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Software Architecture Reconstruction: Abstraction

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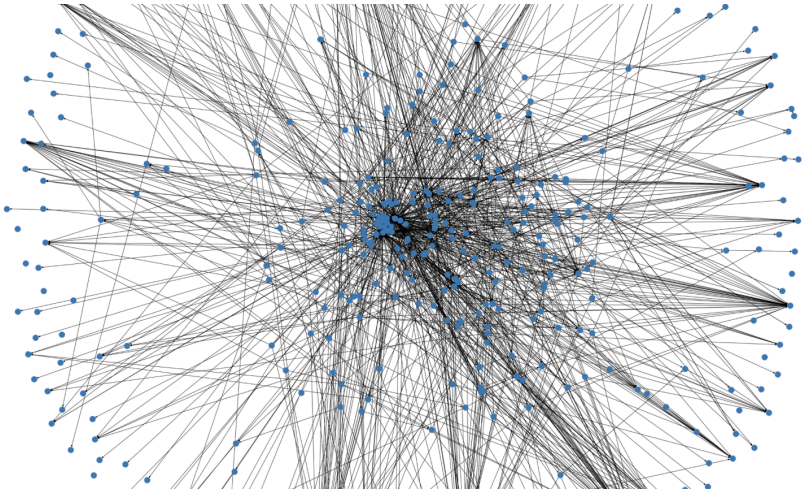
github.com/mircealungu/reconstruction

The *source view* obtained last time...

... is beautiful... isn't it?



- **System**: zeeguu/api
- **Source View**: Modules & Dependencies
- **Entities**: .py files in the project
- **Relationships**: import statements between .py files

(*Image from the Basic Data Gathering notebook*)

What can we can do to simplify the source view?

1/ Remove irrelevant nodes?

- the view shows dependencies to external modules. if goal is understanding *this system's structure* ... are they needed?
  - Discuss: how to we define *external* modules?
- Notebook activity: [**Filter out the non-system dependencies](Basic Abstraction. Does the graph look better?
- Conclusion: filtering is a useful *tool* in AR

**2 / Try different layouts? layout from networkx

Notebook activity: try the draw_kamada_kawai layout - Lesson: layouts can make a difference

Knowledge Inference / Abstraction

Symphony... (Sec. 6.2): "The reconstructor creates the target view by ...

- **condensing the low-level details** of the source view, and
- **abstracting them** into architectural information.

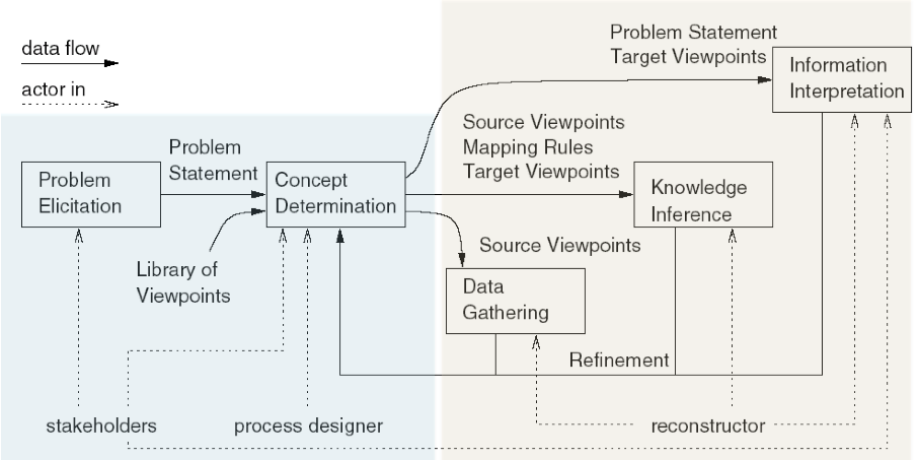


Figure 1: 600

"[...] domain knowledge is used to **define a map between the source and target view**."

> This activity may require either interviewing the system experts in order to formal- ize architecturally-relevant aspects not available in the implementation or to iteratively augment the source view by adding new concepts to the source viewpoint
>
> – Symphony, 6.2

Approach #1: Using the Folder Hierarchy

Hierarchies are powerful. We organize societies in them. And we organize software systems in them.

