Mining and Visualizing Software Repositories to Understand Software Evolution

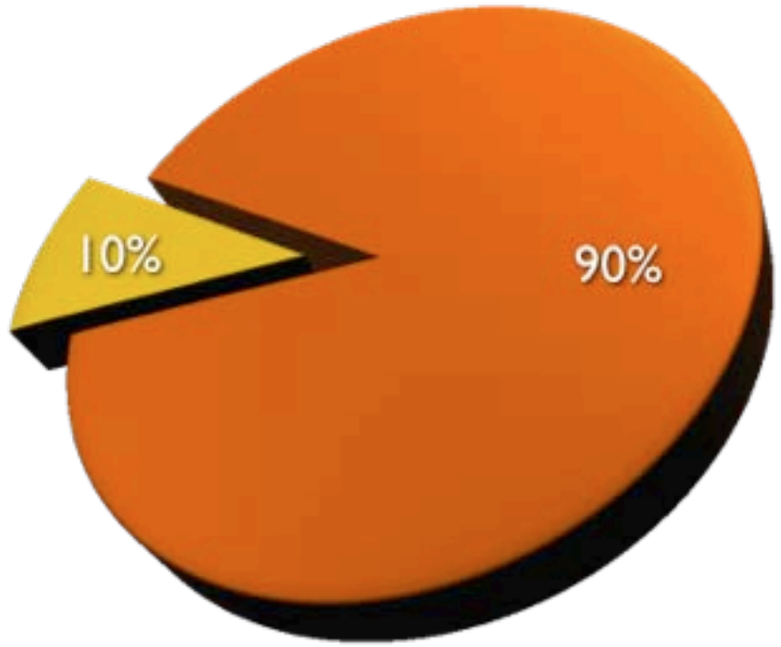
Marco D'Ambros
Faculty of Informatics, University of Lugano
Switzerland

Software Evolution is complex...

6 years of evolution of Mozilla: 3'000'000 lines of C and C++ code, over 1'000'000 of changes, hundreds of developers

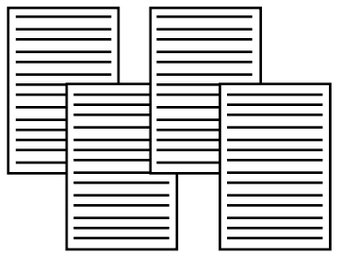
Software Evolution is complex...

... and expensive [1]

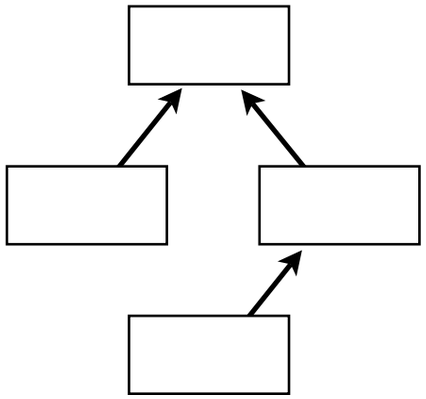


[1] L. Erlikh. *Leveraging legacy system dollars for e-business.* IT Professional 2, 3 (May. 2000)

Software Evolution Analysis

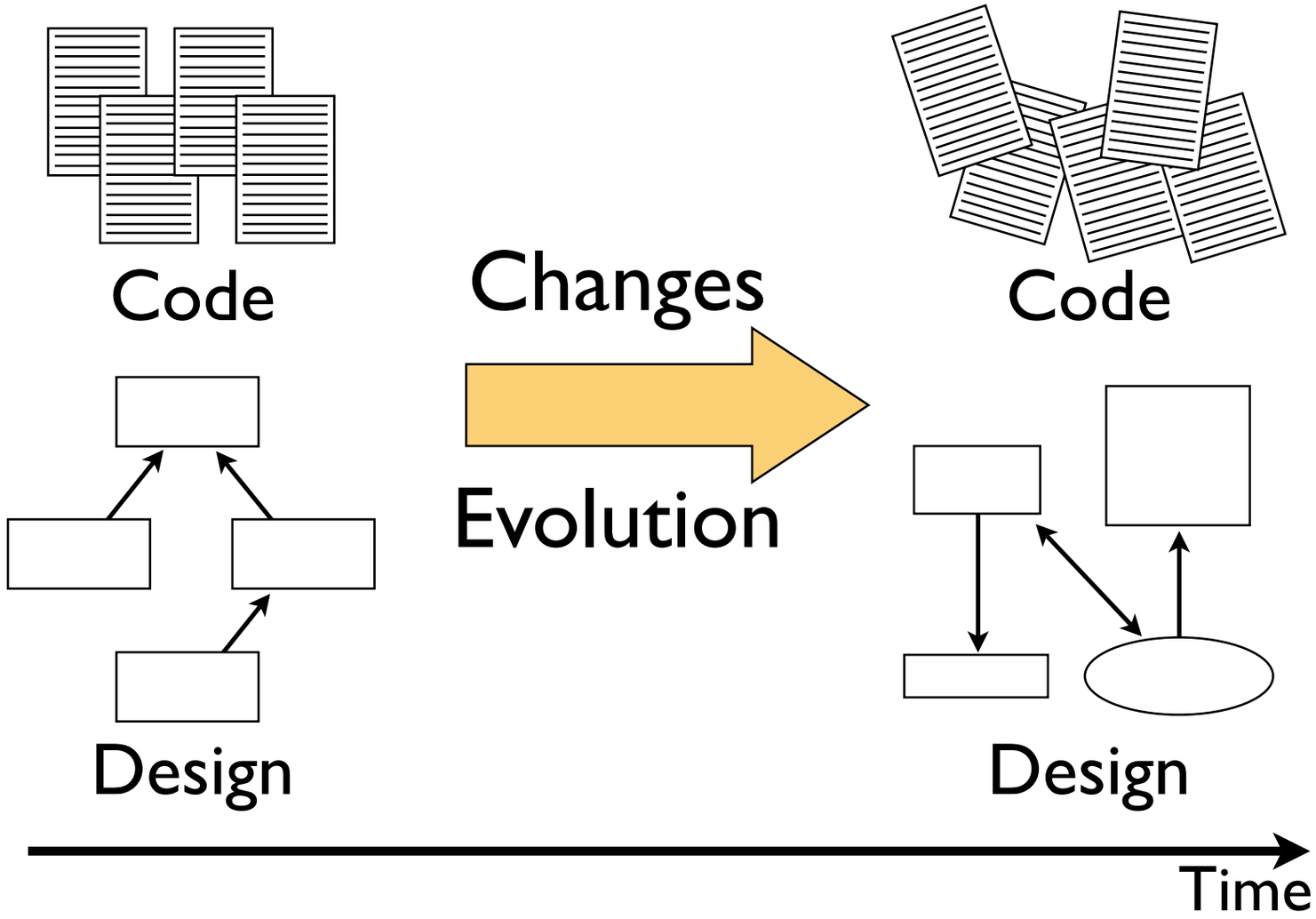


Code



Design

Software Evolution Analysis



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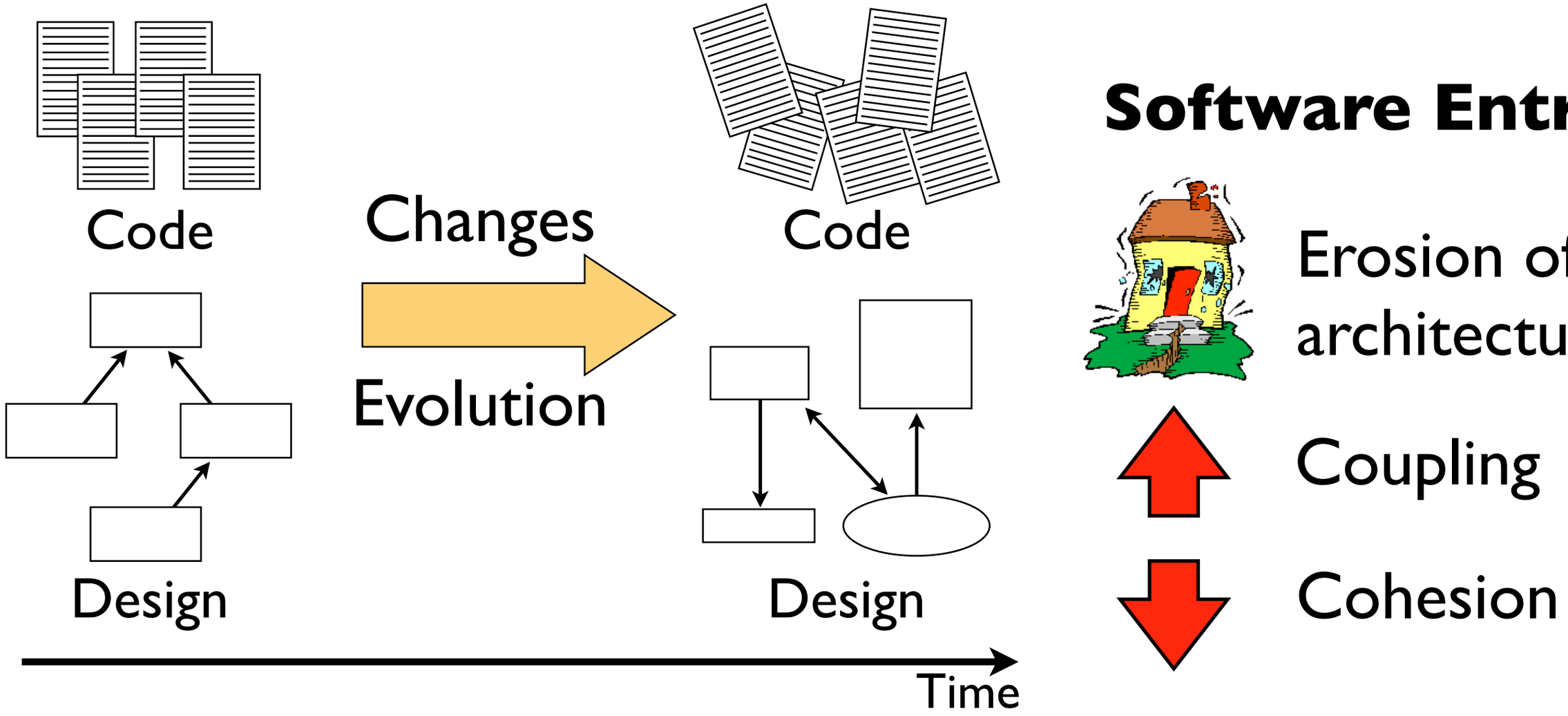


