Architectural Investigation of XCTL by URCA

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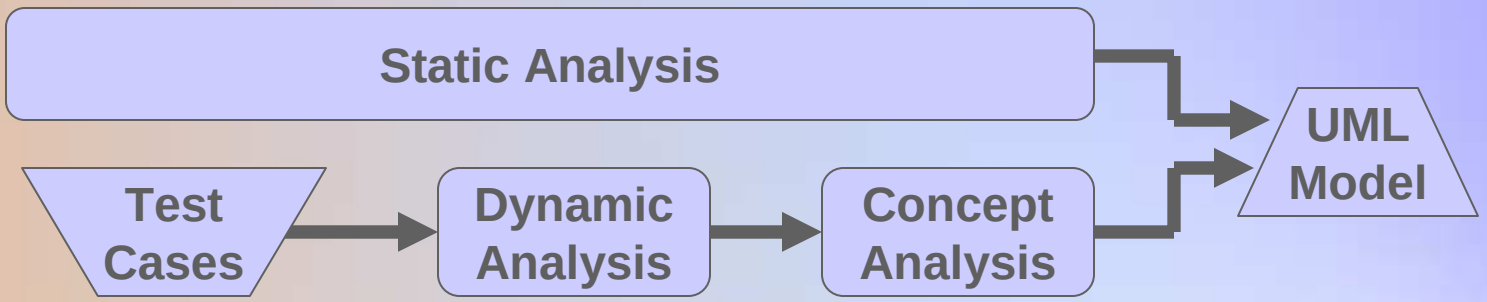
Agenda

- Introduction to URCA
- Formal Concept Analysis
- XCTL project
- Reverse engineering process
- Results comparison & Conclusion

Introduction

- Use case Design Recovery
  by means of Formal Concept Analysis (URCA)
- Recovers all mandatory elements
  of the Rational Unified Process model template
- Static analysis → basic model elements
  Dynamic analysis → behavioral aspects
  Concept analysis → relationships and roles



Formal Concept Analysis

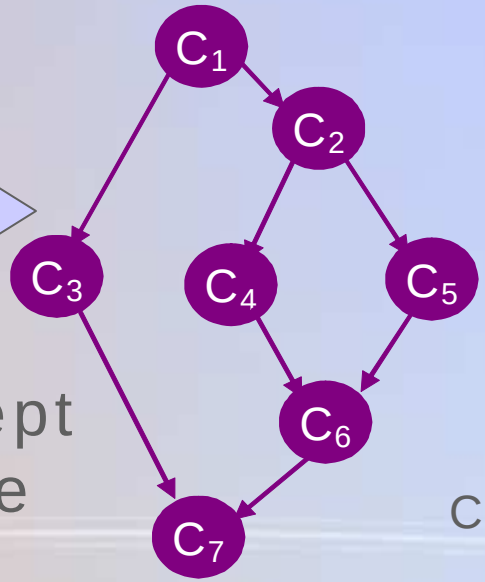
	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8
O_1	X	X						
O_2			X	X	X			
O_3			X	X		X	X	X
O_4			X	X	X	X	X	X

Concept

Context relation

Concept Analysis is used to identify groupings of objects that posses common attributes – Burmeister (1998).

Partial order via super & sub concept ordering



Concept lattice

$C_1 = (\{O_1,O_2,O_3,O_4\}, \{\})$

$C_2 = (\{O_2,O_3,O_4\}, \{A_3,A_4\})$

$C_3 = (\{O_1\}, \{A_1, A_2\})$

$C_4 = (\{O_2,O_4\}, \{A_3,A_4,A_5\})$

$C_5 = (\{O_3,O_4\}, \{A_3,A_4,A_6,A_7,A_8\})$

$C_6 = (\{O_4\}, \{A_3,A_4,A_5,A_6,A_7,A_8\})$

$C_7 = (\{\}, \{A_1,A_2, A_3,A_4,A_5,A_6,A_7,A_8\})$

Interpretation

- Object maps to Function in code (O → F)
  (both class member and global)
- Attribute maps to Use case (A → U)
- Context relation – "implements"
  There exist at least one test case
  that executes F and exercise U
- Concept contains:
  - Set of use cases – cardinality 1 in ideal case
  - Set of related functions

