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Software Architecture Reconstruction: Abstraction

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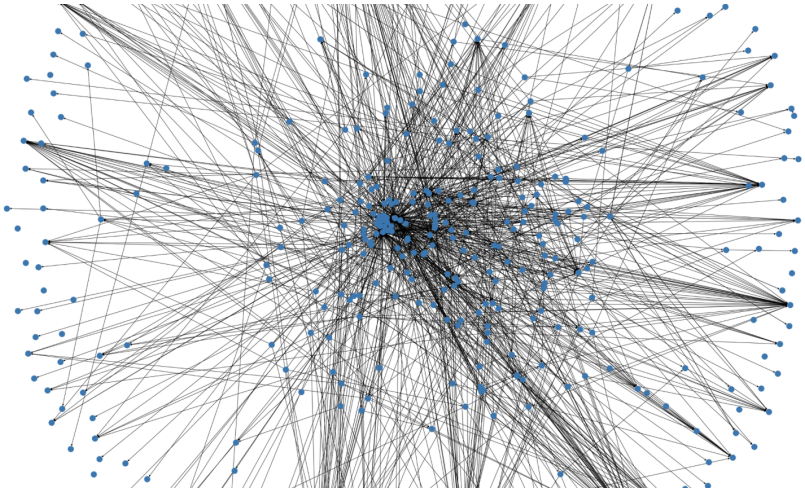
github.com/mircealungu/reconstruction

The *source view* obtained last time

It is beautiful, isn't it?



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

Refining the source view to simplify it?

Starting from the Basic Data Gathering notebook...

1/ Add labels to the nodes. Do you see irellevant nodes?

- the view shows dependencies to external modules
- if goal is understanding *this system's structure* ... are they needed?

2/ **Filter out the non-system dependencies** *(approx. all that don't start with* `zeeguu`*)* **Does the graph look better?**

Lesson: filtering is an important tool for AR

2 / Let's try another layout from networkx (e.g. draw_kamada_kawai). Can you spot other irellevant modules?

- tests are also not very relevant
- Lesson: layouts are important

3 / Filter out tests. Does the view look cleaner?

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What else can we do here to simplify?

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.

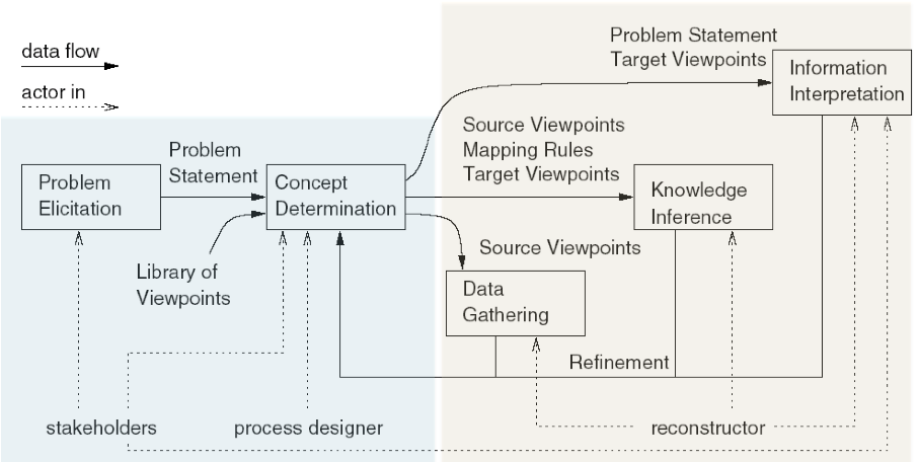


Figure 1: 600

"[...] 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 im- plementation or to iteratively augment the source view by adding new concepts to the source viewpoint
>
> – Symphony, 6.2

Approach #1: Mapping Using Naming Conventions

[..] **if the mapping contains a rule about using naming conventions to combine classes into modules**, the resulting map lists each class and the module to which it belongs."

