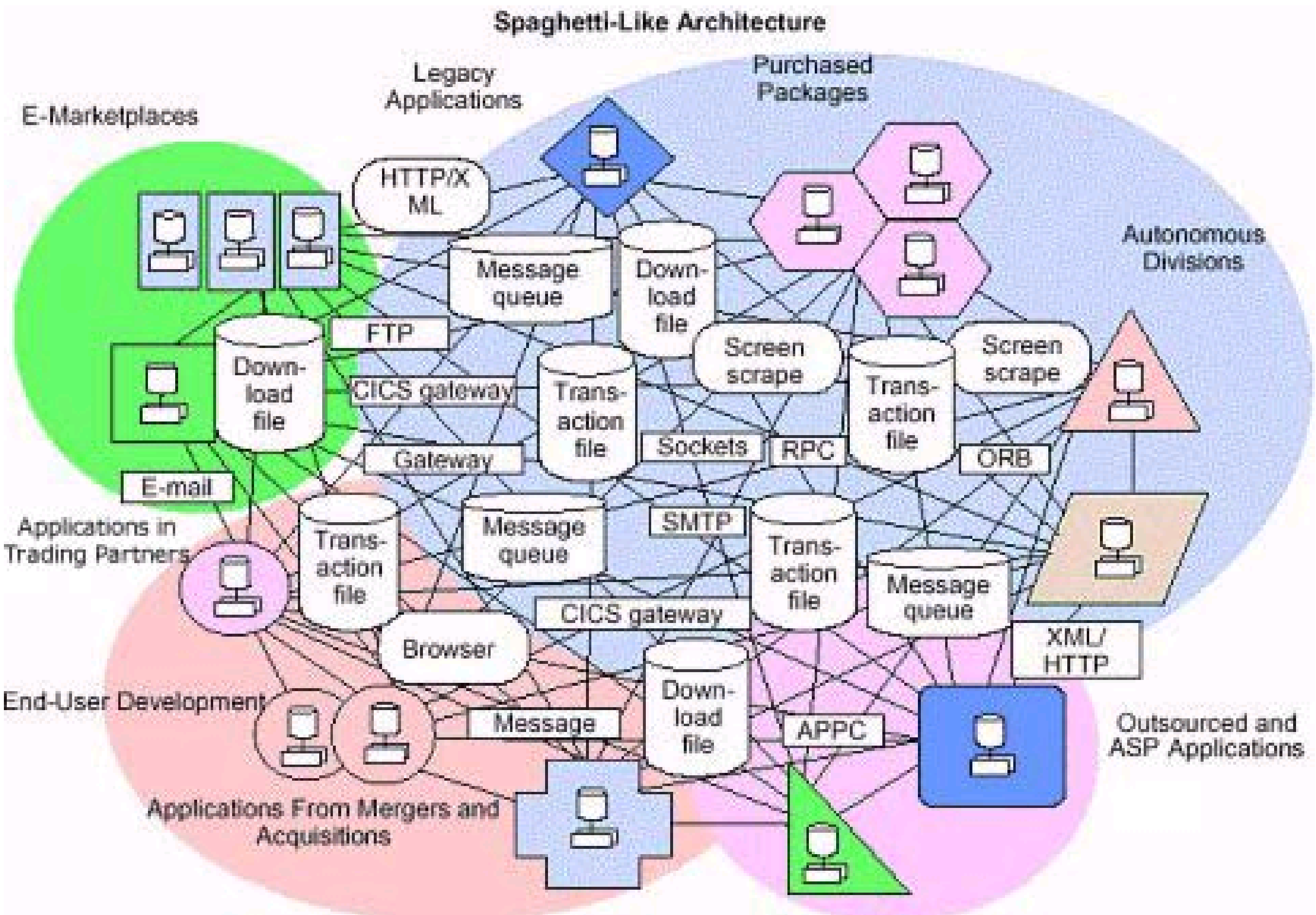
Klocwork Architecture Excavation Methodology

Nikolai Mansurov
Chief Scientist & Architect

Overview

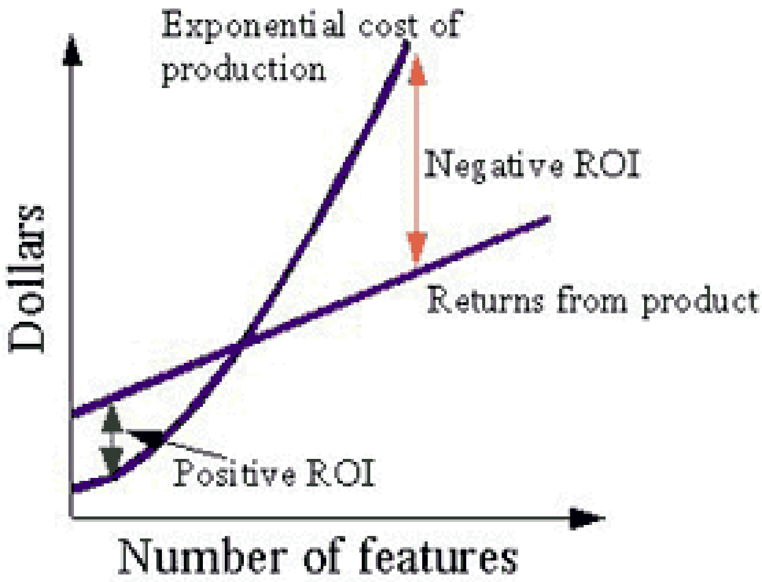
- **Introduction**
  - Production of software is evolutionary and involves multiple releases
  - Evolution of existing code has significant economic impact
  - Why the cost of production increases over time ?
- **Architecture Excavation : single most important investment in software production management**
  - Challenges
- **Klocwork Architecture Excavation Methodology**
  - Focus
  - Container Models
  - Basic Operations
  - Strategy
- **Examples**
- **What next?**
- **Key points**

Spaghetti-like at the enterprise application integration level



Why the cost of production increases over time ?

- **The cost of changing software increases over time, and is not linear, but exponential**
  - Brooks attributes the exponential rise in costs to the cost of communication.
  - Maintenance corrupts the software structure so makes further maintenance more difficult
  - The number of error reports increases
  - Productivity of the maintenance staff decreases
  - Code becomes harder to understand
- ***Architecture Erosion*: Positive feedback between**
  - the loss of software architecture coherence
  - the loss of the software knowledge
    - less coherent architecture requires more extensive knowledge
    - if the knowledge is lost, the changes will lead to a faster deterioration
- **loss of key personnel = loss of knowledge**
- **Exponential cost of production may lead to *project failures* (Negative ROI)**



From C.Mangione, CIO Update, 2003

Architecture Excavation

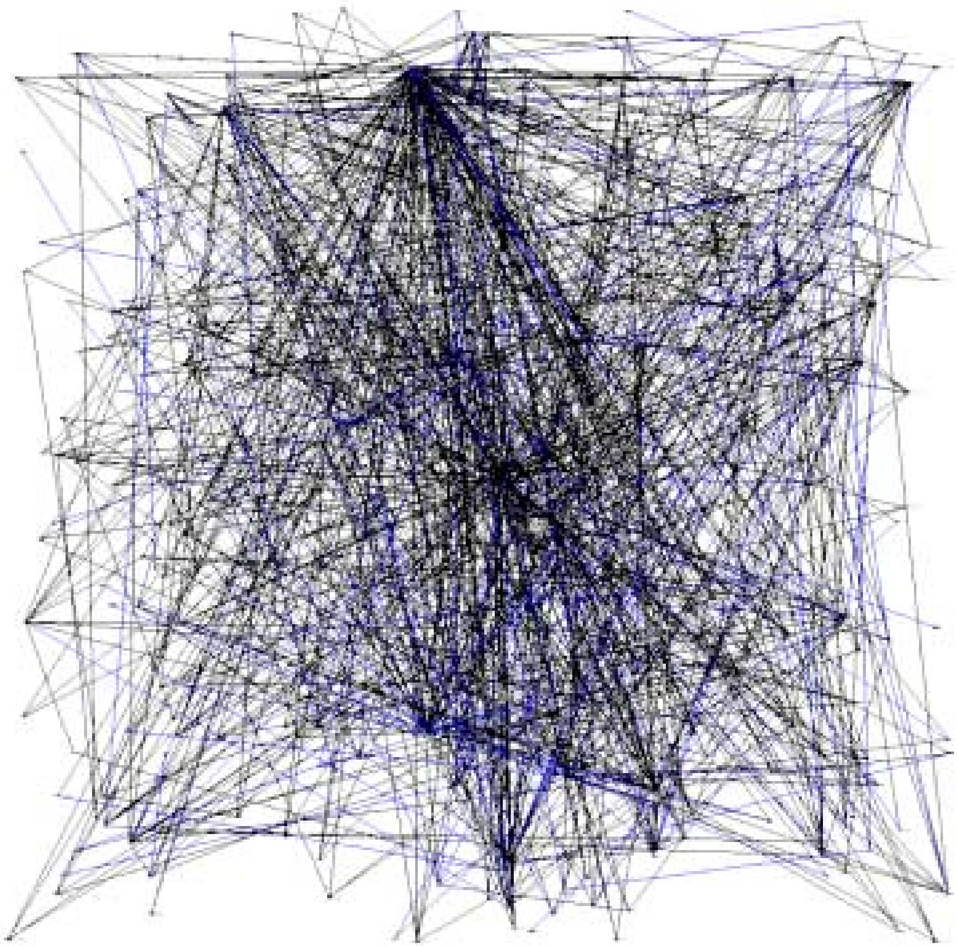
- **Visualize *Architecture* of the "as built" software as a *model***
- **"*Excavation*", because the model is likely to be created manually by abstracting from existing code**
  - Abstraction level is *sufficient*, when the architect can
    - Explain the model to the team
    - Use the architecture model to detect anomalies
    - Plan refactorings through the model
    - Enforce integrity of the model

