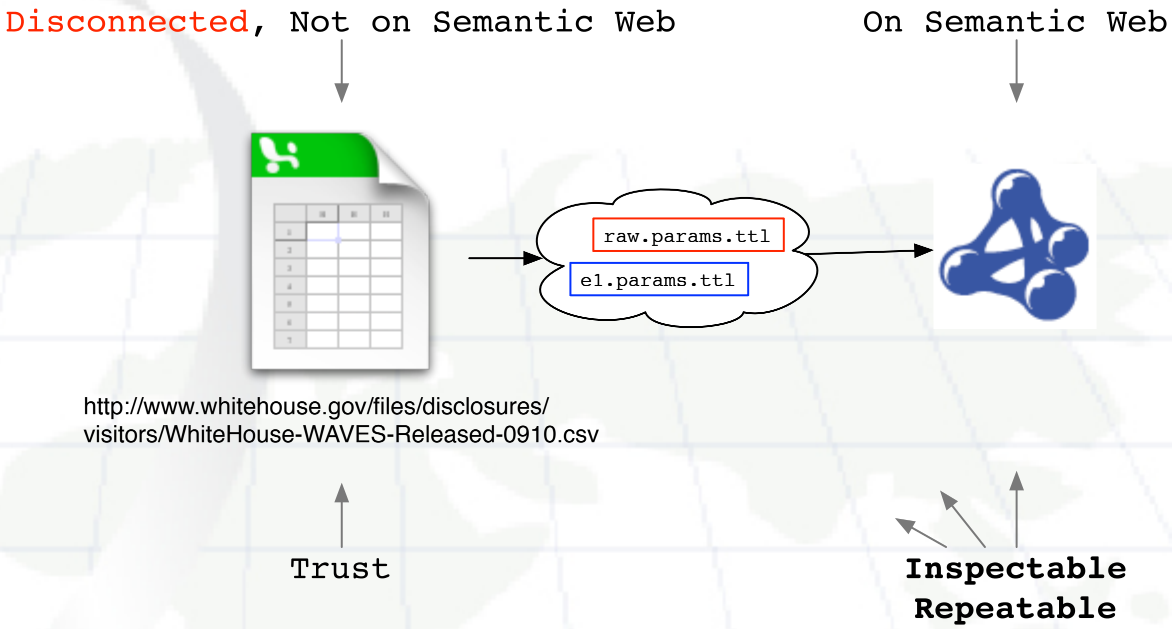
Disconnected, Not on Semantic Web

On Semantic Web

http://www.whitehouse.gov/files/disclosures/
visitors/WhiteHouse-WAVES-Released-0910.csv

Trust

Don't Trust



Disconnected, Not on Semantic Web

On Semantic Web

raw.params.ttl

e1.params.ttl

http://www.whitehouse.gov/files/disclosures/
visitors/WhiteHouse-WAVES-Released-0910.csv

Trust

**Inspectable**
**Repeatable**

- Citing original data location
- Exposing intermediate steps
- Parameterized interpretations w/o modifying original dataset
- Consumer chooses the interpretation layer that they trust
- Producing intuitively-structured RDF

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  - Naming a Dataset
  - Naïve CSV conversion
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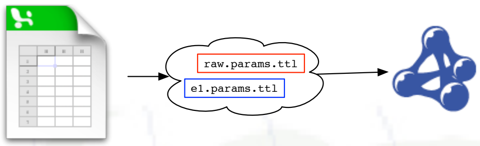


# Naming a Dataset

<http://base.edu /source/ SSS /dataset/ DDD /version/ VVV>

| | Name Component | Naming Convention | e.g. |
|---|---|---|---|
| "Who?" | source | organization's dns | "nci-nih-gov" |
| | | | "census-gov" |
| | | | "nber-org" |
| "What?" | dataset | ID from organization | "353" |
| | | | "tus-cps" |
| | | | "stack-heights" |
| "Which?" | version | broad classification | "1st-anniversary" |
| | | official release date | "2010-Jan-15" |
| | | HTTP last_mod date | "2008-Jul-03" |

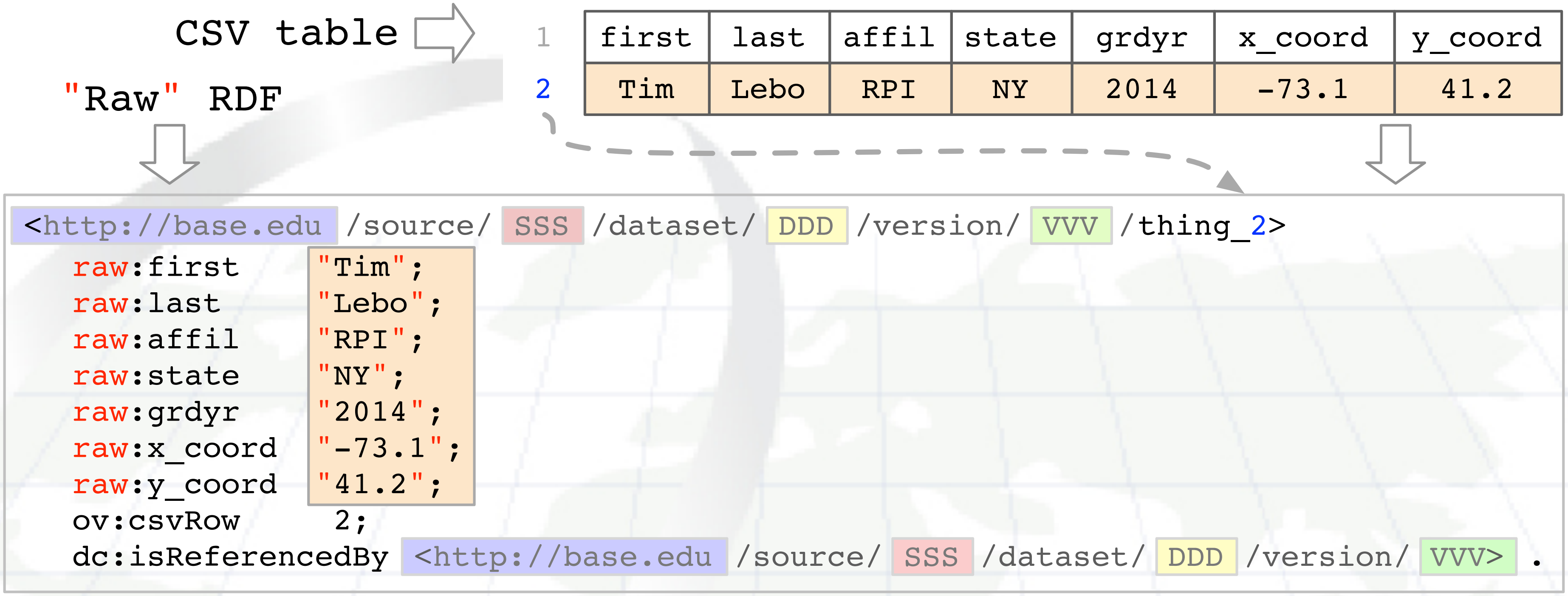
**Dataset's URI:**

http://logd.tw.rpi.edu /source/ census-gov /dataset/ tus-cps /version/ 2008-Jul-03

# Dataset’ s Name

```
@prefix void: <http://rdfs.org/ns/void#> .

< http://base.edu /source/ SSS /dataset/ DDD /version/ VVV >
   rdf:type void:Dataset;

   conversion:source_identifier   "SSS" ;
   conversion:dataset_identifier  "DDD" ;
   conversion:version_identifier  "VVV" ;
.
```