Reflexion Model

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

1. Convergences
2. Divergences
3. Absences

Obtaining it 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"
```

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

Case Study In **Software Reflexion Models: Bridging the Gap between Design and Implementation** *Murphy et al.*: - 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 ...

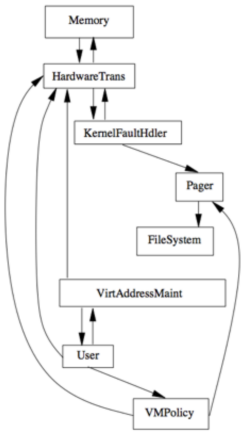
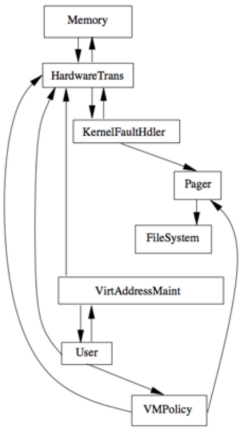


Figure 2: 900

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



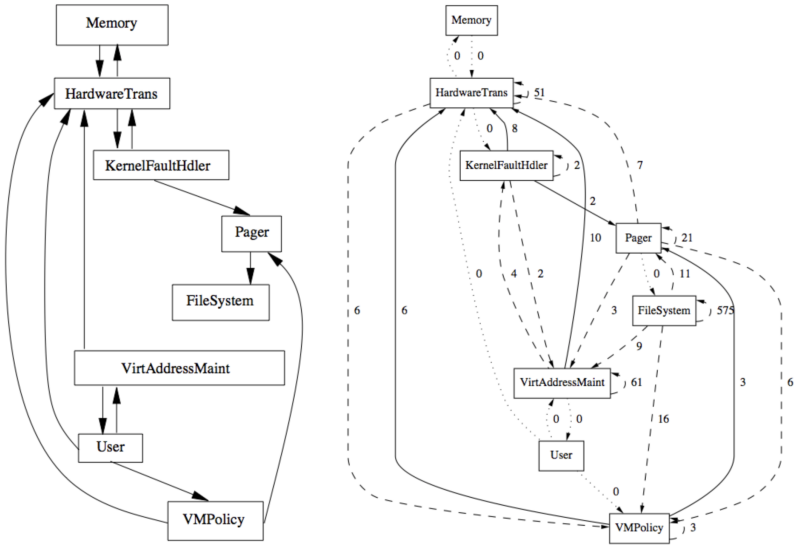
The Mapping

```
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



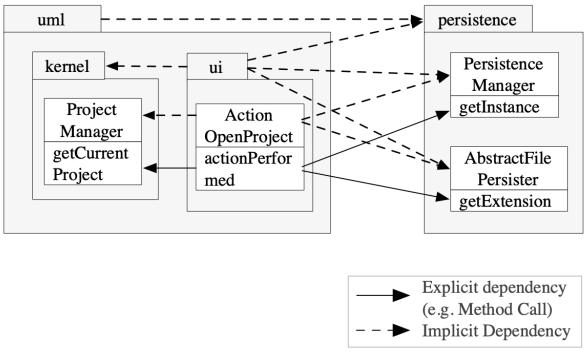
From: Software Reflexion Models: Bridging the Gap ...

Approach #2: Using the Folder Hierarchy for Aggregation

Developers hierarchically organize files in folders. *Let us use that!* 1. Aggregate nodes 2. Aggregate dependencies 3. Show the aggregated dependencies & nodes

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

Example from ArgoUML



Two types of dependencies: 1. Explicit 2. Implicit

From: Evolutionary and Collaborative Software Architecture Recovery with Softwarenaut, by Lungu et al.

Basic Implementation in Python

Code: Basic Abstraction

Approach #3: Using Metrics for Abstraction

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

Q: *So how is this a complementary tool?*

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

–

A: Metrics can express these "properties".