- **Preserve and *automatically update* the model as changes are made to the software – helps preserve and accumulate knowledge at minimum effort**
- **Align the "as built" model with the "as designed" description, if available**
- **Use the architecture model to proactively refactor software**
  - Minor refactorings to restore architecture cohesion
  - Larger refactorings to improve architecture robustness
  - Major refactorings (modernizations, reuse, redevelopment)
- **Use the architecture model to enforce integrity of the software during the evolution**

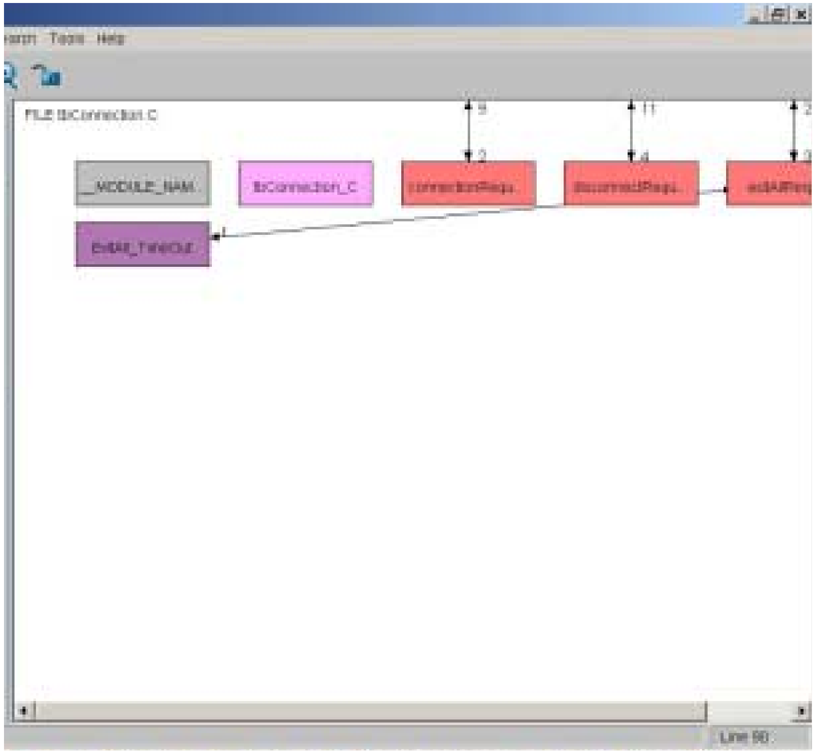
What are the challenges of Architecture Excavation?

- **Comprehension issues**
- **Architecture is intangible**
- **Gap between code and architecture levels**
  - Structure and behavior
  - Implementation vs interface
- **Erosion makes it more difficult to recover original vision**
- **There exist multiple architecture views/concerns**
- **The model should be used at multiple abstraction levels**
- **Scope vs precision**
- **Distributed design plans**

What's wrong with low levels of abstraction?



..either too many model elements



..or insufficient scope

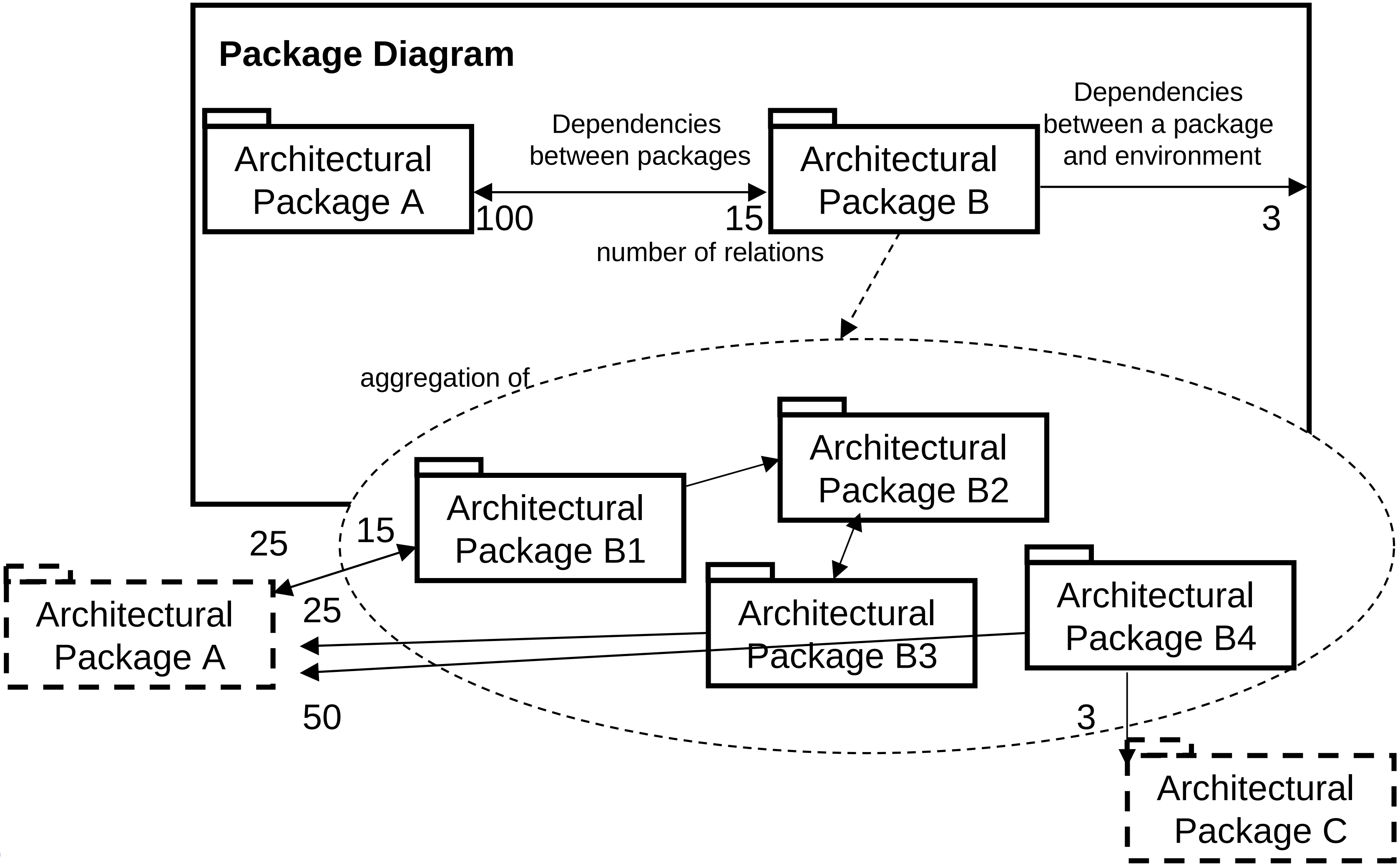
Klocwork Architecture Excavation Methodology