# Naïve CSV Conversion



CSV table

"Raw" RDF

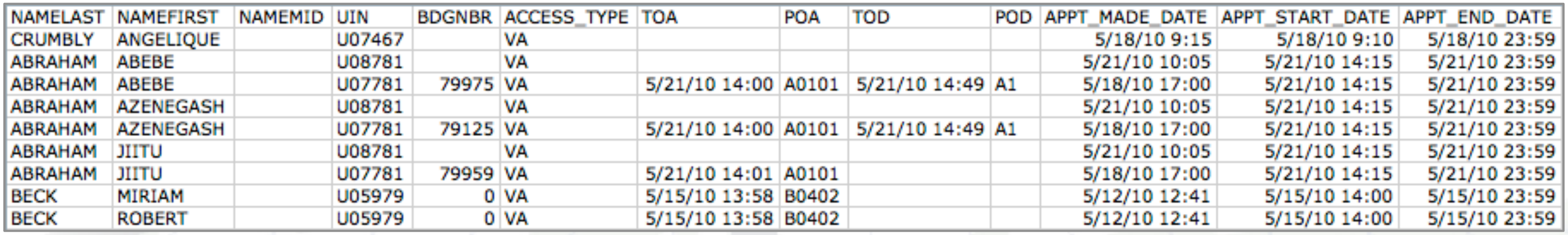
|   | first | last | affil | state | grdyr | x_coord | y_coord |
|---|---|---|---|---|---|---|---|
| 2 | Tim | Lebo | RPI | NY | 2014 | -73.1 | 41.2 |

```
<http://base.edu/source/SSS/dataset/DDD/version/VVV/thing_2>
   raw:first        "Tim";
   raw:last         "Lebo";
   raw:affil        "RPI";
   raw:state        "NY";
   raw:grdyr        "2014";
   raw:x_coord      "-73.1";
   raw:y_coord      "41.2";
   ov:csvRow         2;
   dc:isReferencedBy <http://base.edu/source/SSS/dataset/DDD/version/VVV> .
```

- Dataset URI re-purposes as subject namespace
- All subjects point to dataset
- Position in original table preserved
- All values are untyped literals
- Rows are rarely conceptually normalized
- Columns may not express a binary relationship

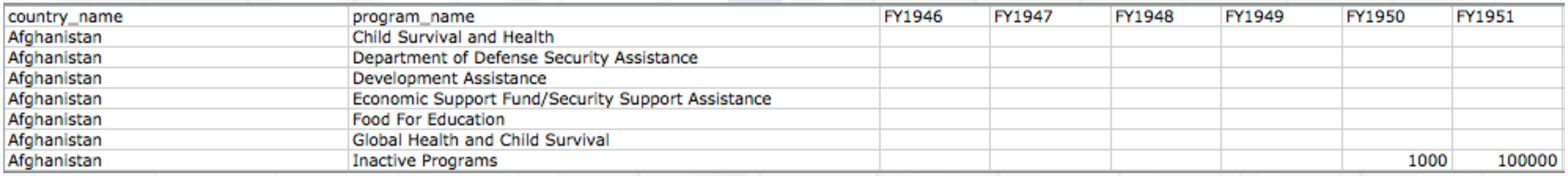
# Problem:
# The Real World is Messy

whitehouse-gov's visitor-records



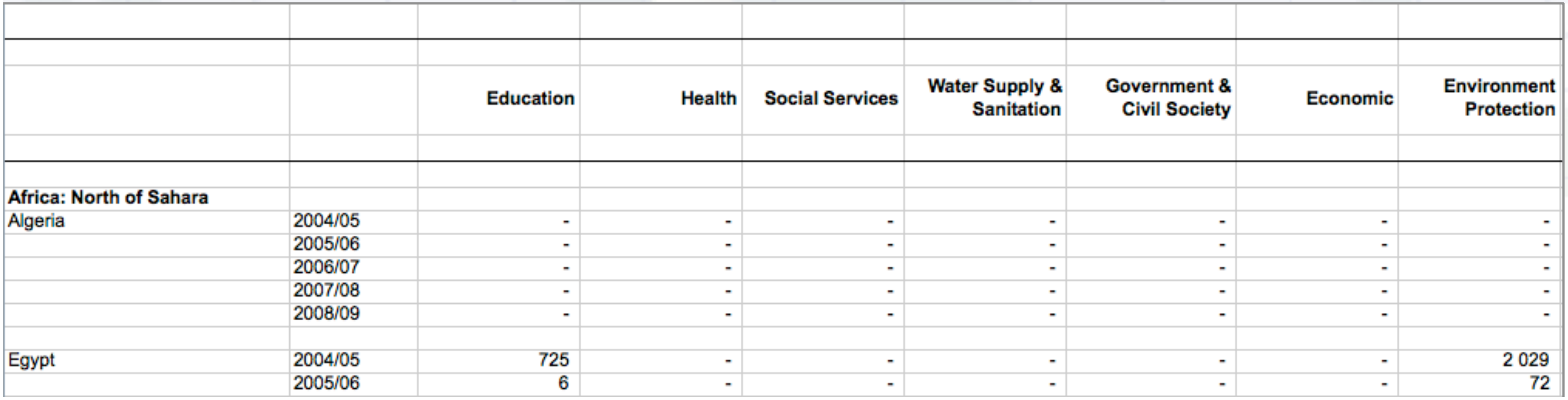
| NAMELAST | NAMEFIRST | NAMEMID | UIN | BDGNBR | ACCESS_TYPE | TOA | POA | TOD | POD | APPT_MADE_DATE | APPT_START_DATE | APPT_END_DATE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CRUMBLY | ANGELIQUE | | U07467 | | VA | | | | | 5/18/10 9:15 | 5/18/10 9:10 | 5/18/10 23:59 |
| ABRAHAM | ABEBE | | U08781 | | VA | | | | | 5/21/10 10:05 | 5/21/10 14:15 | 5/21/10 23:59 |
| ABRAHAM | ABEBE | | U07781 | 79975 | VA | 5/21/10 14:00 | A0101 | 5/21/10 14:49 | A1 | 5/18/10 17:00 | 5/21/10 14:15 | 5/21/10 23:59 |
| ABRAHAM | AZENEGASH | | U08781 | | VA | | | | | 5/21/10 10:05 | 5/21/10 14:15 | 5/21/10 23:59 |
| ABRAHAM | AZENEGASH | | U07781 | 79125 | VA | 5/21/10 14:00 | A0101 | 5/21/10 14:49 | A1 | 5/18/10 17:00 | 5/21/10 14:15 | 5/21/10 23:59 |
| ABRAHAM | JIITU | | U08781 | | VA | | | | | 5/21/10 10:05 | 5/21/10 14:15 | 5/21/10 23:59 |
| ABRAHAM | JIITU | | U07781 | 79959 | VA | 5/21/10 14:01 | A0101 | | | 5/18/10 17:00 | 5/21/10 14:15 | 5/21/10 23:59 |
| BECK | MIRIAM | | U05979 | 0 | VA | 5/15/10 13:58 | B0402 | | | 5/12/10 12:41 | 5/15/10 14:00 | 5/15/10 23:59 |
| BECK | ROBERT | | U05979 | 0 | VA | 5/15/10 13:58 | B0402 | | | 5/12/10 12:41 | 5/15/10 14:00 | 5/15/10 23:59 |

