Extending a co-authorship network analysis to include theses

Lars Vilhuber[*] Carl Lagoze[†] Ben Perry[‡] others

October 31, 2014

1 Data

The core data is derived from the RePEc data archives. Basic data on person nodes, including a list of author-edges, is available in ReDIF [1] format from the RePEc:per archive at `ftp://ftp.repec.org/opt/ReDIF/RePEc/per/`. All persons, institutions, and papers/articles are indexed by their RePEc handle.

1.1 ReDIF source data

The ReDIF data format is a machine-readable yet humanly interpretable metadata format [1]. Its basic structure for a field is

```
field_name: field value
```

Of interest to this paper are the following fields: Short−ID identifies person-node, author−paper, author−article, author−book identify written products ('entities') that may be co-authored, and thus implicitly identify some of the edges of the graph. We could also use Workplace−Institution as an additional node identifier, but defer this to future work. For the work here, data on the actual papers is not necessary, but may be used to populate the user interface. Deduplication of papers (papers with same names) are identified in the form of Perl statements at `ftp://repec.oru.se/RePEc/cpd/conf/relatedworks.dat`. The data for the RePEc Genealogy database is not (yet) publicly available.

Pre-computed network metrics for persons is available through the CollEc project at `ftp://ftp.repec.org/opt/CollEc/CollEc.txt` in the form of tabular data.

2 Graph components

2.1 Thesis

The data for the thesis components are derived from RePEc Genealogy. It encompasses a single *entity* type (thesis), a single *activity* (implicit in the data: Ph.D.) combined via two *relationships* or *roles* – advisor and author of the thesis – as well as associated *agents*.

1. Ph.D.: Activity

2. Entity: Thesis

3. Agent: Advisor

4. Agent: Ph.D. Candidate/Author

[*] Cornell University, corresponding author. This work is funded by NSF Grant 1131848.

[†] University of Michigan

[‡] Cornell University

Note that we will define a generic thesis “entity” with each thesis in the database being a specialization of this generic entity.

Agents

```
<prov:agent prov:id=”repec:pab175”>
  <prov:type>prov:Person</prov:type>
  <foaf:givenName>John M. Abowd</foaf:givenName>
</prov:agent>

<prov:agent prov:id=”repec:pze9”>
  <prov:type>prov:Person</prov:type>
  <foaf:givenName>Arnold Zellner</foaf:givenName>
</prov:agent>

<prov:agent prov:id=”repec:phe22”>
  <prov:type>prov:Person</prov:type>
  <foaf:givenName>James M. Heckman</foaf:givenName>
</prov:agent>

<prov:agent prov:id=”repec:pvi26”>
  <prov:type>prov:Person</prov:type>
  <foaf:givenName>Lars Vilhuber</foaf:givenName>
</prov:agent>
```

(XML file attached : theses-agents.xml)

Entities

```
<prov:entity prov:id=”exn:thesis”>
  <dct:title>A doctoral thesis</dct:title>
</prov:entity>
<prov:entity prov:id=”exn:thesispab175”>
  <dct:title>An Econometric Model of the U.S. Market for Higher Education<
      /dct:title>
  <dct:date>1977</dct:date>
</prov:entity>
```

(XML file attached : theses-entities.xml)

Note that the thesis could be fleshed out with full bibliographic information, although that information may not be available within the RePEc network. Our definition includes a generic “advisor” activity, although we will not use that, instead highlighting that relationship through a “role.”

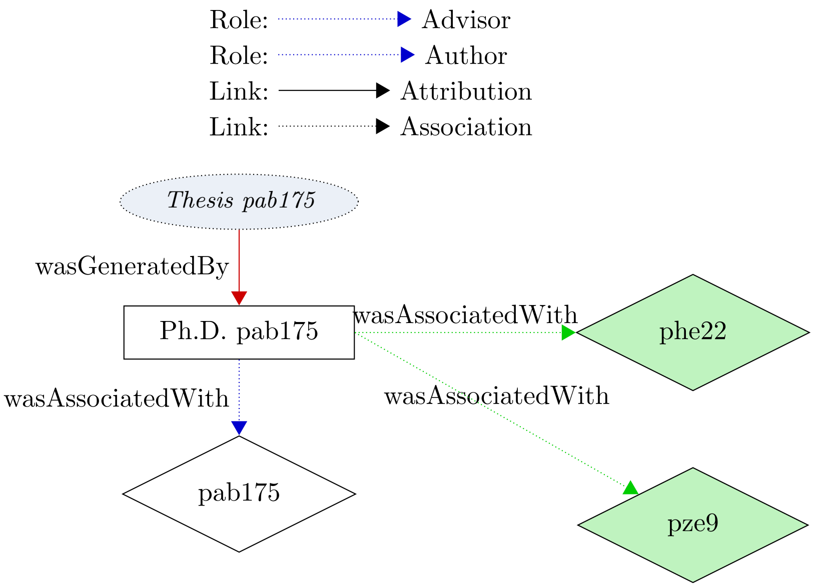
Activities

```
<prov:activity prov:id=”repec:PhD”/>
<prov:activity prov:id=”repec:PhDpab175”/>
<prov:activity prov:id=”repec:advisor”/>
<prov:activity prov:id=”repec:advisorpab1751”/>
<prov:activity prov:id=”repec:advisorpab1752”/>
```