Exemplifying with a few classes from ArgoUML

Based on containment relationships we can: 1. Aggregate nodes 2. Aggregate dependencies

The following image presents a few classes and packages from the FOSS project ArgoUML

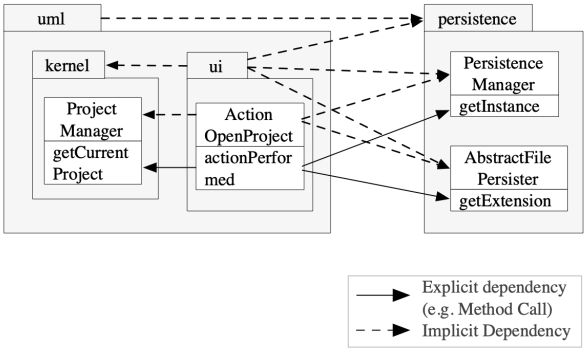


Figure shows that we can distinguish between 1. **Explicit dependencies** - method call - import - subclassing 2. **Implicit aggregated dependencies** (because there are other kinds of implicit dependencies we will see next time)

To Which Level Do we Aggregate?

Notebook: Basic Abstraction: Exploring aggregation levels..

Conclusion: you can not know upfront to what level to aggregate. So it is good to be able to explore various levels.

It might be that different modules need to be explored at different levels.

Pros and Cons of Folder-Based Aggregation

Pros: 1. Works for many languages & systems 2. Can be used in a MSc thesis :) (e.g. topic1, topic2)

Cons: - Some languages don't use the folder structure the same way: C# has folders vary independent from namespaces. There you have to analyze namespaces. - COBOL does not have a folder structure at all. Smalltalk also does not.

Approach #2: Using Metrics

A software metric is a **measure of software characteristics** which are measurable or countable

Types of metrics: 1. Product - measure the resulting product, e.g. source code 2. Process - measure the process, e.g. frequency of change

So how is this a complementary tool?

Remember the def of architecture: **"[. . .] modules, their properties, and the relationships between them"**

Metrics can express these *"properties"*.

Product metrics that can be aggregated from files to higher level abstractions

Almost anything. The only choice is: how do you aggregate? Do you sum? Do you average? It depends on the question you are asking.

For **Files/Methods** - **Cyclomatic Complexity** (wiki) - number of linearly independent code paths through source code (functions of the number of branches) - often used in quality: too much complexity is a bad thing - hidden partially by polymorphism

For **Modules** - **Size** - LOC - lines of code - NOM - number of methods

For **Dependencies** - **Total count** of explicit low-level dependencies - **Number of distinct** explicit low-level dependencies

Augmenting Recovered Views with Metrics

One approach would be an interactive top-down exploration approach combined with metrics is Softwarenaut (video, paper) described in Evolutionary and Collaborative Software Architecture Recovery with Softwarenaut, by Lungu et al.