- **Focus:**
  - Containers, interfaces, dependencies on top of entities and relationships
- **Container Models**
  - Are scalable and precise; can be used for both abstraction and refactoring
  - Not UML, because of scalability, the need to evolve with the code, and specific “existing code” understanding concerns, like links to the code, navigation, etc.
  - Transition to UML is straightforward
- **Strategy**
  - Top-down
  - As deep as necessary, as shallow as possible
  - incremental
- **Operations:**
  - Aggregation of entities into bigger containers
  - Refactoring (moving entities between containers)

Container models

- **Represent "containers" and relations between "containers":**
  - each "container" has dependencies on other "containers"
  - each "container" provides an API to other "containers"
- **This model is scalable:**
  - aggregation of "containers" is another "container"
  - The aggregation depends on everything that individual parts depended on
  - The aggregation provides the union of APIs, provided by individual parts
- **Model can be refactored**
  - subcontainers can be moved from one container to another, model shows how dependencies and APIs change
- **This model is precise**
  - With respect to the contents of aggregations
  - With respect to APIs
- **This model is meaningful and useful**
  - Leaf "containers" can be procedures, variables, files, etc.
  - Leaf relations (APIs) are e.g. procedure-calls-procedure, etc.
- **Model can be preserved and automatically updated as changes are made to software**
  - Leaf containers and their relations are automatically extracted from source; the model stores only the hierarchy of containers; relations are recalculated on-the-fly

Container models



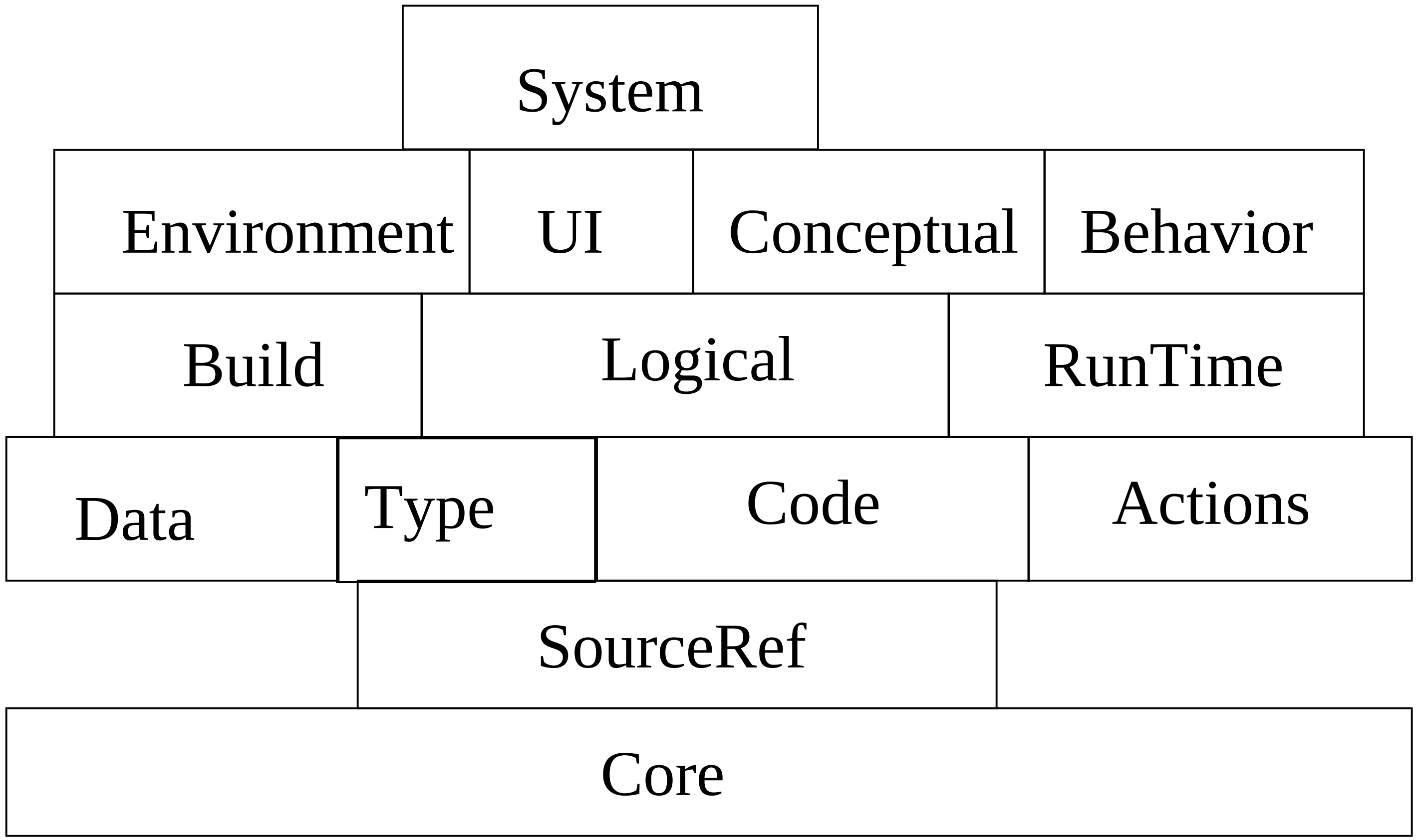
Containers can represent multiple architecture views

Entry point

Higher-level, implicit, experts, analysts

Primitives, explicit, automatically extracted

meta-model



Excavate logical architecture: overview

The excavation process consists of the following 5 phases:

1. **Collect existing architecture information**

   During this phase objectives for the excavation are reviewed, existing architecture information is collected and reviewed, initial architecture view of the software is reviewed, target architecture view is selected

2. **Identify components**

   During this phase we identify subsystems that belong to same high-level component and group them together. The newly recovered component is given a meaningful name, is meaningfully resized and is meaningfully placed on the diagram

3. **Evaluate coupling and refactor**

   During this phase coupling between high-level components is evaluated. Use refactoring in order to simplify dependencies between components. Move the anomalous subcomponent, even as small as an individual symbol, to a different container, and reduce the coupling.

4. **Evaluate cohesion and refactor**

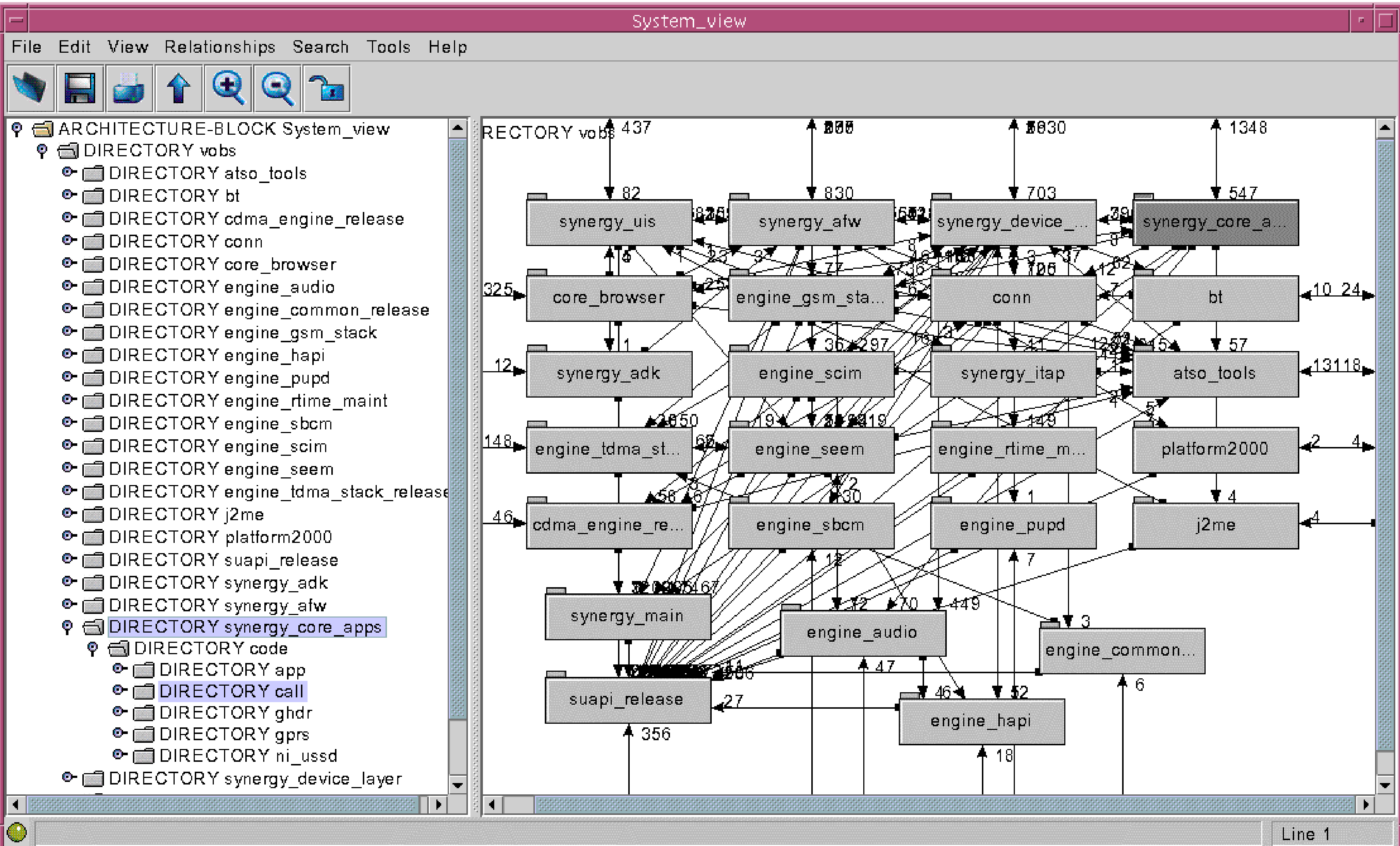
   During this phase cohesion of selected components can be evaluated. Use refactoring In order to improve cohesion of components. Identify cohesion anomalies and move to proper containers or collect in new components

