# Source-code quality

## Part 2. Software Visualizations

Andy Kellens

*"If I could say it in words, there would be no reason to paint"*

*-- Edward Hopper*

# In this lecture ...

- What is (software) visualization?
- What makes a good visualization?
- Software visualizations
- Moose tool suite
- Build your own visualization

# What is software visualization?

# What is software visualization?

- **Use of graphic means**
  - Typography
  - Graphic design
  - Animation
  - ...
- **To facilitate human understanding and effective use of computer software**

*(Stasko et al. , Software Visualization - Programming as a Multimedia Experience, MIT Press, 1998)*

# Why Software Visualizations?

- Process large quantities of information
- Human brain good at combining complex information from visual clues
- Pre-attentative process: draw attention to important parts

## Need for tools

- **Manual effort**
  - Review meetings
  - Find quality issues
  - 2 seconds per line of code
    - 250 KLOC * 2
    - 500 000 seconds
    - 140 hours
    - 18 days


**Need for tools that help in assessing quality attributes**

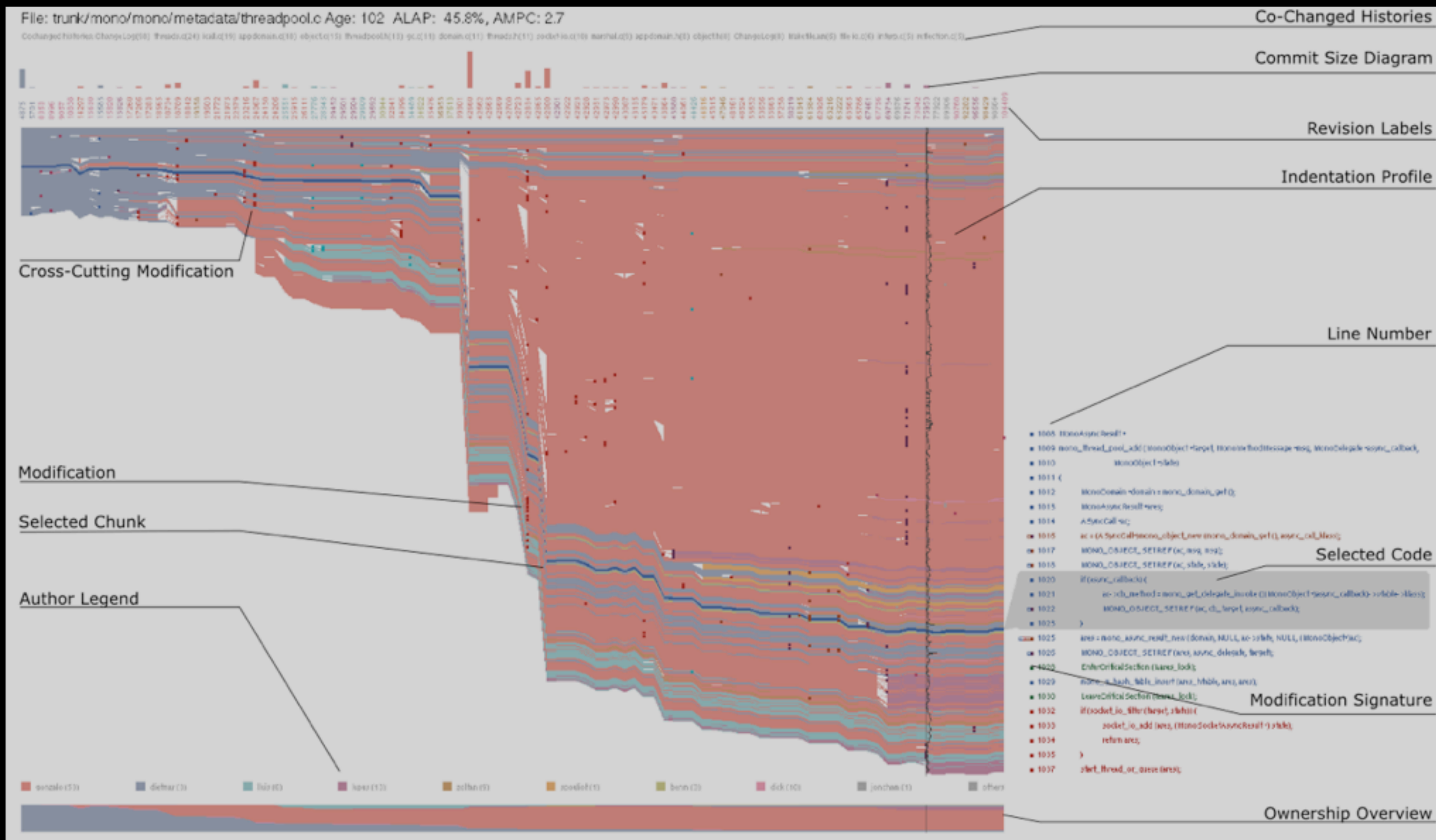
# For example: commit logs

```
------------------------------------------------------------------------
r19692 | cderoove | 2012-02-19 20:28:21 +0100 (Sun, 19 Feb 2012) | 2 lines

intro of three

------------------------------------------------------------------------
r19691 | cderoove | 2012-02-19 19:14:58 +0100 (Sun, 19 Feb 2012) | 2 lines

minor changes to section 2 + bib

------------------------------------------------------------------------
r19690 | cderoove | 2012-02-19 18:44:00 +0100 (Sun, 19 Feb 2012) | 2 lines

proper (;)) capitalization of SOOT and SOUL

------------------------------------------------------------------------
r19689 | cderoove | 2012-02-19 18:32:59 +0100 (Sun, 19 Feb 2012) | 2 lines

soul section

------------------------------------------------------------------------
r19681 | akellens | 2012-02-17 15:52:38 +0100 (Fri, 17 Feb 2012) | 1 line

Bigger boxplots
------------------------------------------------------------------------
r19680 | cnoguera | 2012-02-17 15:39:29 +0100 (Fri, 17 Feb 2012) | 2 lines

Added ref to acceleo, also explained a bit more on the transformation

------------------------------------------------------------------------
r19679 | akellens | 2012-02-17 14:53:39 +0100 (Fri, 17 Feb 2012) | 1 line

Iteration done
------------------------------------------------------------------------
r19678 | cnoguera | 2012-02-17 14:44:16 +0100 (Fri, 17 Feb 2012) | 2 lines
```

Structured data

What can we see?