XCTL Project

- An application for controlling laboratory equipment at Max Planck Institute
- A reference software reengineering project at the Humboldt University
- XCTL – classical Windows application
  - 46 classes
  - 496 member functions and global functions
  - 38,5 KLOC

Reverse Engineering Process (1)

- **STEP 1**
  Identify "architecturally relevant" use cases

- **STEP 2**
  Define test cases that exercise each use case
  - Start & Exit
  - Motor control
  - Detector use
  - Flow control
  - Topography
  - General Attitude
  - Diffraction/Reflection Area Scan
  - Diffraction/Reflection Line scan
  - Representation of measured data
  - Automatic adjustment
  - Manual adjustment
  - Half-width measure

Reverse Engineering Process (2)

- STEP 3

  Collecting dynamic information
  by executing application for each use case

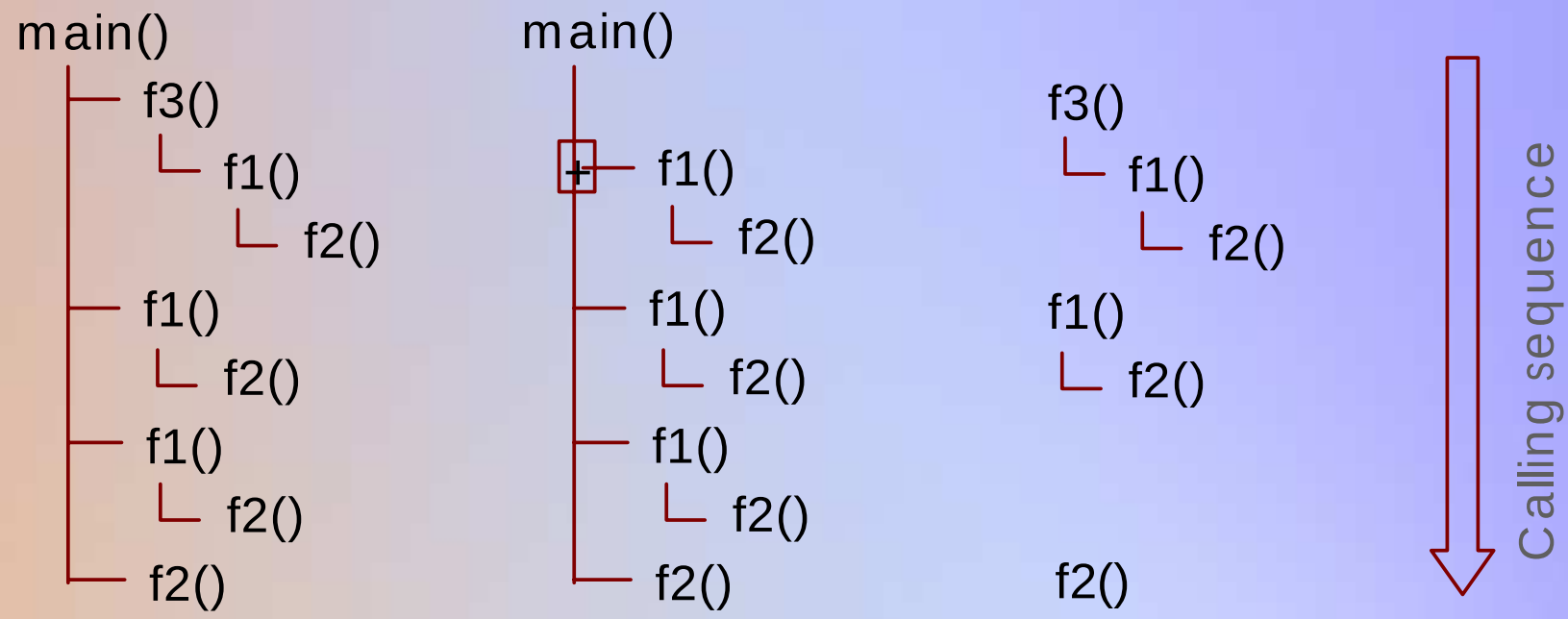
  - Profiling data (function execution count)
  - Function Activation Tree (UML interaction diagrams)