data-gov's 1554



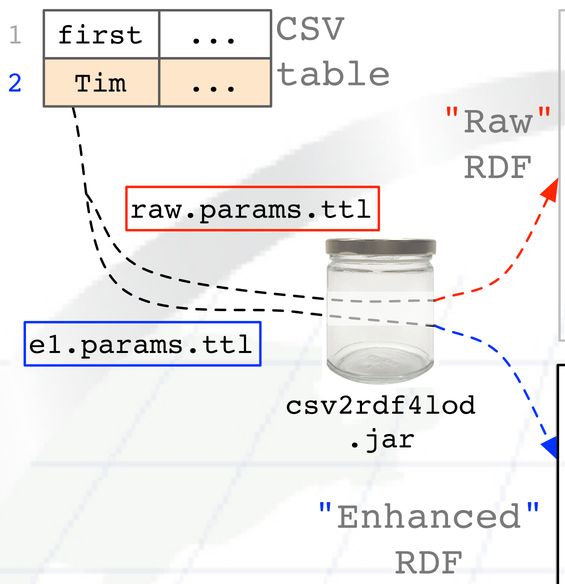
| country_name | program_name | FY1946 | FY1947 | FY1948 | FY1949 | FY1950 | FY1951 |
|---|---|---|---|---|---|---|---|
| Afghanistan | Child Survival and Health | | | | | | |
| Afghanistan | Department of Defense Security Assistance | | | | | | |
| Afghanistan | Development Assistance | | | | | | |
| Afghanistan | Economic Support Fund/Security Support Assistance | | | | | | |
| Afghanistan | Food For Education | | | | | | |
| Afghanistan | Global Health and Child Survival | | | | | | |
| Afghanistan | Inactive Programs | | | | | 1000 | 100000 |

dfid-gov-uk's statistics-on-international-



| | | Education | Health | Social Services | Water Supply & Sanitation | Government & Civil Society | Economic | Environment Protection |
|---|---|---|---|---|---|---|---|---|
| **Africa: North of Sahara** | | | | | | | | |
| Algeria | 2004/05 | - | - | - | - | - | - | - |
| | 2005/06 | - | - | - | - | - | - | - |
| | 2006/07 | - | - | - | - | - | - | - |
| | 2007/08 | - | - | - | - | - | - | - |
| | 2008/09 | - | - | - | - | - | - | - |
| | | | | | | | | |
| Egypt | 2004/05 | 725 | - | - | - | - | - | 2 029 |
| | 2005/06 | 6 | - | - | - | - | - | 72 |

# Solution:
# Interpretation Parameters



|   |       |     |
|---|-------|-----|
| 1 | first | ... |
| 2 | Tim   | ... |

```
<http://base.edu /source/ SSS /dataset/ DDD /version/ VVV /thing_2>
    raw:first       "Tim";
    raw:last        "Lebo";
    raw:affil       "RPI";
    raw:state       "NY";
    raw:grdyr       "2014";
    raw:x_coord     "-73.1";
    raw:y_coord     "41.2";
.
```

```
<http://base.edu /source/ SSS /dataset/ DDD /version/ VVV /graduation_2>
    a z:Graduation;
    e1:student                x:student_2;
    e1:institution            y:RPI;
    e1:completion_year       "2014"^^xsd:gYear
.
```

```
x:student_2
    a z:Student, foaf:Person;
    foaf:firstName   "Tim";
    foaf:family_name "Lebo";

.
```

```
y:RPI
    a z:Institution, foaf:Organization;
    dc:identifier                "RPI";
    wgs:lat                       41.2;  wgs:long -73.1;
    geonames:parentFeature s:NY;
    owl:sameAs                    dbp:Rensselaer_Polytechnic_Institute;
.
```

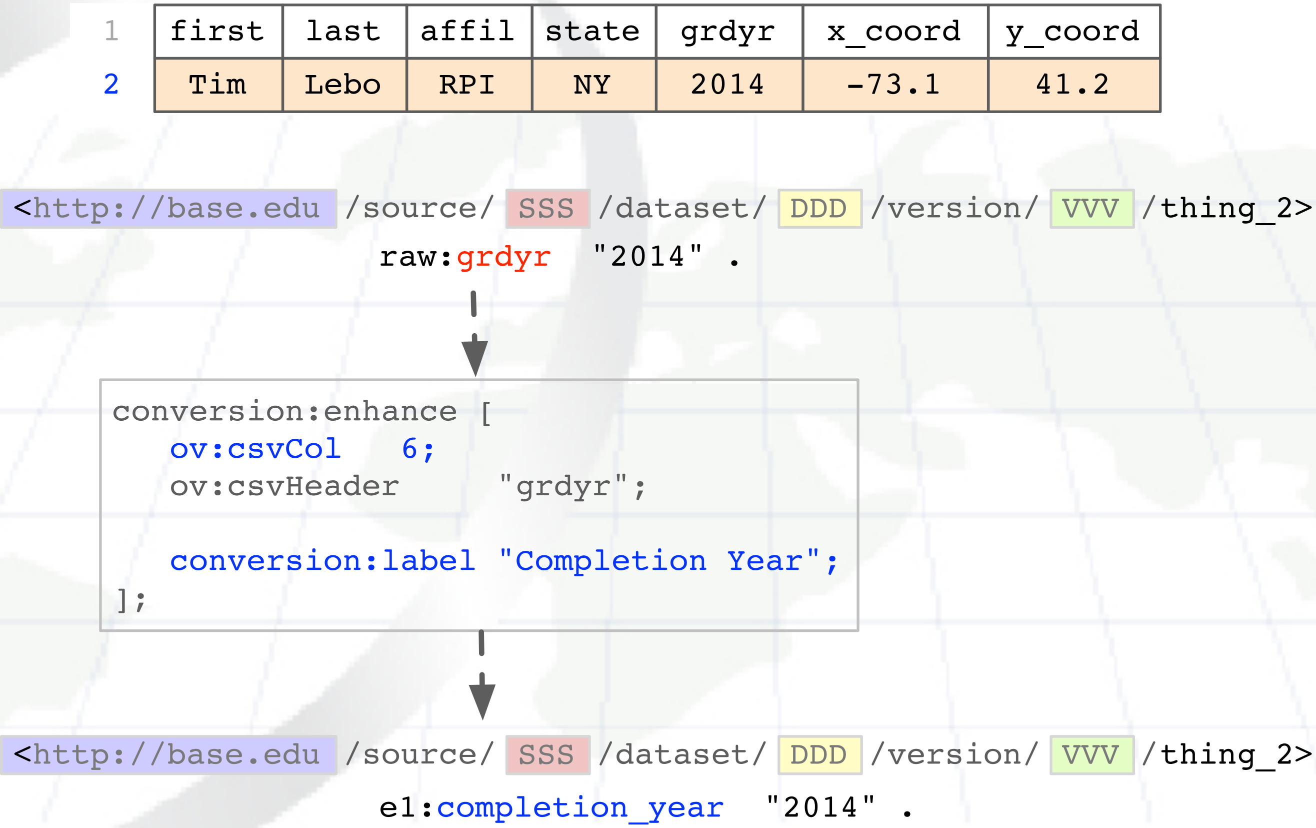
```
s:NY
    a z:State, wgs:SpatialThing;
    dc:identifier  "NY";
    owl:sameAs     <http://www.rfabout.com/rdf/usgov/geo/us/NY>,
                   <http://sws.geonames.org/5128638/>,
                   <http://dbpedia.org/resource/New_York>;
.
```