(XML file attached : theses-activities.xml)

Linking them

Figure 1: Thesis graph

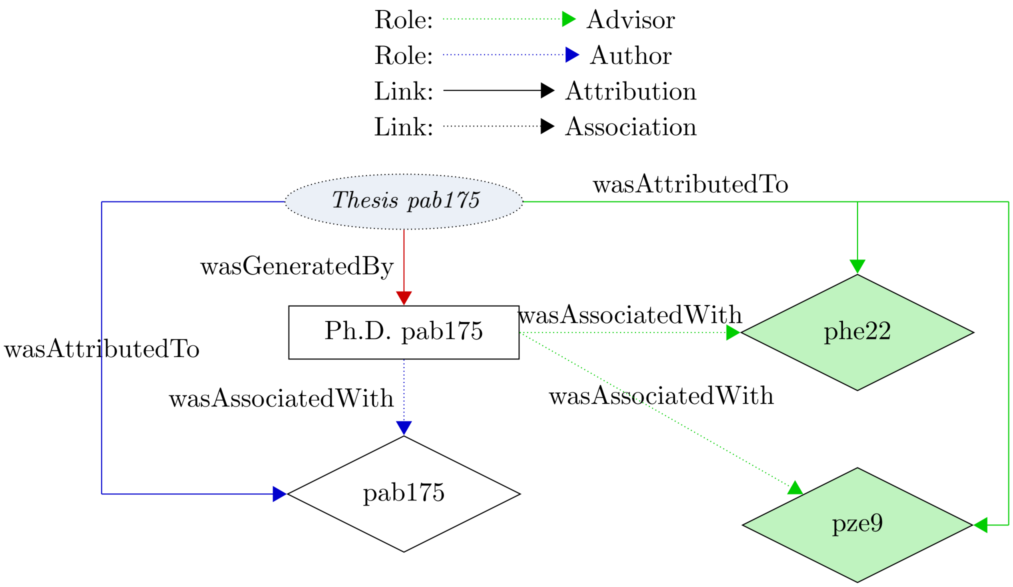


```
<prov:wasAssociatedWith>
  <prov:activity  prov:ref=”repec:thesispab175”/>
  <prov:agent  prov:ref=”repec:pab175”/>
  <prov:role>repec:author</prov:role>
</prov:wasAssociatedWith>

<prov:wasAssociatedWith>
  <prov:activity  prov:ref=”repec:thesispab175”/>
  <prov:agent  prov:ref=”repec:pze9”/>
  <prov:role>repec:advisor</prov:role>
</prov:wasAssociatedWith>

<prov:wasAssociatedWith>
  <prov:activity  prov:ref=”repec:thesispab175”/>
  <prov:agent  prov:ref=”repec:phe22”/>
  <prov:role>repec:advisor</prov:role>
</prov:wasAssociatedWith>

<prov:wasGeneratedBy>
      <prov:entity    prov:ref=”repec:thesispab175”/>
      <prov:activity  prov:ref=”repec:PhDpab175”/>
</prov:wasGeneratedBy>
```

(XML file attached : theses-links1.xml) Pulling these together generates the simple subgraph in Figure 1: However, by explicitly incorporating attributions, we recover the original database construction.

```
<prov:wasAttributedTo>
      <prov:entity    prov:ref=”repec:thesispab175”/>
  <prov:agent  prov:ref=”repec:pab175”/>
```

Figure 2: Thesis graph with attribution



```
  <prov:role>repec:author</prov:role>
</prov:wasAttributedTo>

<prov:wasAttributedTo>
      <prov:entity   prov:ref=”repec:thesispab175”/>
  <prov:agent prov:ref=”repec:pze9”/>
  <prov:role>repec:advisor</prov:role>
</prov:wasAttributedTo>

<prov:wasAttributedTo>
      <prov:entity   prov:ref=”repec:thesispab175”/>
  <prov:agent prov:ref=”repec:phe22”/>
  <prov:role>repec:advisor</prov:role>
</prov:wasAttributedTo>
```

XML file attached Incorporating this into the graph, we first obtain a more complex graph (Figure 2): However, collapsing the graph to only the attribution links yields a representation amenable to the usual bipartite graph visualization (Figure 3).