  We define some operation on dynamic data

  - Differing execution count
    (for extends relations differentiation)
  - Function filtering
    (needed to decompose interactions)
  - Elimination of repeating calling sequences
    (loops elimination)

Reverse Engineering Process (3)

- Example of operations over activation tree



The original tree Filtering out f3() Filtering out main() and eliminating f1()-f2() sequence

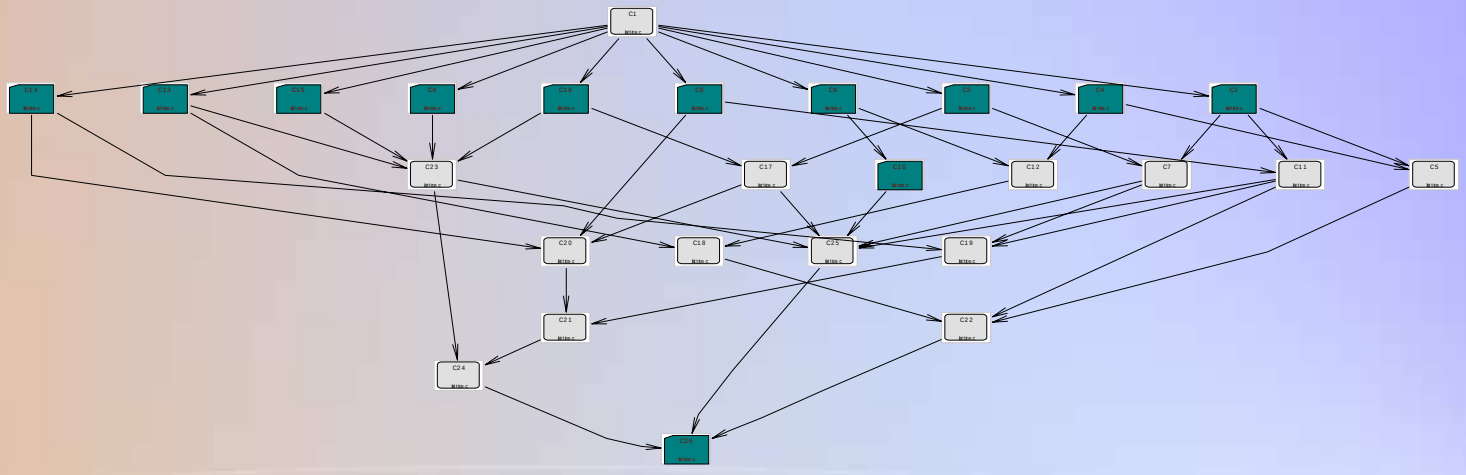
Reverse Engineering Process (4)