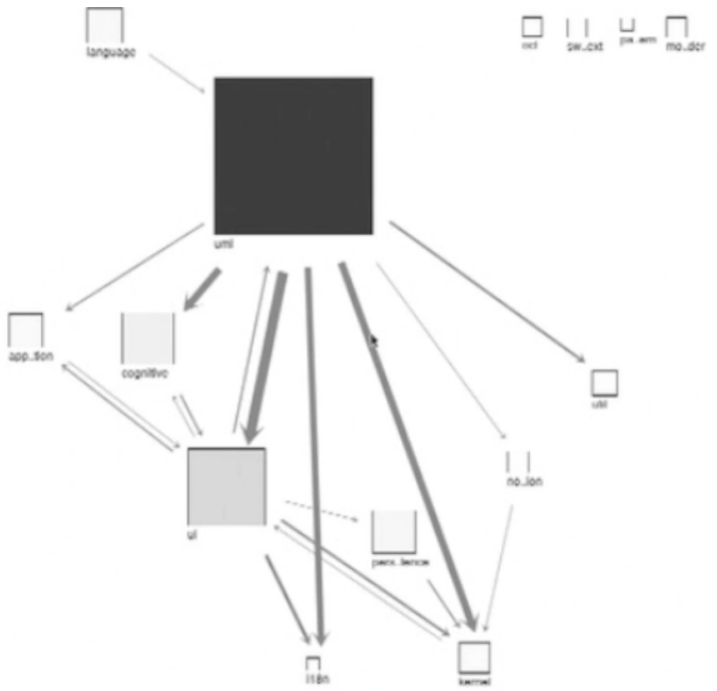
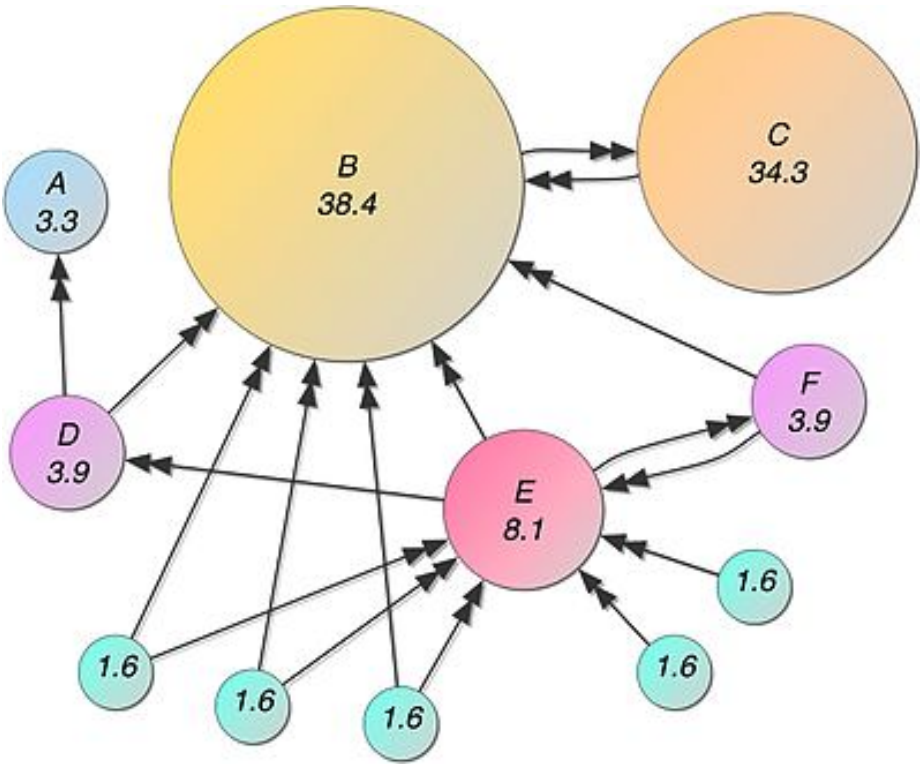


Figure: Augmeting nodes and dependencies with metrics in ArgoUML packages.

Approach #3: Detecting Essentials With Network Analysis

The PageRank algorithm that made Google famous tries to gauge the importance of a page in a network of pages based on the references pages make to each other.



The their paper, Ranking software artifacts, by Perin, Renggli, and Ressia applied the algorithm in order to attempt to detect the most relevant elements in a software system.