2.2 Co-authorship

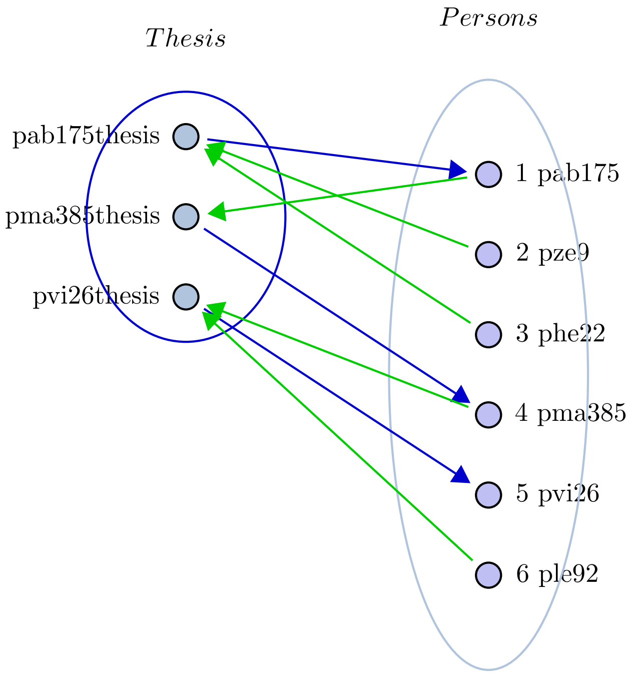
The RePEc coauthorship network already exists at `http://collec.repec.org`. (internal representation to be added here).

Implicit in that network is a simple bi-partite network between articles (entities) and authors (agents). Translated into PROV (`http://www.w3.org/TR/2013/NOTE-prov-primer-20130430/`), the definition of agents are as before, whereas the new entities are

Entities

```
<prov:entity prov:id=”exn:article”>
```

Figure 3: Theses as bipartite graph



```
    <dct:title>A published paper</dct:title>
  </prov:entity>
  <prov:entity prov:id=”hdl:RePEc:eee:econom:v:161:y:2011:i:1:p:82-99”>
    <dct:title>National estimates of gross employment and job flows from the
         Quarterly Workforce Indicators with demographic and industry detail
       </dct:title>
    <dct:date>2011</dct:date>
  </prov:entity>

  <prov:entity prov:id=”exn:paper”>
    <dct:title>A working paper</dct:title>
  </prov:entity>
  <prov:entity prov:id=”hdl:RePEc:cen:wpaper:10-11”>
    <dct:title>National estimates of gross employment and job flows from the
         Quarterly Workforce Indicators with Demographic and Industry Detail
       </dct:title>
    <dct:date>2010</dct:date>
  </prov:entity>
```

(XML file attached : coauthor-entities.xml)

Activities

For completeness, we define a research activity to generate articles and papers, although we could directly associate the paper with its authors:

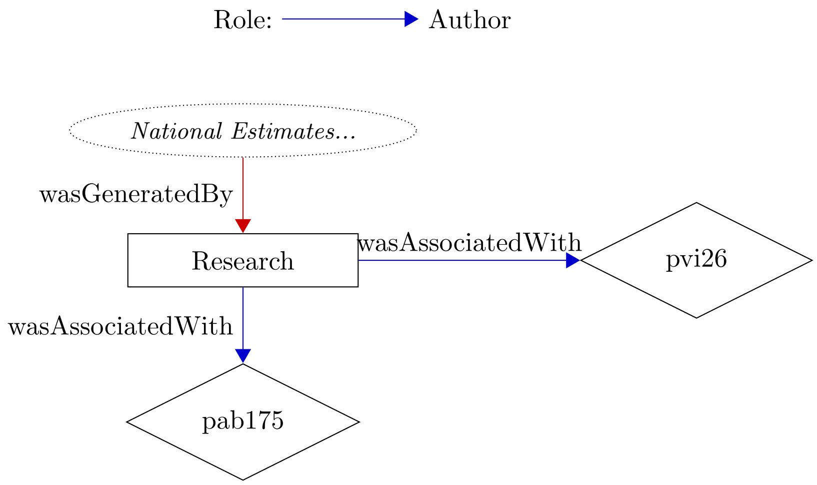
```
  <prov:activity prov:id=”repec:research”/>
  <prov:activity prov:id=”repec:research12345”/>
```

(XML file attached : coauthor-activities.xml)