- STEP 4

  Construction of Context relation

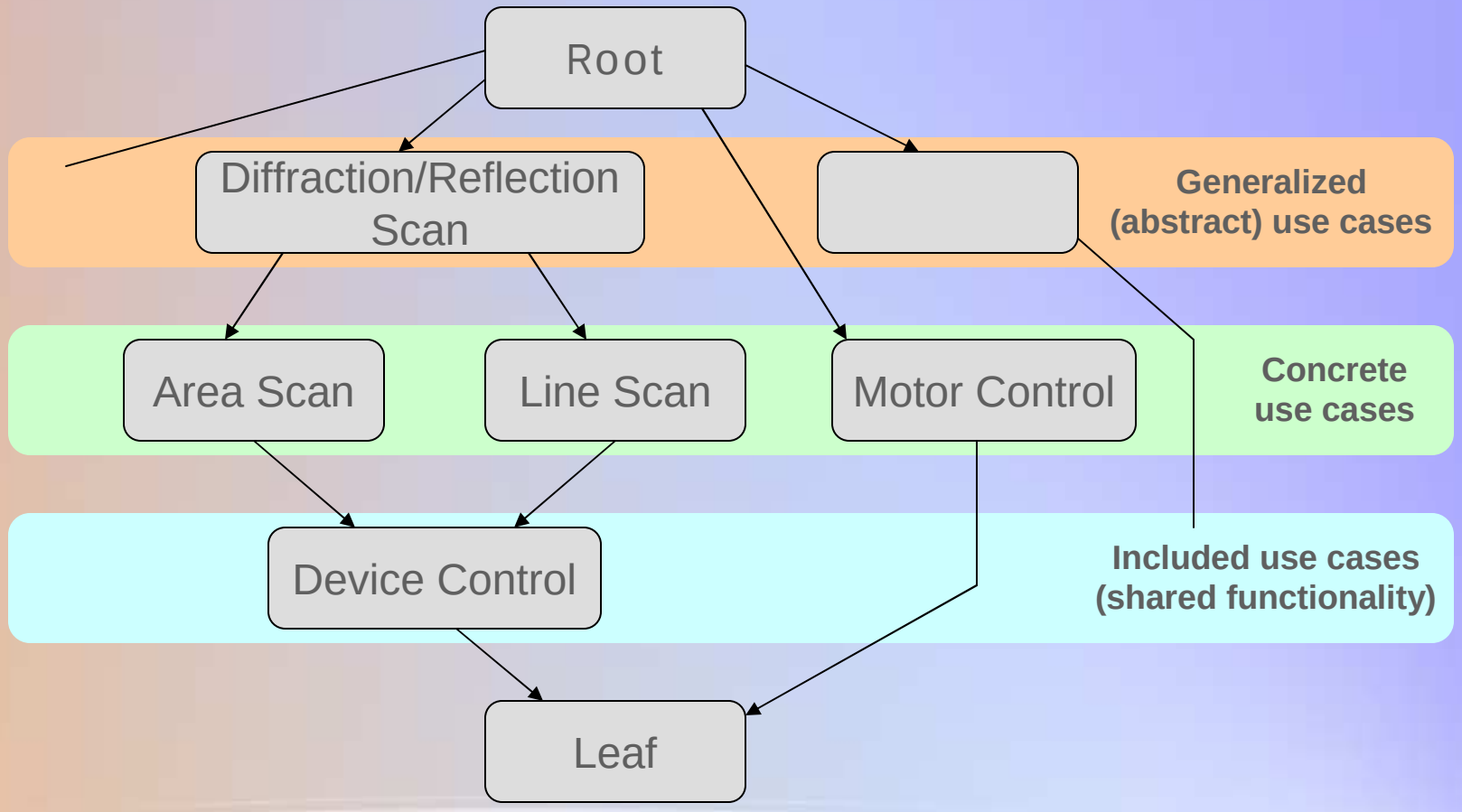
- STEP 5

  Construction of Concept lattice
  by means of Formal Concept Analysis



Reverse Engineering Process (5)