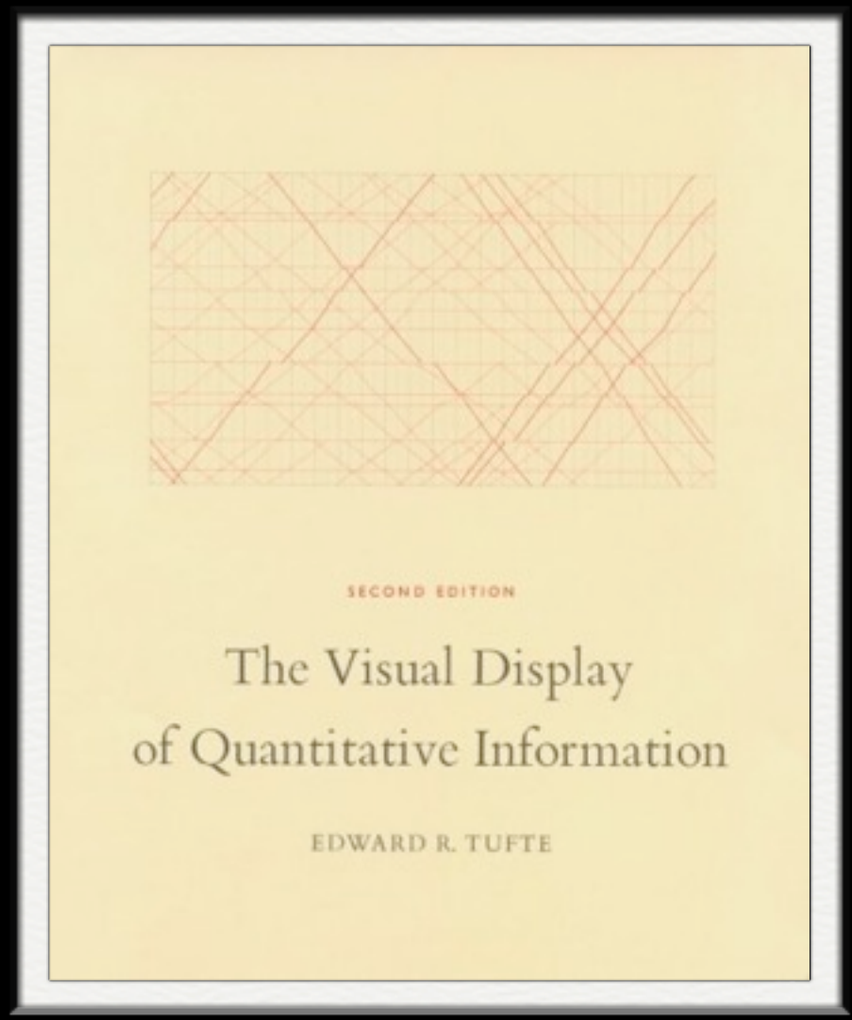
# Visualizing commits



# Properties of good visualizations

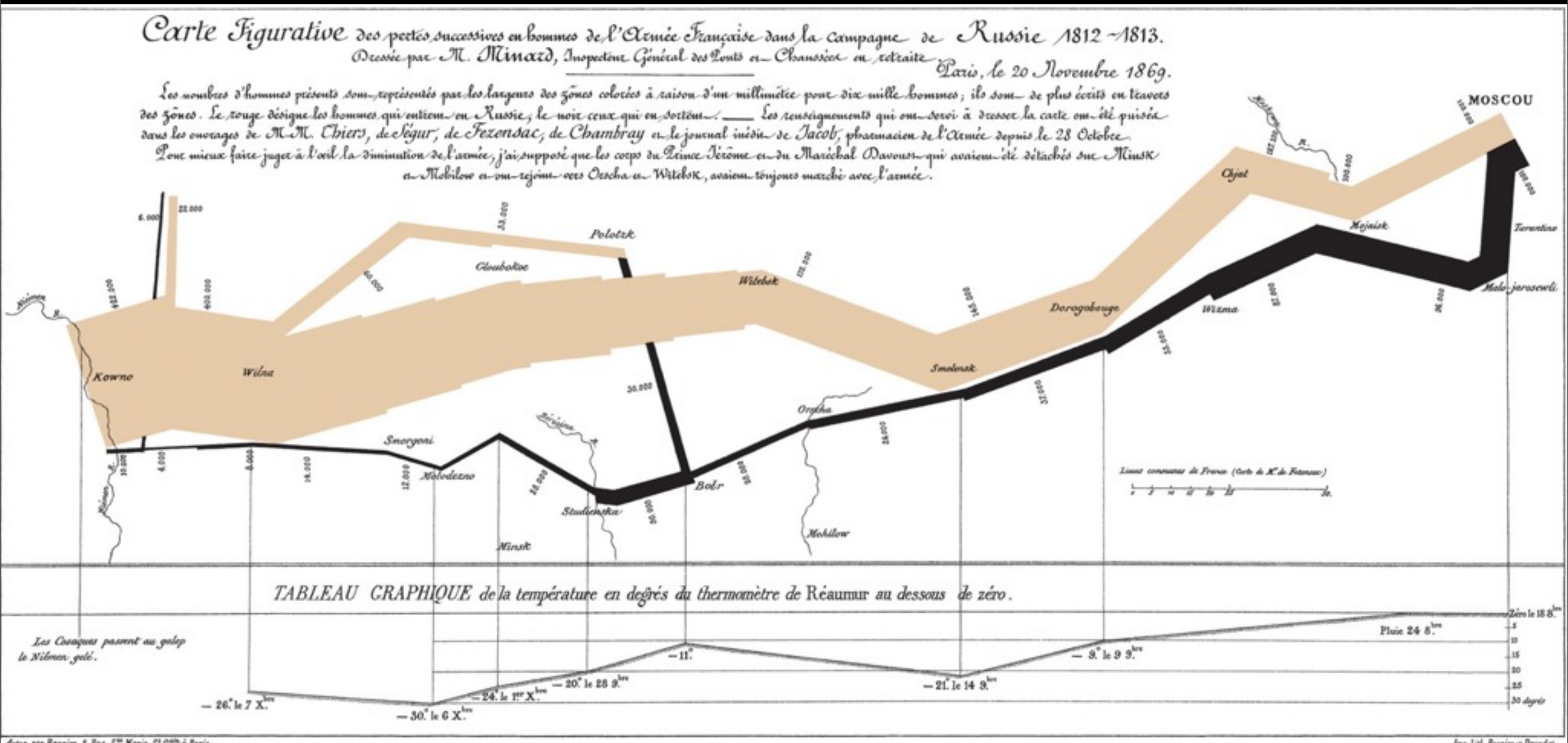
# What makes a good visualization?

- Designing good visualizations not trivial
- Sufficiently rich to convey info
- Not overwhelming
- Studied in cognitive sciences




**(Edward Tufte, 1983)**


# (John Snow, 1854)

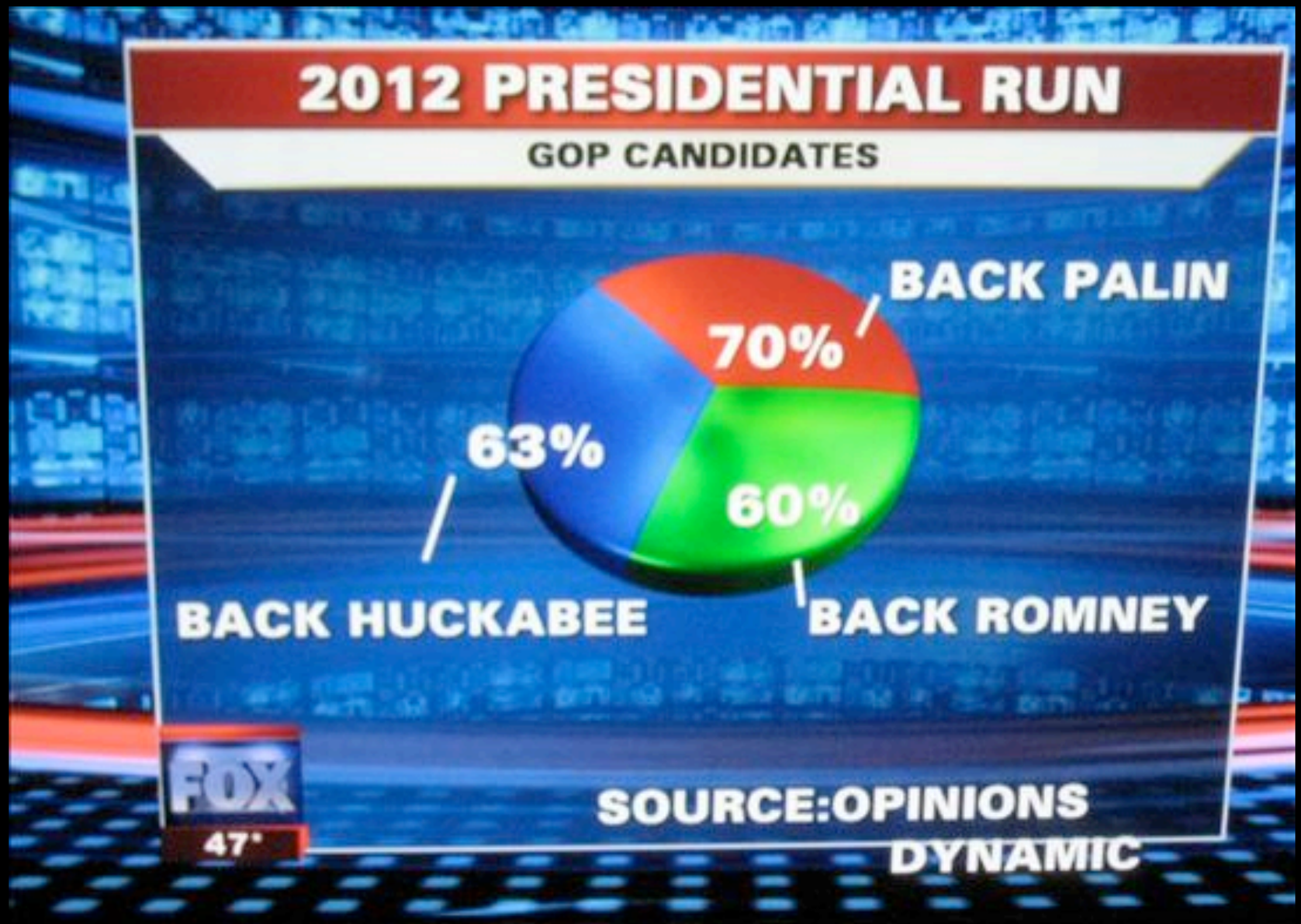



# (Charles Minard, 1861)

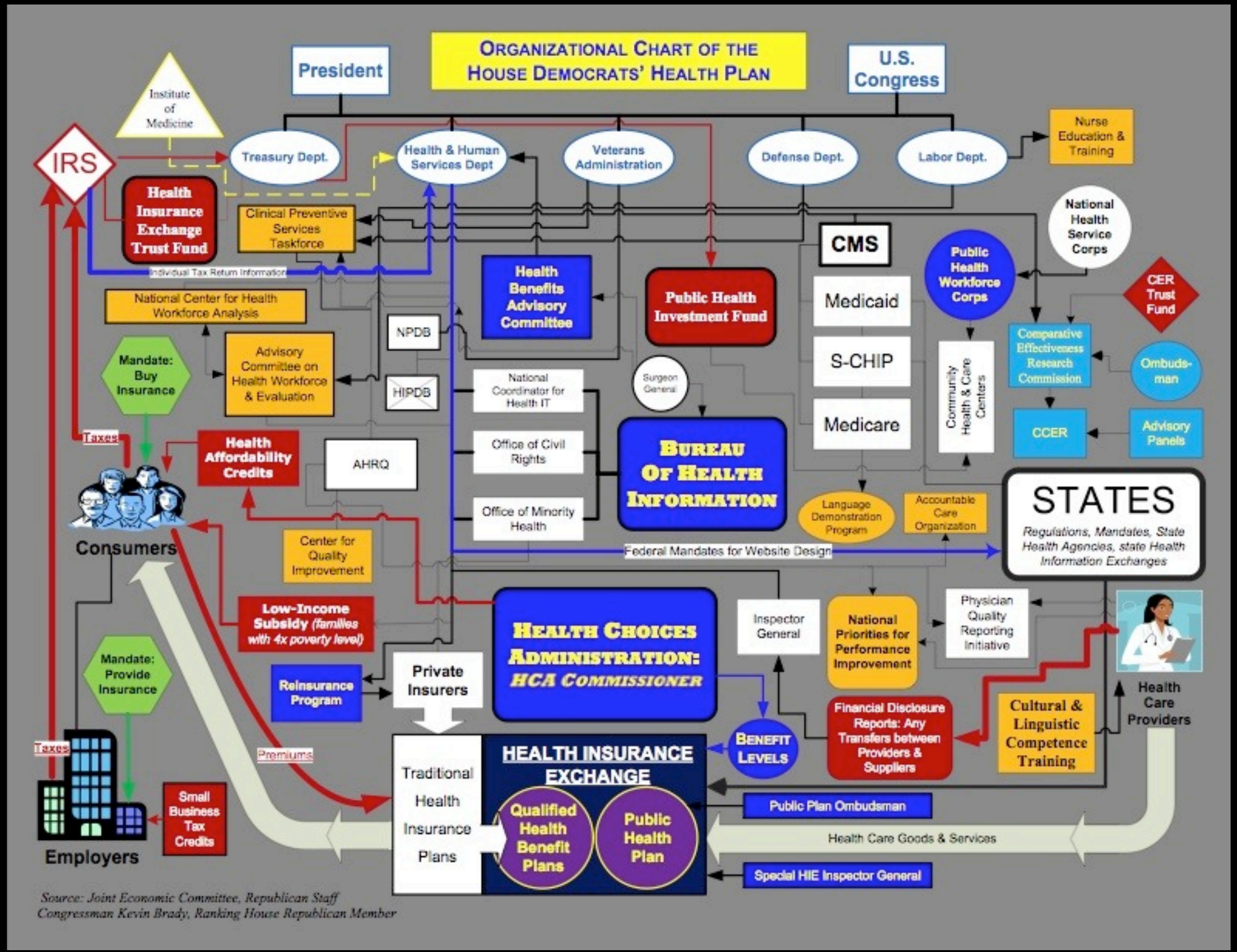
# Visualization Pitfalls

- **Colors:**
  - Attribute meaning to color
  - Max. 10 colors
- **Mapping to reality:**
  - Link with domain concepts; intuitive mapping
- **Information density:**
  - Every visual element should have a meaning
- **Scalability:**
  - Deal with lots of data
- **Interactivity:**
  - Intelligent use of interaction to increase usefulness