Linking them

```
  <prov:wasAssociatedWith>
    <prov:activity prov:ref=”repec:research12345”/>
    <prov:agent prov:ref=”repec:pab175”/>
    <prov:role>repec:author</prov:role>
  </prov:wasAssociatedWith>

  <prov:wasAssociatedWith>
    <prov:activity prov:ref=”repec:research12345”/>
    <prov:agent prov:ref=”repec:pvi26”/>
    <prov:role>repec:author</prov:role>
  </prov:wasAssociatedWith>

  <prov:wasGeneratedBy>
              <prov:entity prov:id=”
                  hdl:RePEc:eee:econom:v:161:y:2011:i:1:p:82-99” />
              <prov:activity prov:ref=”repec:research12345”/>
  </prov:wasGeneratedBy>
  <prov:wasGeneratedBy>
          <prov:entity prov:id=”hdl:RePEc:cen:wpaper:10-11” />
              <prov:activity prov:ref=”repec:research12345”/>
  </prov:wasGeneratedBy>
```

Figure 4: Authorship with latent research activity



(XML file attached : coauthor-links.xml)

Pulling these together generates the subgraph in Figure 4.

The indirect association with the (latent) research activity is implicit in RePEc's linkage of different versions of the same article. Alternatively, these could be noted as revisions; however, the linkage through a research activity is potentially more general. In this case, the attribution is directly coded in the RePEc database, and the implicit research activity is deduced.

```
<prov:wasAttributedTo>
  <prov:entity prov:id=”hdl:RePEc:eee:econom:v:161:y:2011:i:1:p:82−99” />
  <prov:agent prov:ref=”repec:pab175”/>
  <prov:role>repec:author</prov:role>
</prov:wasAttributedTo>

<prov:wasAttributedTo>
  <prov:entity prov:id=”hdl:RePEc:eee:econom:v:161:y:2011:i:1:p:82−99” />
  <prov:agent prov:ref=”repec:pvi26”/>
  <prov:role>repec:author</prov:role>
</prov:wasAttributedTo>
```

(XML file attached : coauthor-links2.xml)

For simplicity, a simplified version of the graph, omitting the latent research activity, more closely approximates the bipartite representation:

Figure 5: Authorship with direct attribution

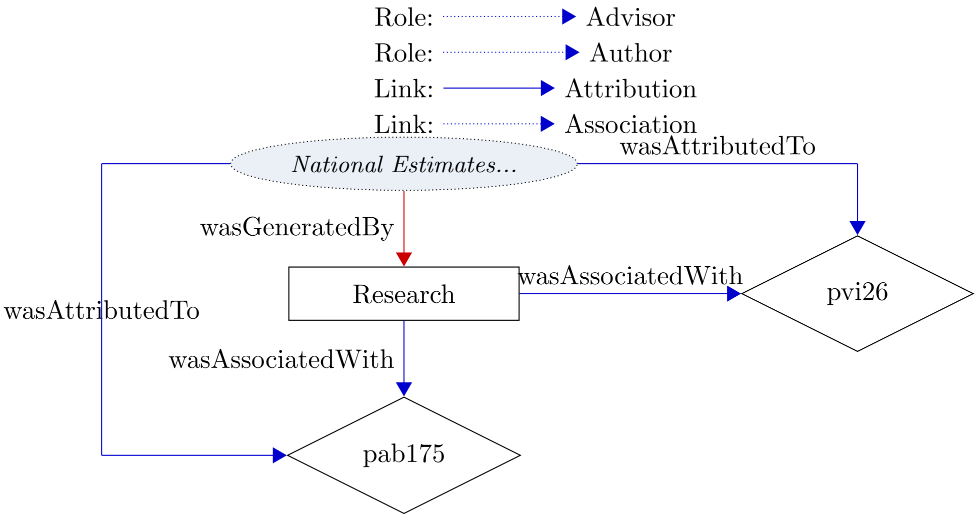


Figure 6: Authorship with direct attribution

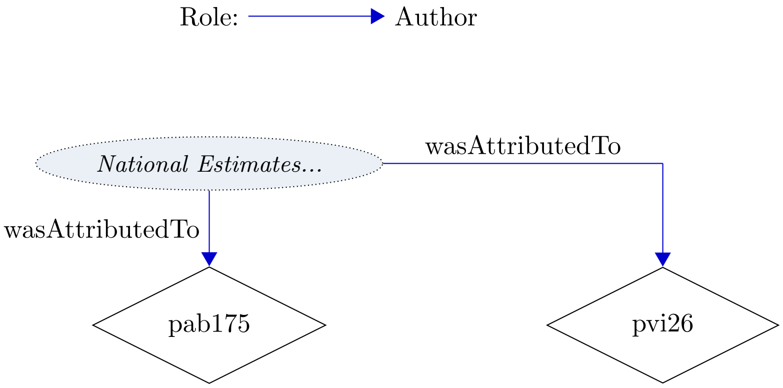
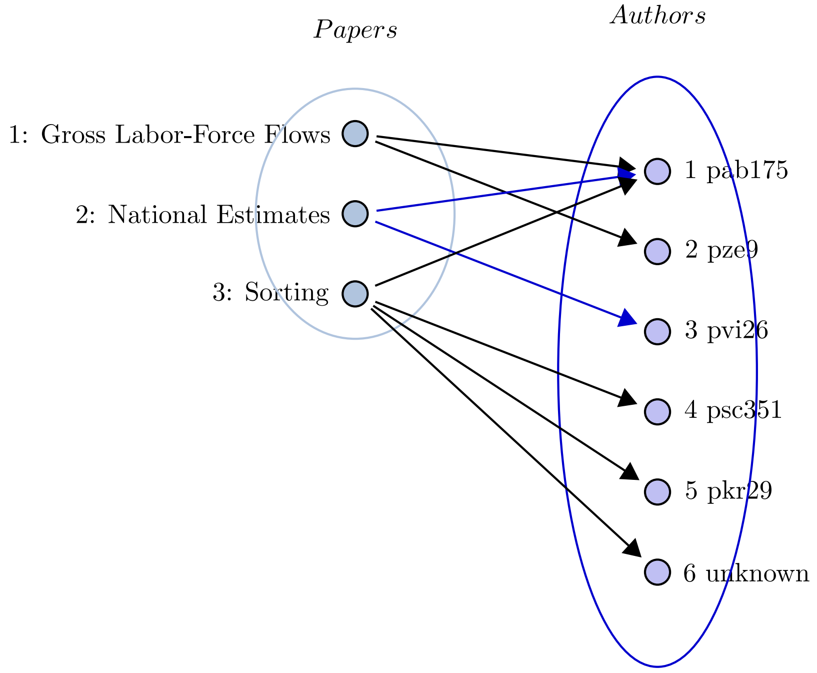


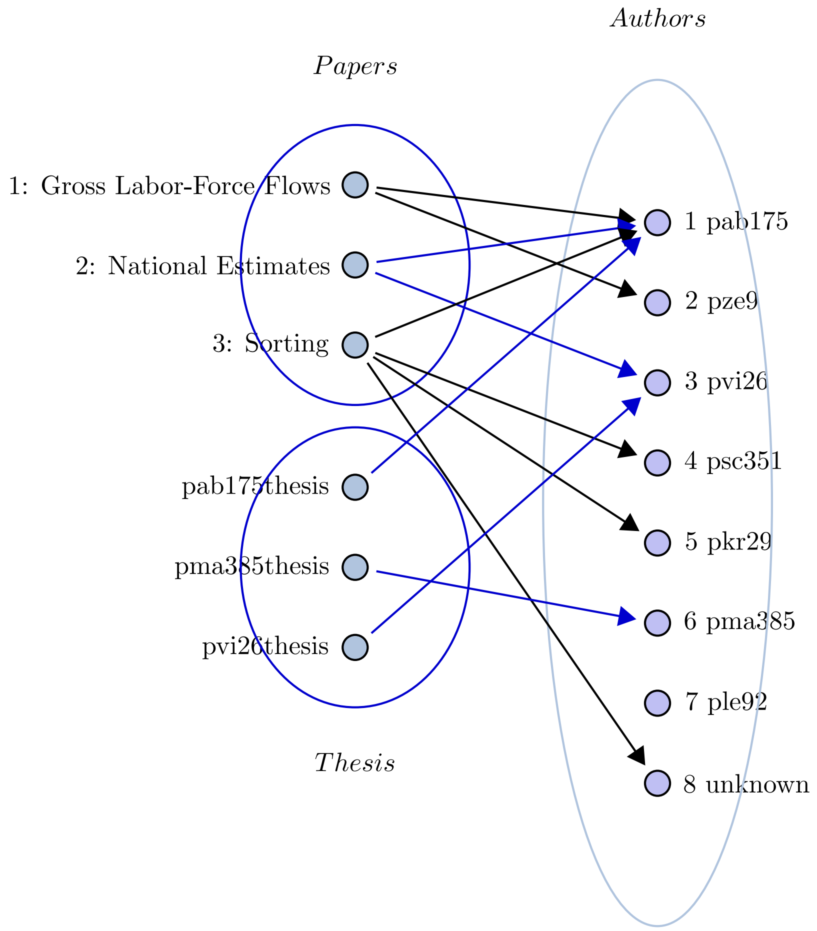
Figure 7: Authorship with direct attribution



3 Combining the subgraphs

We set up the subgraphs such that concepts are identical, and in particular, theses can be treated in much the same way that published articles and working papers can be: they are written artifacts ("entities") of a particular type, that are associated with authors ("agents"). The connectedness of the authorship network is entirely driven by co-author relations: entities with more than one edge generated connected groups. Adding theses to such a network does not change much: almost by definition, each theses has only one author. The average degree of the network might be slightly reduced, in fact, although the RePEc network has an upward bias in the degrees - authors who only publish their thesis and then exit academia, and who those have a low degree, are (probably) under-represented. Figure 8 shows the bipartite representation of the RePEc network with theses added in.[1]