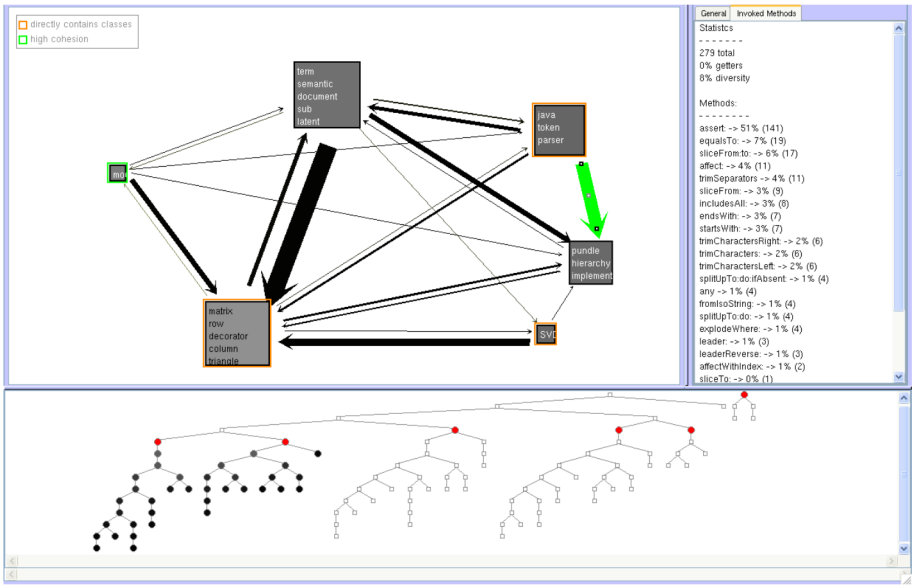
Consider trying it out in your project if you're interested in network analysis!

`networkx` supports various methods of network analysis, e.g. centrality, HITS, pagerank

Approach #4 - Automatic Clustering

What if we did unsupervised learning? We could do hierarchical clustering, of the system, for example, and hope that the clusters are mapped on architectural components.

Example: Interactive Exploration of Semantic Clusters by Lungu et al.



Automatic clustering has been tried with - coupling and cohesion metrics - natural language analysis - ...

In all of the cases we still need human intervention to explore the result of the automatically detected clusters.

Reflexion Models

= an architectural viewpoint that indicates **where the source model and high-level model differ**

1. Convergences
2. Divergences
3. Absences

Introduced in **Software Reflexion Models: Bridging the Gap between Design and Implementation** *Murphy et al.* which:

- Ask Linux maintainers to
  1. draw dependencies between subsystems (*as-expected* architecture)
  2. provide mappings from file names to subsystems
- Recover the *as-implemented module view*
- Compare the *as-implemented* architecture with the *as-expected* architecture

Step 1.a. Maintainers draw dependencies between subsystems From: Software Reflexion Models: Bridging the Gap ...

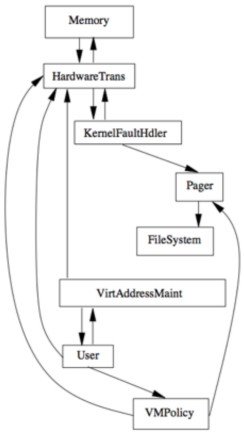
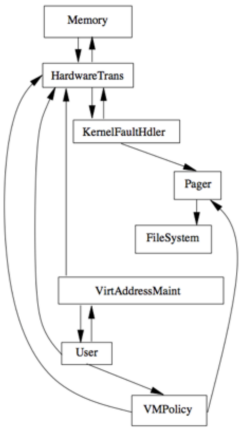


Figure 2: 900

Step 1.b. Maintainers provide mappings from file names to subsystems



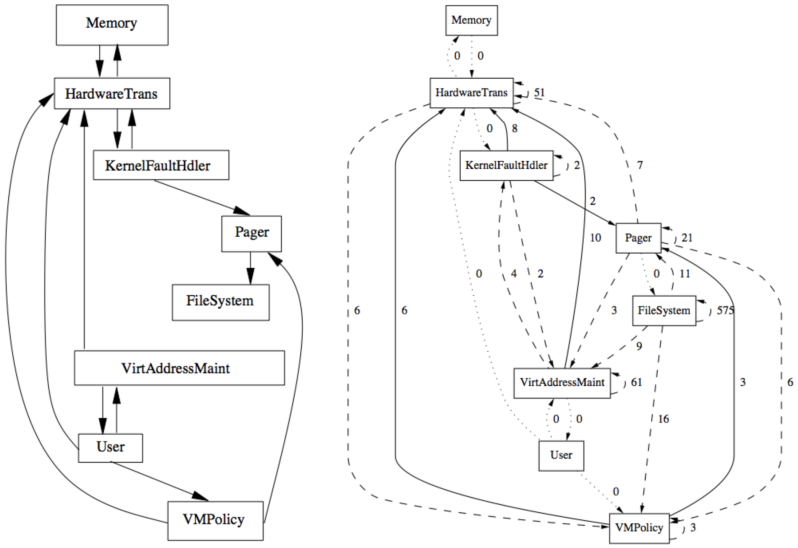
The Mapping

```
file= .*pager.*      mapTo=Pager
file= vm_map.*       mapTo=VirtAddressMaint
file=vm_fault\.c     mapTo=KernelFaultHandler
dir=[un]fs           mapTo=FileSystem
dir=sparc/mem.*]     mapTo=Memory
file=pmap.*          mapTo=HardwareTrans
file=vm_pageout\.c   mapTo=VMPolicy
```