Product metrics

For **Files/Methods** - **Cyclomatic Complexity** (aggregated from file level) - CYCLO - 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** (Aggregated from file level) - 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

Useful in top-down interactive exploration, e.g. Softwarenaut (video, paper)

e.g., Augmeting nodes and dependencies with metrics in ArgoUML packages with a *polymetric view*

Coding Assignment: Compute size metrics, and map them on the nodes in your module view at the end of the Abstraction notebook

Approach #4 (research!): Keep Only the Most Essential Elements Based on Network Analysis

e.g. Paper: Ranking software artifacts. by Perin, Renggli, and Ressia - Use the PageRank algorithm of Google - Abstracts by filtering out the less relevant nodes

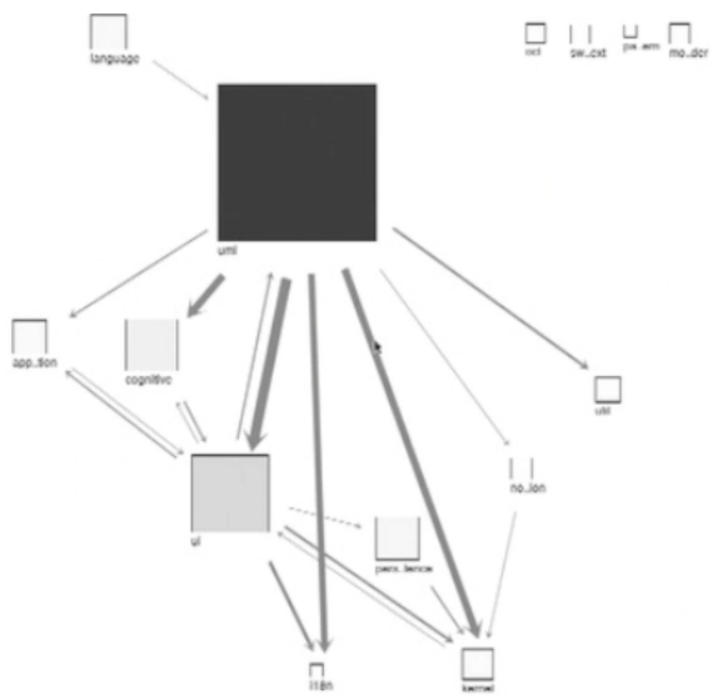

Figure 3: 400

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

???

- Automatic Clustering
  - has been tried with
    - coupling cohesion
    - natural language analysis
  - even in the case of clustering we still need human intervention

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

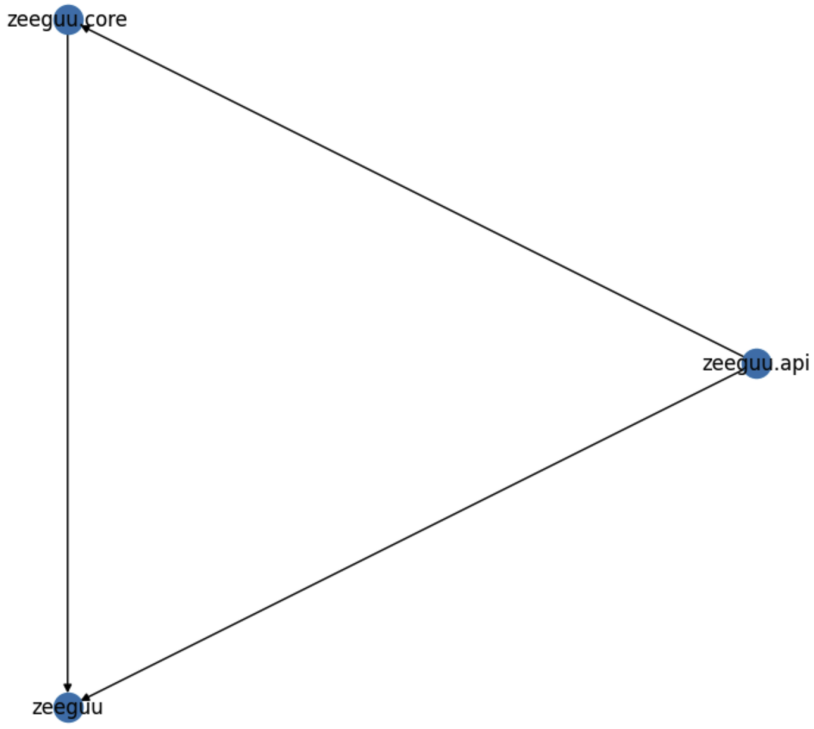

Figure 4: 300

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

To Think About

- Mapping metrics on visualizations helps 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?**

Personalizing your Project

- Can you complete the implementation of the import extractor with the missing part?
- 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

To Do: start working on your project! Don't leave it all for the last moment!