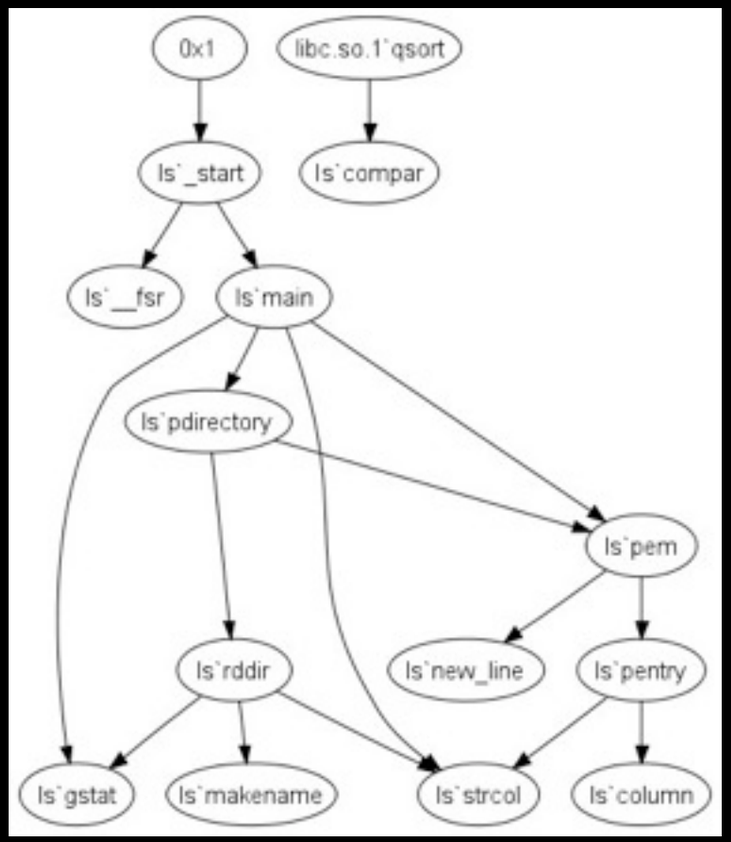
# Poor visualization 1



# Poor visualization 2



# Poor visualization 3

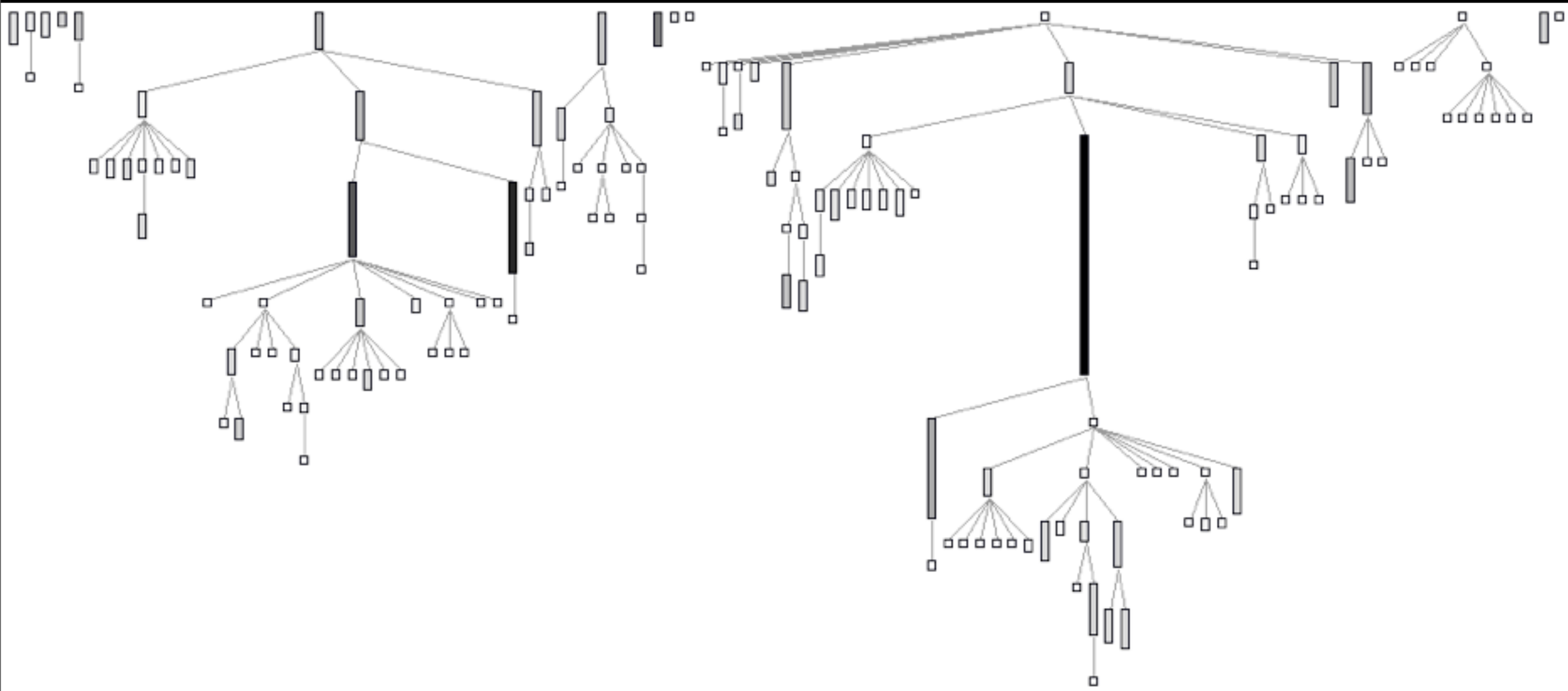



## Call graph

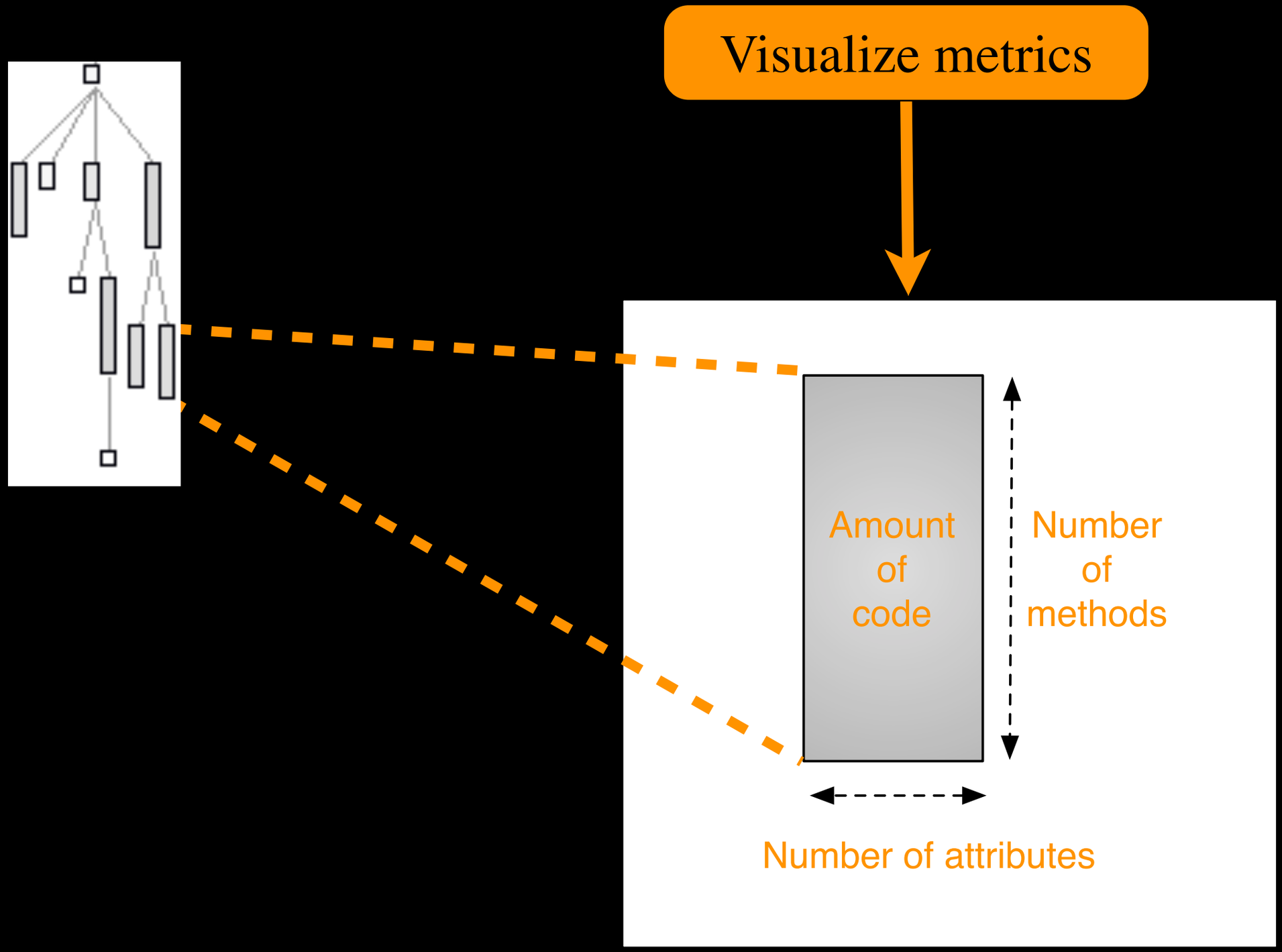
# Software Visualizations

# System complexity view [Lanza&Ducasse] (2003)

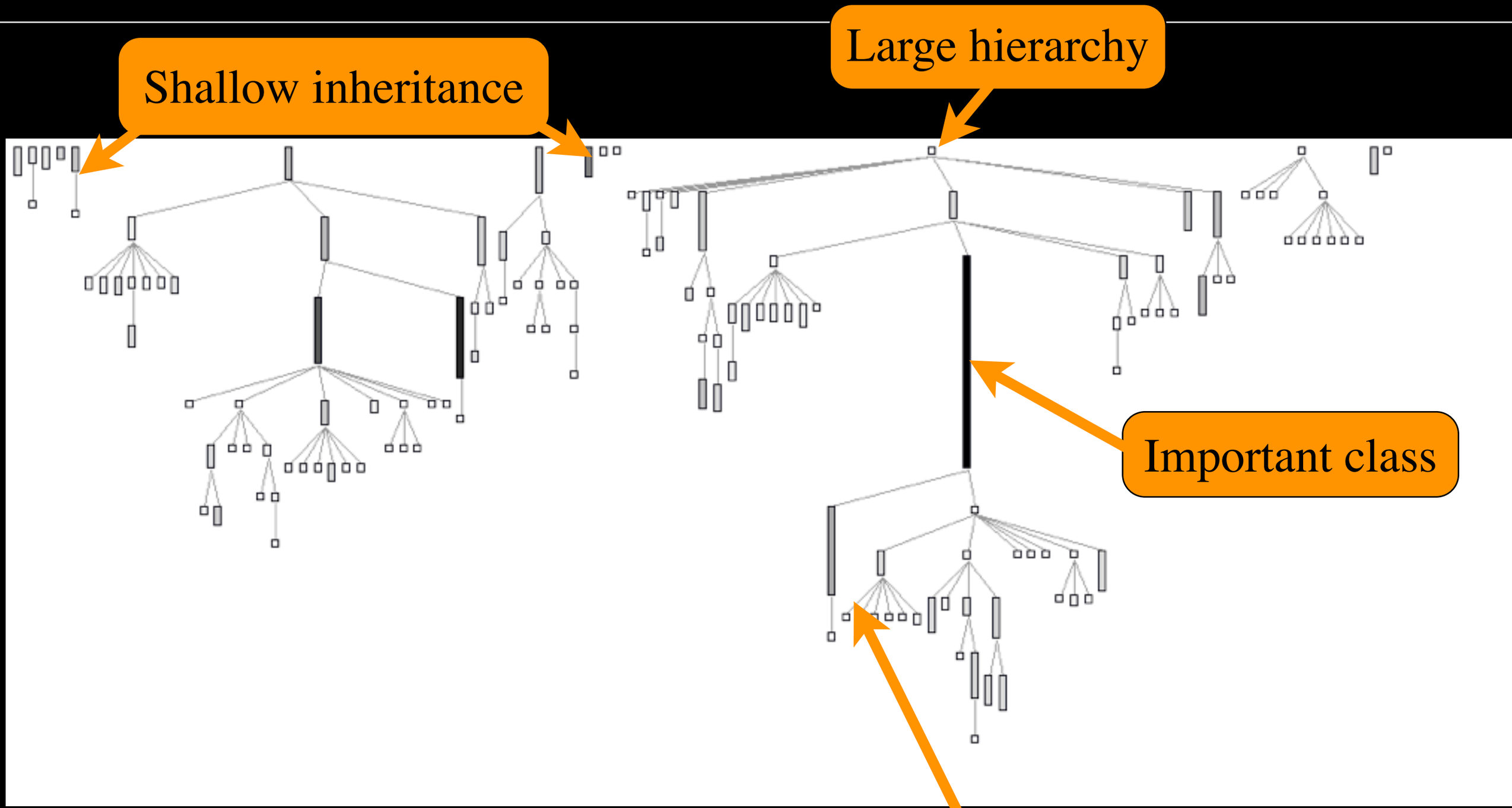
## Visualize the system's structure



# What does it mean?

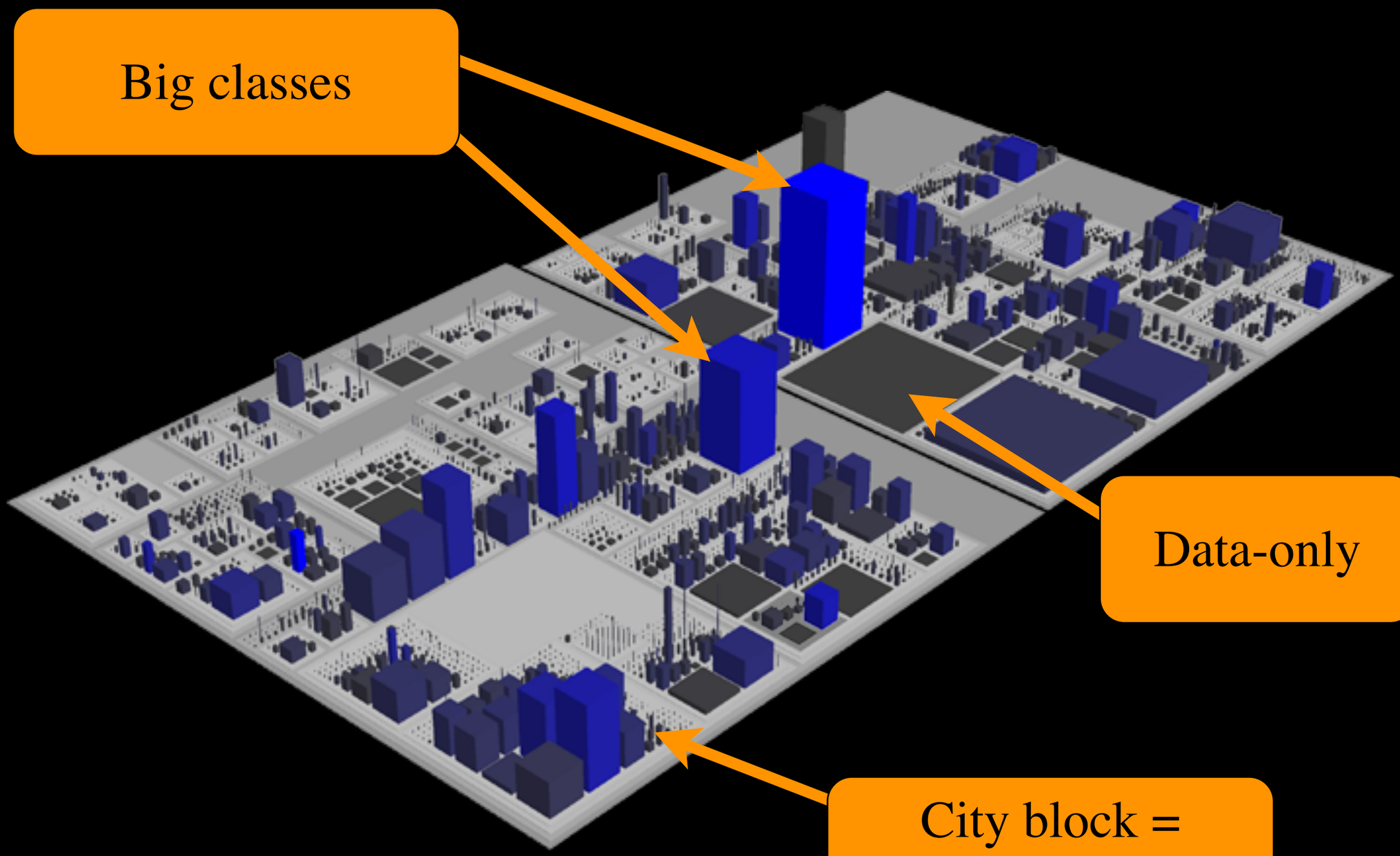


# What do we see?



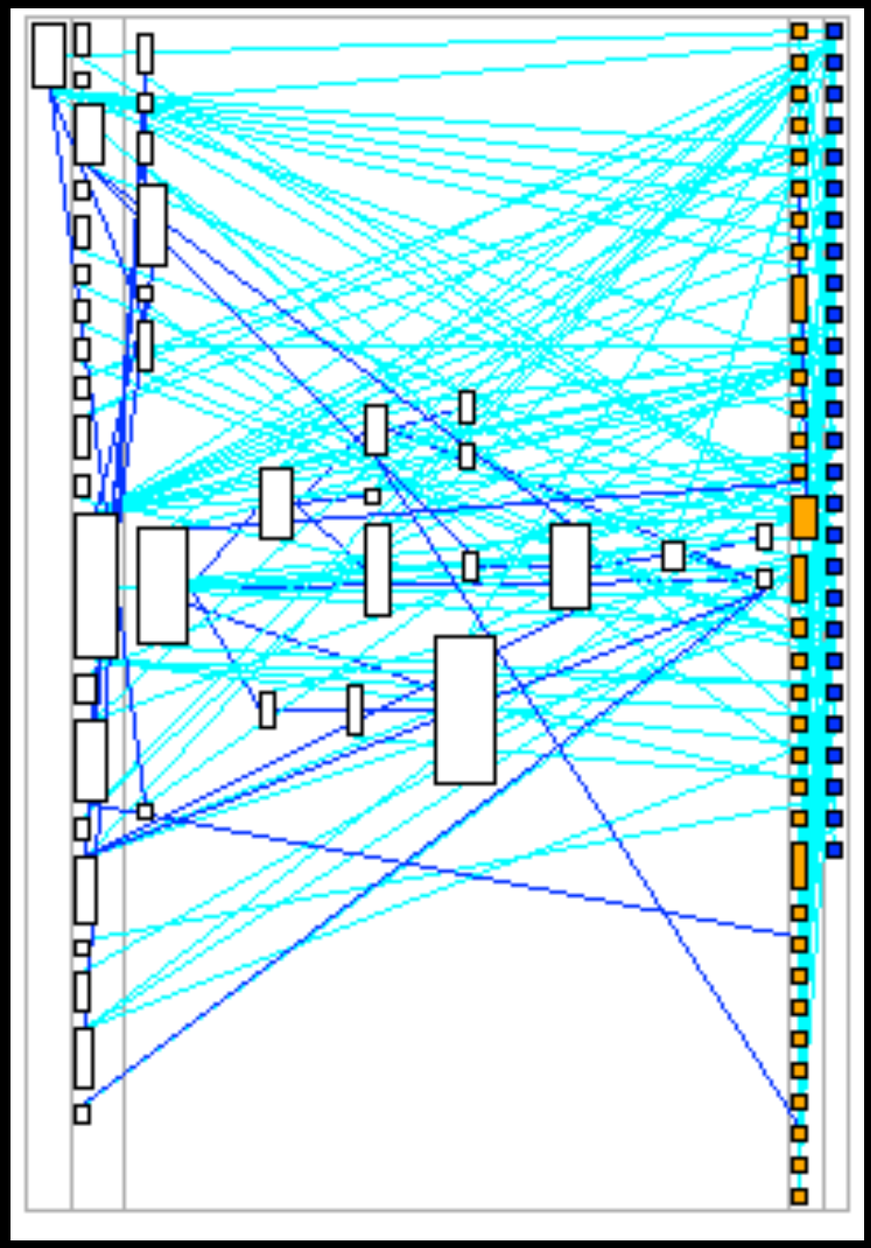
# CodeCity [Wettel et al.] (2011)