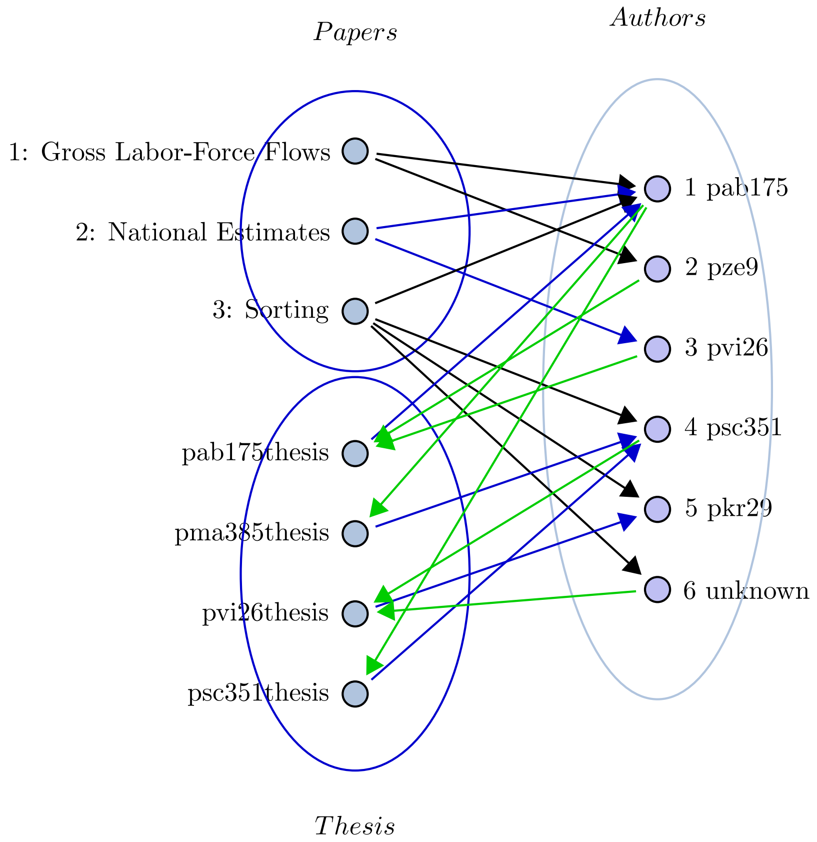
Figure 8: Authorship with theses



However, by adding in a new type of link – advisorship –, the RePEc collaboration network quite naturally is extended, and a substantial amount of new edges are added (Figure 9).

[1] Note that theses are not captured by the RePEc network, and thus don't actually have an entry.

Figure 9: Authorship with theses and advisors



4 Network metrics before and after

We should compute the network metrics before and after the inclusion of thesis advisors in the collaboration network. (average number of edges, average path length, changes in ranking of betweenness).