   Phases 2,3 and 4 can be repeated iteratively (recovering more high-level components after refactoring has sufficiently simplified the view) as well as recursively (excavating subcomponents of high-level components) , based on the initial objectives

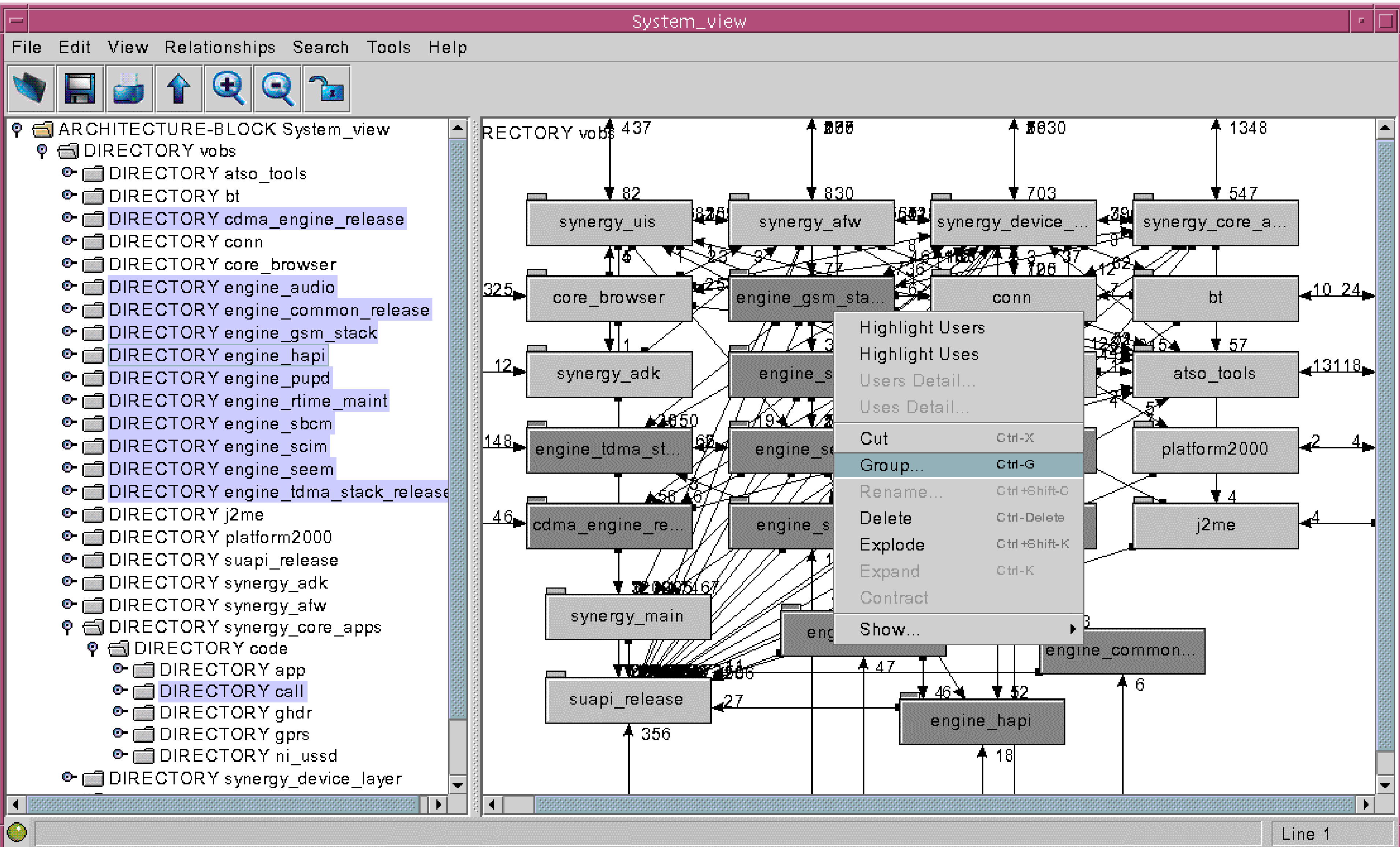
5. **Finalize architecture description**

   Excavated architecture model should be saved and exported as XML file to be used fo subsequent software builds. Thus the excavated architecture model becomes a "living" document.