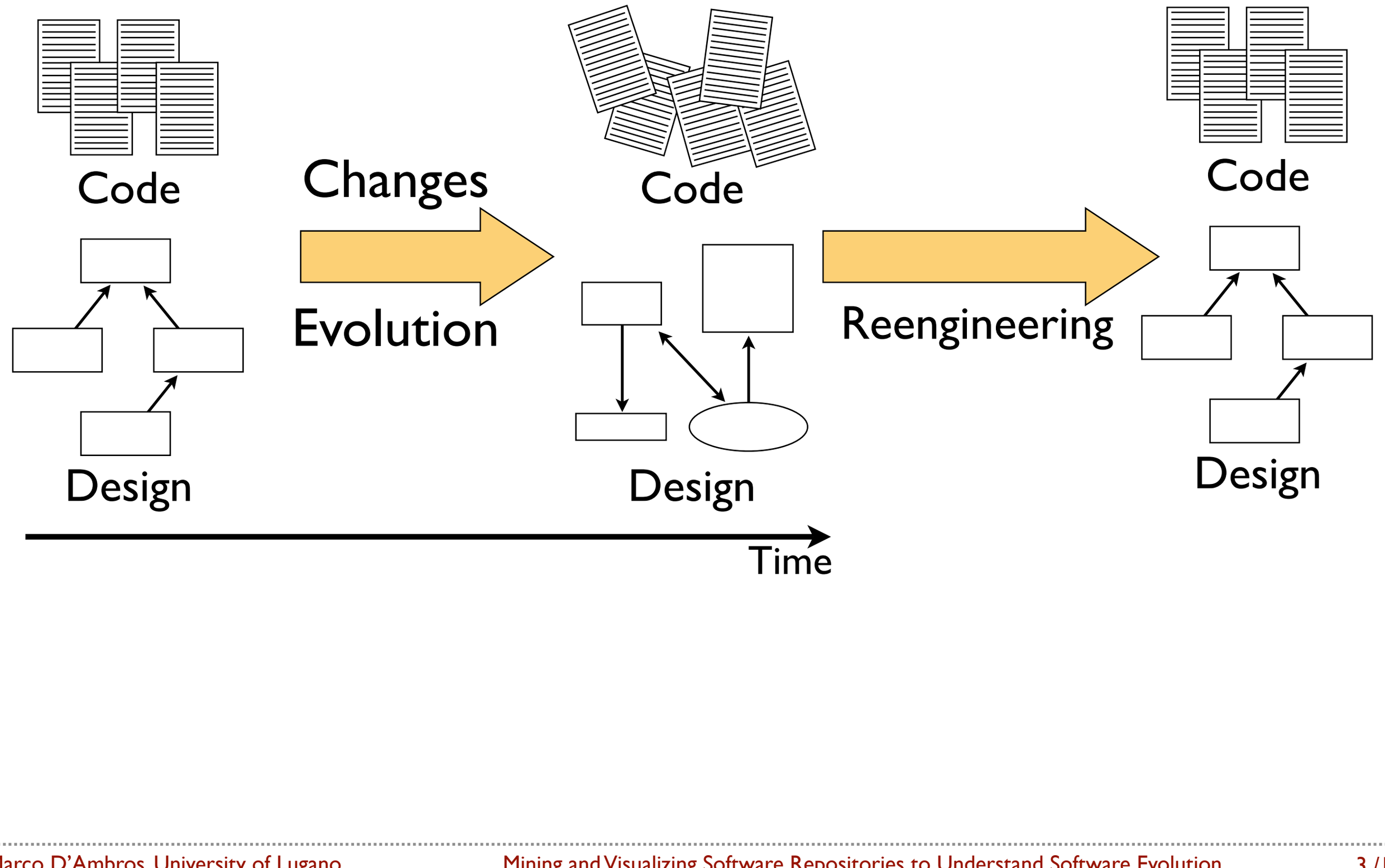
Software Entropy

Erosion of architecture

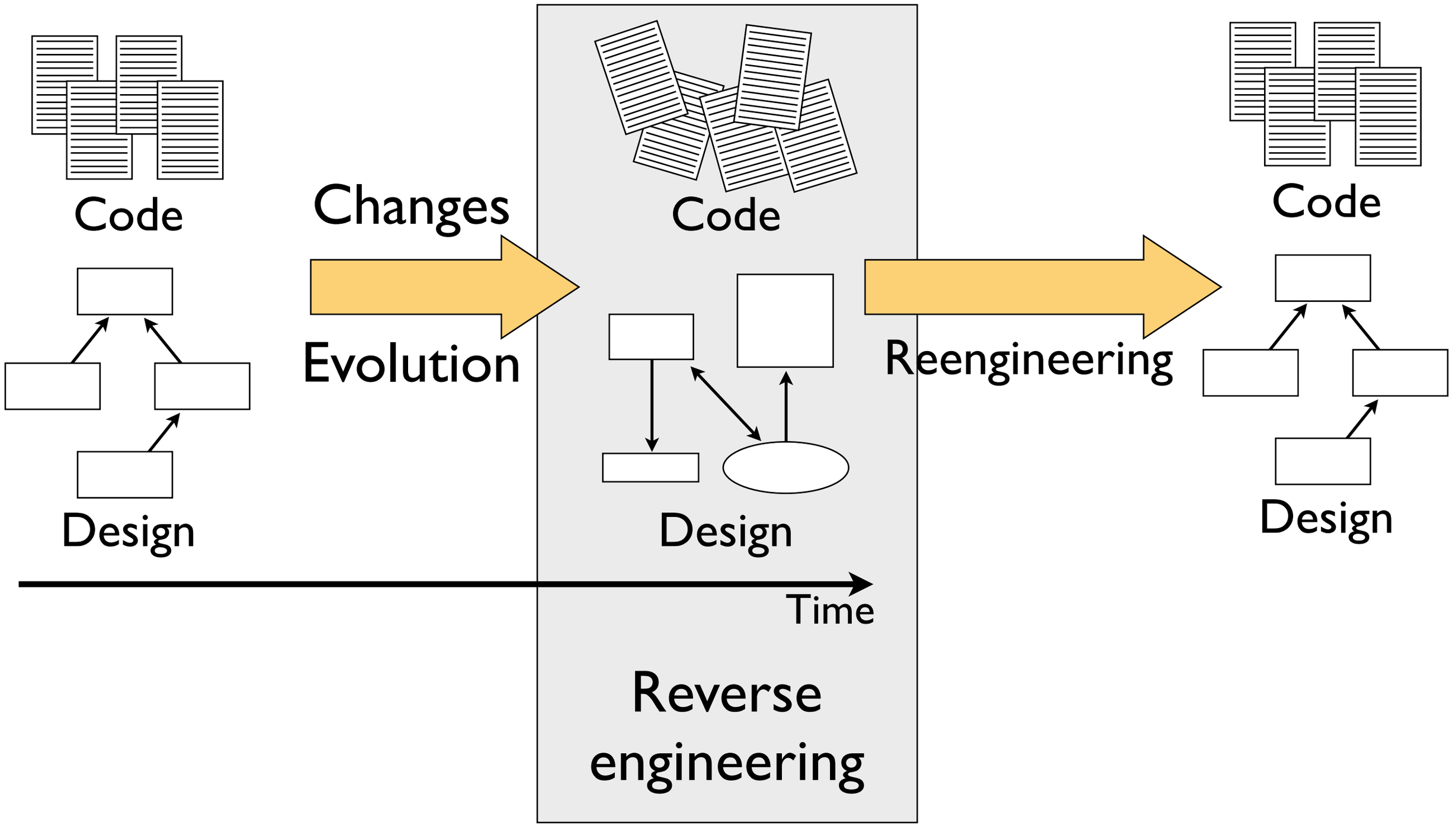
Coupling

Cohesion

Software Evolution Analysis



Software Evolution Analysis



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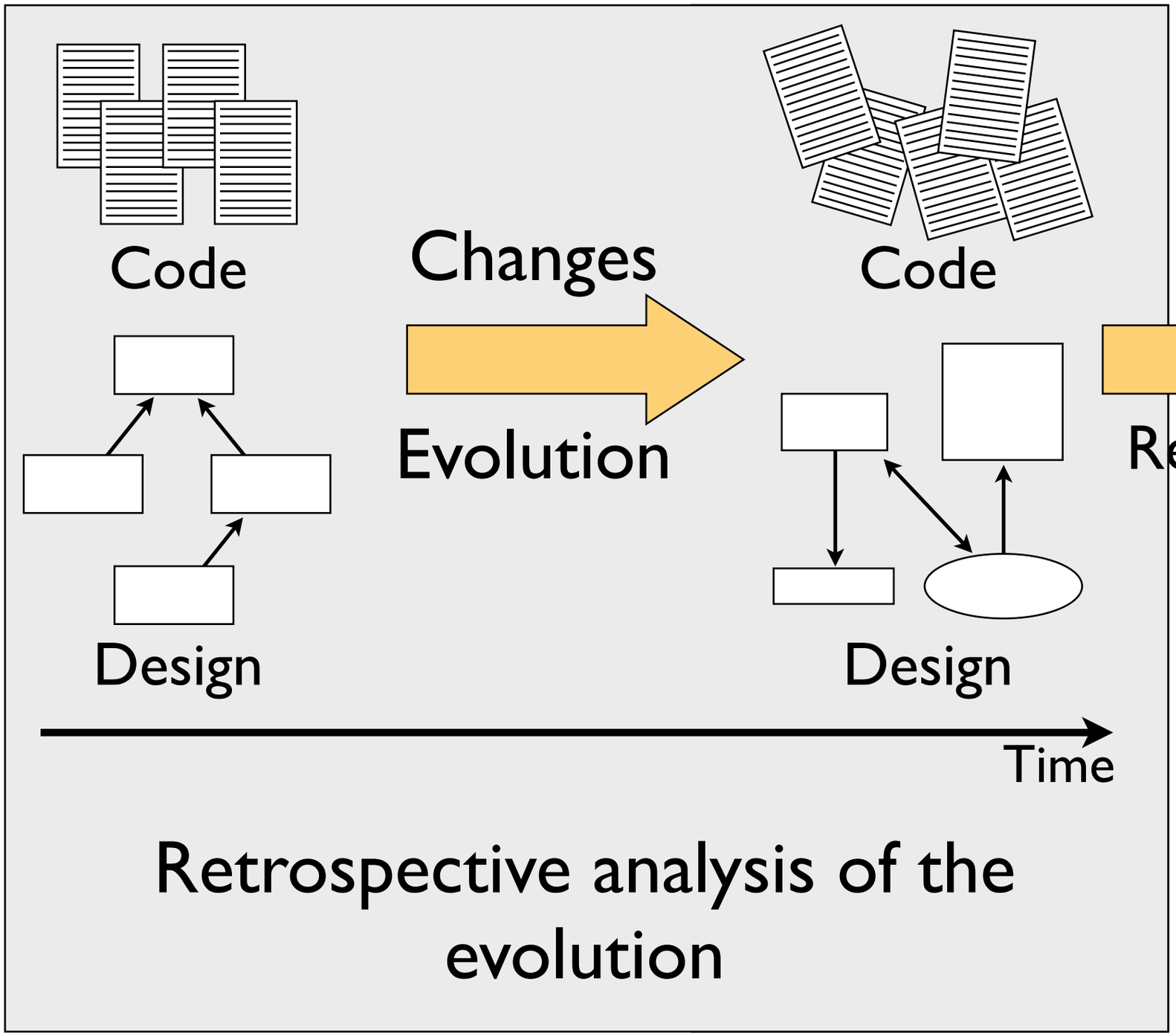
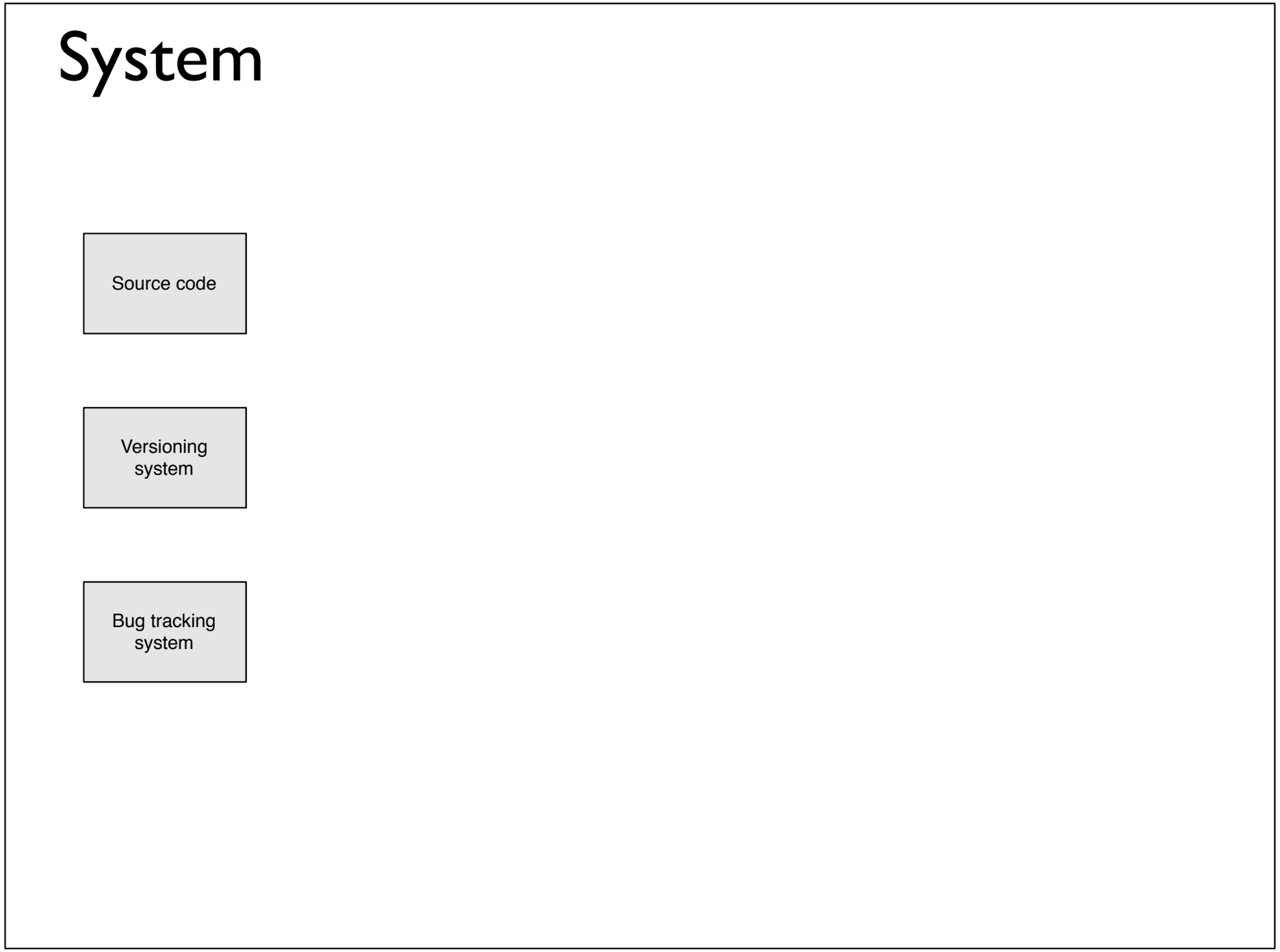


Software Evolution Analysis

Goal

Detecting potential shortcoming in the architecture, design and logical structure of the system

Our approach



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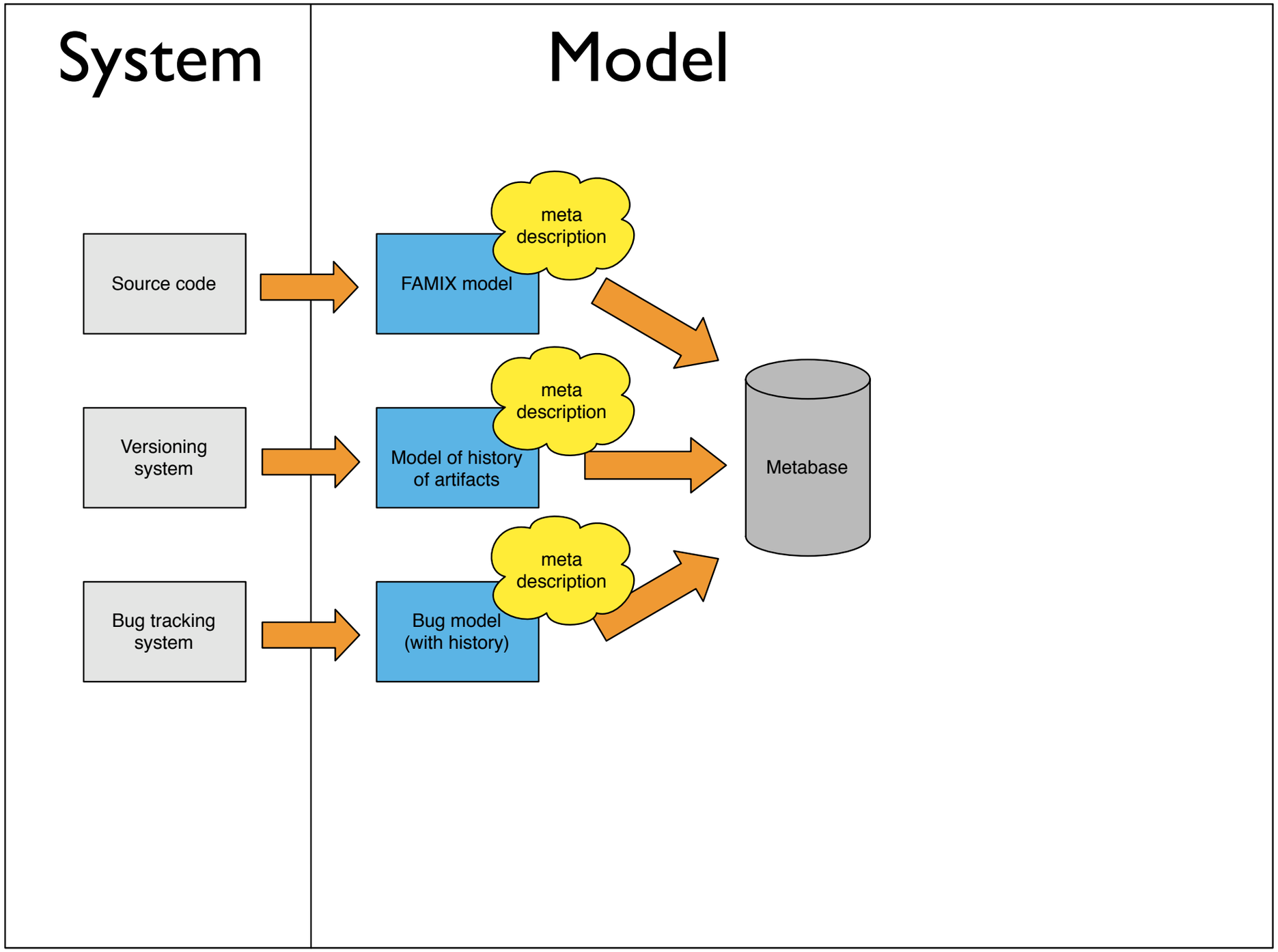

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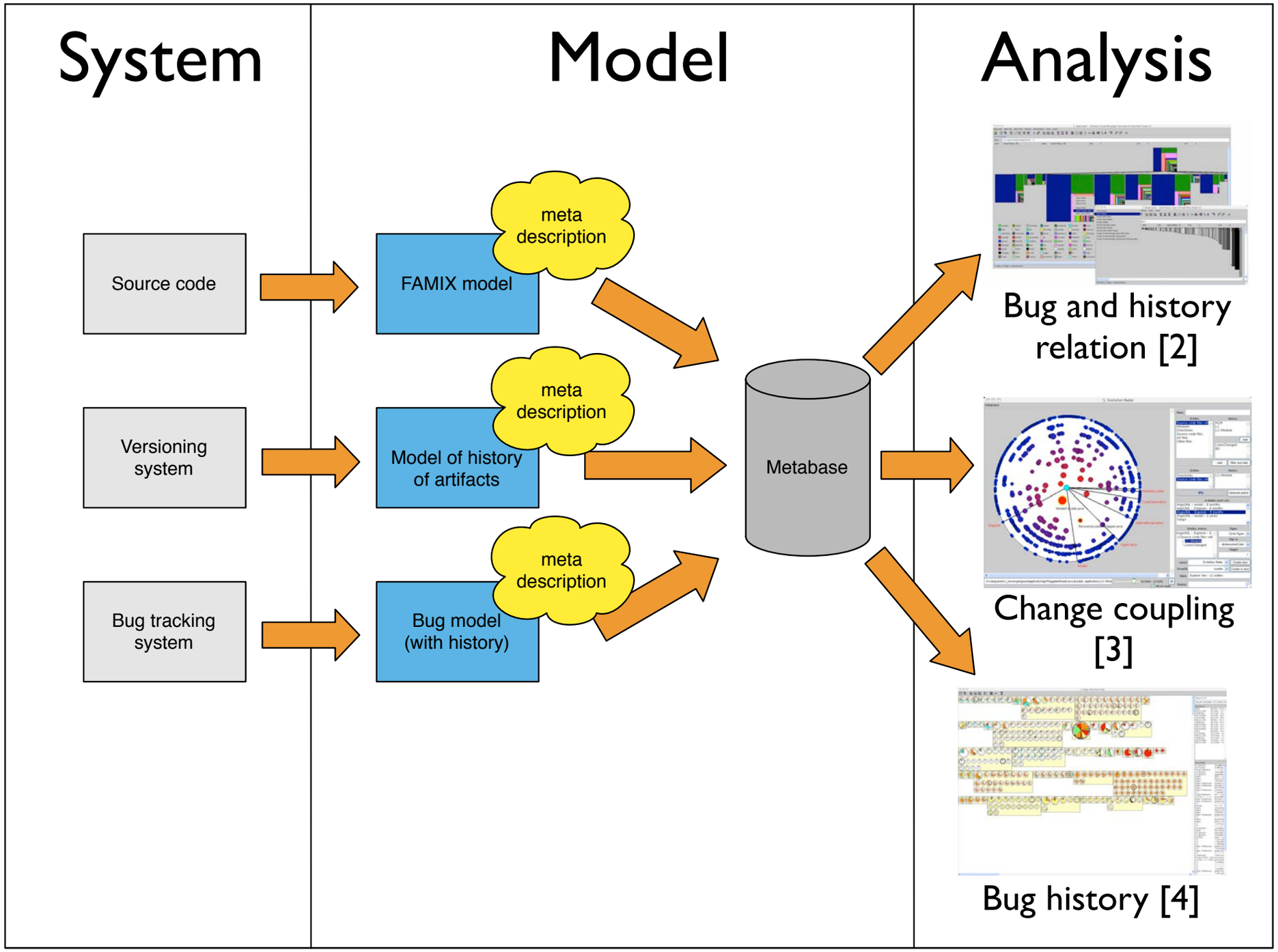


[2] M. D'Ambros, Michele Lanza. *Software Bugs and Evolution: A Visual Approach to Uncover Their Relationships*. CSMR 2006

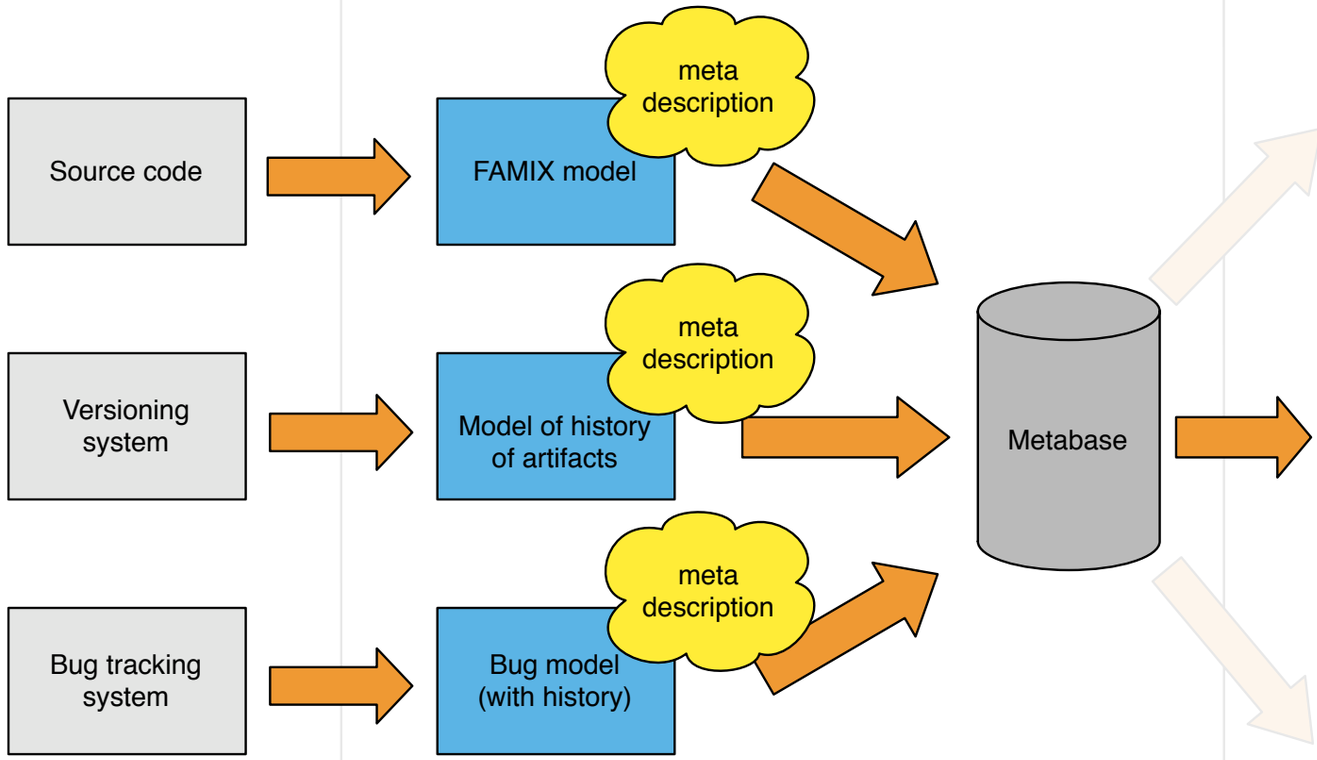
[3] M. D'Ambros, Michele Lanza. *Reverse Engineering with Logical Coupling*. WCRE 2006

[4] M. D'Ambros, Michele Lanza, Martin Pinzger. "*A Bug's Life*" - *Visualizing a Bug Database*. VISSOFT 2007

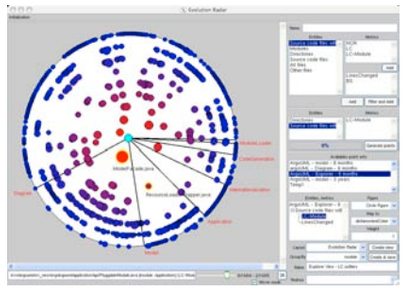
Our approach

System Model Analysis

Available as web service



Bug and history relation [2]



Change coupling [3]

Bug history [4]