## Structure of a system as a city



# Class blueprint

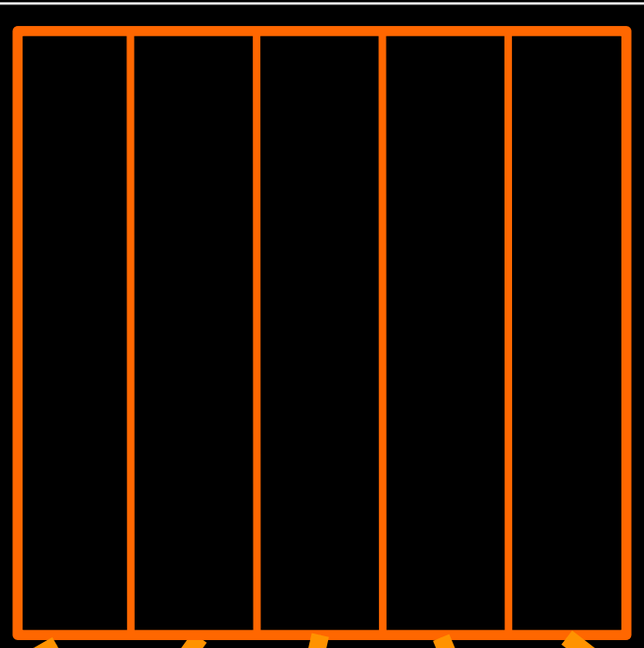
Visualize complexity and cohesion of a class

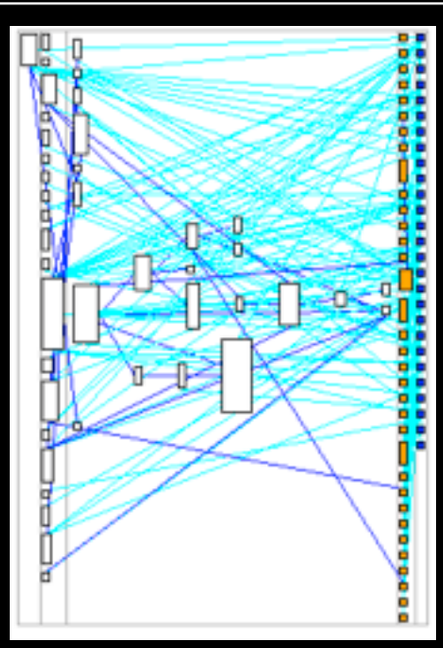


# What does it show?

Invocations in blue

Accesses in cyan





Initialization layer

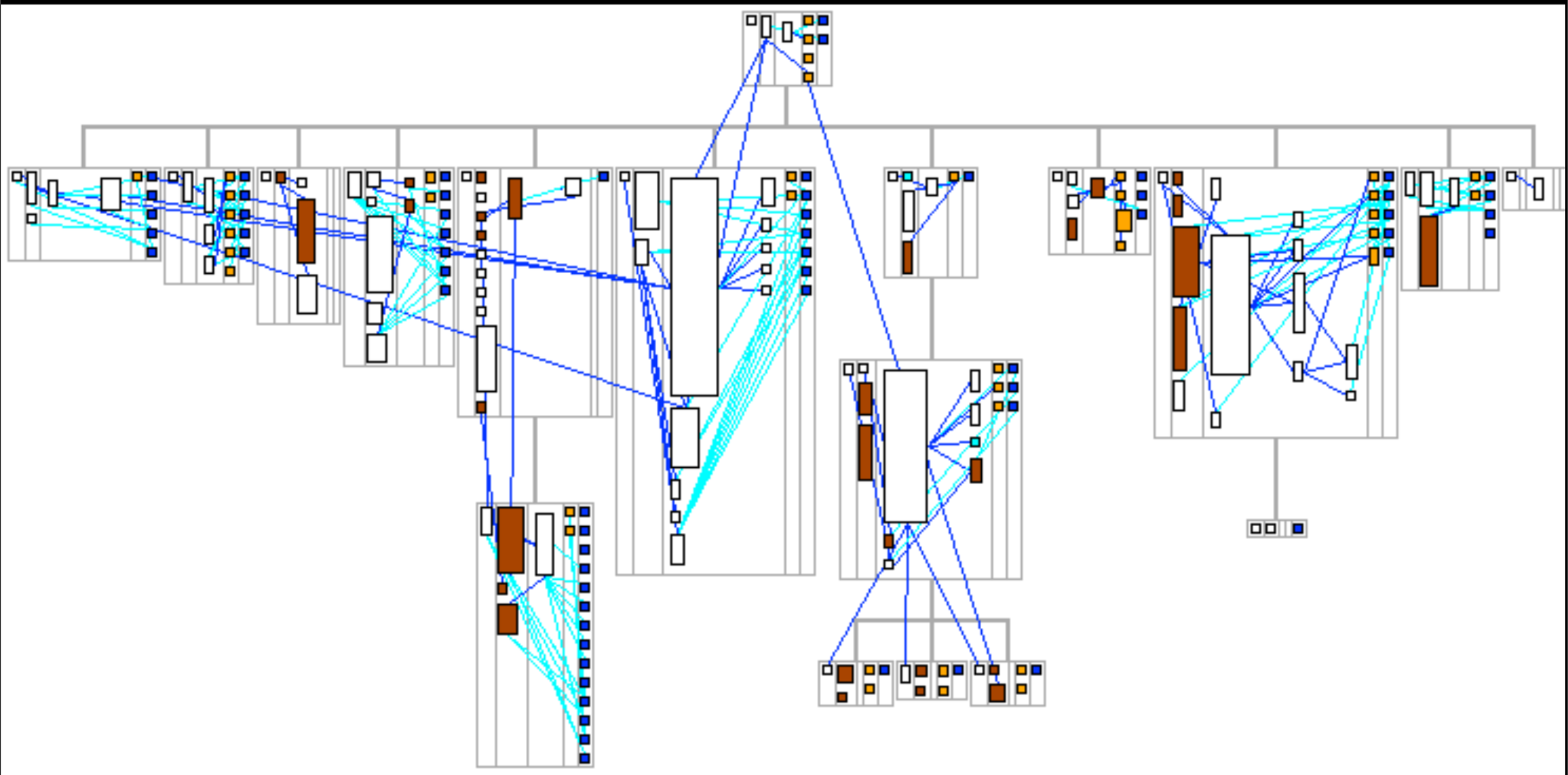
Private implementation

Attribute layer

Public interface

Accessor layer

# What do we see?



# Distribution map

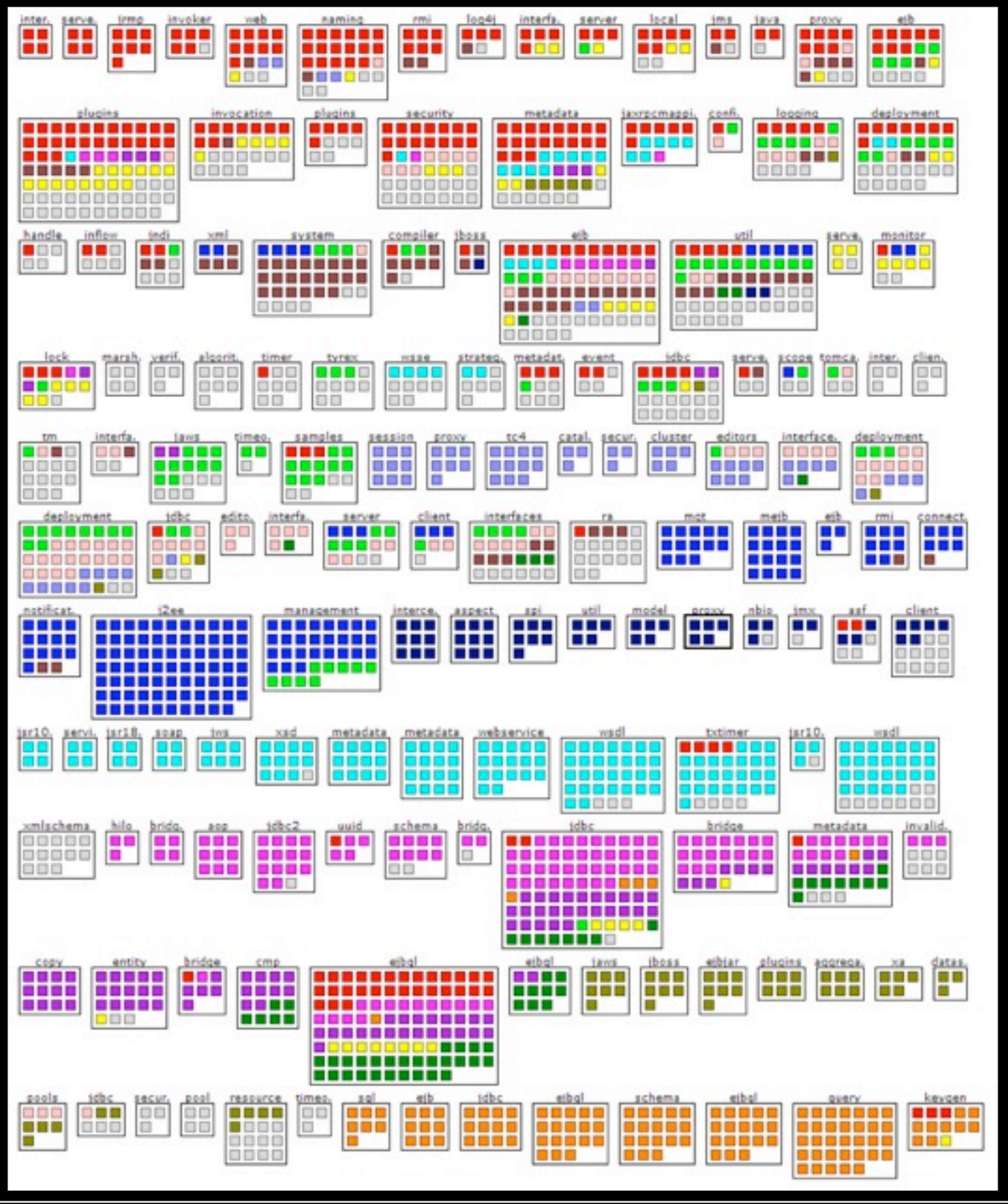
How are different properties distributed over the system?