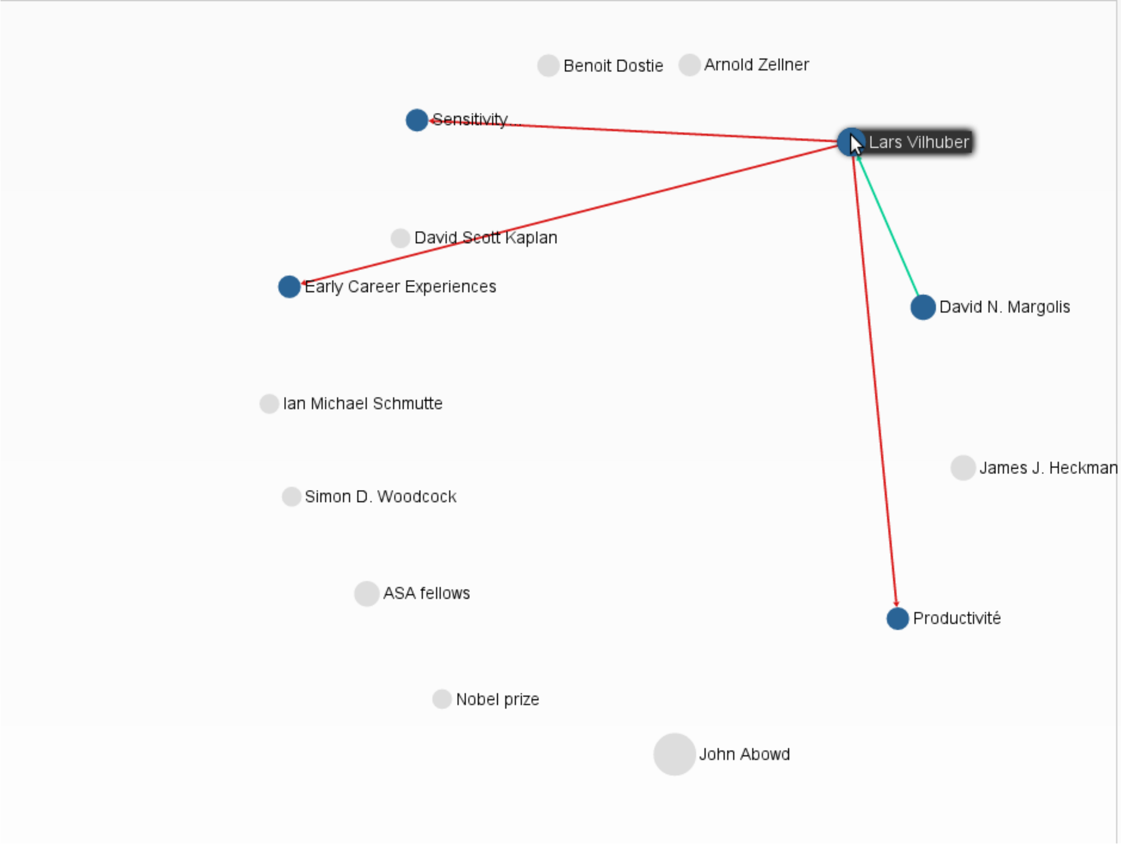
5 An exploratory interface

In order to provide a graphical frontend to the expanded network, we proceeded as follows:

- Combined information from the CollEC activity (list of the authorship network) with information from the RePEc Genealogy project (list of thesis advisors and advisees). Because thesis titles themselves are not captured, we define an implicit thesis entity; however, future enhancements to the RePEc Genealogy database may capture actual thesis titles, a complete list of advisors (when they are not yet identified on the RePEc network), and possibly URIs for each thesis.
- We note that the CollEC activity already defines a mechanism for storing node and edge information; the Genealogy project data is translated into this format to create the basis for the expanded network.
- A PROV representation of the data (as per the specifications defined earlier) is created (optional, but desirable)
- Finally, a graphical network browser that efficiently handles following edges to nodes (=entities) of all kinds, showing summary information while in the browser, and exiting to the full information on each node (people, institutions, articles and papers, datasets) when requested.

Here plug in the graphical interface. See examples of a thesis-based graph at `http://www.vrdc.cornell.edu/repecgraph/` and Figure 10. An example mechanism is being developed at `http://dev.ncrn.cornell.edu/ced2ar-web/prov2/` and may serve as the basis.