# Specifying Dataset Enhancements

```
@prefix void: <http://rdfs.org/ns/void#> .

<http://base.edu /source/ SSS /dataset/ DDD /version/ VVV>
   rdf:type void:Dataset;
.
```

```
@prefix conversion: <http://purl.org/twc/vocab/conversion/> .

:dataset a void:Dataset;
   conversion:base_uri           "http://base.edu"^^xsd:anyURI;
   conversion:source_identifier  "SSS";
   conversion:dataset_identifier "DDD";
   conversion:dataset_version    "VVV";
   conversion:conversion_process [
      a conversion:ConversionProcess;
      conversion:enhancement_identifier "1";
      conversion:enhance [
         ...
      ];
      conversion:enhance [
      ];
      ...
   ];
.
```

# Renaming a Property



| first | last | affil | state | grdyr | x_coord | y_coord |
|---|---|---|---|---|---|---|
| Tim | Lebo | RPI | NY | 2014 | -73.1 | 41.2 |

```
<http://base.edu /source/ SSS /dataset/ DDD /version/ VVV /thing_2>
                    raw:grdyr   "2014" .
```

```
conversion:enhance [
   ov:csvCol    6;
   ov:csvHeader     "grdyr";

   conversion:label "Completion Year";
];
```

```
<http://base.edu /source/ SSS /dataset/ DDD /version/ VVV /thing_2>
                    e1:completion_year   "2014" .
```

# Typing a Property’ s Domain

| first | last | affil | state | grdyr | x_coord | y_coord |
|---|---|---|---|---|---|---|
| Tim | Lebo | RPI | NY | 2014 | -73.1 | 41.2 |

```
<http://base.edu /source/ SSS /dataset/ DDD /version/ VVV /thing_2>
                  raw:grdyr  "2014" .
```

↓

```
conversion:enhance [
   ov:csvCol    6;
   ov:csvHeader      "grdyr";
   conversion:label "Completion Year";
   conversion:range  xsd:gYear;
];
```

↓

```
<http://base.edu /source/ SSS /dataset/ DDD /version/ VVV /thing_2>
         e1:completion_year  "2014"^^xsd:gYear .
```

# Typing with Patterns

```
raw:appt_made_date  "1/5/2010 14:49" .
```

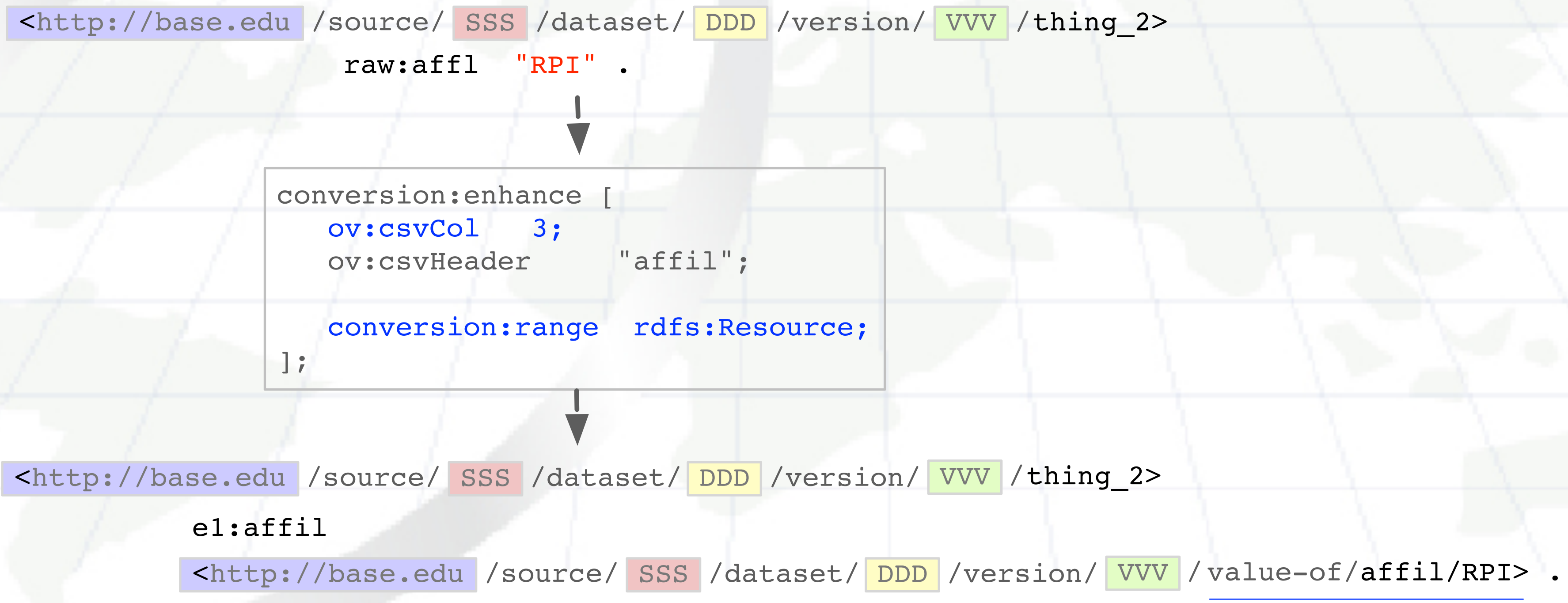
```
conversion:enhance [
   ov:csvCol   6;
   ov:csvHeader     "appt_made_date";

   conversion:range                xsd:dateTime;
   conversion:datetime_pattern "M/d/yy HH:mm";
   conversion:datetime_timezone_offset  -300;
];
```

```
e1:appt_made_date  "2010-01-05T14:49:00-05:00"^^xsd:dateTime .
```

http://logd.tw.rpi.edu/source/whitehouse-gov/dataset/visitor-records/version/0510

# Promoting a value to a Resource

| first | last | affil | state | grdyr | x_coord | y_coord |
|---|---|---|---|---|---|---|
| Tim | Lebo | RPI | NY | 2014 | -73.1 | 41.2 |