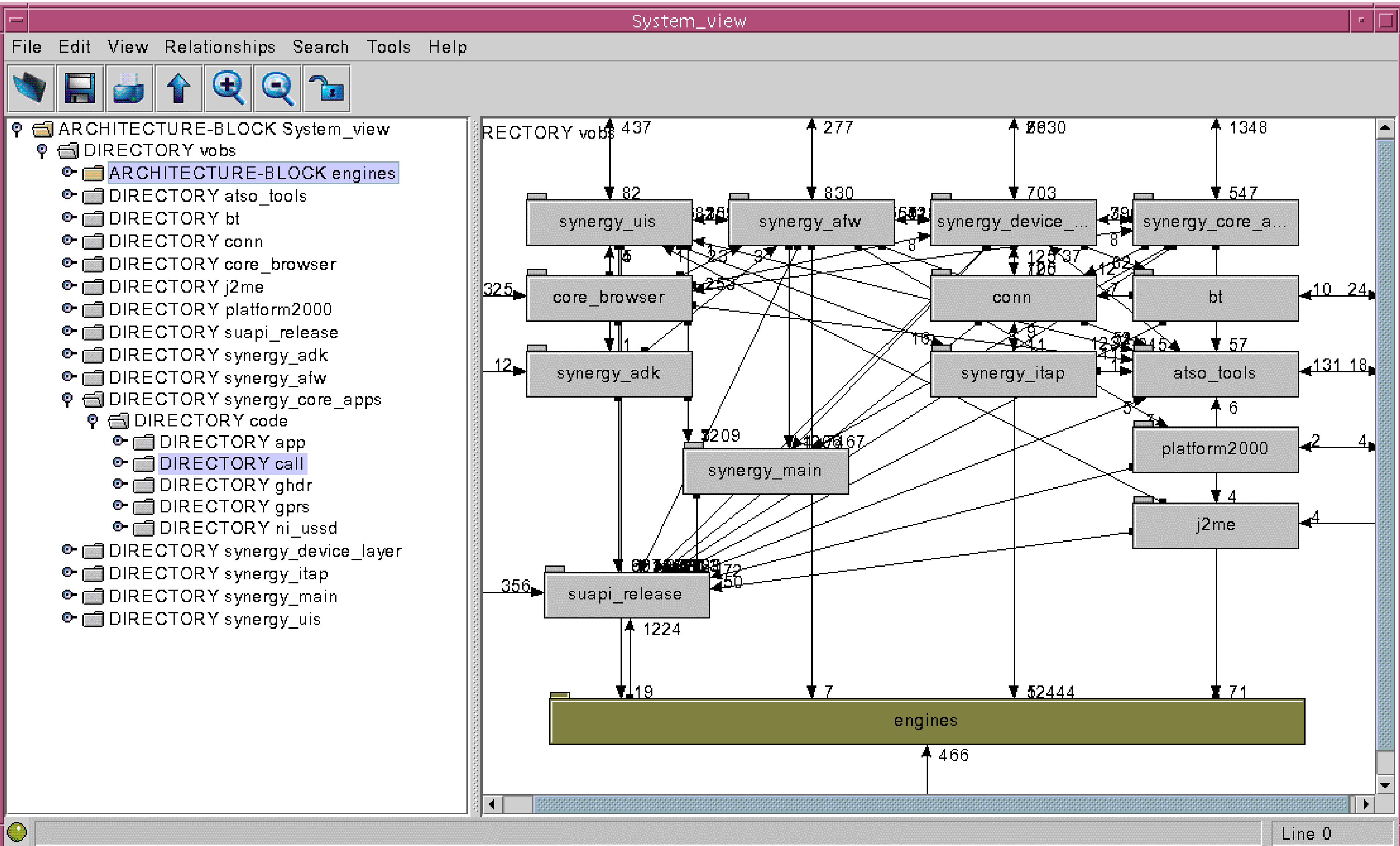
Excavation: Initial component model



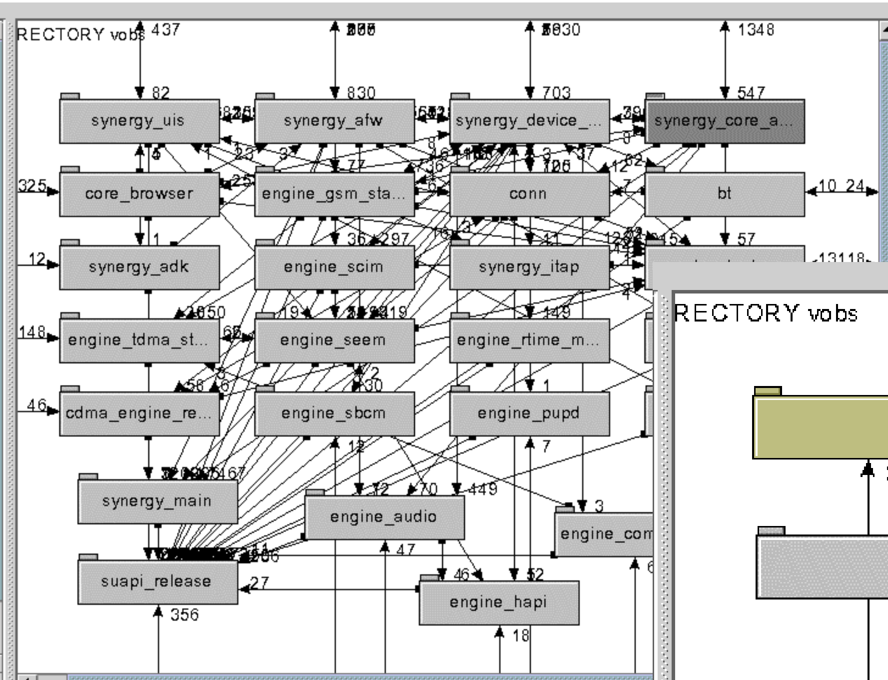
Excavation: Identifying components



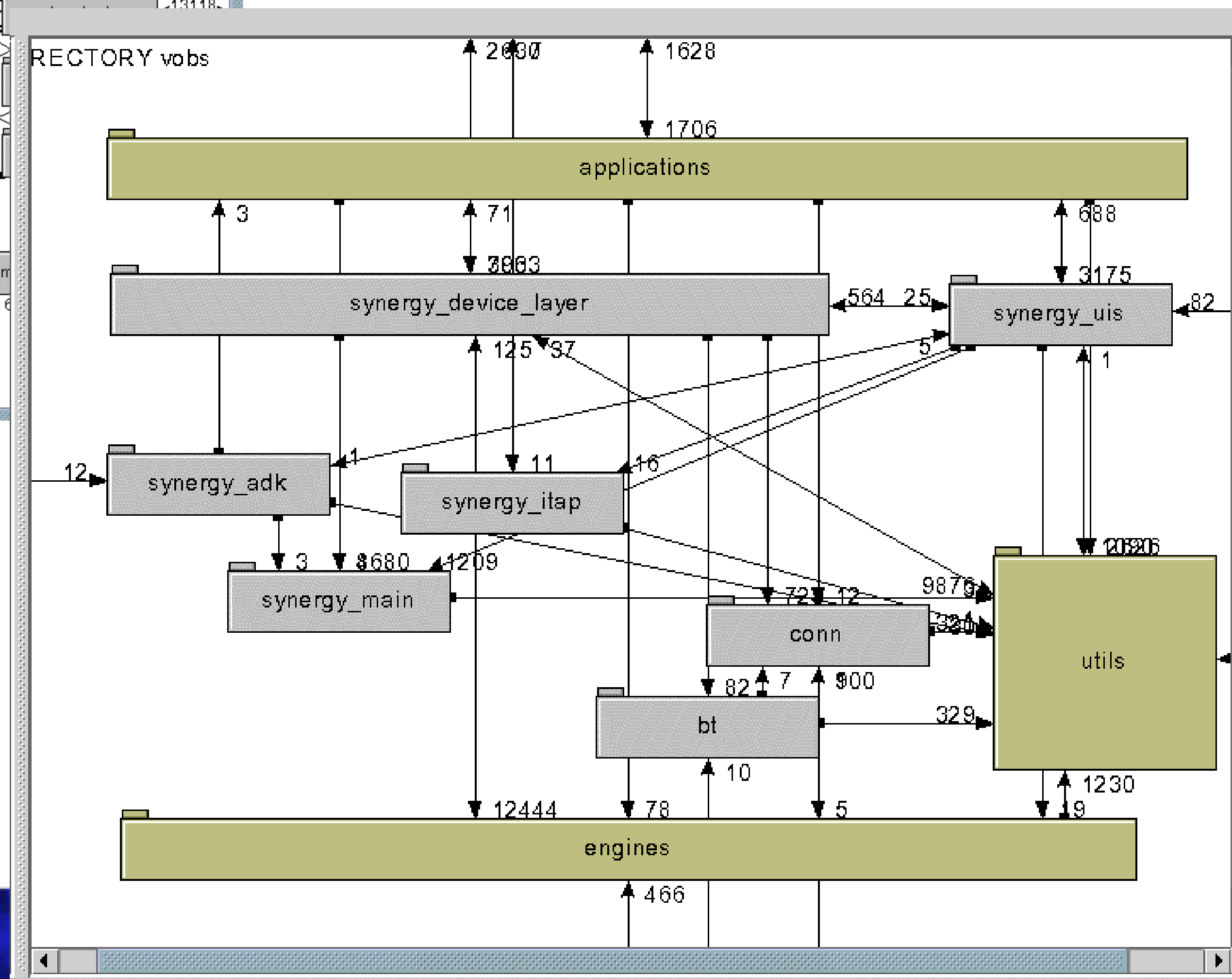
Excavation: Aggregating components