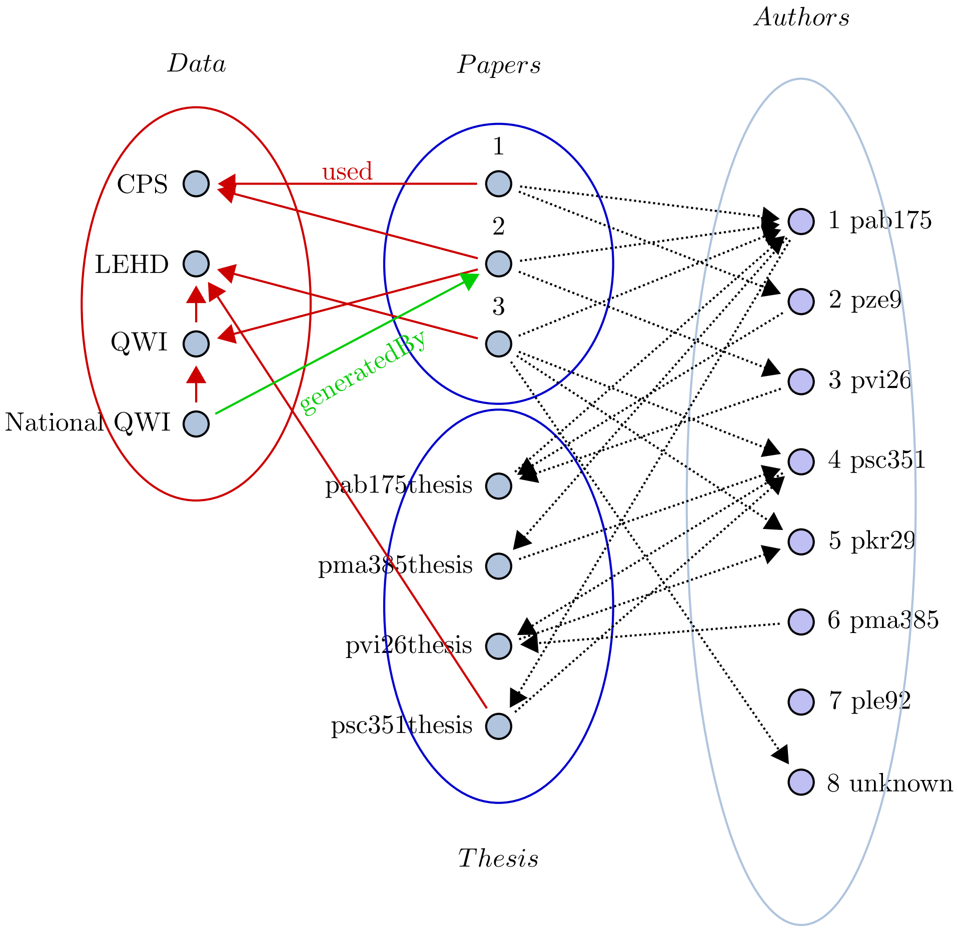
Figure 10: Example webinterface



6 Future work

Already present in the RePEc network are citation links (linking papers among themselves). This work links in with CED^{2}AR work (citations) and other efforts for linking papers and articles to the data used for (empirical) papers. Establishing such links can be represented by a tripartite graph:

Figure 11: Authorship with theses, data



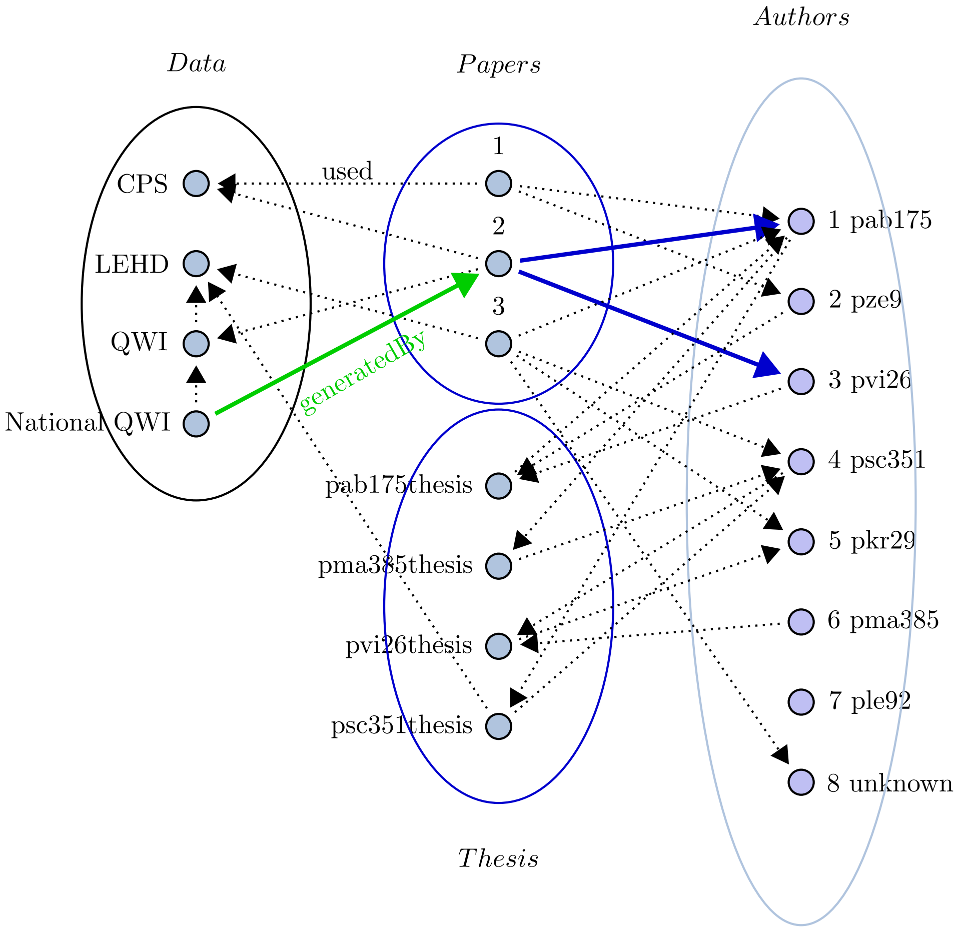
This will ultimately allow to attribute authorship for certain datasets in a clear fashion, which is currently not usual in the social sciences.[2] For an example, see Figure 12.

References

[1] Thomas Krichel. *ReDIF*. RePEc and ReDIf documentation ReDIF. RePEc Team, 1997. URL: `http://ideas.repec.org/p/rpc/rdfdoc/redif.html`.

[2] See ICPSR examples, however.

Figure 12: Authorship of data



Authors
Data
Papers
CPS
used
1
2
LEHD
3
QWI
National QWI
generatedBy
1 pab175
2 pze9
3 pvi26
4 psc351
5 pkr29
6 pma385
7 ple92
8 unknown
pab175thesis
pma385thesis
pvi26thesis
psc351thesis
Thesis