Provided by the developers

From: Software Reflexion Models: Bridging the Gap...

Step 2. Comparing the As-Implemented and the As-Expected Dependencies



Obtaining a reflection model is an **iterative process**:

```
Repeat
    1. Define/Update high-level model of interest
    2. Extract a source model
    3. Define/Update declarative mapping between high- level model and source model
    4. Reflexion model computed by system
    5. Interpret the software reflexion model.
Until "happy"
```

Personalizing your Project

- Can you visualize also dependency metrics with networkx? E.g. a stronger dependency as a thicker arrow?
- Consider using `pyvis` instead of `networkx` – it has much nicer visualizations!
- Consider exporting the data from networkx into specialized graph visualization tools
- Compute size metrics, and map them on the nodes in your module view at the end of the Abstraction notebook

Advice: Start working on your project! Don't leave it all for the last moment!

To Think About

- In which way does mapping metrics on visualizations help make sense of the data
- Semi-automatic (~*automation with human in the loop*) solutions are always required in Architecture Reconstruction
- The difference between the views recovered today and a hand-drawn UML diagram?
  - what we created today is always telling the truth (*live diagrams*)
  - but, **maybe not all the truth?**

Note: Importance of Understanding Dependencies in Architecture Reconstruction AR helps us to *tell a story* about the system.

To tell a story one needs: - subjects - the modules in the view - actions - the dependencies in the view

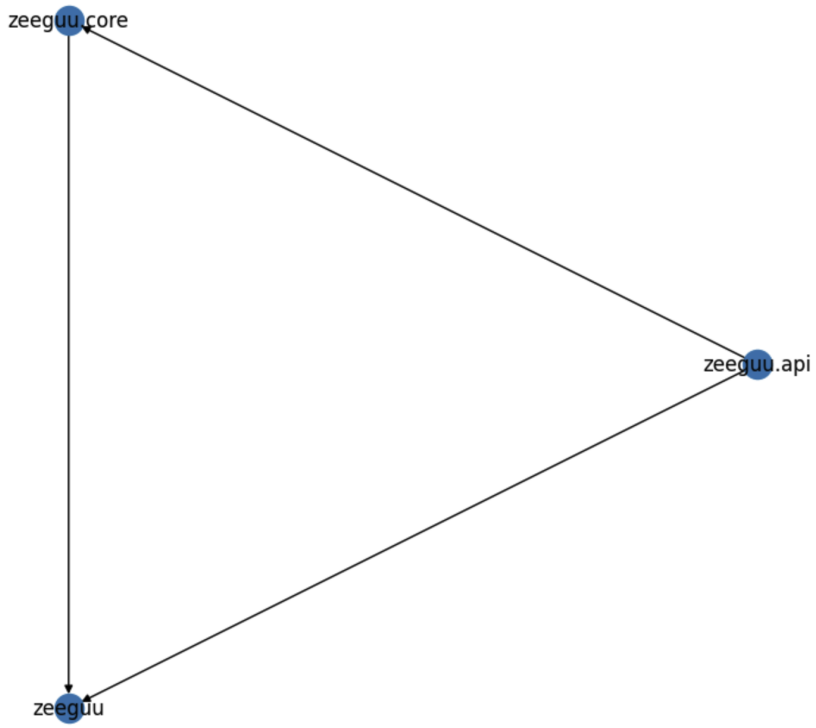


Figure 3: 300

In your project aim to describe also the reason for the dependencies (at least the most essential ones)