Excavated high-level architecture



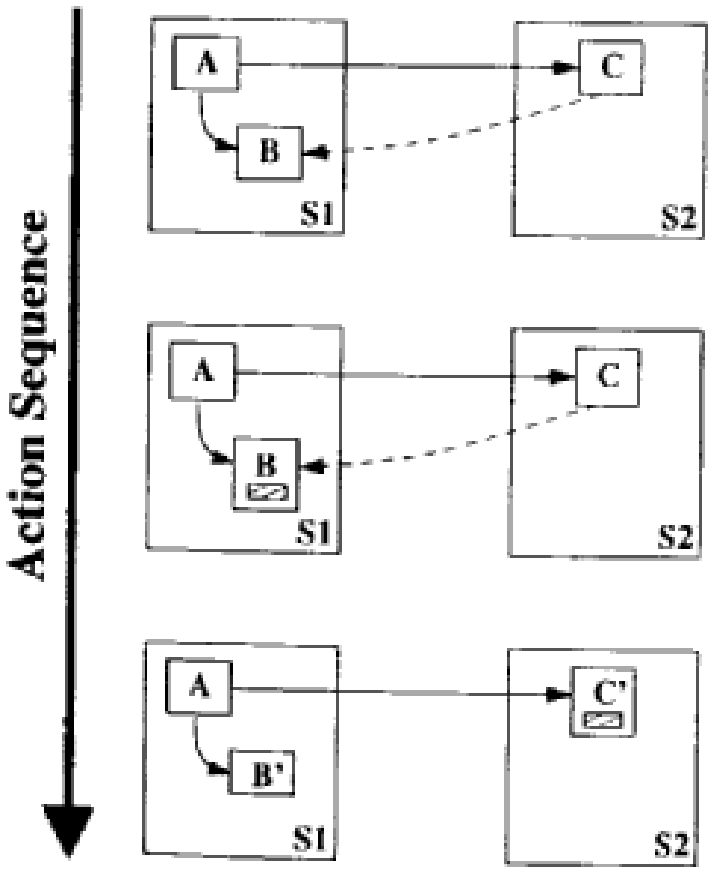
before



after

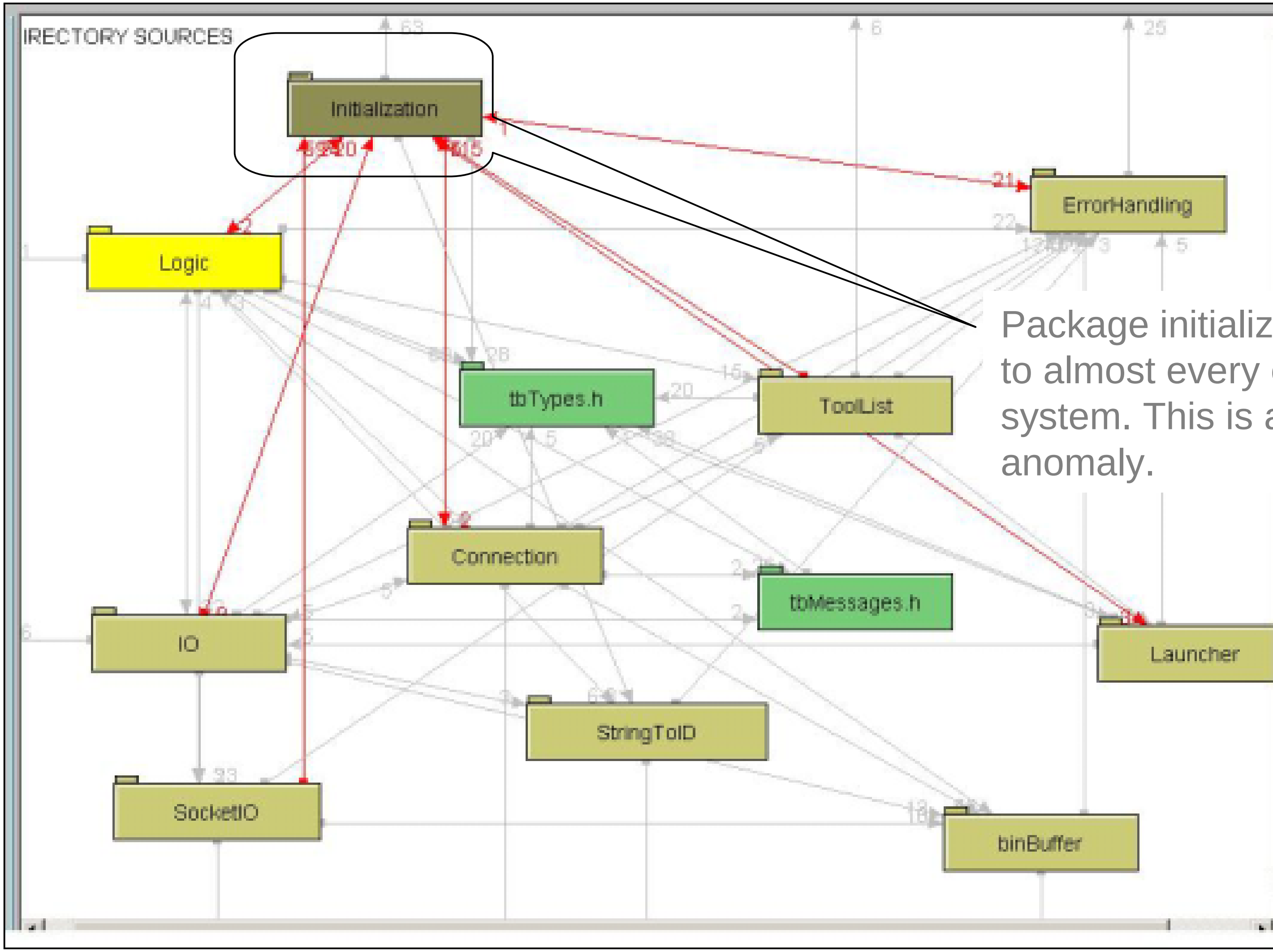
Klocwork

Refactoring removes accidental coupling



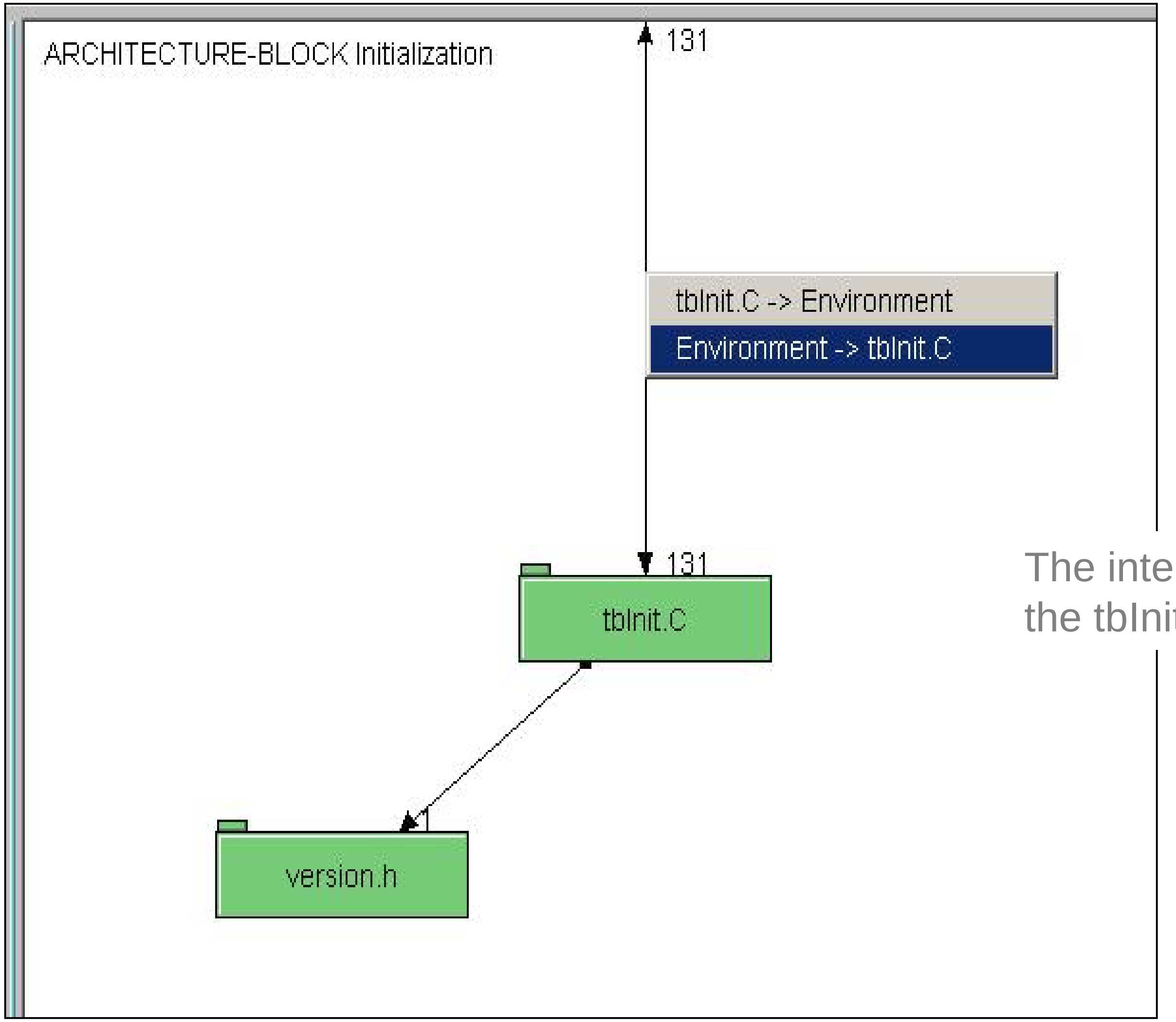
From R.Holt, ICSM, 200

Refactoring (1/6)