- **Different possible properties:**
  - Metrics
  - Concerns
  - Defects/bugs
  - Owners/authors
  - ...

# Example Distribution Map

Ownership within JBoss

Each color is a developer



# Design structure matrices (DSMs)

Entities

| | | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
| Foundations | 1 | * | | | | | |
| Staircases | 2 | 1 | * | | 1 | | |
| Walls | 3 | 1 | 2 | * | | 2 | |
| Floors | 4 | 1 | | 4 | * | | |
| Electricity | 5 | | | | | * | |
| Wiring | 6 | | | 1 | | 2 | * |

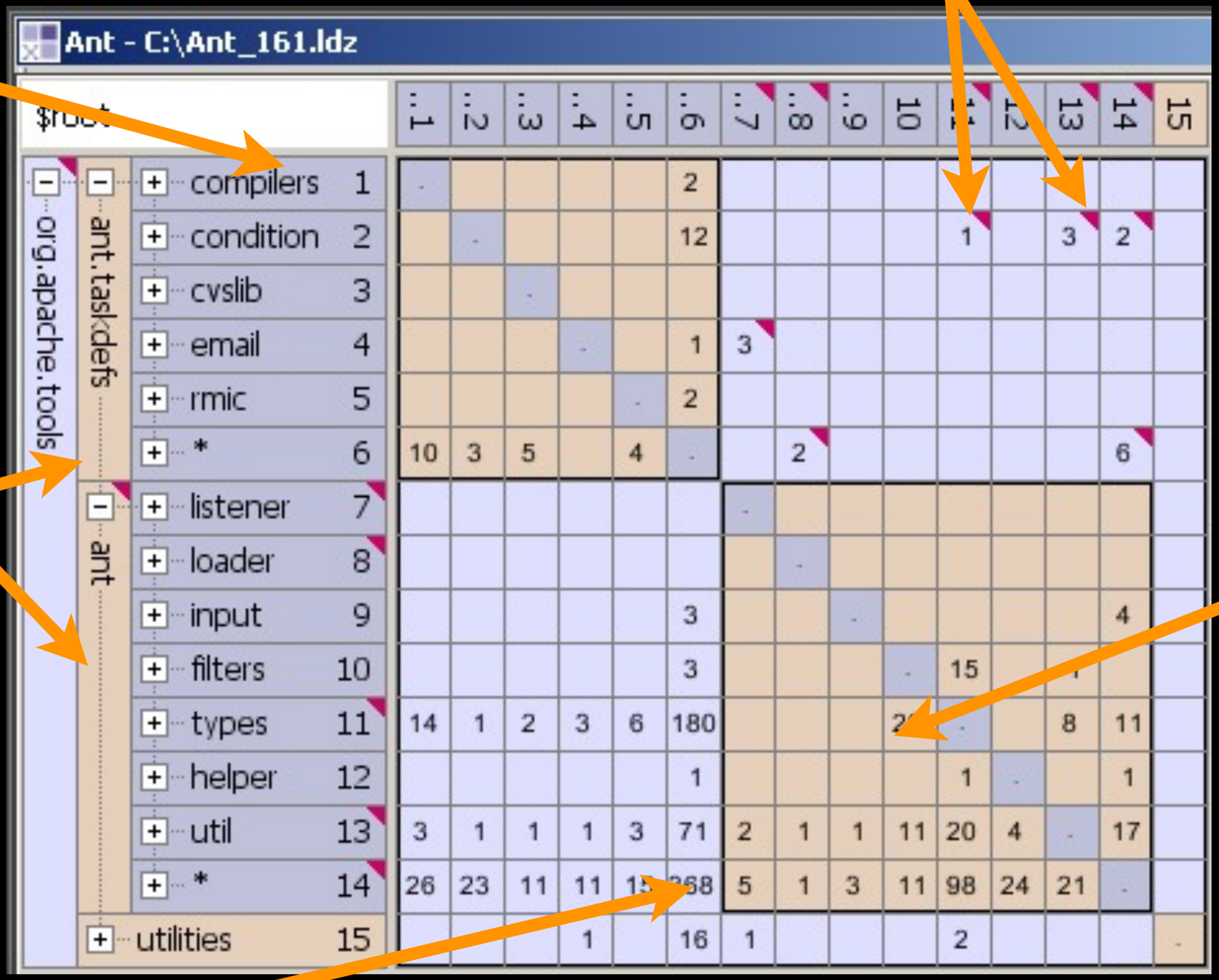
Dependency

Example: building a house

# Assessing modularity with DSMs

Dependencies

Software entities




Modules

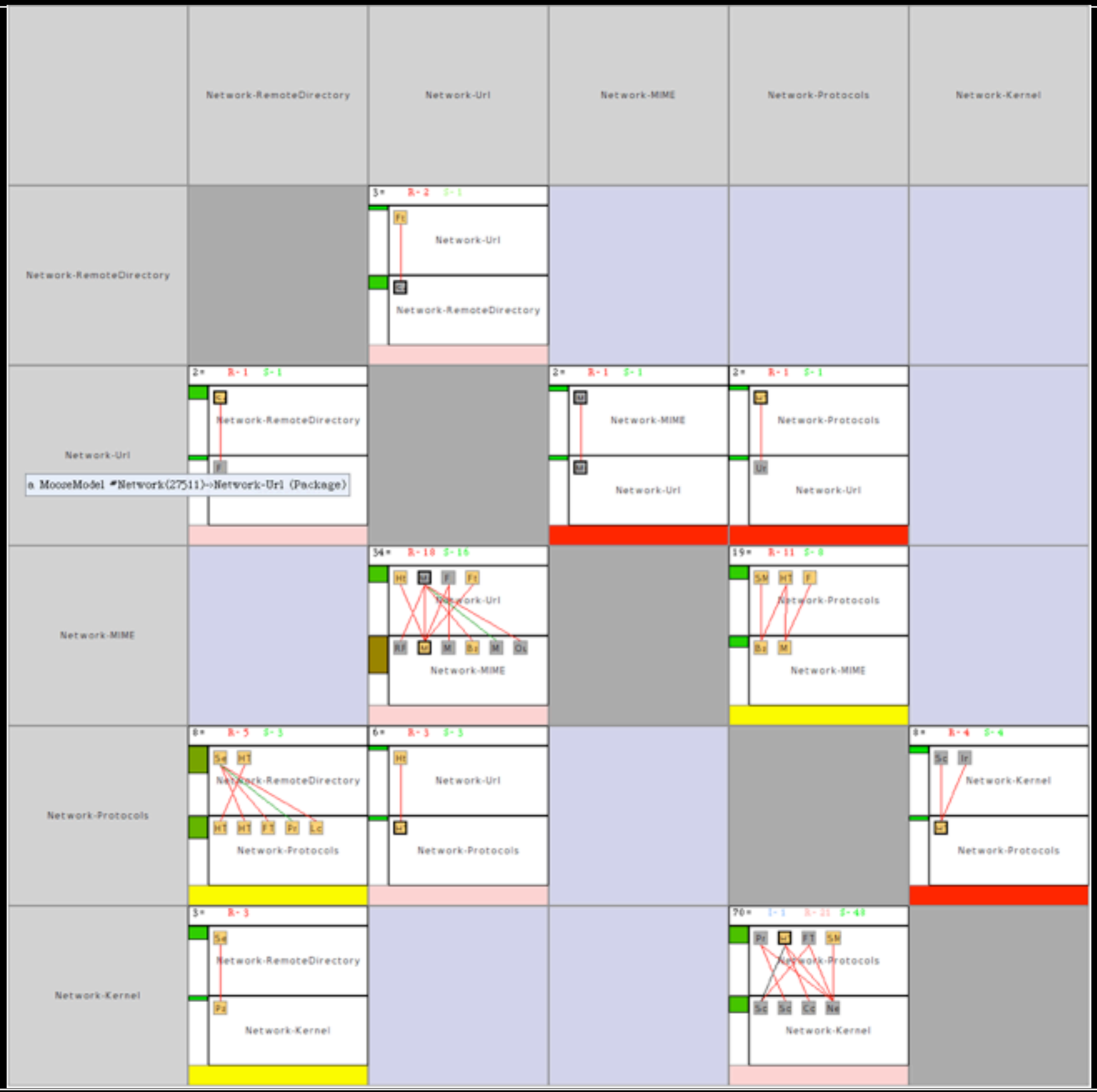
Cohesion

Coupling

# Enriched DSMs

Kinds of dependencies

Identify cycles

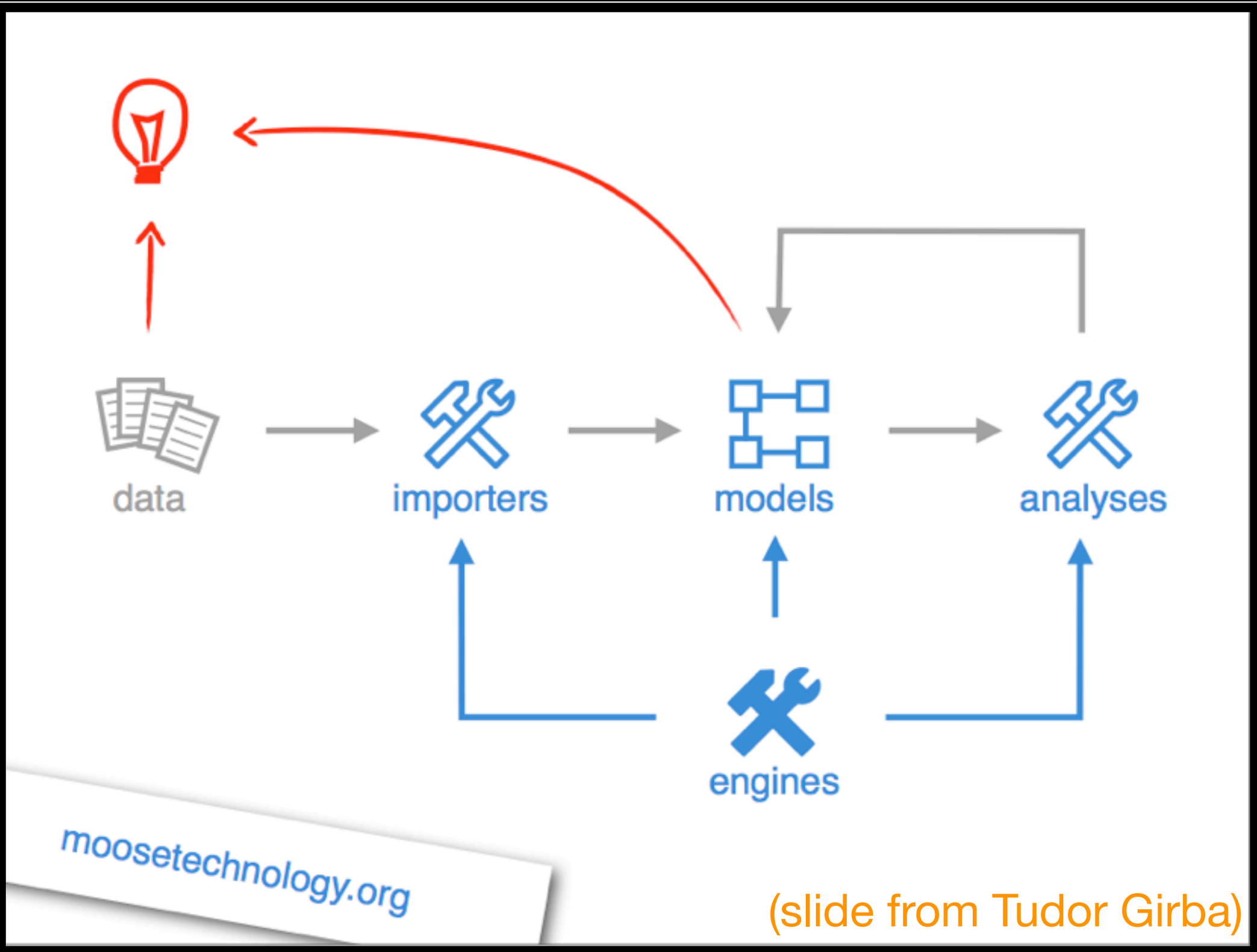


# The Moose tool suite

# Moose tool suite

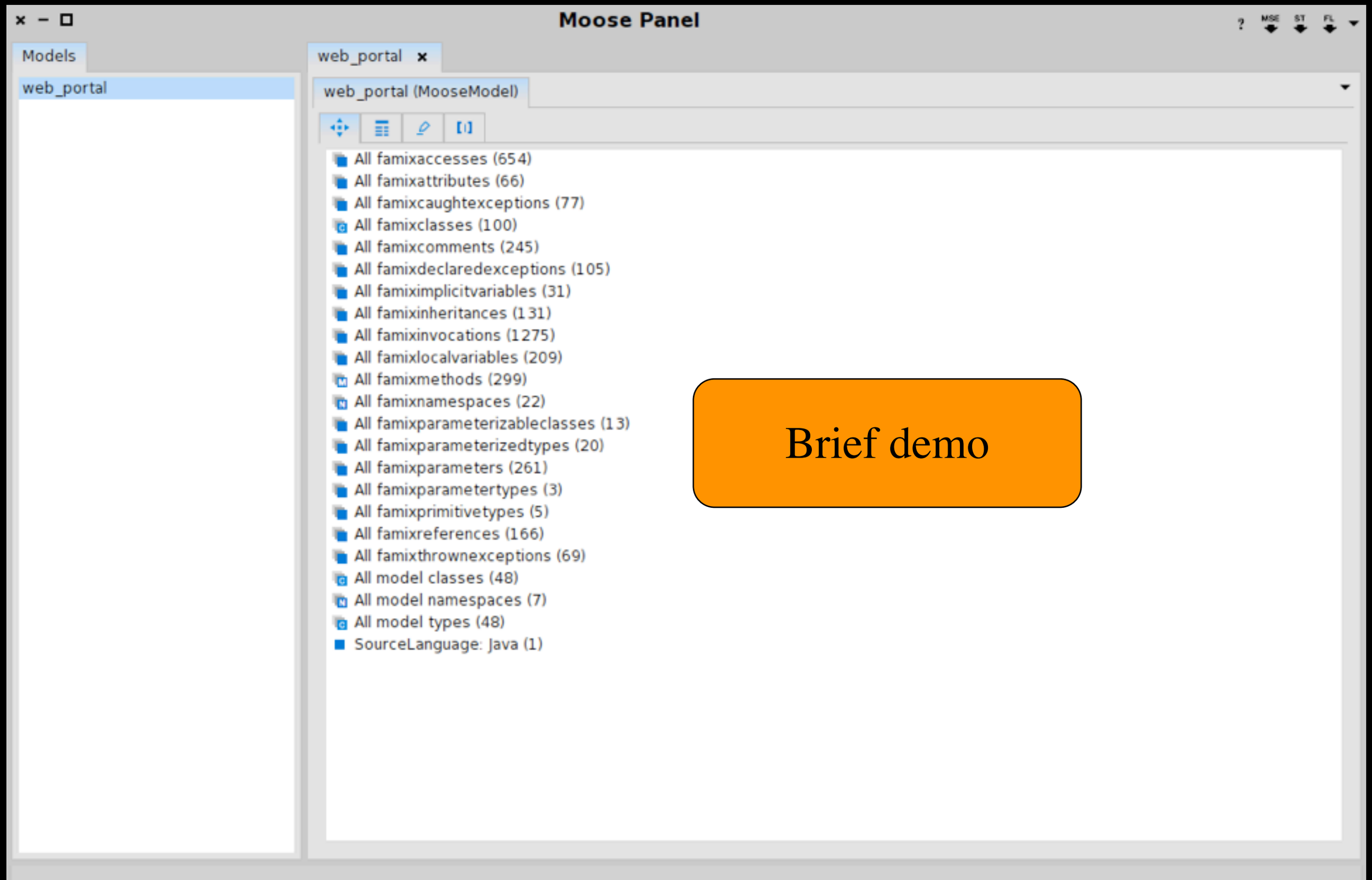
- **Tool suite written in Pharo Smalltalk**
- **Lots of tools for analyzing software**
- **Provides:**
  - A meta-model to represent code