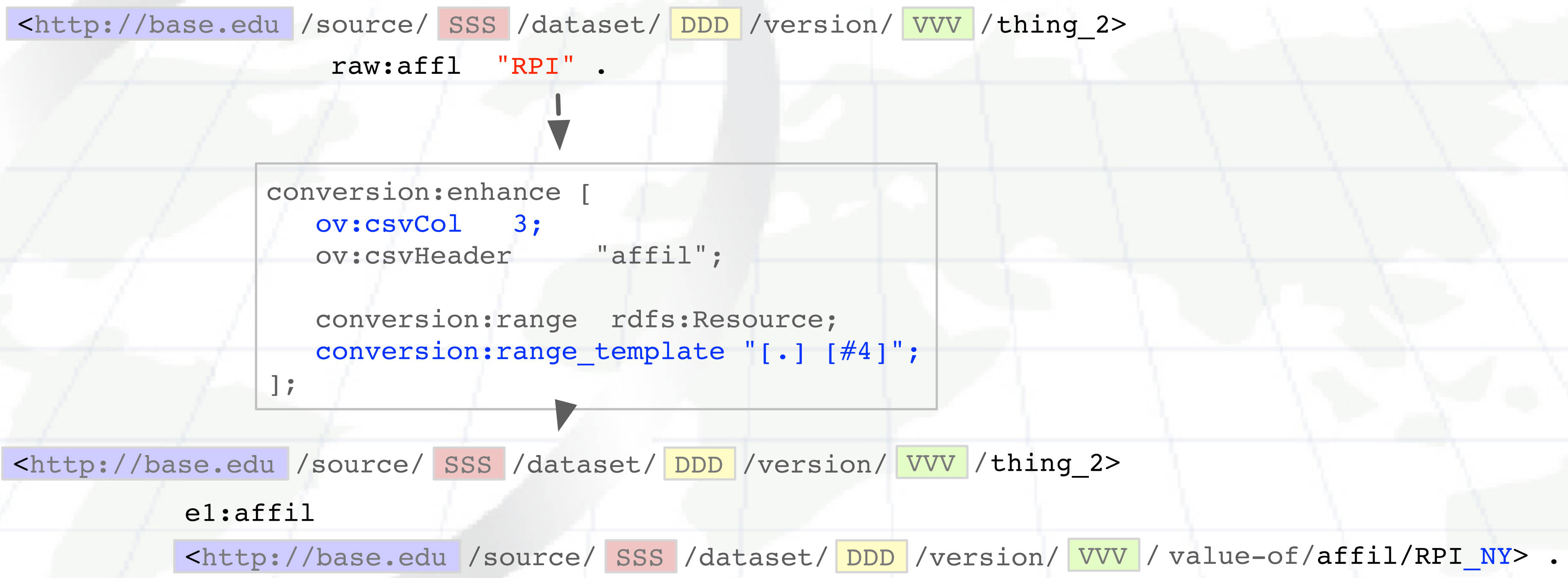
```
<http://base.edu /source/ SSS /dataset/ DDD /version/ VVV /thing_2>
                    raw:affl   "RPI" .
```

```
conversion:enhance [
   ov:csvCol    3;
   ov:csvHeader      "affil";

   conversion:range  rdfs:Resource;
];
```

```
<http://base.edu /source/ SSS /dataset/ DDD /version/ VVV /thing_2>
          el:affil
          <http://base.edu /source/ SSS /dataset/ DDD /version/ VVV /value-of/affil/RPI> .
```

# Domain and Range Templates

| first | last | affil | state | grdyr | x_coord | y_coord |
|---|---|---|---|---|---|---|
| Tim | Lebo | RPI | NY | 2014 | -73.1 | 41.2 |



```
<http://base.edu /source/ SSS /dataset/ DDD /version/ VVV /thing_2>
                       raw:affl  "RPI" .
```

```
conversion:enhance [
   ov:csvCol    3;
   ov:csvHeader      "affil";

   conversion:range  rdfs:Resource;
   conversion:range_template "[.] [#4]";
];
```

```
<http://base.edu /source/ SSS /dataset/ DDD /version/ VVV /thing_2>
            e1:affil
          <http://base.edu /source/ SSS /dataset/ DDD /version/ VVV / value-of/affil/RPI_NY> .
```

# Template Variables

|   | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| 1 | first | last | affil | state | grdyr | x_coord | y_coord |
| 2 | Tim | Lebo | RPI | NY | 2014 | -73.1 | 41.2 |

|   |   |   |
|---|---|---|
| current value | [.] | RPI |
| row number | [r] | 2 |
| column number | [c] | 3 |
| value of column | [#4] | NY |
| value of property | [@state] | NY |
| property name | [@] | affil |
| property domain | [D] | Graduation |
| property range | [R] | Institution |
| enhancement layer | [e] | 1 |
| versioned dataset namespace | [/sdv] | http://base.edu /source/ SSS /dataset/ DDD /version/ VVV / |
| dataset namespace | [/sd] | http://base.edu /source/ SSS /dataset/ DDD / |
| source namespace | [/s] | http://base.edu /source/ SSS / |
| base namespace | [/] | http://base.edu / |

# Linking to LOD

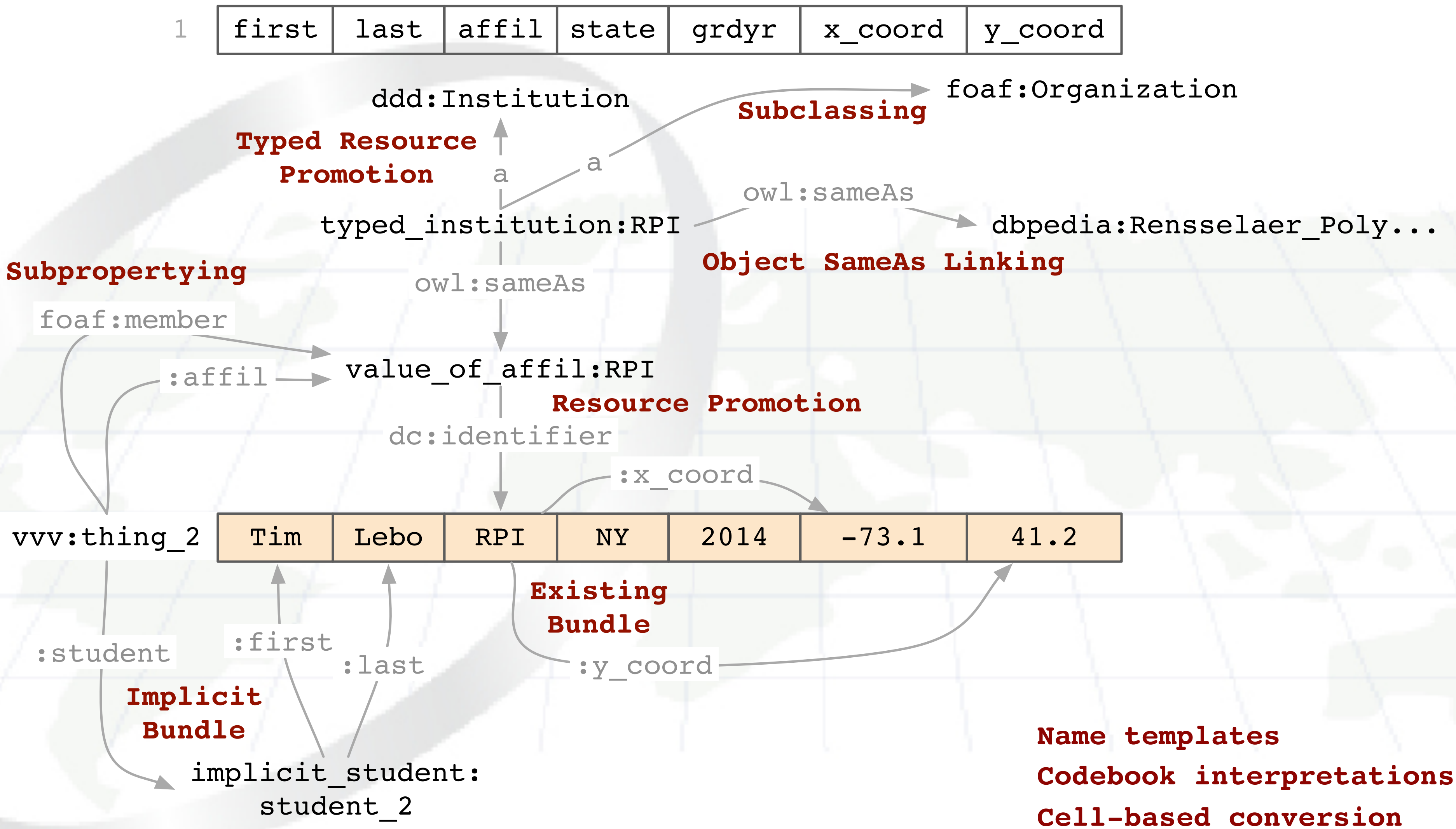
| first | last | affil | state | grdyr | x_coord | y_coord |
|---|---|---|---|---|---|---|
| Tim | Lebo | RPI | NY | 2014 | -73.1 | 41.2 |

```
<http://base.edu /source/ SSS /dataset/ DDD /version/ VVV /thing_2>
                   raw:affl  "RPI" .
```

```
conversion:enhance [
   ov:csvCol    3;
   ov:csvHeader      "affil";
   conversion:range  rdfs:Resource;
   conversion:links_via  <http://www.rpi.edu/~lebot/lod-links/universities.ttl>;
   conversion:subject_of dcterms:identifier;
];
```

```
<http://base.edu /source/ SSS /dataset/ DDD /version/ VVV /thing_2>
          e1:affil
          <http://base.edu /source/ SSS /dataset/ DDD /version/ VVV /value-of/affil/RPI> .

<http://base.edu /source/ SSS /dataset/ DDD /version/ VVV /value-of/affil/RPI>
          owl:sameAs <http://www.dbpedia.org/resource/Rensselaer_Polytechnic_Institute> .
```