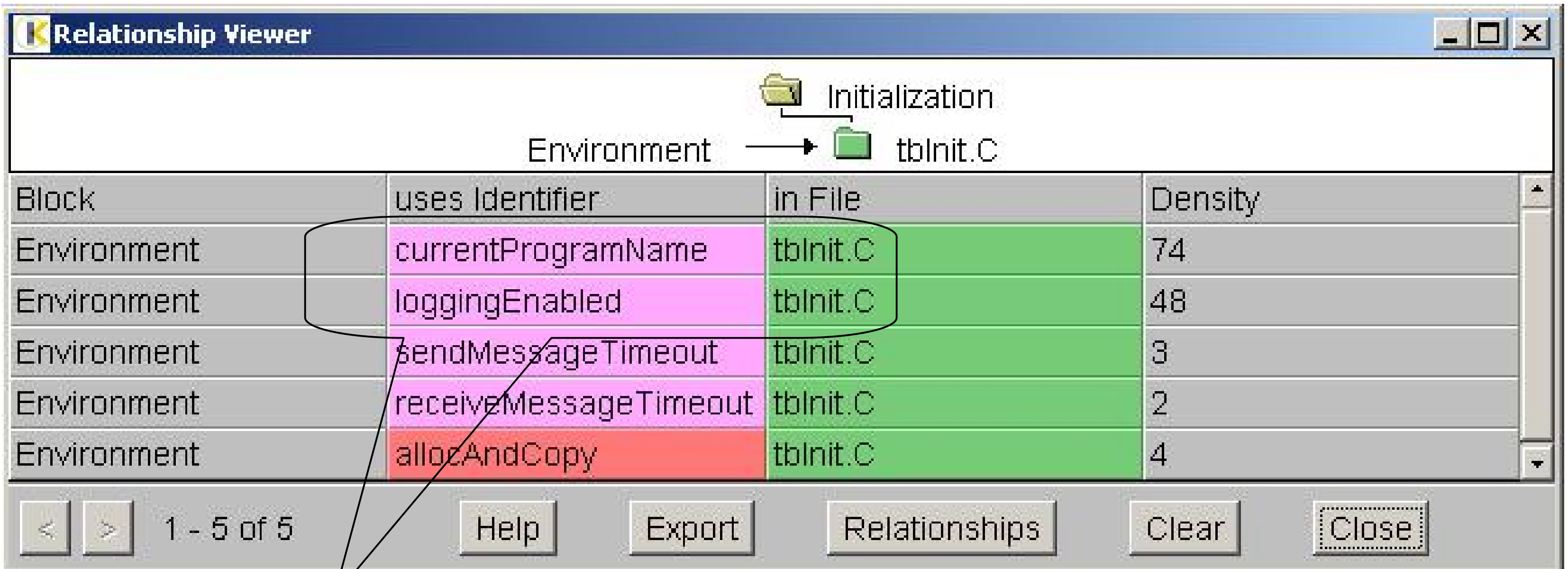
Package initialization provides interface to almost every other package in the system. This is an architectural anomaly.

Refactoring (2/6)



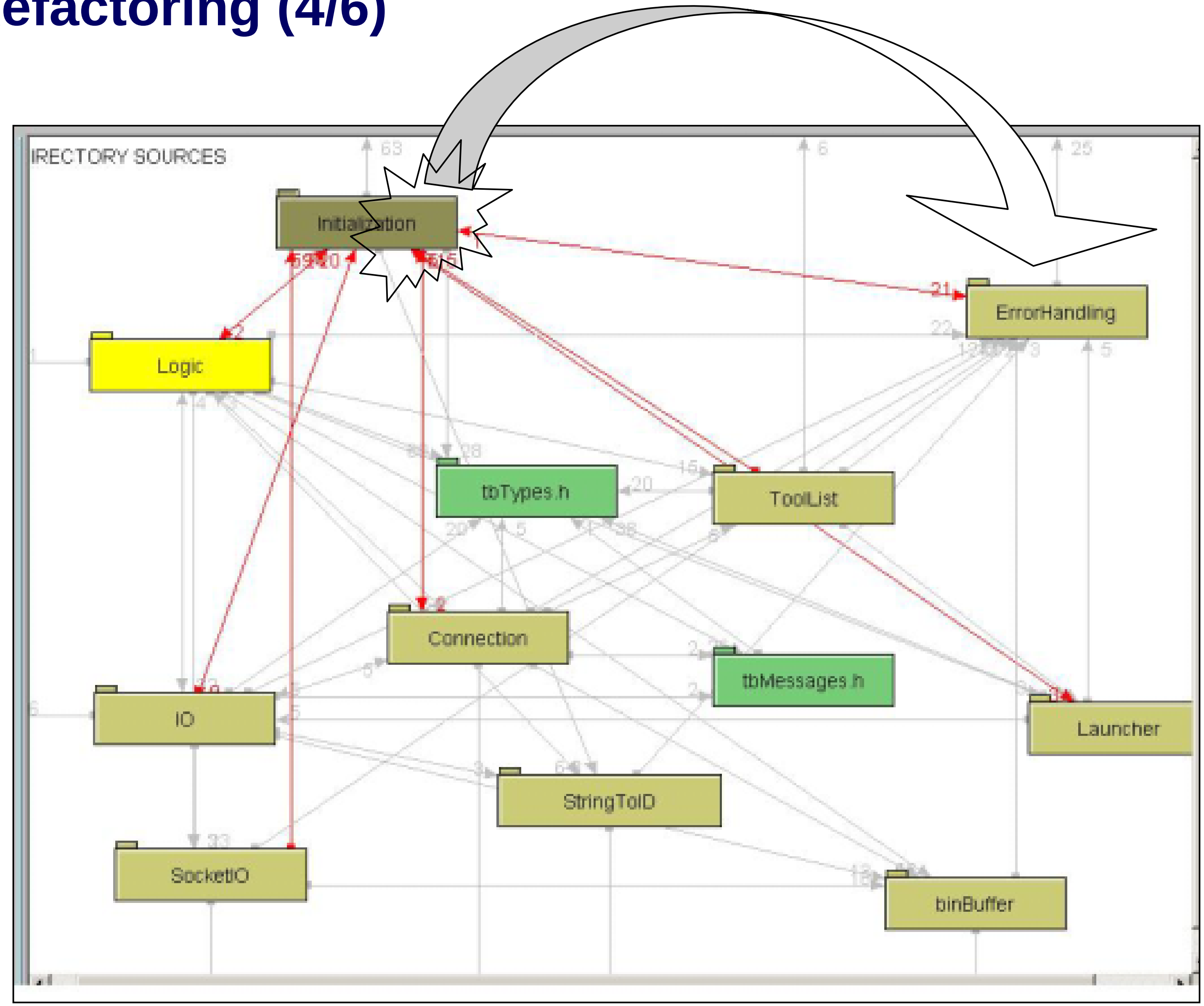
The interface is provided by the tblnit.C file

Refactoring (3/6)