  - Metrics
  - Visualizations
- **Extensible/scriptable**
- **Lots of documentation:**
  - http://www.moosetechnology.org
  - http://www.themoosebook.org/book

# Assessing software




(slide from Tudor Girba)

# Demo


Moose Panel
Models
web_portal
web_portal
web_portal (MooseModel)
All famixaccesses (654)
All famixattributes (66)
All famixcaughtexceptions (77)
All famixclasses (100)
All famixcomments (245)
All famixdeclaredexceptions (105)
All famiximplicitvariables (31)
All famixinheritances (131)
All famixinvocations (1275)
All famixlocalvariables (209)
All famixmethods (299)
All famixnamespaces (22)
All famixparameterizableclasses (13)
All famixparameterizedtypes (20)
All famixparameters (261)
All famixparametertypes (3)
All famixprimitivetypes (5)
All famixreferences (166)
All famixthrownexceptions (69)
All model classes (48)
All model namespaces (7)
All model types (48)
SourceLanguage: Java (1)
Brief demo

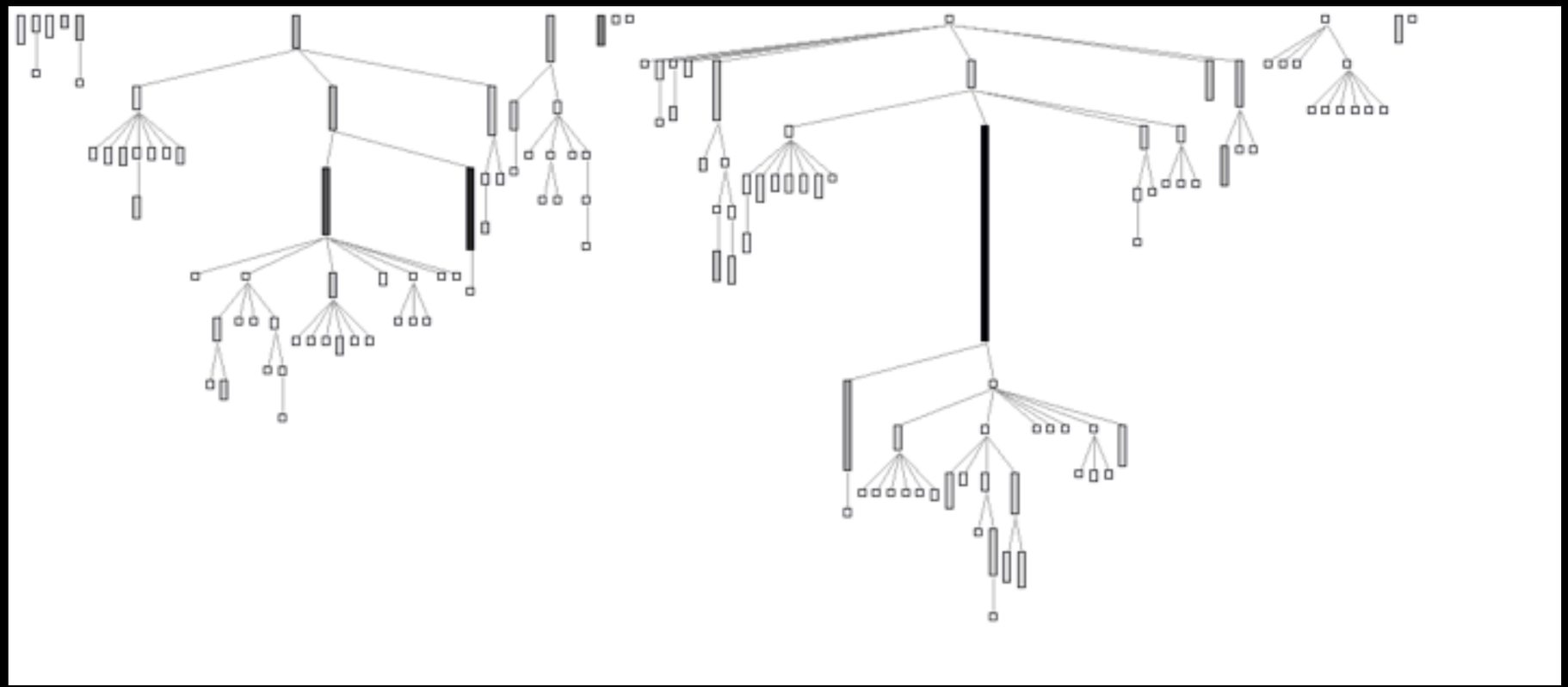
# Build your own visualization with Mondrian and Moose