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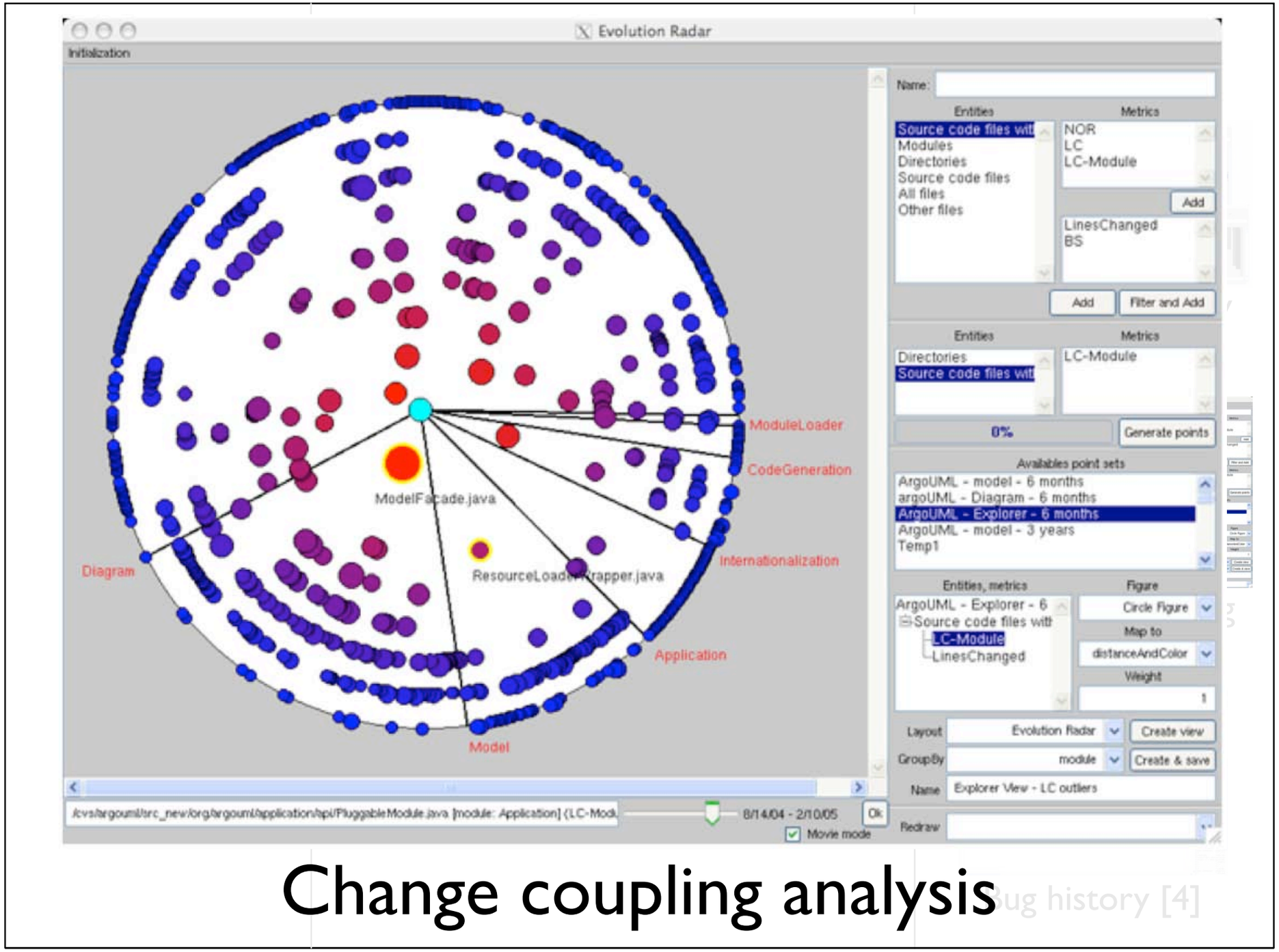

Change coupling analysis

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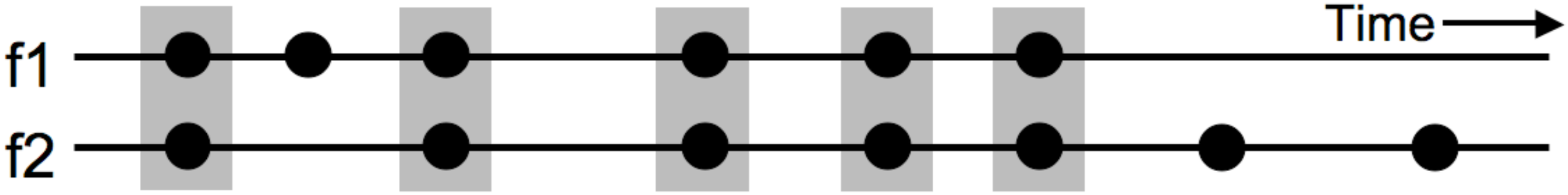
Change Coupling (CC)



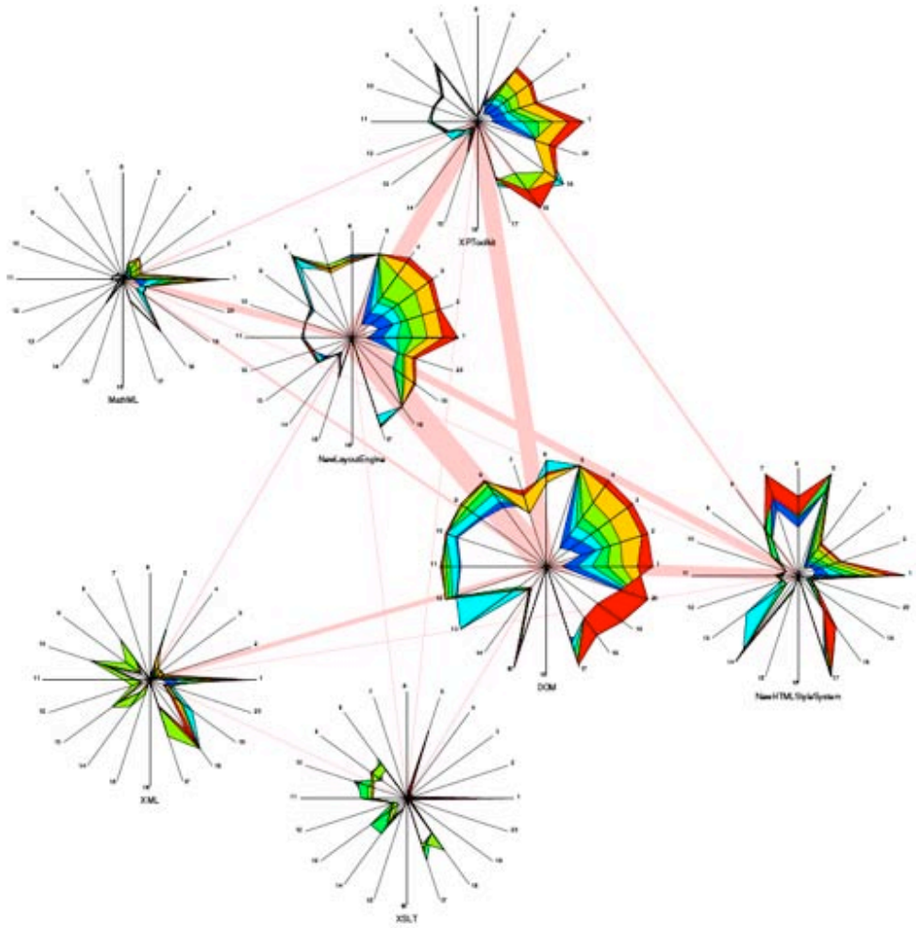
- Implicit dependencies between artifacts observed to change together
- Introduced by Gall *et. al.* in [5]
- Benefits
  - Lightweight
  - Visible only in the evolution, not in the code or documentation
  - Orthogonal to structural analysis

[5] Gall et. al. *Detection of Logical Coupling Based on Product Release History*. ICSM 1998

Current approaches to CC

Architecture level (*e.g.* [6])

- Dependencies among modules or subsystems
- Problem: Loss of detailed information



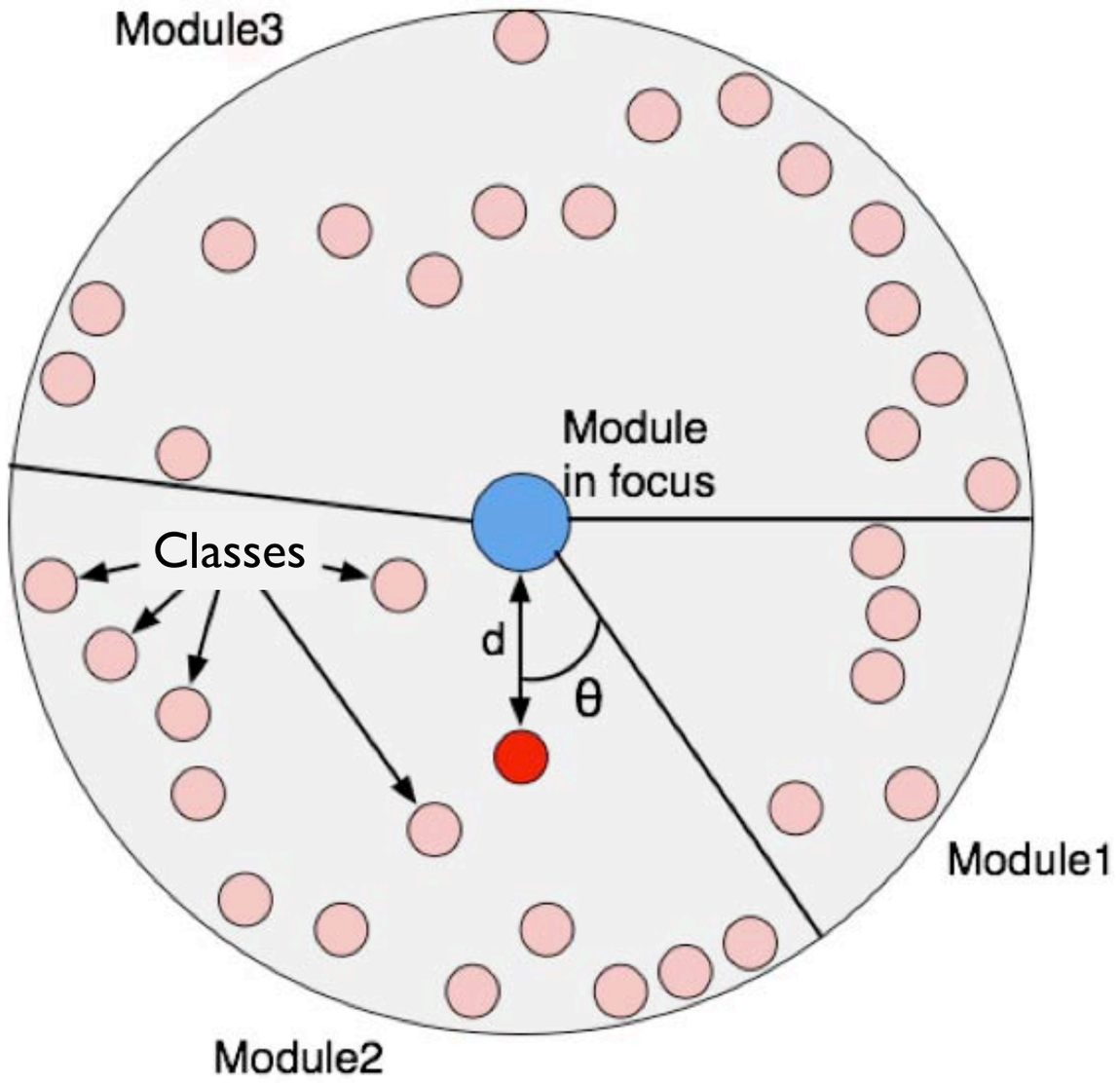
File (or finer) level (*e.g.* [7])

- Predict entities which are likely to be modified
- Problem: No global view of the system

[6] *Pinzger et. al.* Visualizing Multiple Evolution Metrics. SoftVis 2005
[7] *Zimmermann et. al.* Mining version histories to guide software changes. ICSE 2004

The Evolution Radar

- The module in focus (or reference module) is placed in the center



The Evolution Radar

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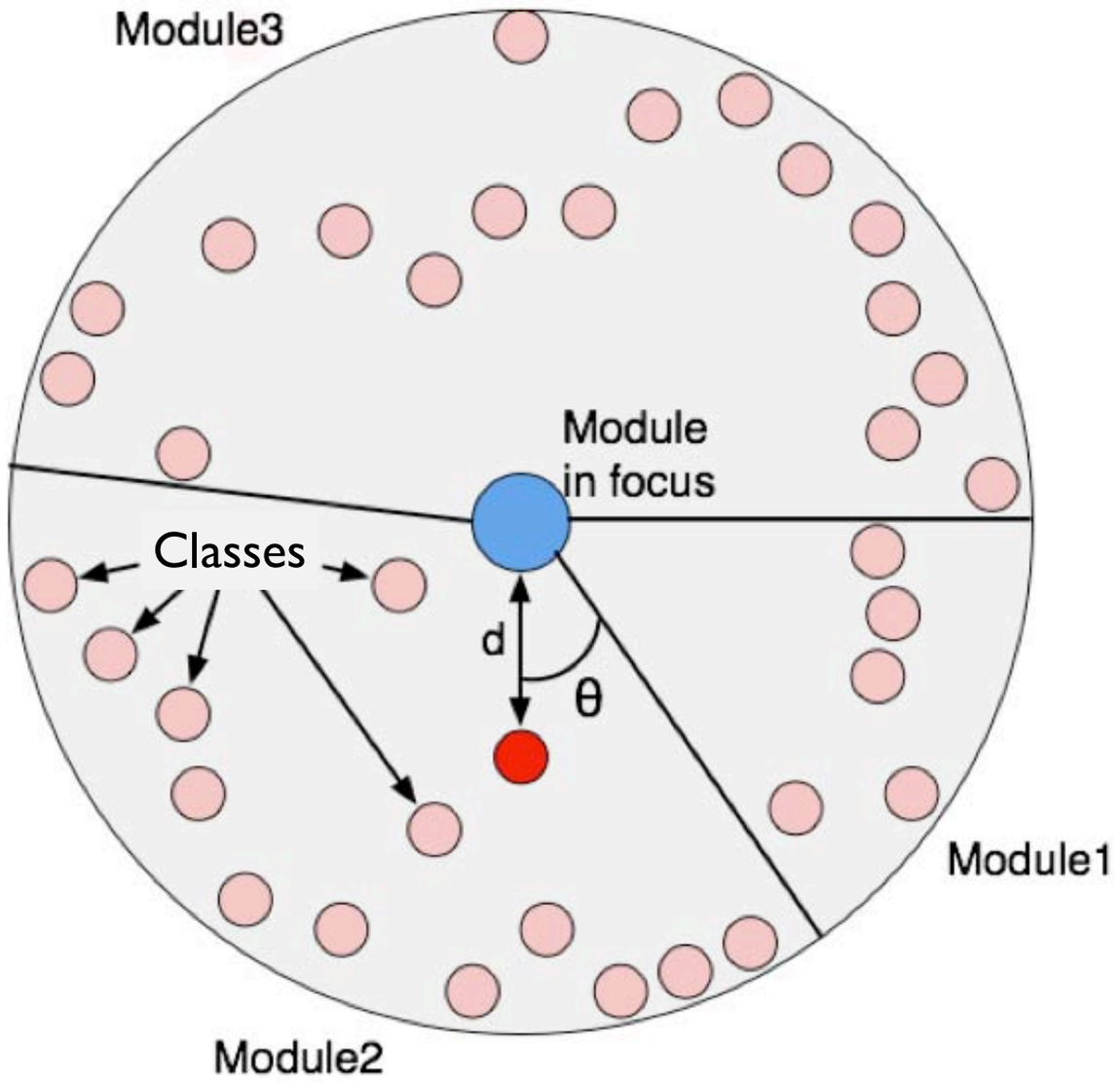

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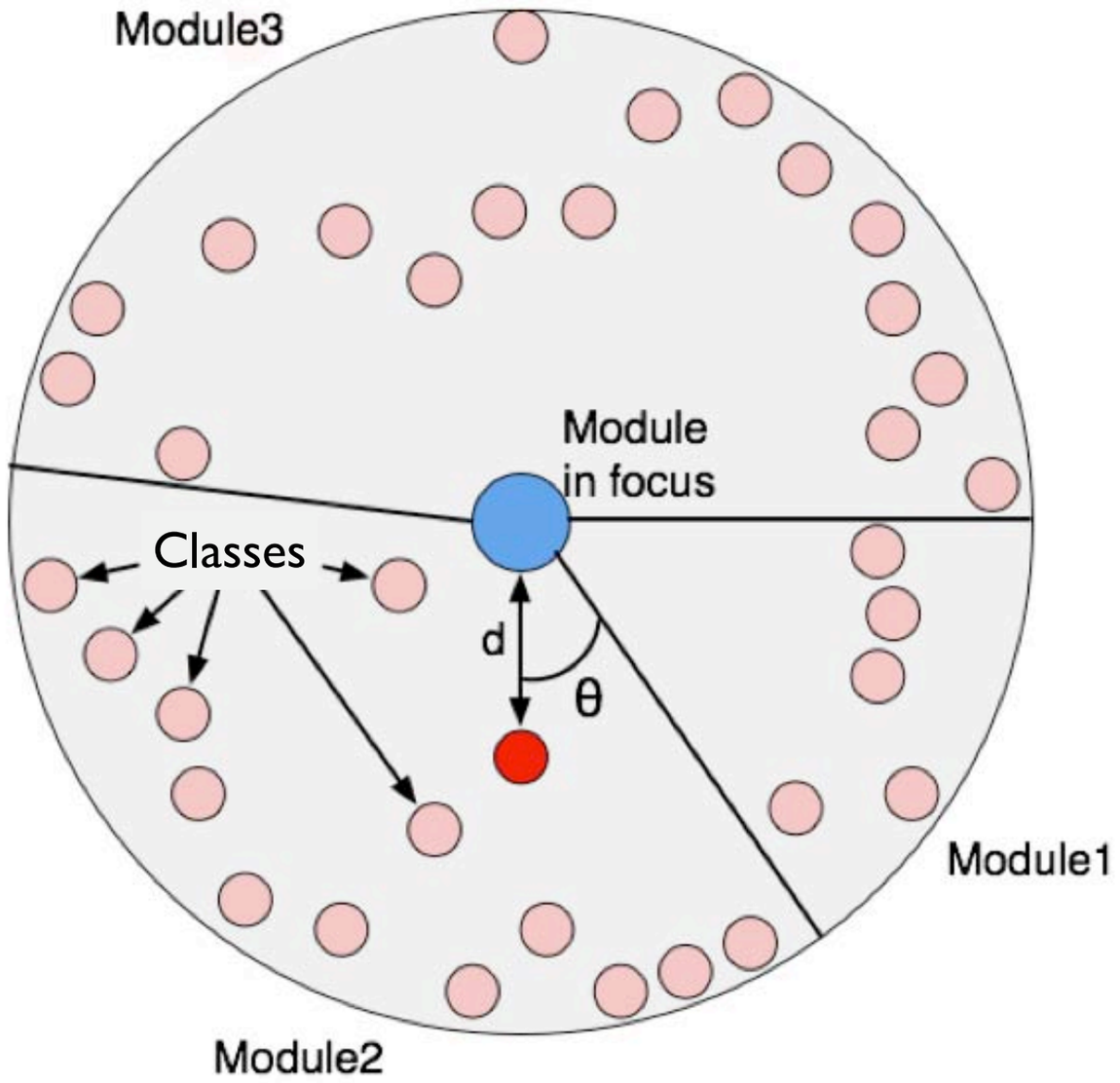
- For each module all its classes are rendered as colored circles and positioned using polar coordinates:



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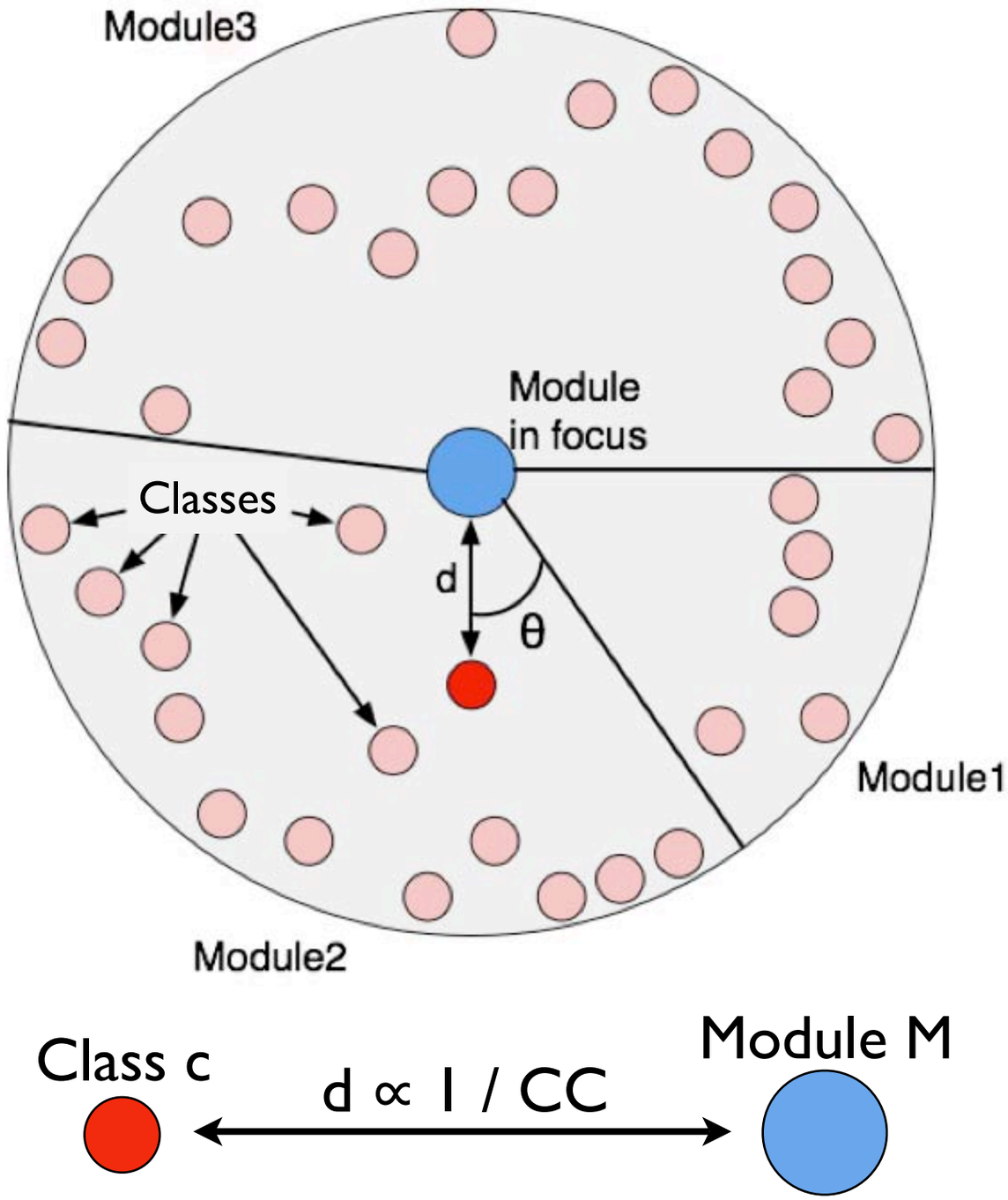

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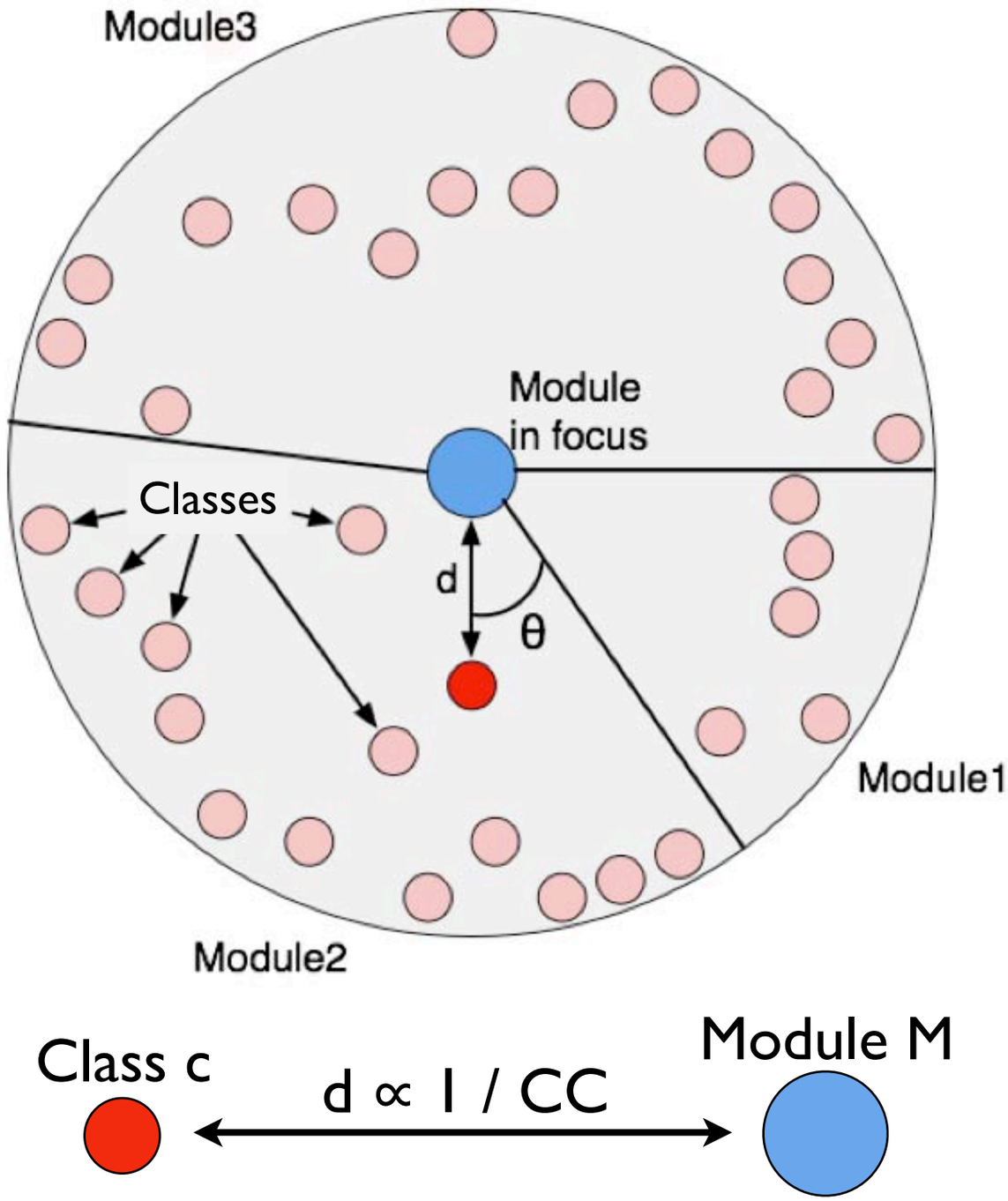

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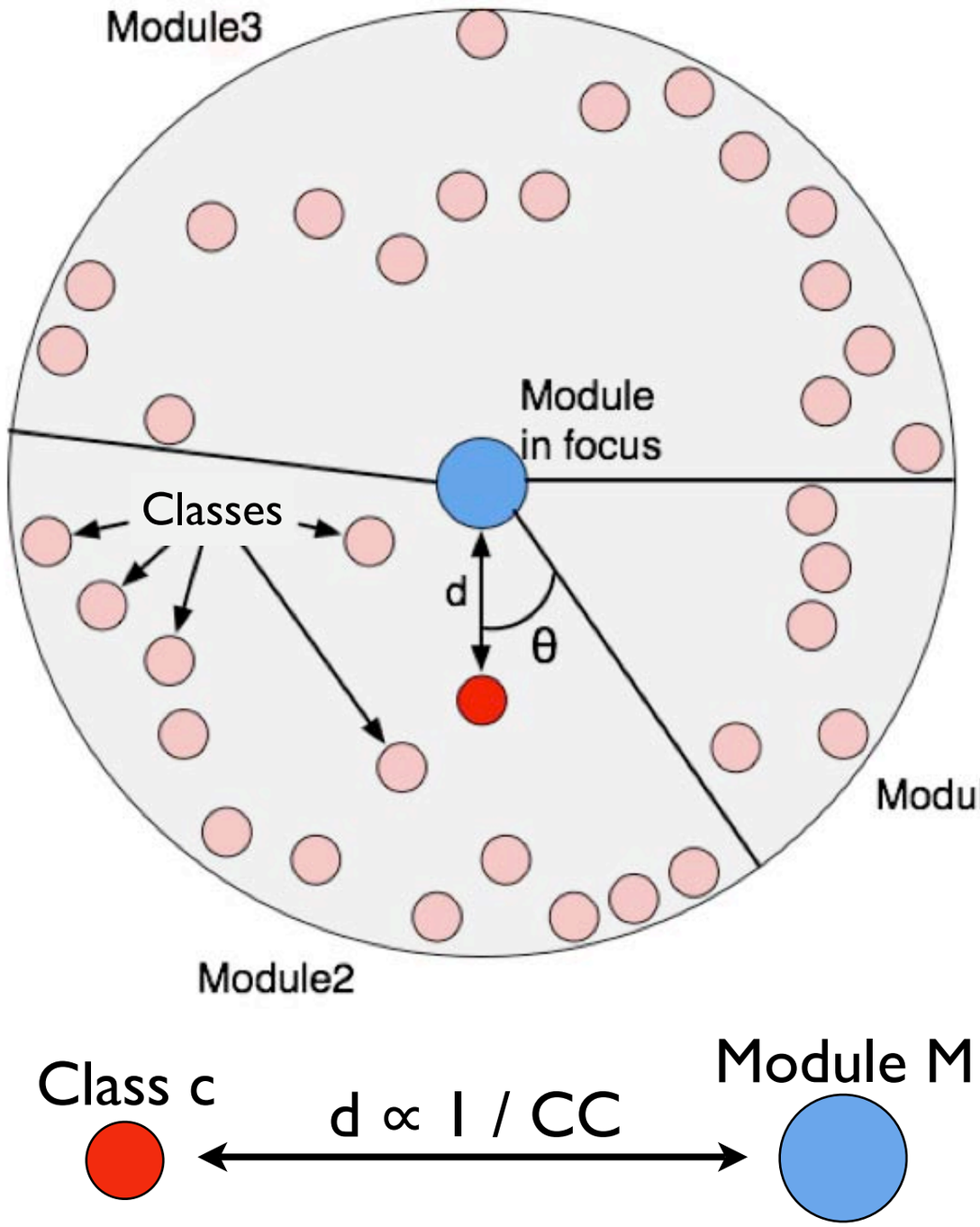

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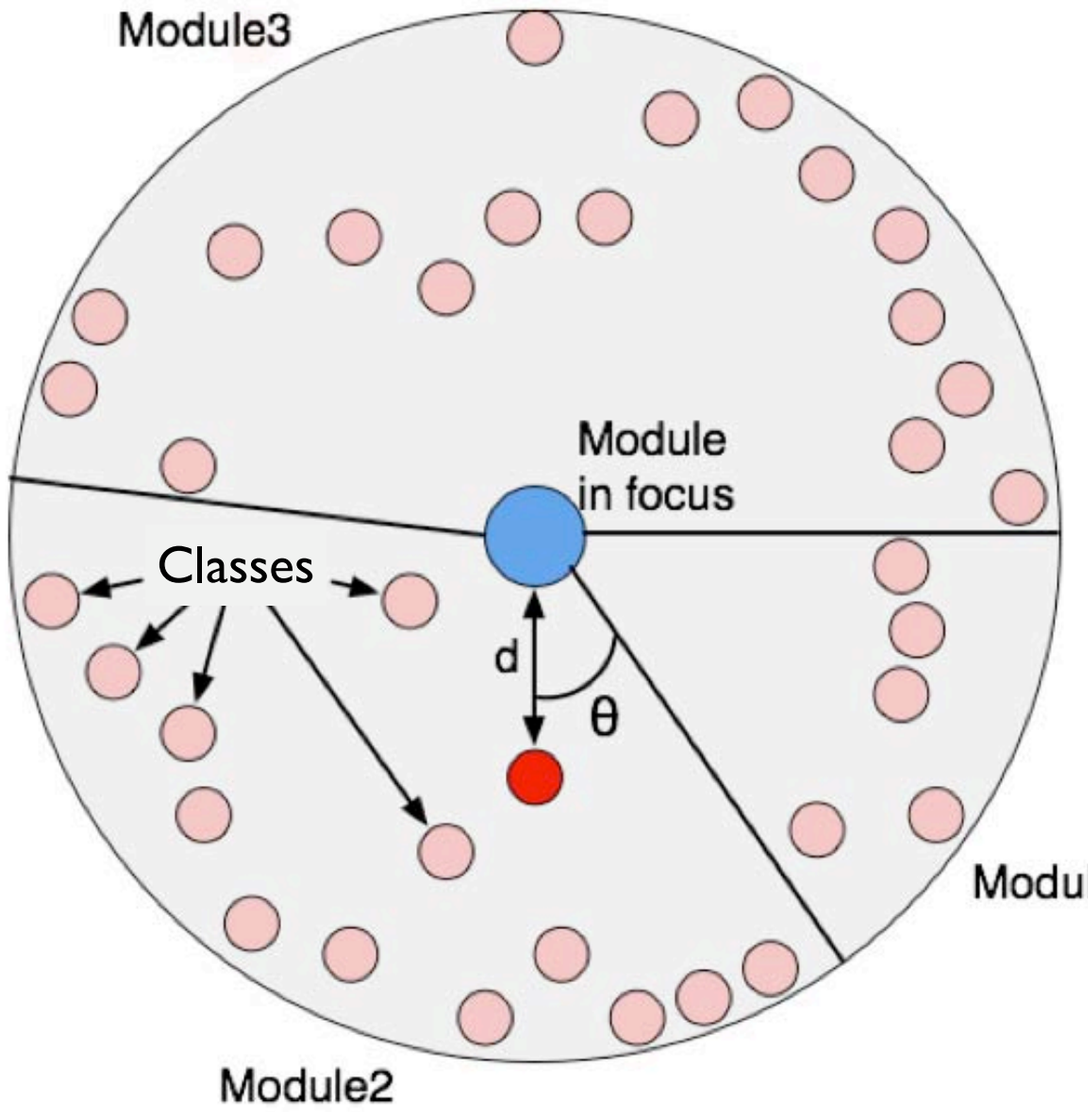
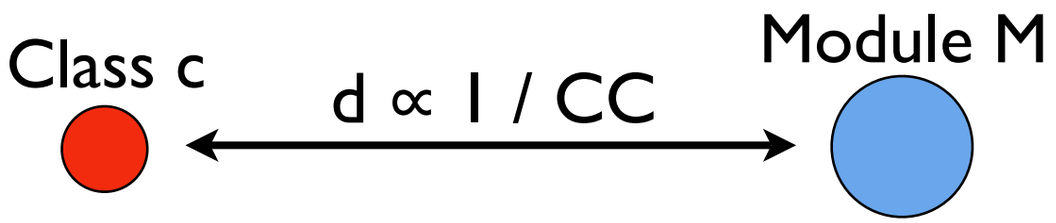
- CC between two classes is the number of “shared” commits





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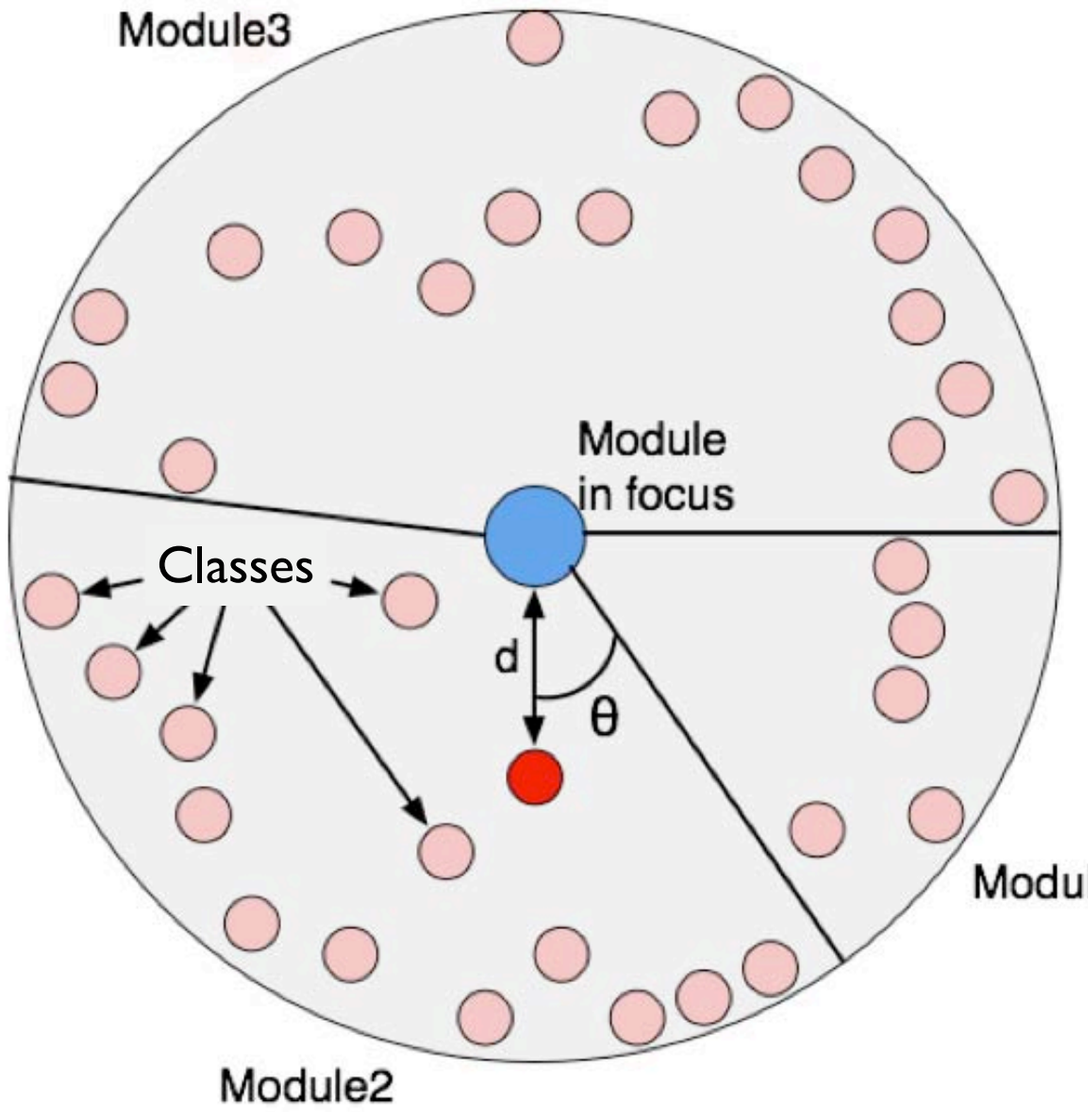
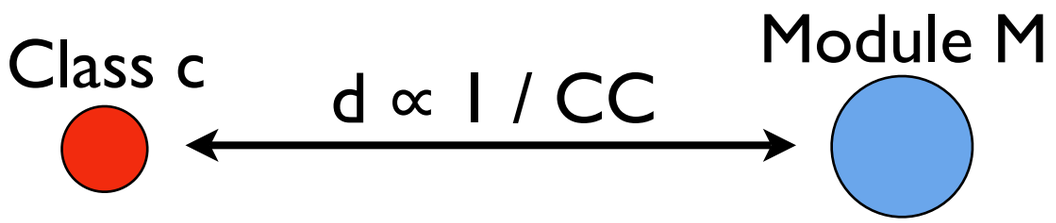
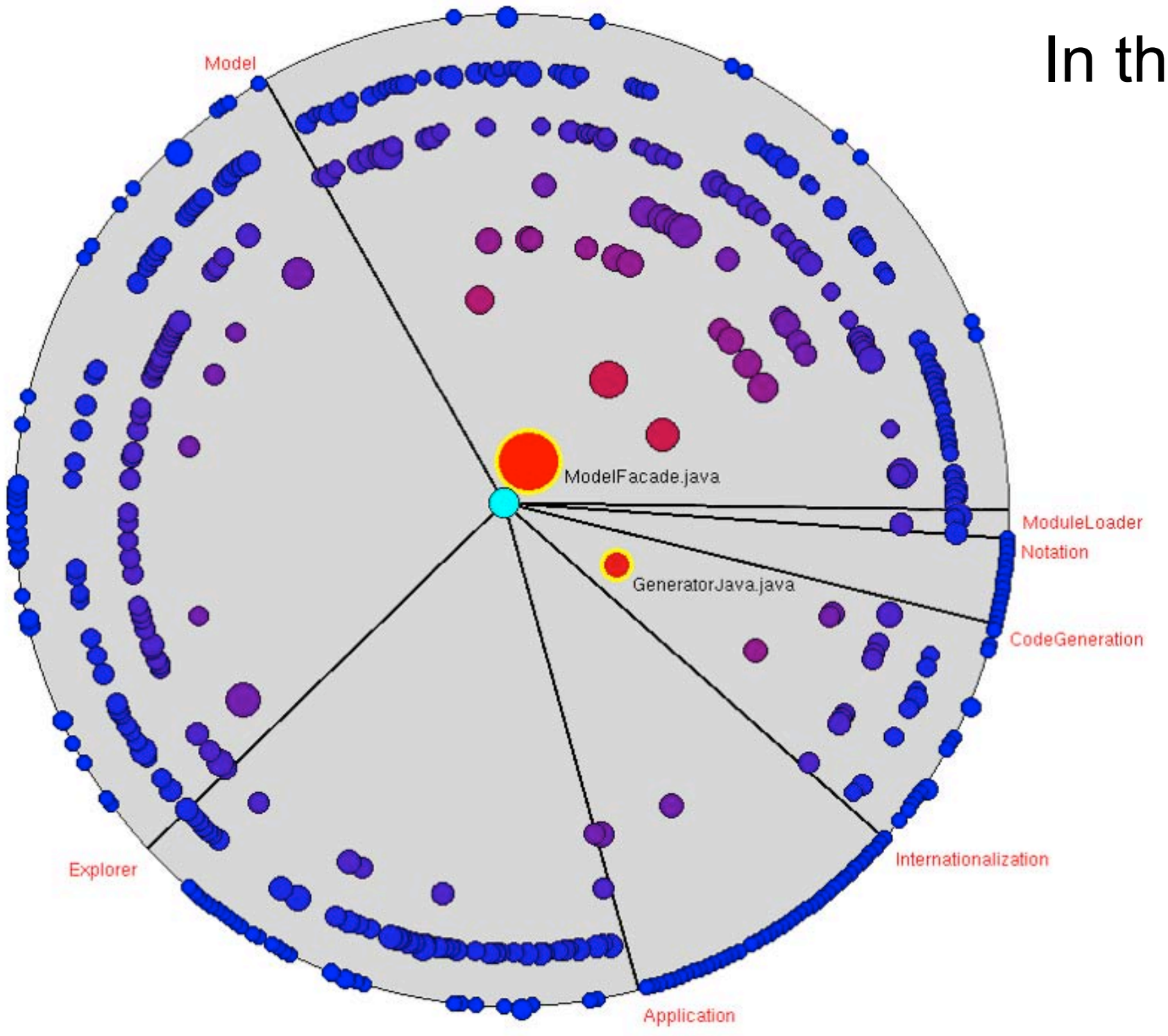
- CC between two classes is the number of “shared” commits
- CC between a class and a module is defined by means of a group operator