# A Few More Enhancements…



| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | first | last | affil | state | grdyr | x_coord | y_coord |
| vvv:thing_2 | Tim | Lebo | RPI | NY | 2014 | -73.1 | 41.2 |

**Name templates**
**Codebook interpretations**
**Cell-based conversion**
**Structure assistance**

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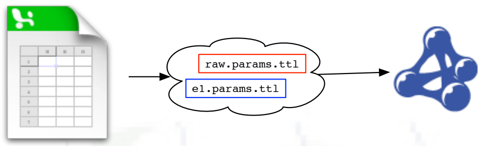
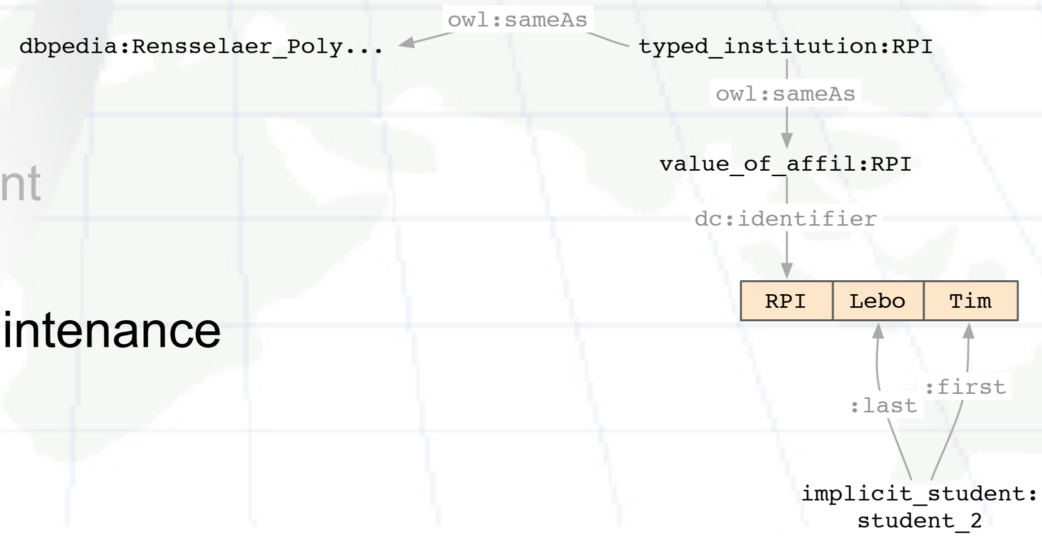
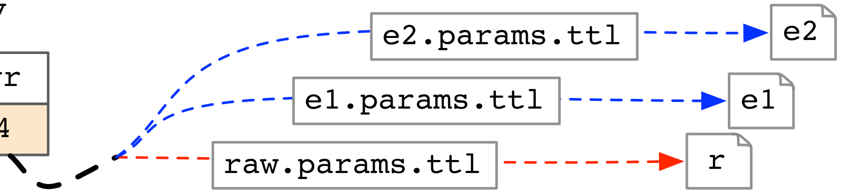