# What is Mondrian?

- Scripting language
- On top of Smalltalk
- Integrated with Moose
- Allow to easily prototype interactive visualizations
- Most visualizations shown before are implemented in Mondrian
- For more information:
  - Chapter 15 of the Moose book (http://www.themoosebook.org/book/internals/mondrian)

# Example

- **Constructing the System Complexity View step-by-step**
  - Visualizing nodes
  - Visualizing edges
  - Picking a shape
  - Simple interaction

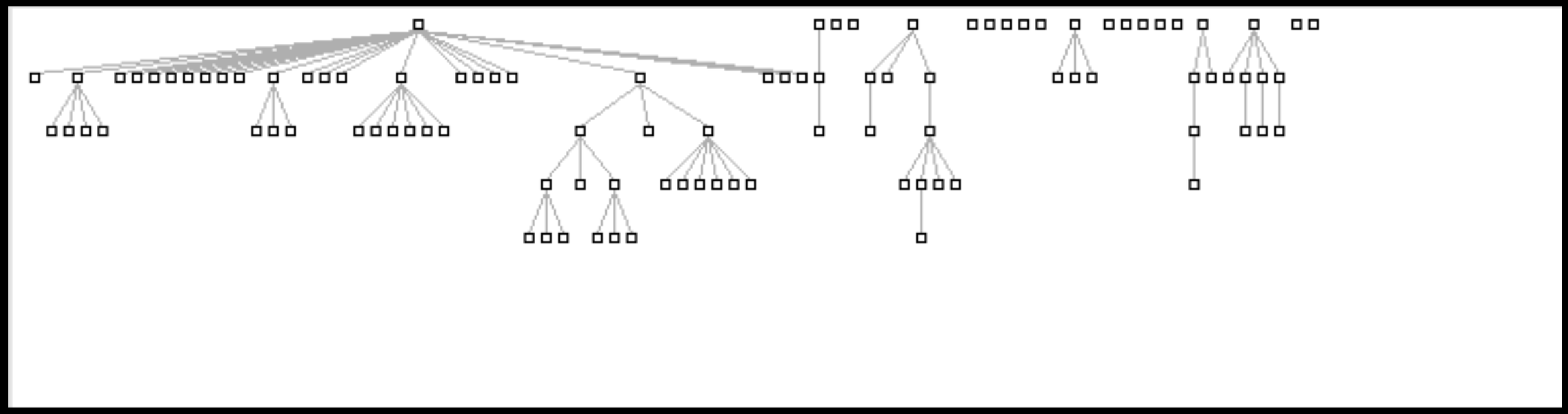


# Visualizing nodes

# Visualizing edges

Script

```
view nodes: (model allClasses).
view edges: (model allClasses) from: [:class | class superclass] to: #yourself.
view treeLayout
```

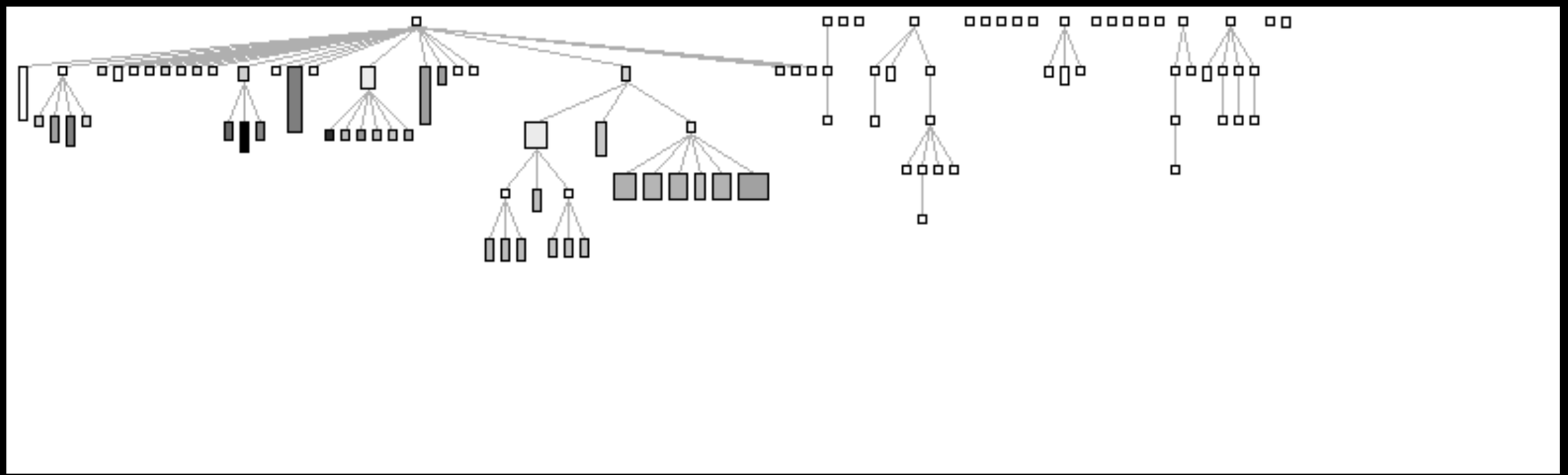


# Picking a shape

Script

```
view shape rectangle
    width: [:class | class numberOfAttributes * 2];
    height:[:class | class numberOfMethods * 2 ];
    linearFillColor: [:class | class numberOfLinesOfCode]  within: (model allClasses).

view nodes: (model allClasses).

view edges: (model allClasses) from: [:class | class superclass] to: #yourself.
view treeLayout
```

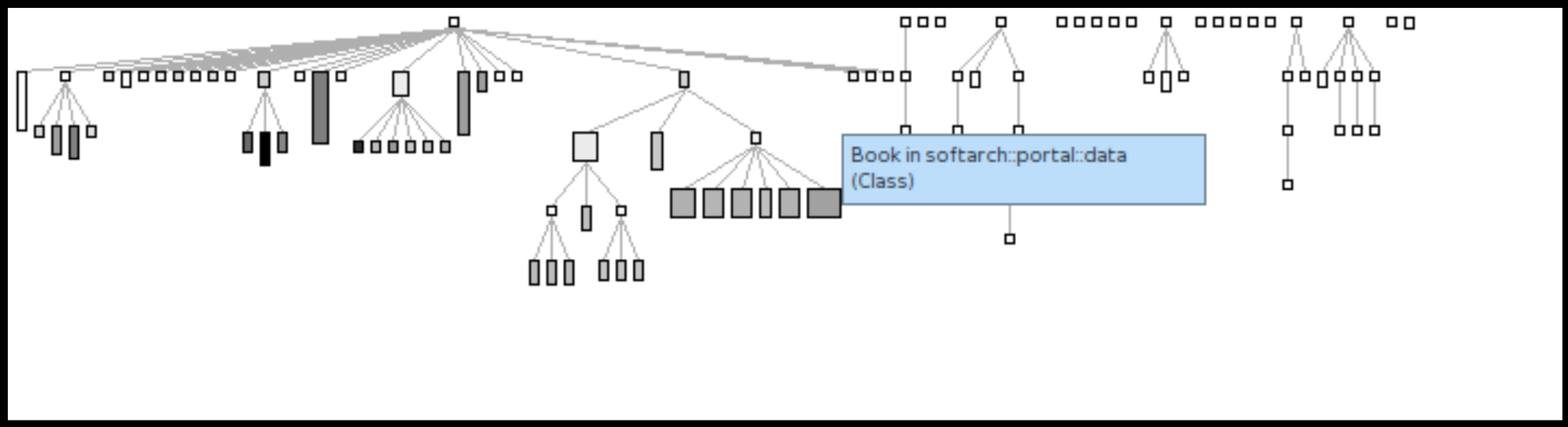
Set shape **before** drawing



# Adding interactions

Script

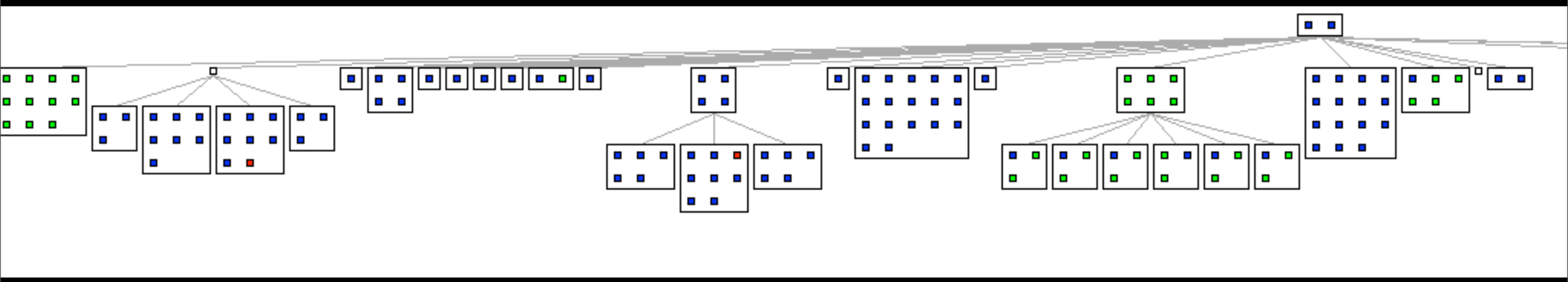
```
view shape rectangle
    width: [:class | class numberOfAttributes * 2];
    height:[:class | class numberOfMethods * 2 ];
    linearFillColor: [:class | class numberOfLinesOfCode]  within: (model allClasses).

view nodes: (model allClasses).
view interaction popupText:[:class | class name].

view edges: (model allClasses) from: [:class | class superclass] to: #yourself.
view treeLayout
```



# A more complex example

Script

```
view shape rectangle
    width:[:cl | cl attributes size * 2];
    height:[:cl | cl methods size * 2].
view nodes: (model allClasses) forEach:[:class |
    view shape rectangle
        fillColor:[:method |
            method isPublic
                ifTrue:[Color blue]
                ifFalse:[method isPrivate ifTrue:[Color red] ifFalse:[Color green]]].
    view nodes: (class methods).
    view gridLayout].
view edges: (model allClasses) from:[:cl | cl superclass ] to: [:cl | cl].
view treeLayout
```



# Conclusion

- **Software visualization:**
  - Represent structural data
  - Good/bad visualizations
  - A way to interpret metrics
- **Mondrian:**
  - Build your own custom visualizations