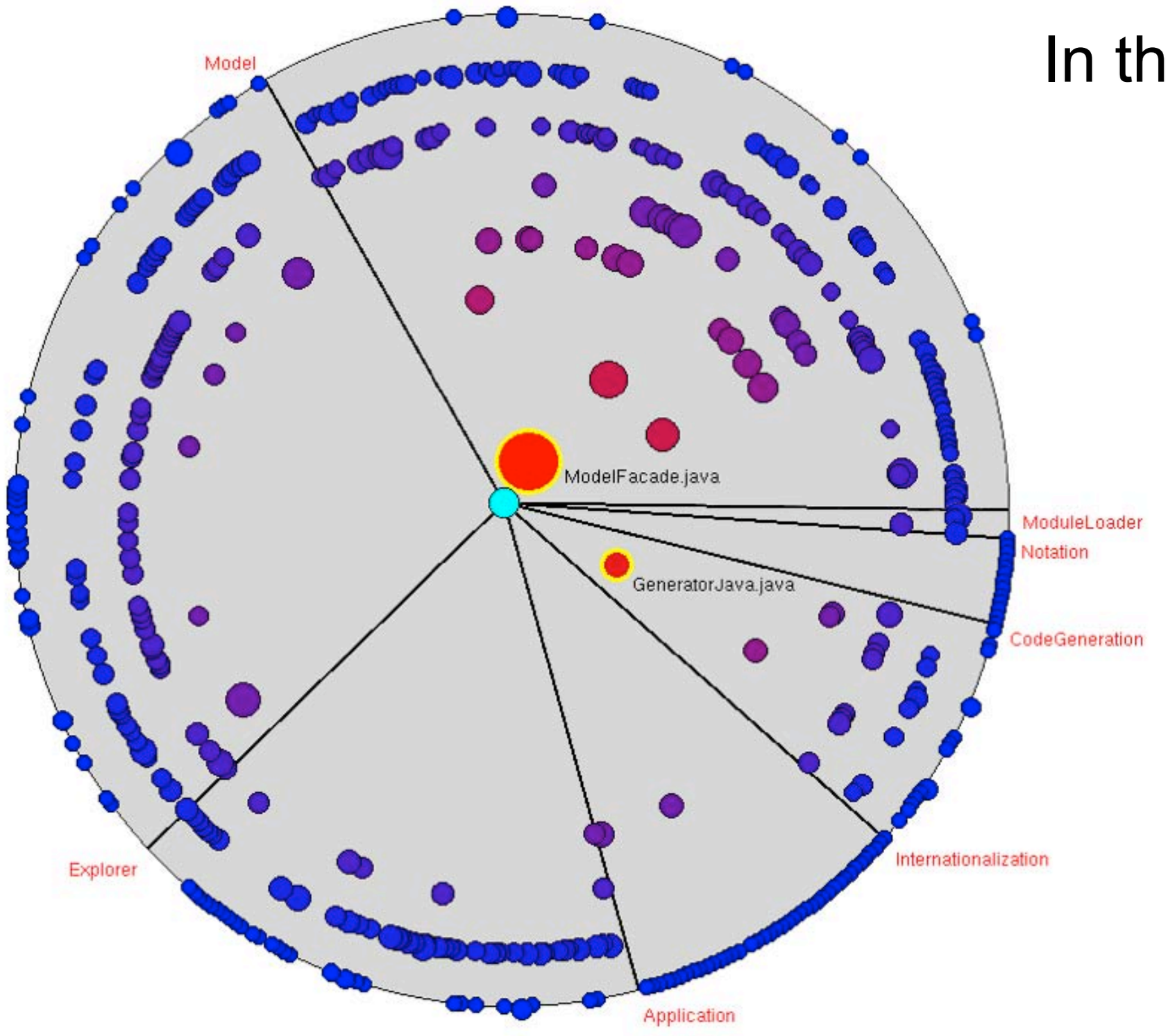
$$CC(M,c) = \max_{c_i \in M} CC(c_i,c)$$

Evolution Radar Exemplified



In the radar we can see:

Evolution Radar Exemplified



In the radar we can see:

- CC between a module and all the other module

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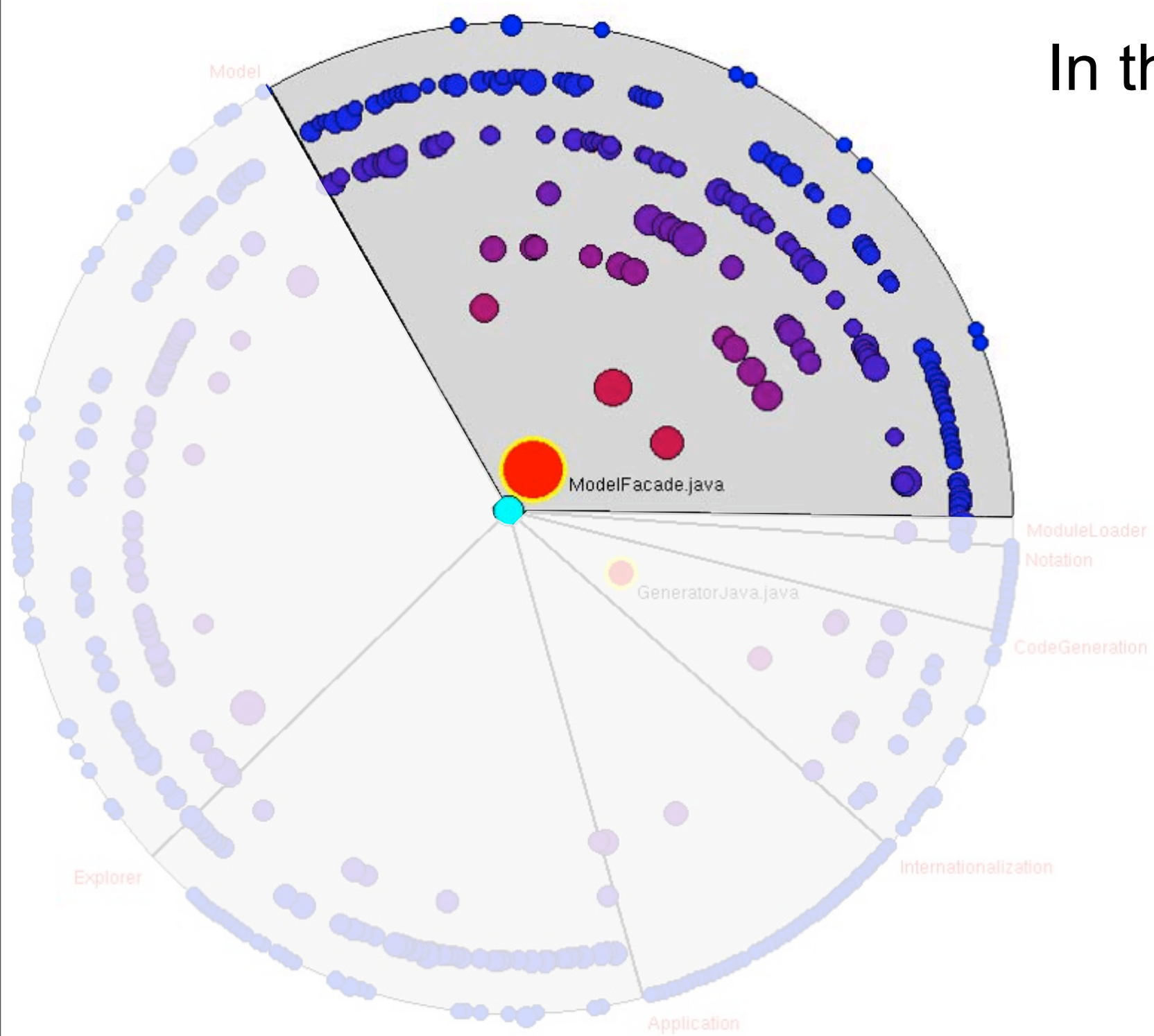

In the radar we can see:

- CC between a module and all the other module
- How the coupling is structured in terms of classes

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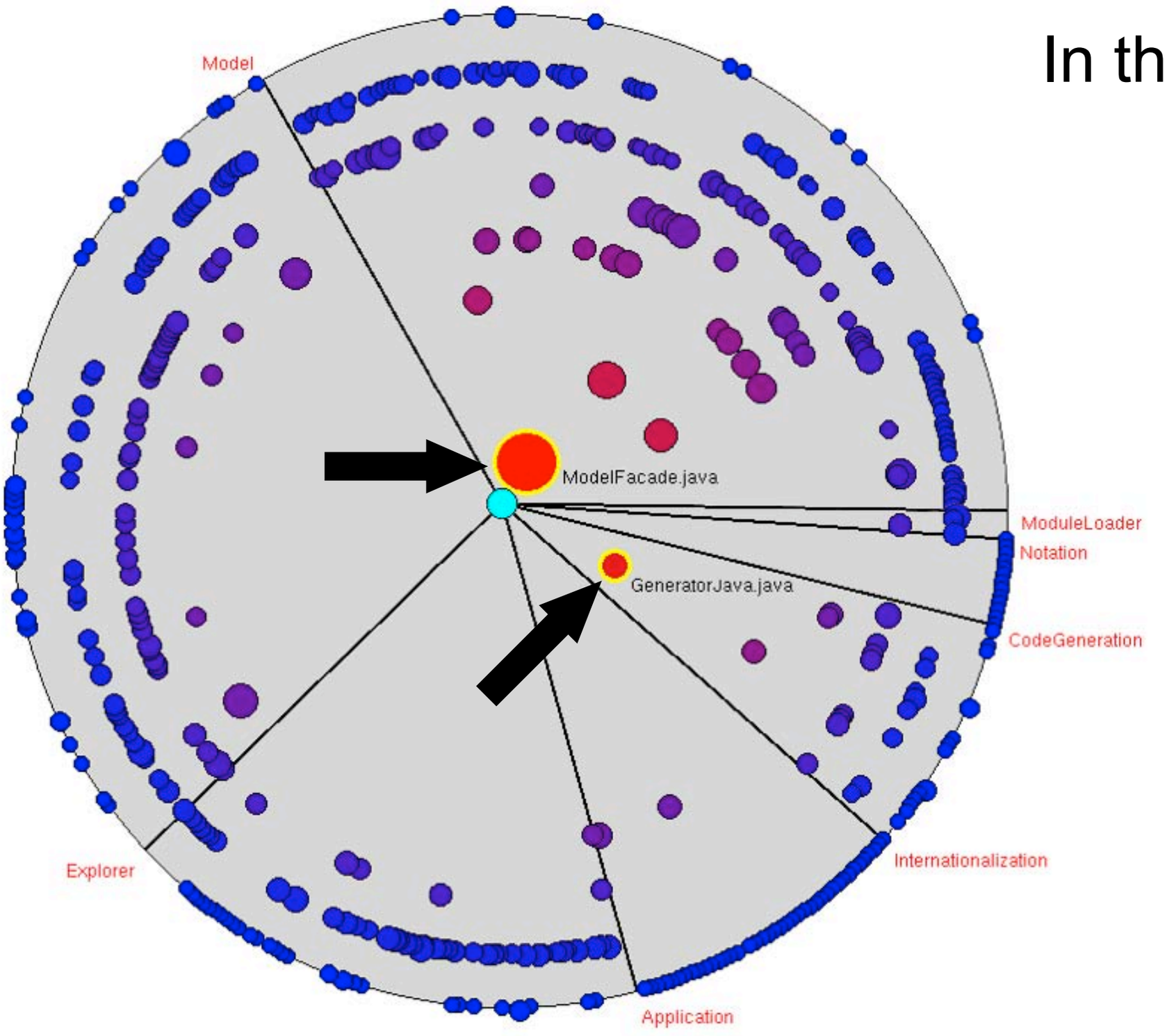

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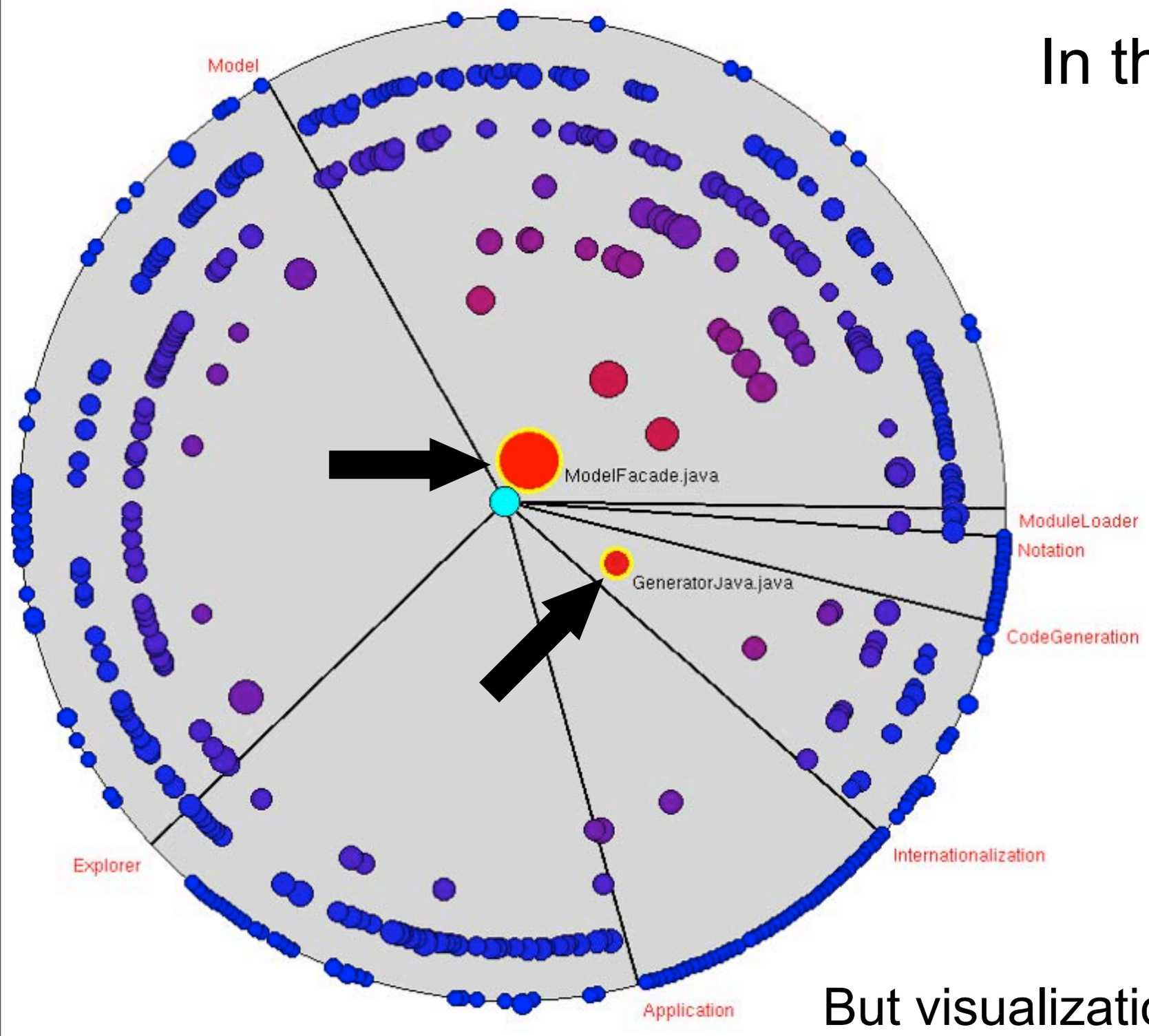

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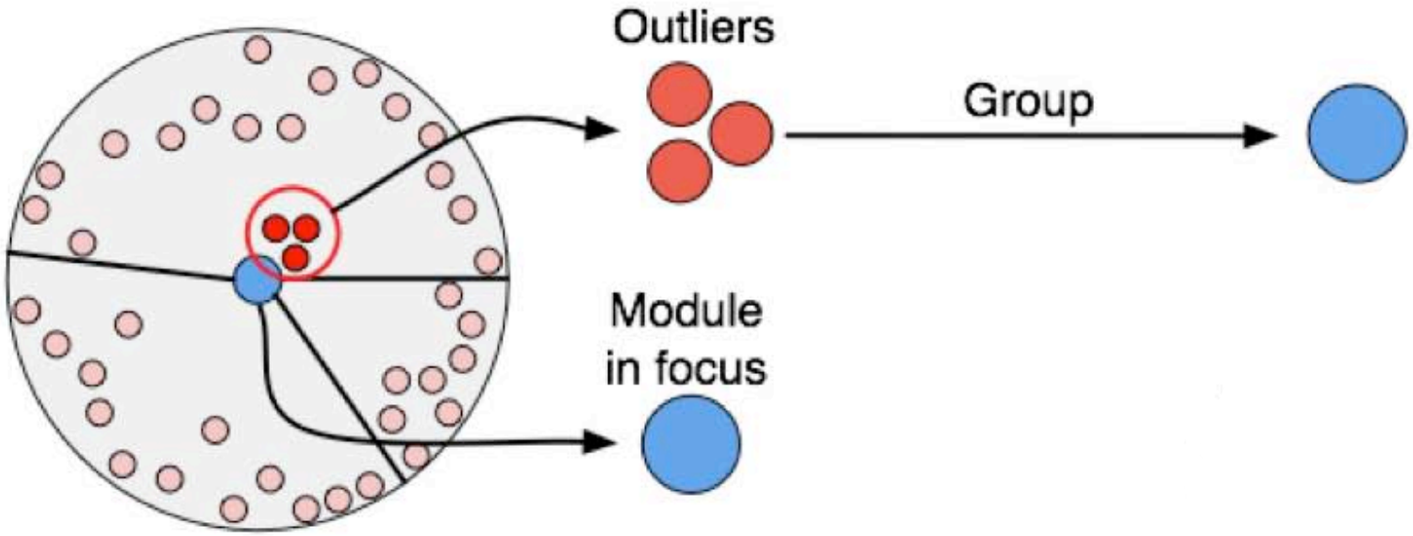
But visualization is not a silver bullet...