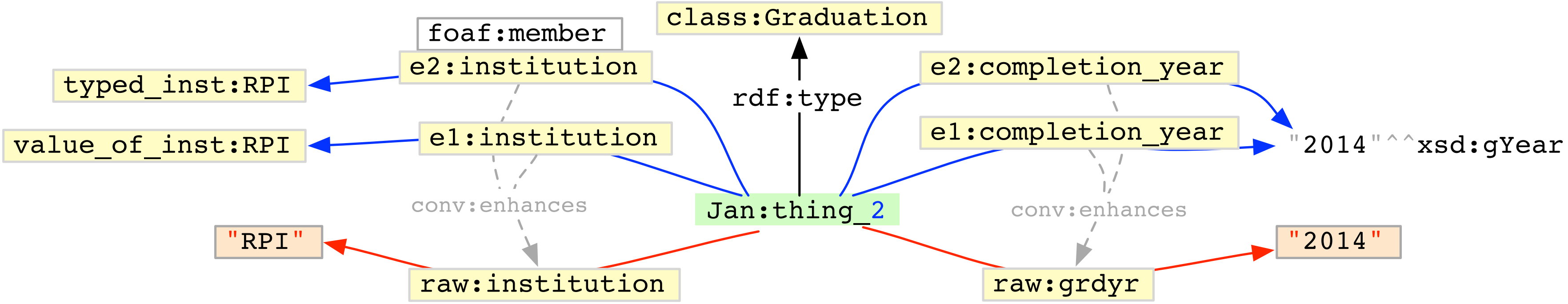
# Predicate Layering

Jan version.csv

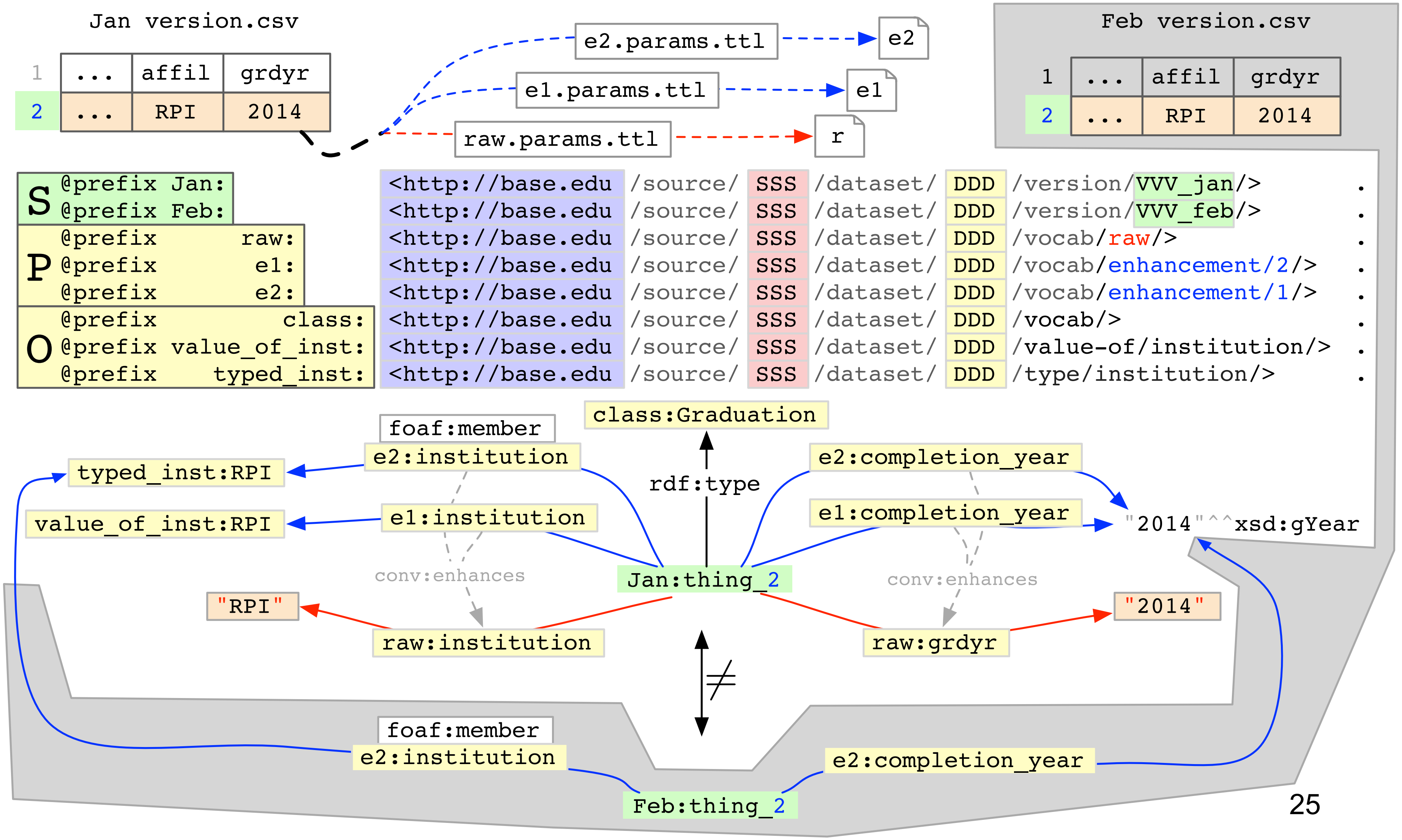
| 1 | ... | affil | grdyr |
|---|---|---|---|
| 2 | ... | RPI | 2014 |



```
S @prefix Jan:              <http://base.edu /source/ SSS /dataset/ DDD /version/VVV_jan/>           .
  @prefix Feb:              <http://base.edu /source/ SSS /dataset/ DDD /version/VVV_feb/>           .
  @prefix        raw:       <http://base.edu /source/ SSS /dataset/ DDD /vocab/raw/>                 .
P @prefix        e1:        <http://base.edu /source/ SSS /dataset/ DDD /vocab/enhancement/2/>       .
  @prefix        e2:        <http://base.edu /source/ SSS /dataset/ DDD /vocab/enhancement/1/>       .
  @prefix           class:  <http://base.edu /source/ SSS /dataset/ DDD /vocab/>                     .
O @prefix value_of_inst:    <http://base.edu /source/ SSS /dataset/ DDD /value-of/institution/>      .
  @prefix     typed_inst:   <http://base.edu /source/ SSS /dataset/ DDD /type/institution/>          .
```



# Subject Versioning



Jan version.csv

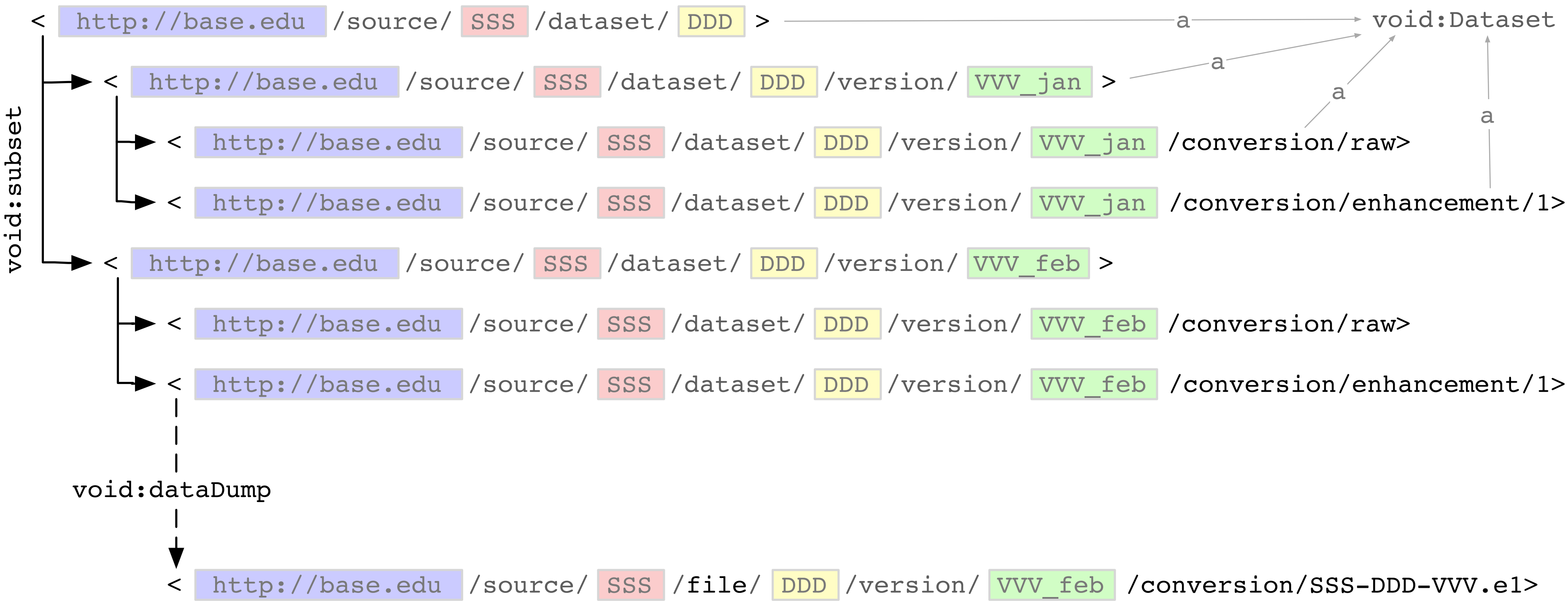
|   |     |       |       |
|---|-----|-------|-------|
| 1 | ... | affil | grdyr |
| 2 | ... | RPI   | 2014  |

Feb version.csv

|   |     |       |       |
|---|-----|-------|-------|
| 1 | ... | affil | grdyr |
| 2 | ... | RPI   | 2014  |

```
S @prefix Jan:            <http://base.edu/source/SSS/dataset/DDD/version/VVV_jan/>       .
  @prefix Feb:            <http://base.edu/source/SSS/dataset/DDD/version/VVV_feb/>       .
P @prefix raw:            <http://base.edu/source/SSS/dataset/DDD/vocab/raw/>             .
  @prefix e1:             <http://base.edu/source/SSS/dataset/DDD/vocab/enhancement/2/>   .
  @prefix e2:             <http://base.edu/source/SSS/dataset/DDD/vocab/enhancement/1/>   .
O @prefix class:          <http://base.edu/source/SSS/dataset/DDD/vocab/>                 .
  @prefix value_of_inst:  <http://base.edu/source/SSS/dataset/DDD/value-of/institution/>  .
  @prefix typed_inst:     <http://base.edu/source/SSS/dataset/DDD/type/institution/>      .
```

# void:Dataset subset hierarchy with void:dataDumps



< http://base.edu /source/ SSS /dataset/ DDD > a void:Dataset

< http://base.edu /source/ SSS /dataset/ DDD /version/ VVV_jan > a

< http://base.edu /source/ SSS /dataset/ DDD /version/ VVV_jan /conversion/raw> a