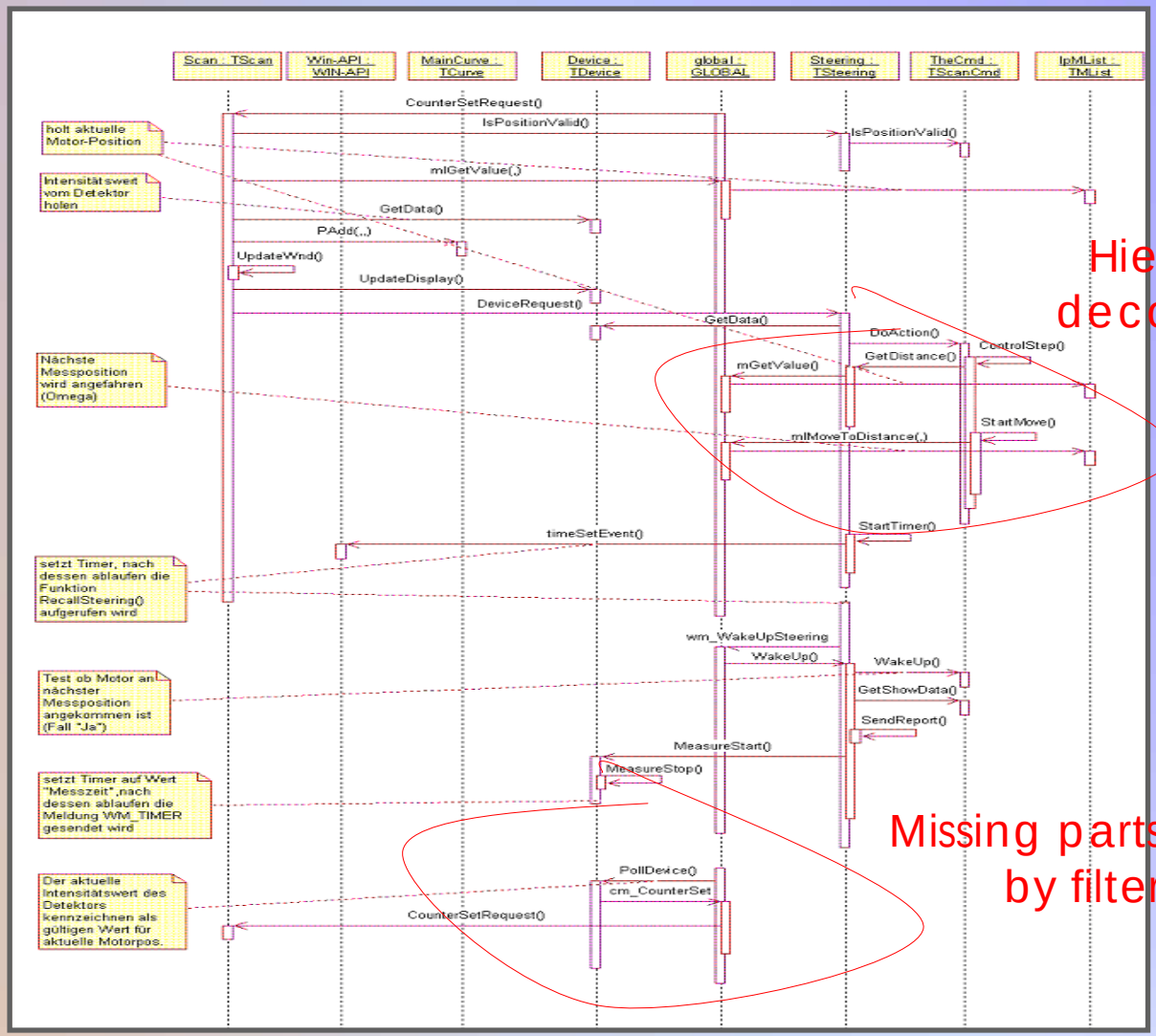
- Interpretation of the Concept lattice



Reverse Engineering Process (6)

- STEP 6
  Construction of the initial UML model
  based upon the results of the Static analysis
- STEP 7
  Supplementing of the initial UML model
  based upon the results of Concept analysis