Interacting with the radar

- Basic interaction
  - Any entity in the visualization (classes and module in focus) can be inspected
    - Source code
    - Commit-related information
    - Contents
- Advanced interaction
  1. Spawning
  2. Moving trough time
  3. Tracking

Spawning

To understand which files are coupled with selected files in the module in focus



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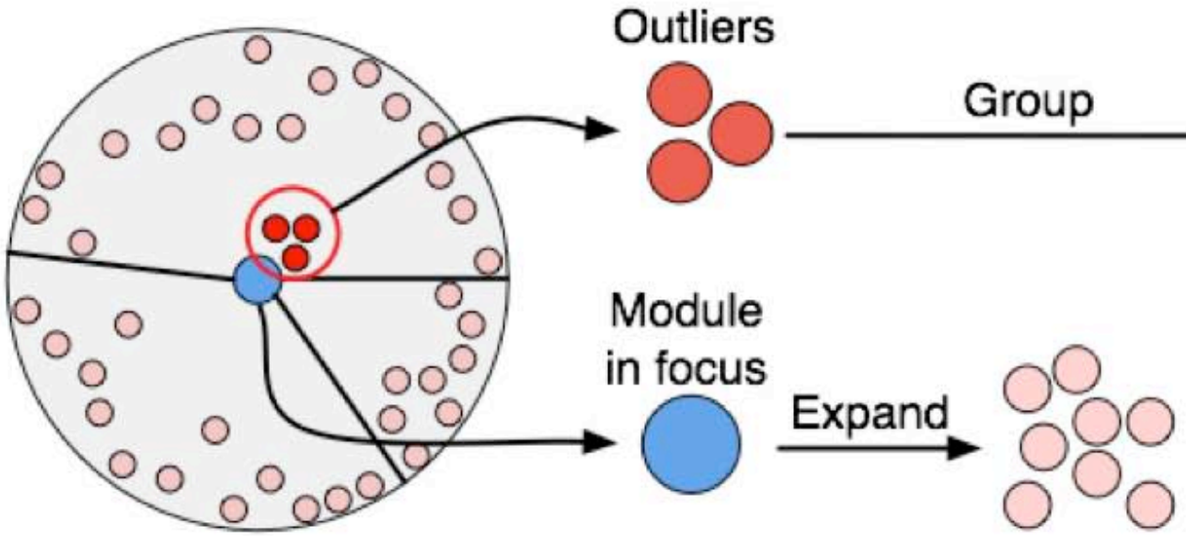

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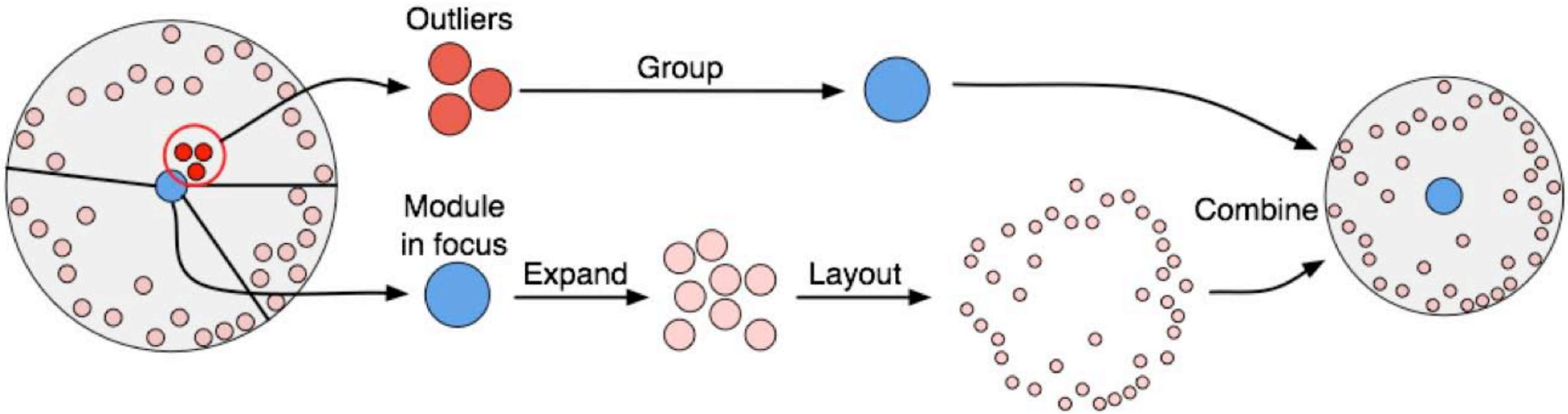

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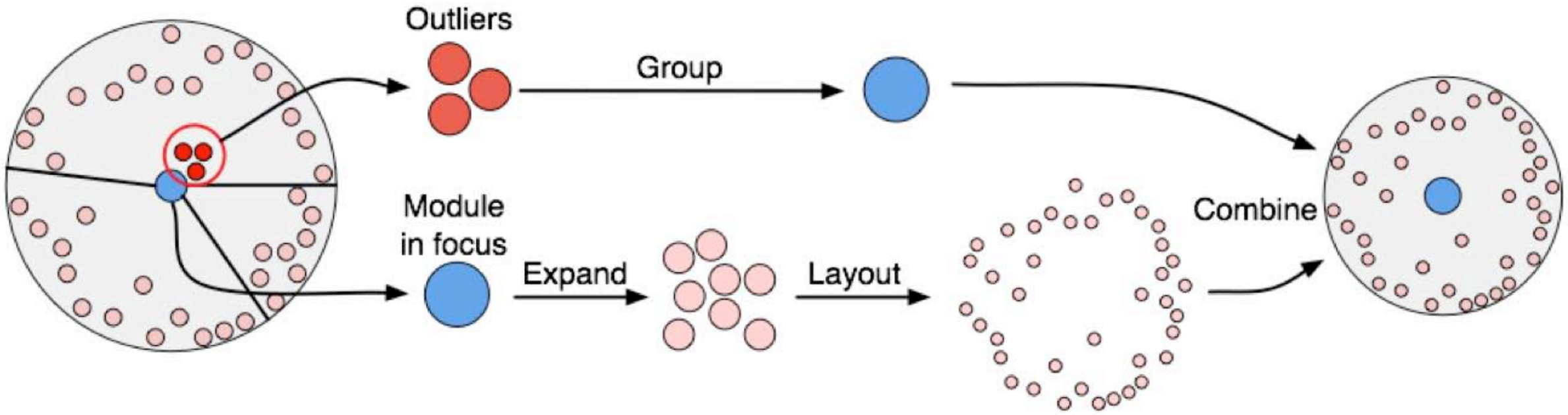

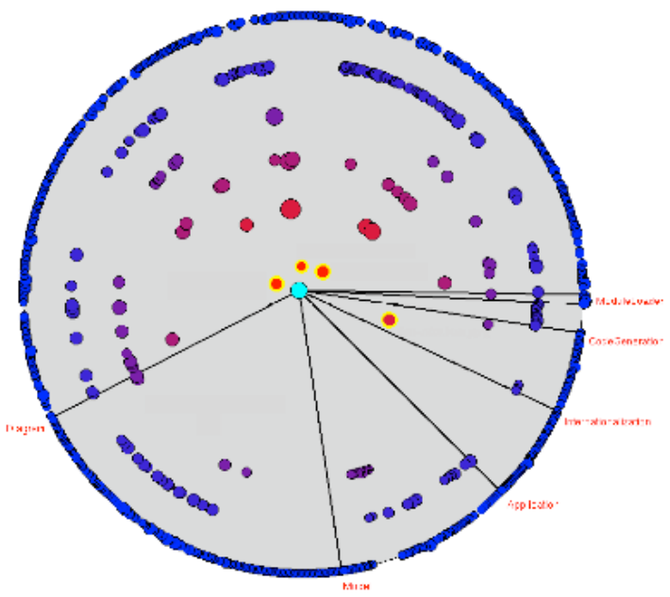

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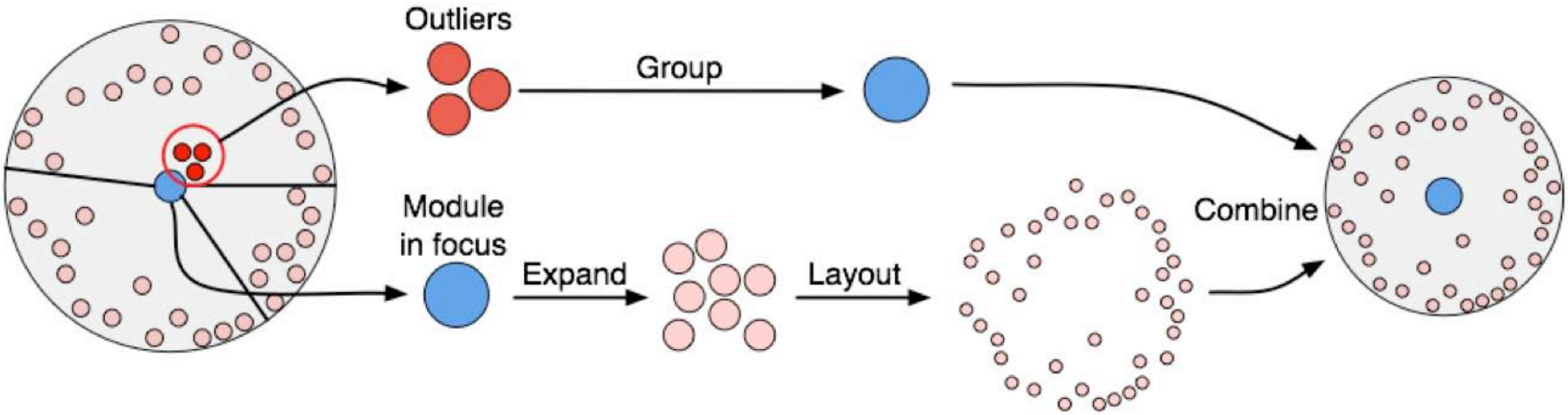

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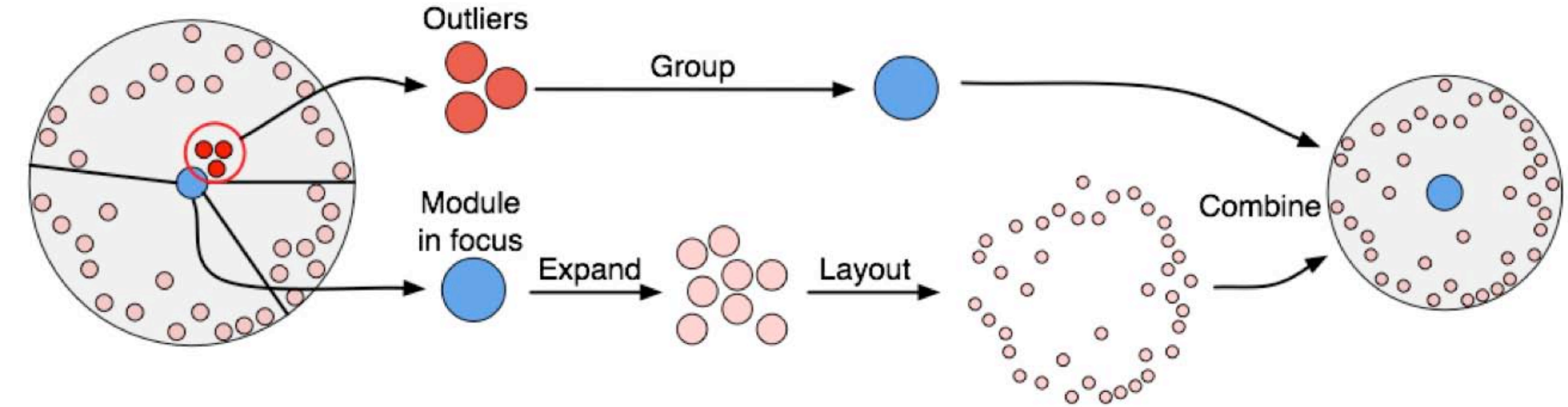

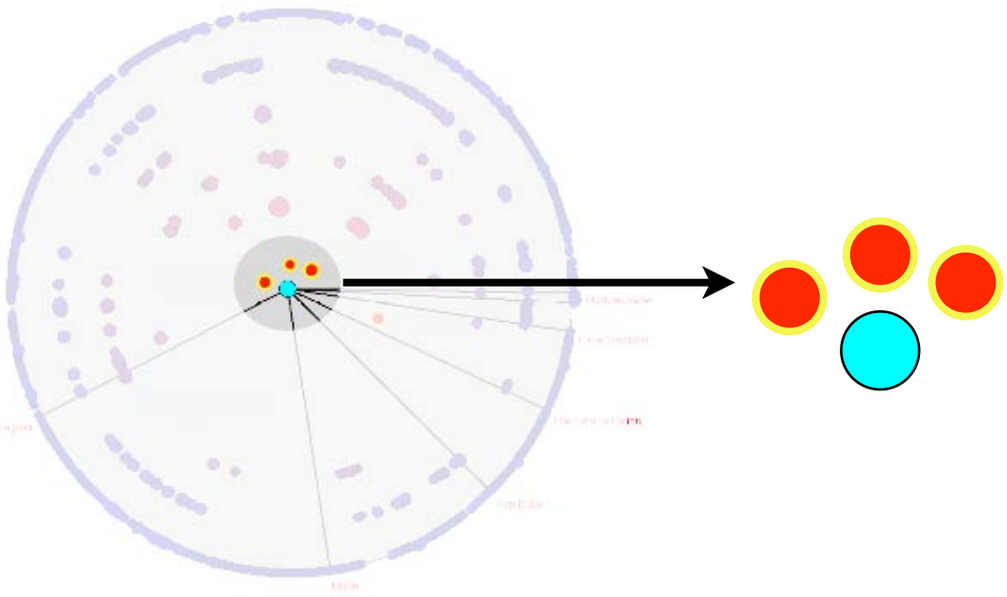

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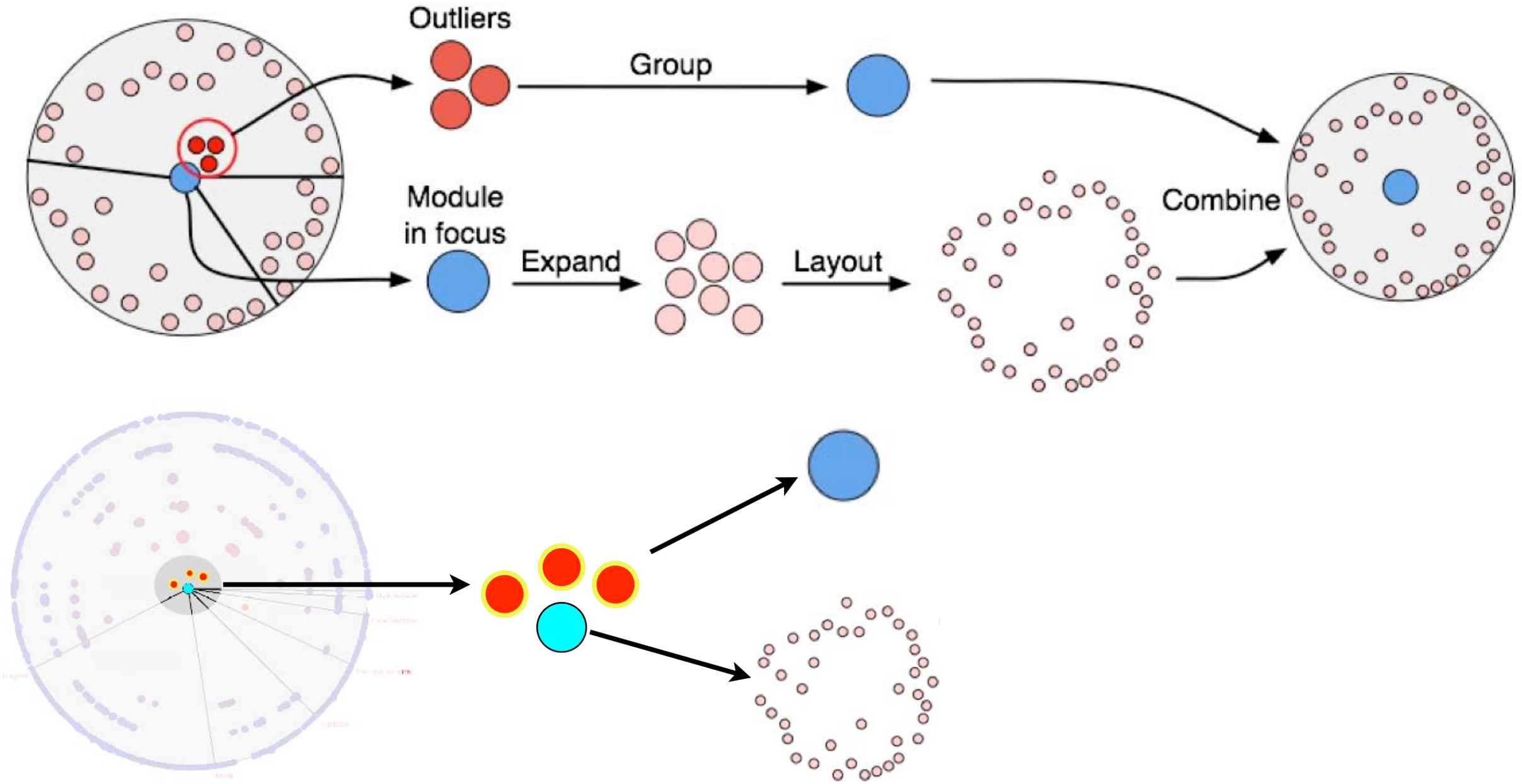