< http://base.edu /source/ SSS /dataset/ DDD /version/ VVV_jan /conversion/enhancement/1> a

< http://base.edu /source/ SSS /dataset/ DDD /version/ VVV_feb >

< http://base.edu /source/ SSS /dataset/ DDD /version/ VVV_feb /conversion/raw>

< http://base.edu /source/ SSS /dataset/ DDD /version/ VVV_feb /conversion/enhancement/1>

void:subset

void:dataDump

< http://base.edu /source/ SSS /file/ DDD /version/ VVV_feb /conversion/SSS-DDD-VVV.e1>

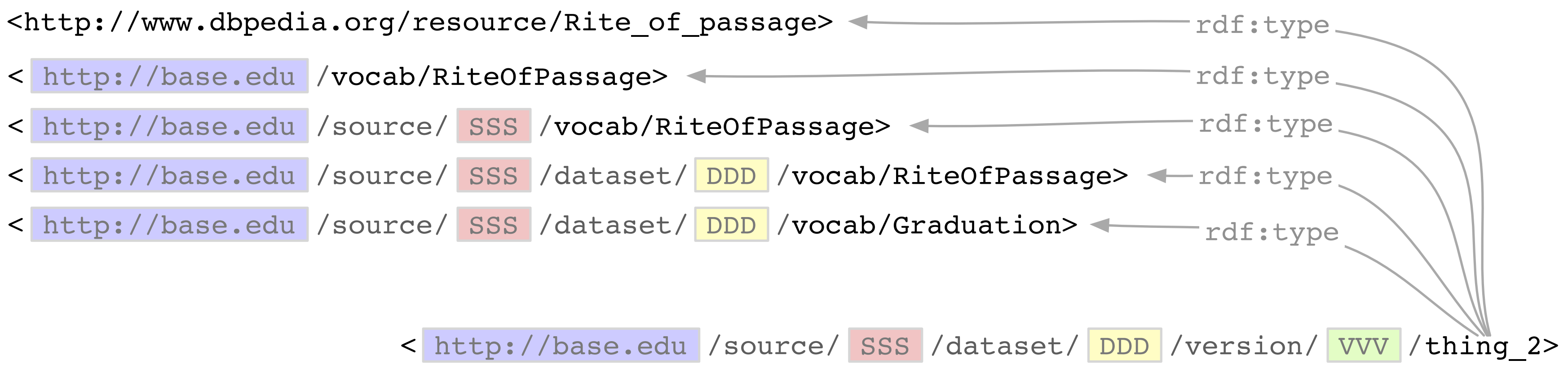
# URI hierarchy integration – Plenty of [name]space for integration

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| 1 | first | last | affil | state | grdyr | x_coord | y_coord |
| 2 | Tim | Lebo | RPI | NY | 2014 | -73.1 | 41.2 |

```
http://base.edu /source/ SSS /dataset/ DDD /version/ VVV /thing_2>  raw:affil  "RPI" .
```

```
conversion:enhance [
   ov:csvCol                3;
   ov:csvHeader            "affil";
   conversion:domain_name  "Graduation";
   conversion:range         rdfs:Resource;
];
```

```
conversion:enhance [
   conversion:class_name "Graduation";
   conversion:subclass_of
      "[/sd]vocab/RiteOfPassage";
       "[/s]vocab/RiteOfPassage";
        "[/]vocab/RiteOfPassage";
      <http://www.dbpedia.org/resource/Rite_of_passage>;
];
```

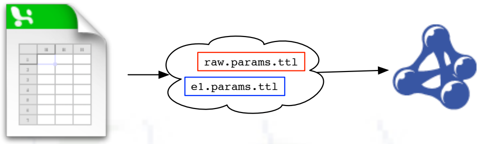


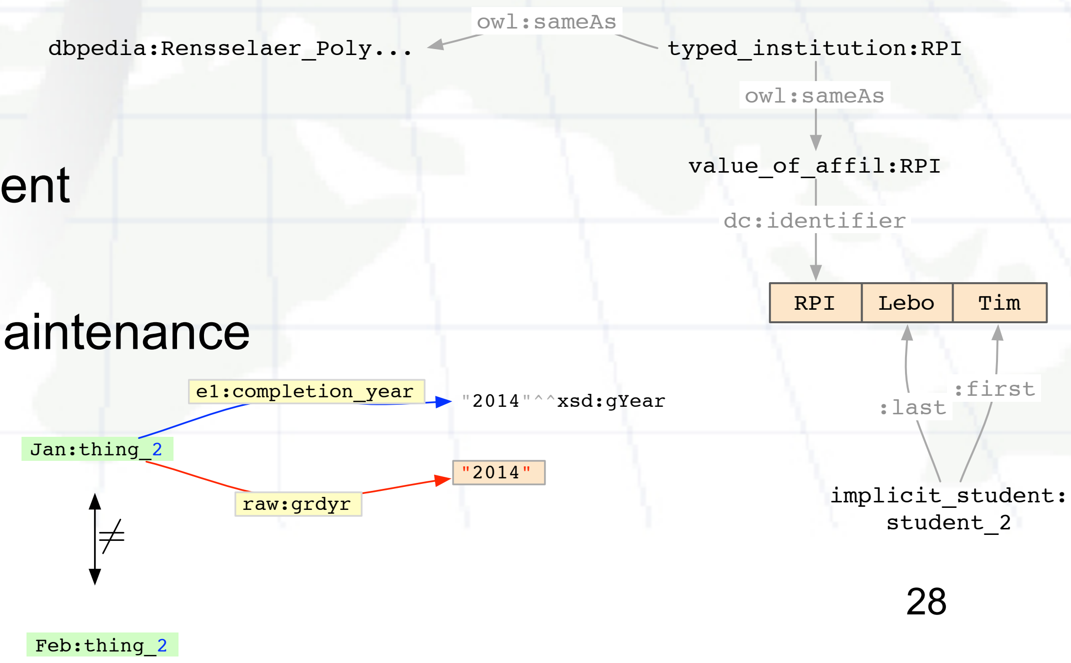
```
<http://www.dbpedia.org/resource/Rite_of_passage>                              rdf:type
< http://base.edu /vocab/RiteOfPassage>                                        rdf:type
< http://base.edu /source/ SSS /vocab/RiteOfPassage>                           rdf:type
< http://base.edu /source/ SSS /dataset/ DDD /vocab/RiteOfPassage>             rdf:type
< http://base.edu /source/ SSS /dataset/ DDD /vocab/Graduation>                rdf:type

                       < http://base.edu /source/ SSS /dataset/ DDD /version/ VVV /thing_2>
```

# Summary

- Challenges for Data Aggregators
- Trust in aggregated product
  - Provenance capture
  - Parameterized interpretations
  - Intuitively-structured RDF
- Interpretation knowledge vocabulary
  - Naming a Dataset
  - Naïve CSV conversion
  - Specifying an enhancement
  - A few simple examples
- URIs designed for dataset maintenance
  - Predicate Layering
  - Subject Versioning
  - VoID subset Hierarchy
  - Hierarchical Integration


raw.params.ttl
e1.params.ttl


owl:sameAs
dbpedia:Rensselaer_Poly...
typed_institution:RPI
owl:sameAs
value_of_affil:RPI
dc:identifier
RPI
Lebo
Tim
:last
:first
implicit_student:
student_2
e1:completion_year
"2014"^^xsd:gYear
Jan:thing_2
raw:grdyr
"2014"
≠
Feb:thing_2