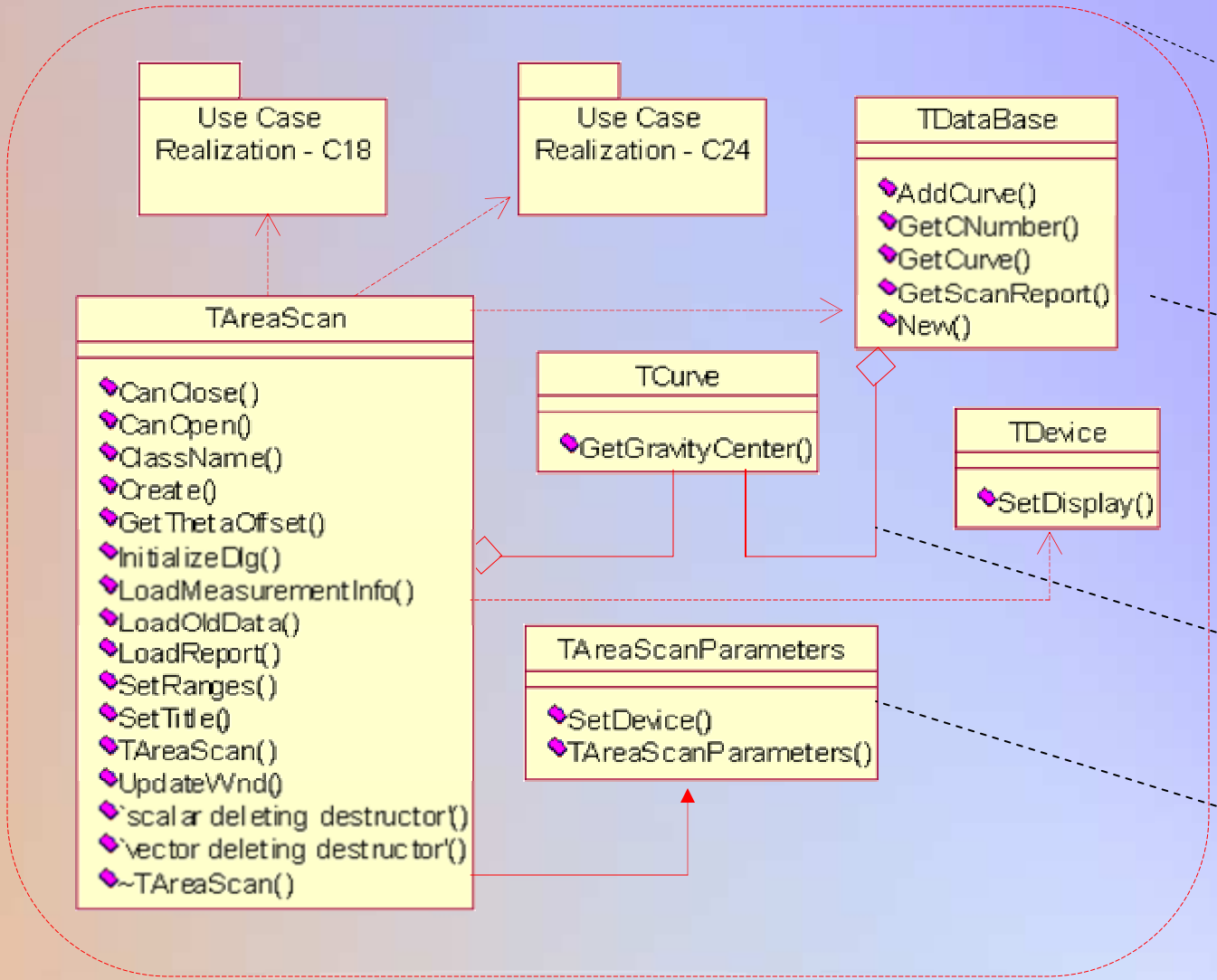
Results comparison



Hierarchical decomposition

Missing parts caused by filtering

Result comparison



one use case realization for each concept

function is attached to lowest concept that contains it

these relations are obtained by static analysis

class role (a part of class that participates in realization)

Result comparison & Conclusion

- Similarities
  - Same grouping criterion (use case realizations)
- Differences
  - Class roles are not present in the manual analysis
  - Human intelligent abstraction logic
  - Hierarchies as a level of abstraction

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