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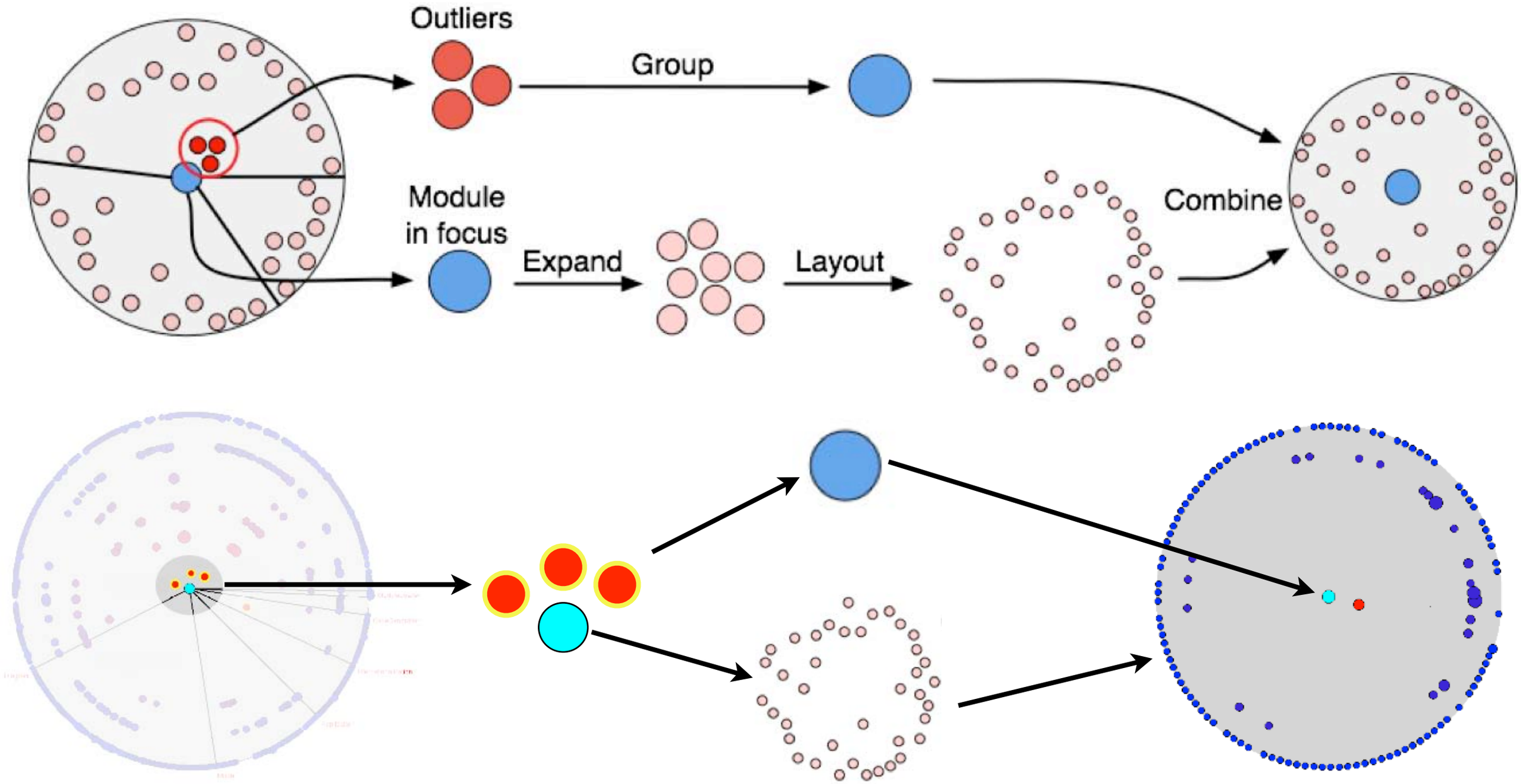

Moving Through Time & Tracking

Problem: The coupling value depends on the time window considered

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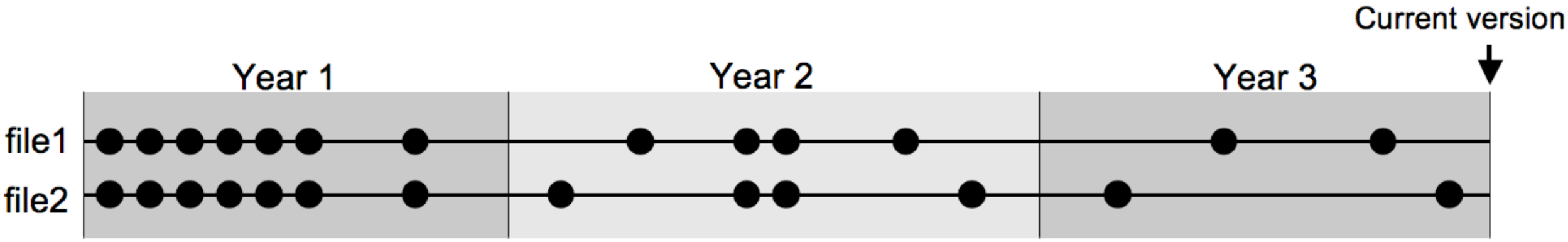

CC Entire history: 9/17 ⇒ Strong CC

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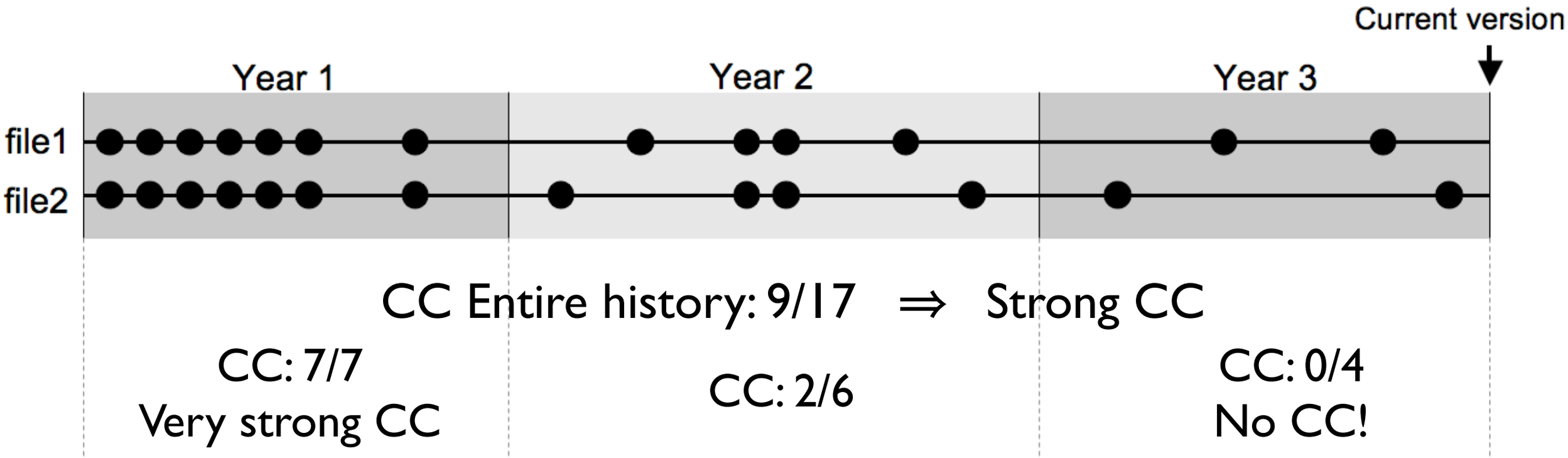

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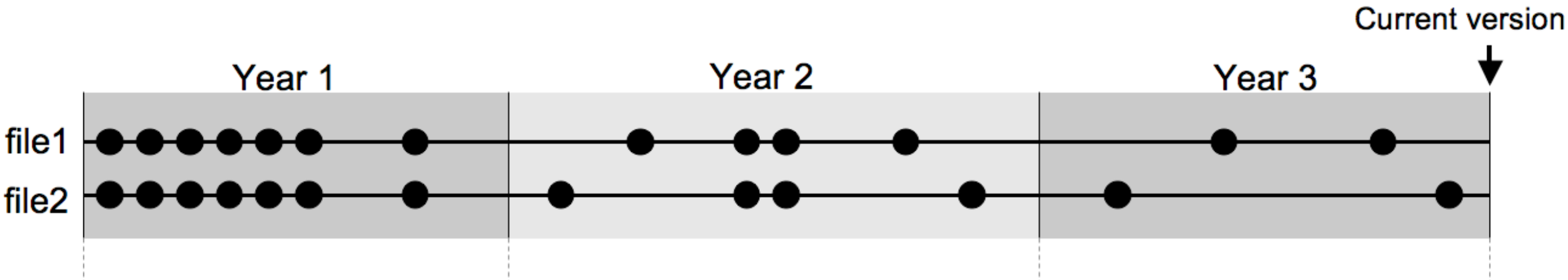
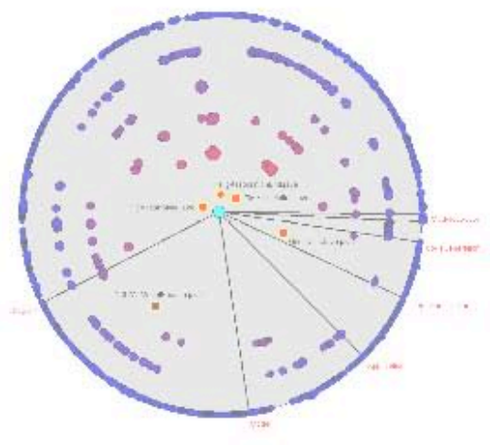


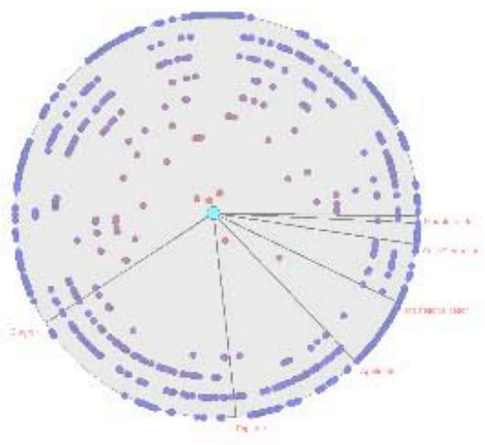
CC Entire history: 9/17 ⇒ Strong CC

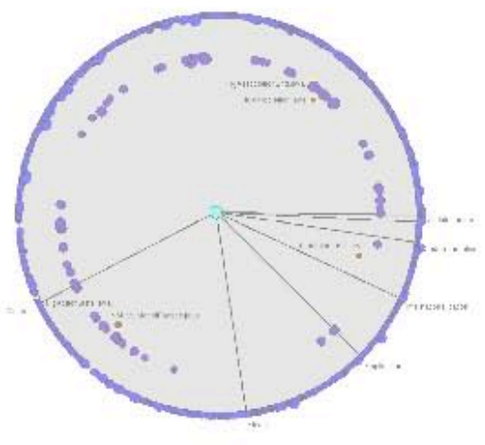
CC: 7/7
Very strong CC

CC: 2/6

CC: 0/4
No CC!







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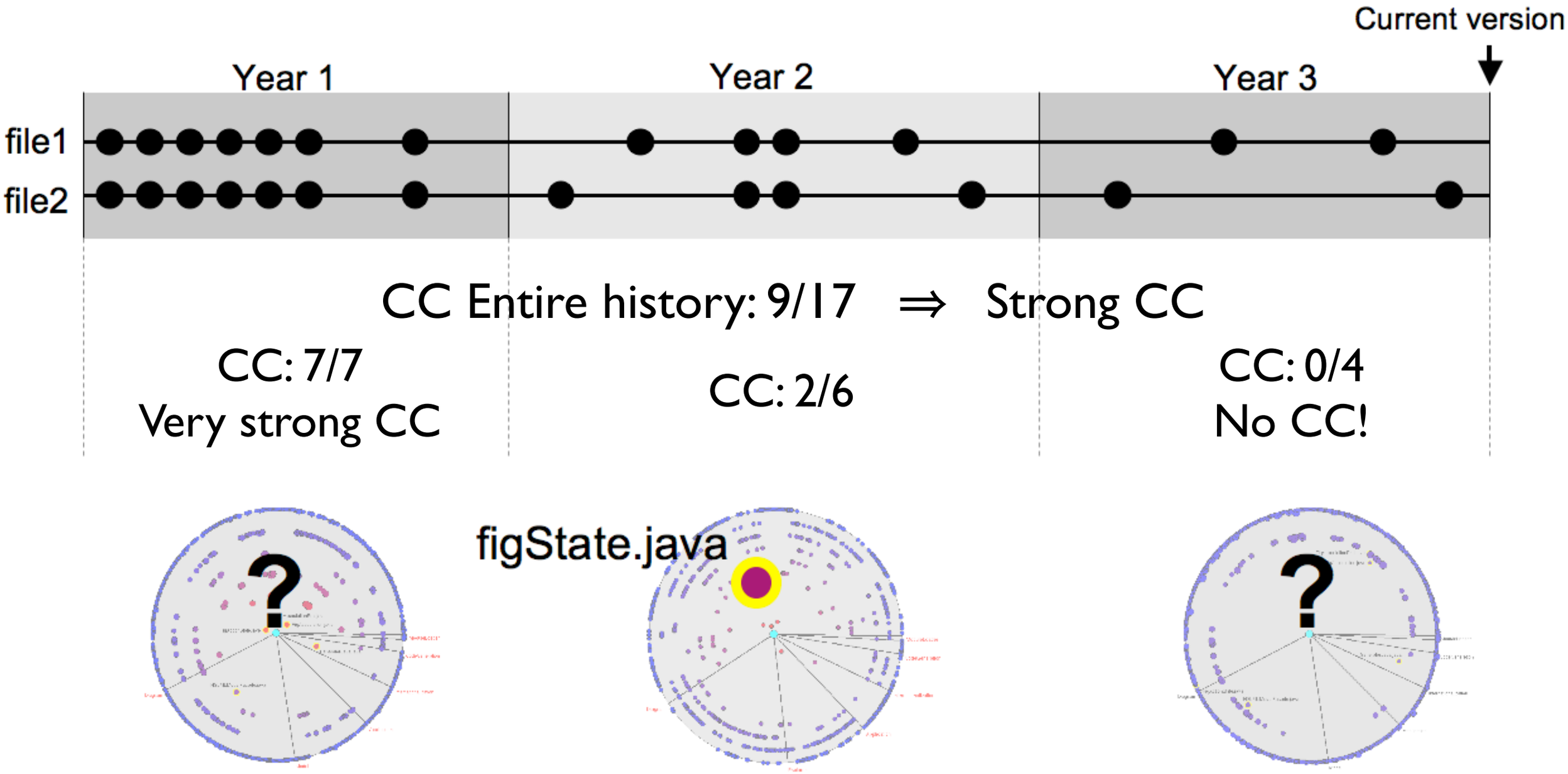

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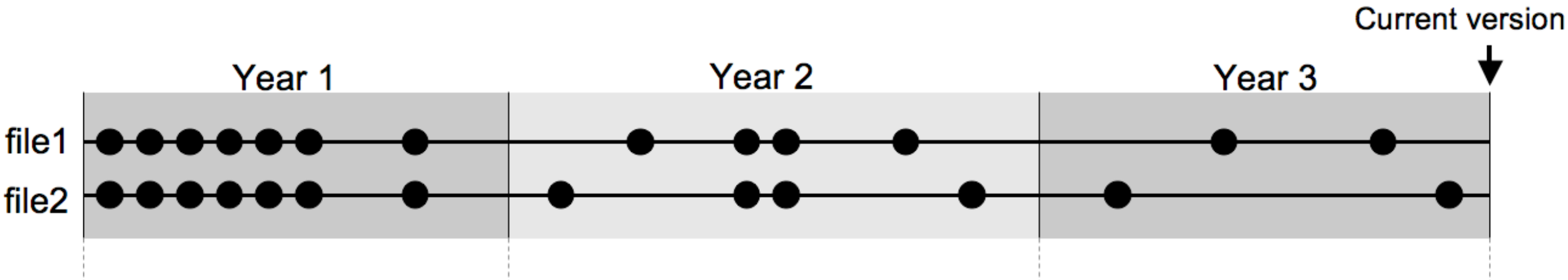
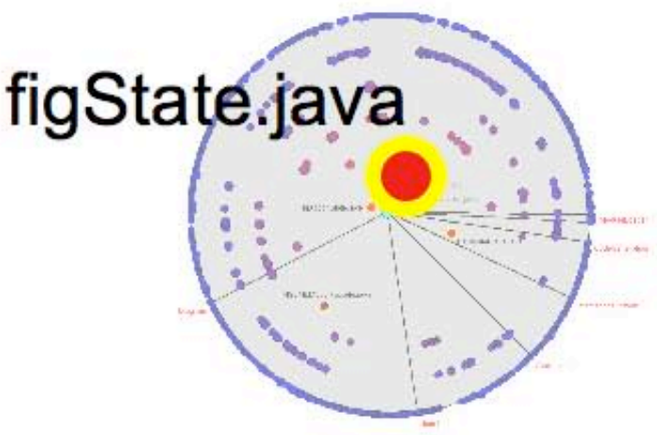


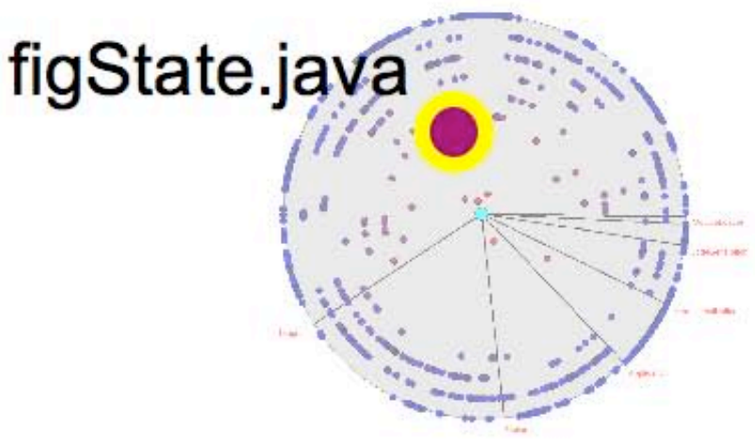
CC Entire history: 9/17 ⇒ Strong CC

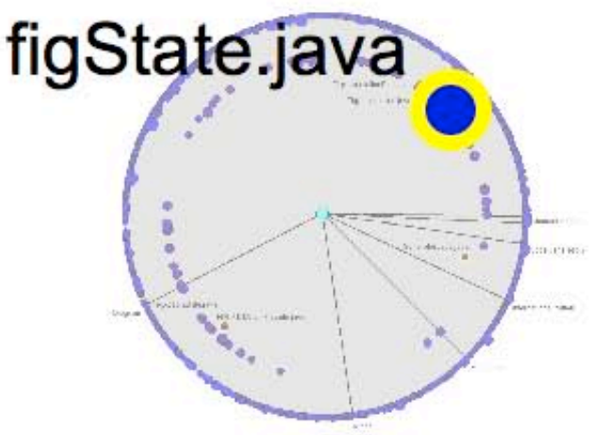
CC: 7/7
Very strong CC

CC: 2/6

CC: 0/4
No CC!