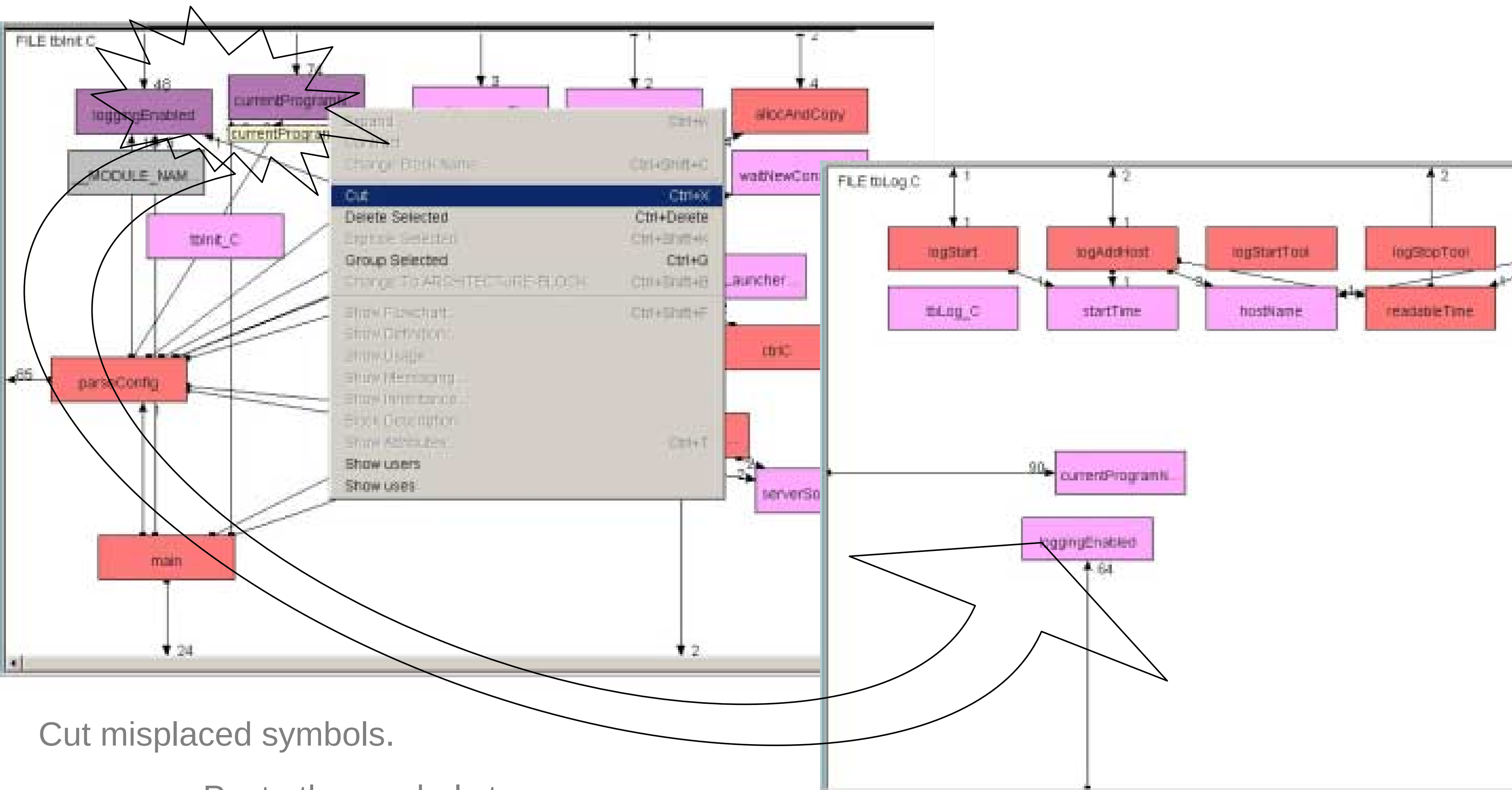


The interface consists of only 5 symbols. Variables **CurrentProgramName** and **loggingEnabled** are very frequent. Look For comments to find that they belong to logging.

Refactoring (4/6)



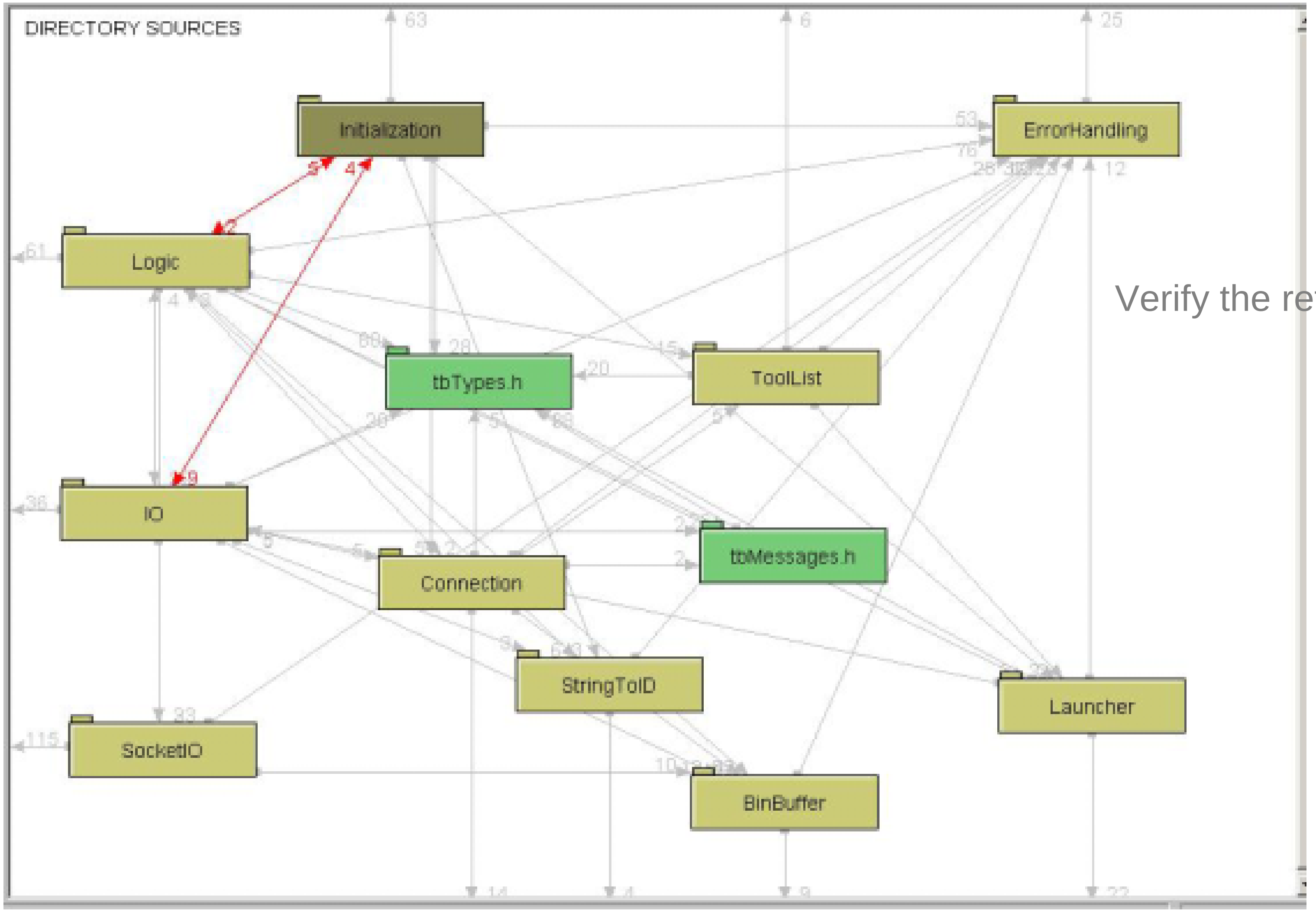
Refactoring (5/6)



Cut misplaced symbols.

Paste the symbols to a new container (file tbLog.C).

Refactoring (6/6)



Verify the refactoring effect.

What next?

- **Architecture model is recovered and evolves alongside with the code**
  - Automatically updated as changes are made to the code
  - Refactored and improved periodically
- **Use the model to accumulate and disseminate knowledge about the software (from architects to developers)**
  - Annotations are added to the model (one-stop-shop)
  - Understand the impact of changes
  - Training of new personnel
- **Proactively enforce integrity of the code using the model**
  - Tools are available (desktop, or integrated into ClearCase)
- **Use the model to harvest reusable components and manage the software product line**
- **Use the model to launch transition to MDA**
- **Plan new feature development using the model**
- **Use the model to plan modernizations**

Remaining challenges

- **Mechanics vs the need to understand the software**
- **Complexity**
  - Use complementary architecture views
  - In order to improve efficiency, focus on use cases
  - Focus on selected components
- **Keep the balance between refactorings for comprehension and "real" refactorings**

Key points: Klocwork Architecture Excavation

- **Focus:**
  - Containers, interfaces, dependencies on top of entities and relationships
- **Container Models**
  - Are scalable and can be used for both abstraction and refactoring
  - Not UML, because of scalability, the need to evolve with the code, and specific “existing code” understanding concerns, like links to the code, navigation, etc.
  - Transition to UML is straightforward
- **Strategy**
  - Top-down
  - As deep as necessary, as shallow as possible
  - Model is built manually by abstracting from code
  - Model is updated and improved incrementally
  - Model is automatically updated as changes are made to the code
- **Steps of the methodology:**
  - Aggregation of entities into bigger containers
  - Refactoring (moving entities between containers)

Key points (cont'd)

- **Model preserves and accumulates the architectural knowledge about the software**
- **Architecture model is shared among the whole development team**
- **Model facilitates code understanding**
- **Model visualizes the effects of architecture erosion**
- **Eliminates erosion:**
  - Restore architecture cohesion, therefore slowing down architecture erosion
  - Proactively slow down erosion by impact analysis
  - Plan modernizations to improve the robustness of the software infrastructure as the new features are being added
- **Model is changed to drive new development**