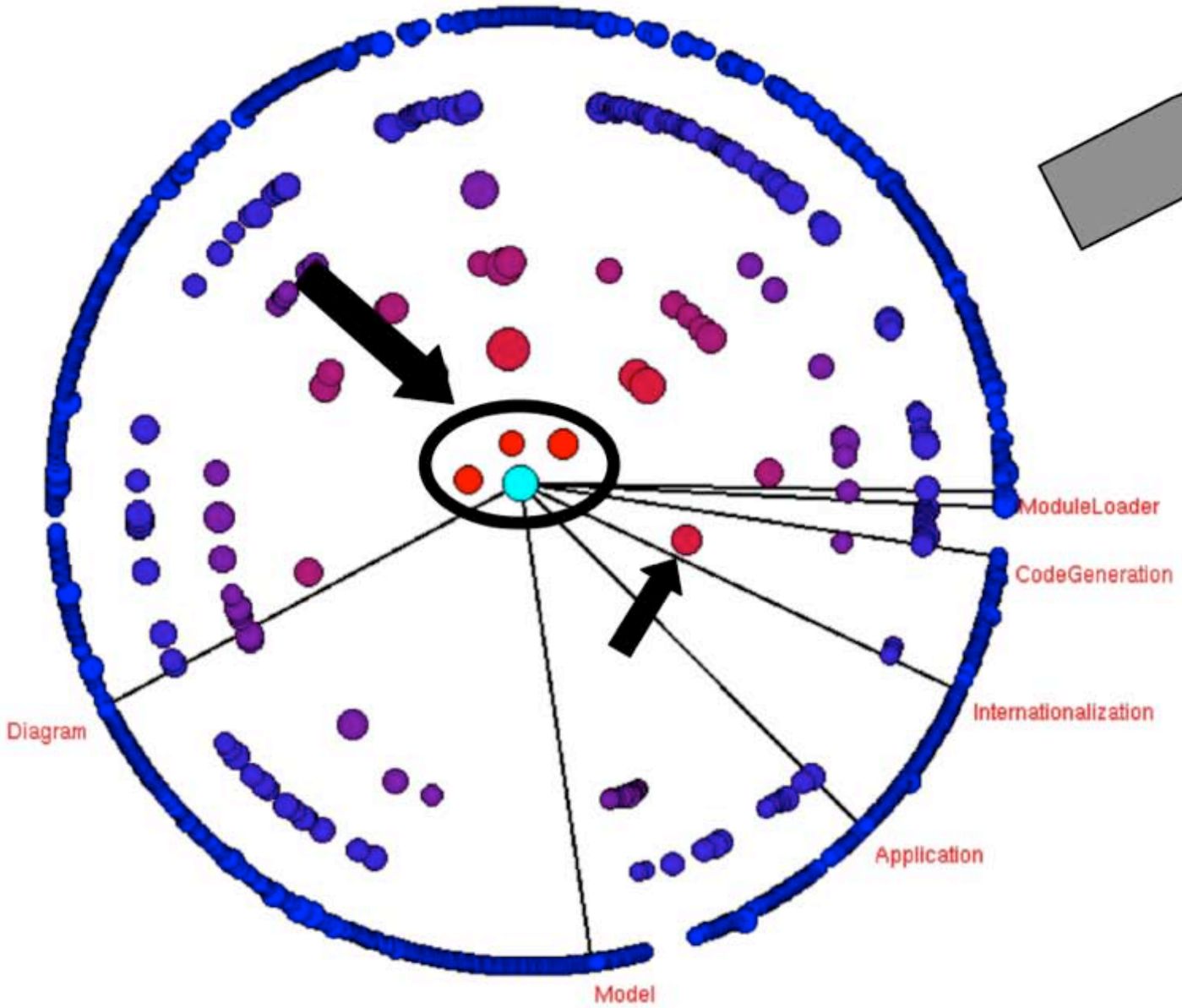


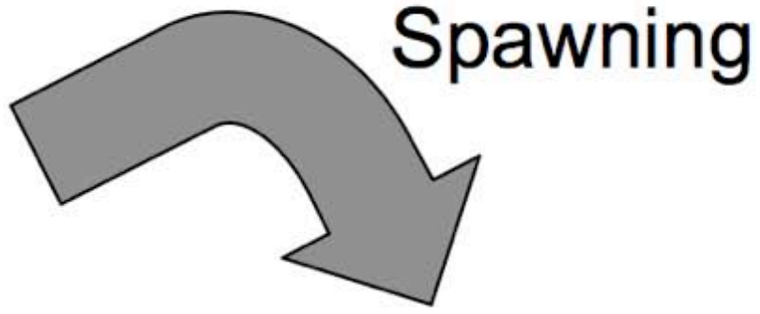
Validation: ArgoUML

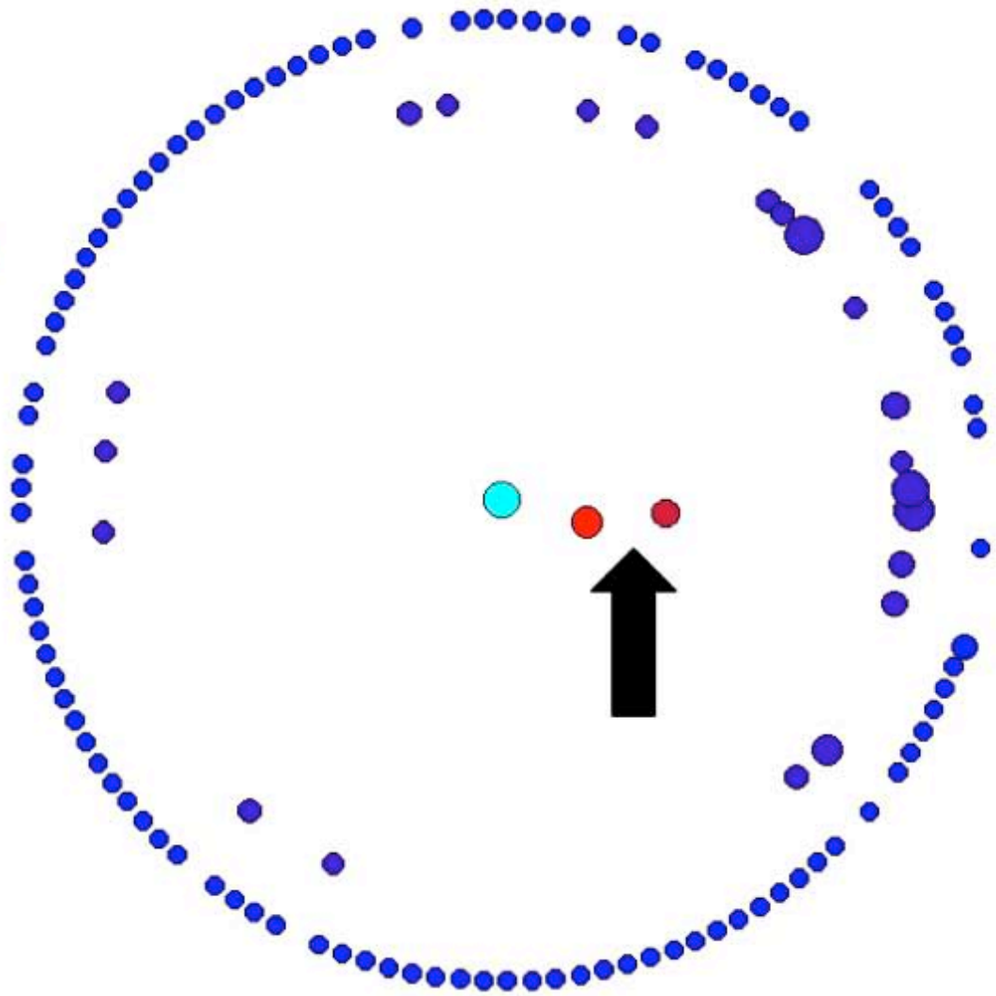
LOC	#Classes	#Commits	Time Interval
~ 220K	~ 2500	~ 50'000	2000 - 2005

- Methodology
  - Consider time interval of 6 months
  - Apply one radar per time interval

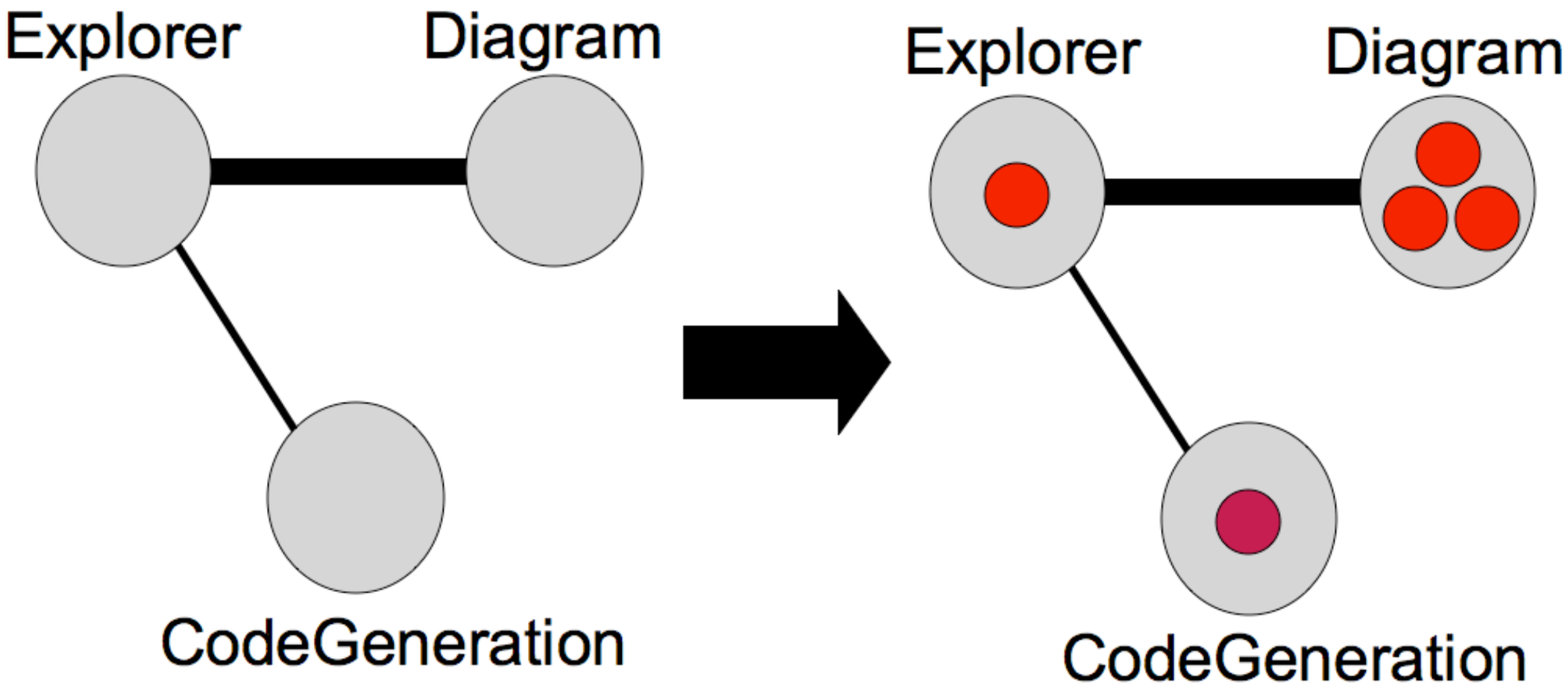
Explorer: August - December '05





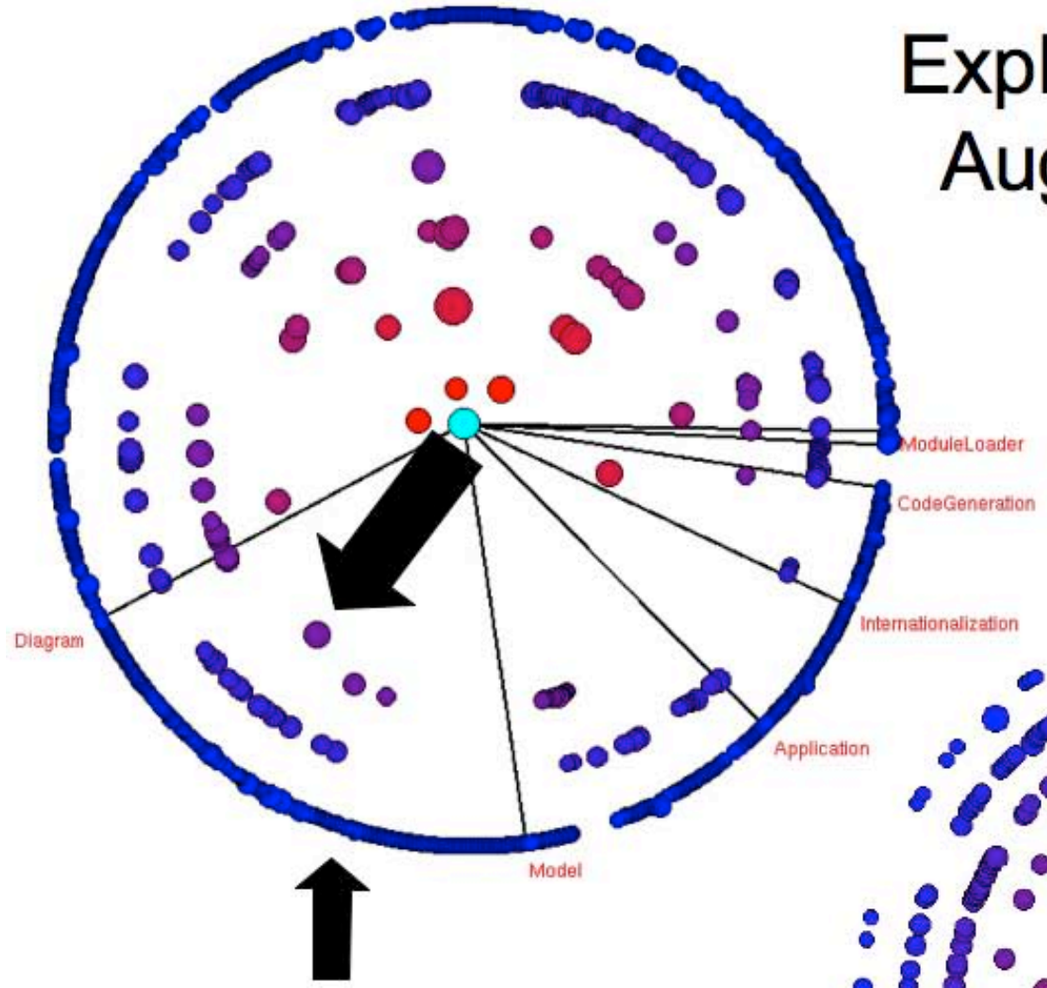


Information Crystallization



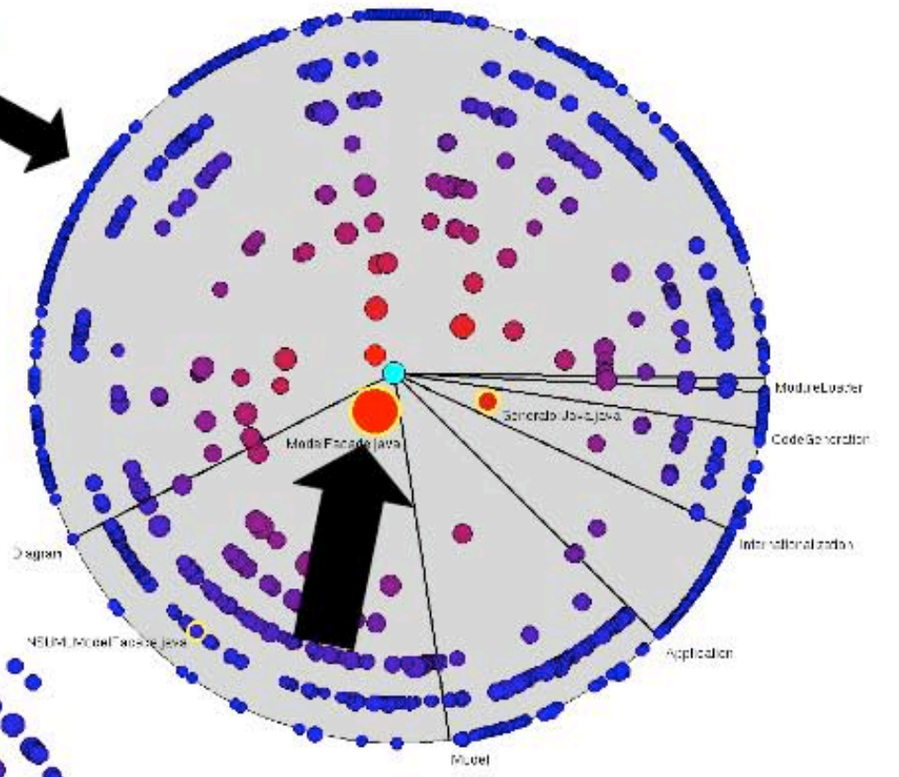
- Dependencies between modules are simplified to dependencies between small sets of classes.
- These classes are candidates for reverse engineering

The Evolution of Model Facade



Explorer in focus
Aug-Dec 2005

Explorer in focus
Aug-Dec 2004



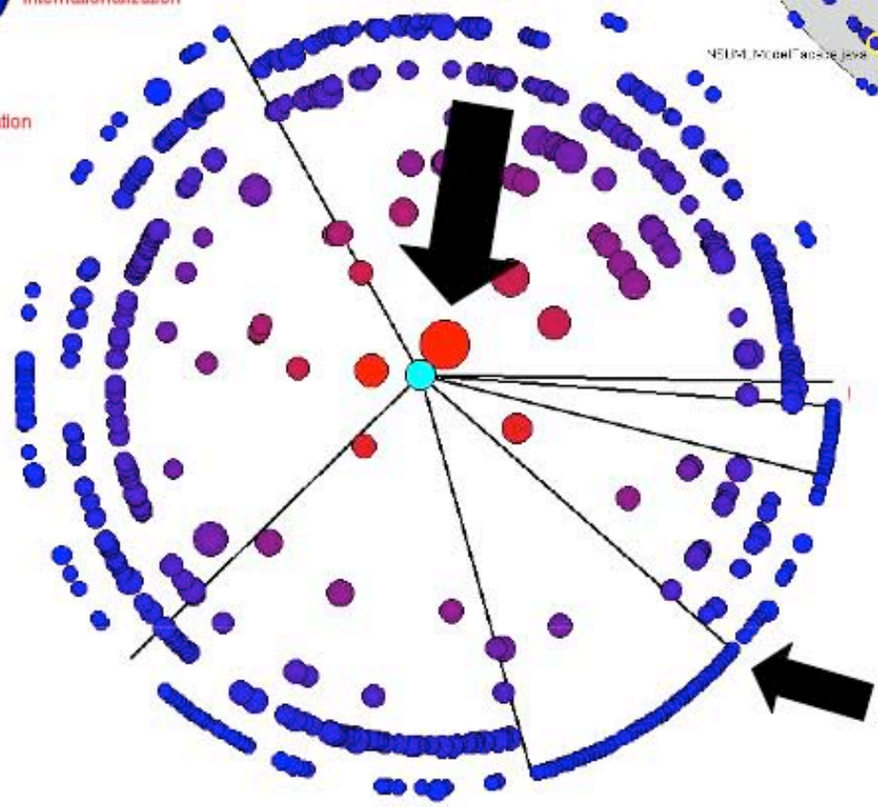


Diagram in focus
Aug-Dec 2004

Evolution Radar Discussion

The Evolution Radar visualizes **integrated** change coupling information. It shows:

- Dependencies at the module level
- The structure of these dependencies in terms of classes, by rendering the classes themselves

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Pros	Cons
• Interactivity and control of time • Scalability • Does not suffer from overplotting • General technique applicable to any groups of entities given a distance measure	• Need an authority system decomposition • The visualization has to be learnt • May suffer from the outliers problem

Epilogue: From study to control Software Evolution

Change coupling (as well as bug and change history) is helpful to detect architecture shortcoming but is **only one aspect** of the evolution of a system

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Change coupling (as well as bug and change history) is helpful to detect architecture shortcoming but is **only one aspect** of the evolution of a system

*The goal is to aggregate all the pieces of information to tell the story of the system and then to monitor and **control** its evolution*

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Mining version histories to guide software changes

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Marco D'Ambros, Harald Gall, Michele Lanza, Martin Pinzger
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