Structure of the lecture

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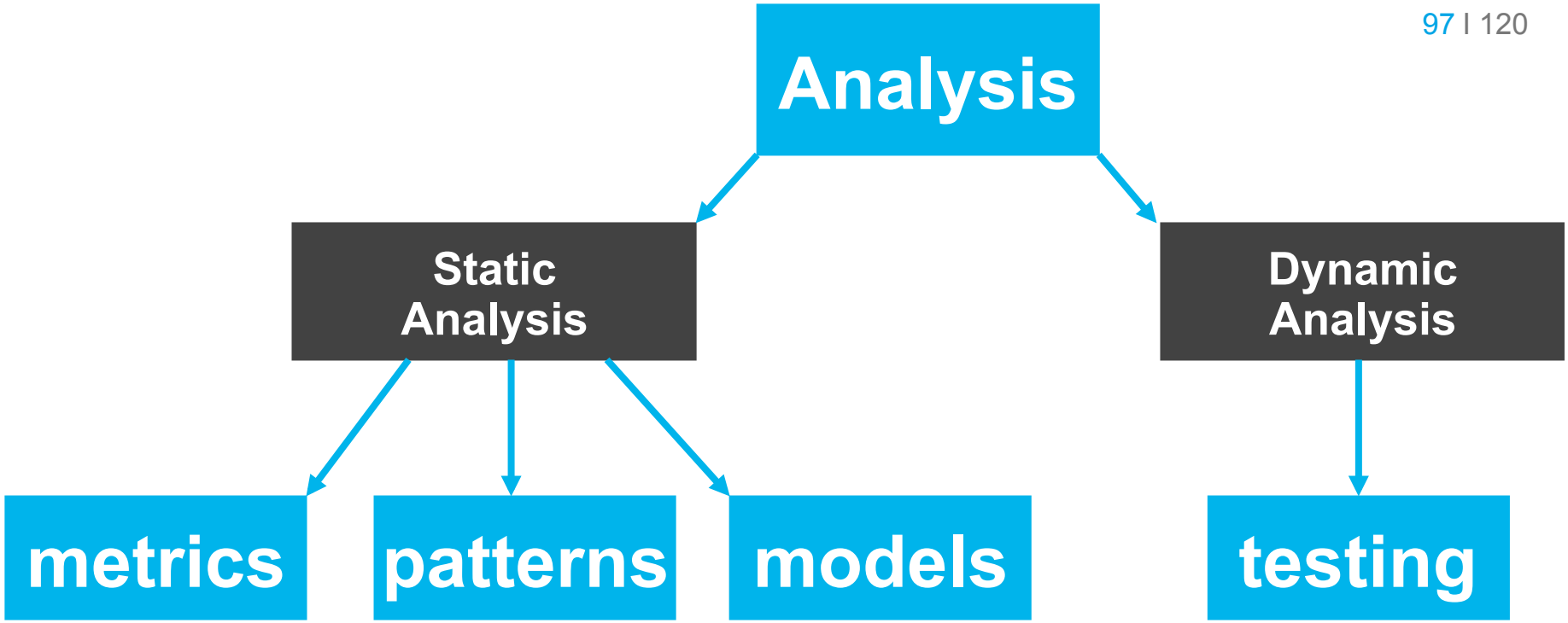

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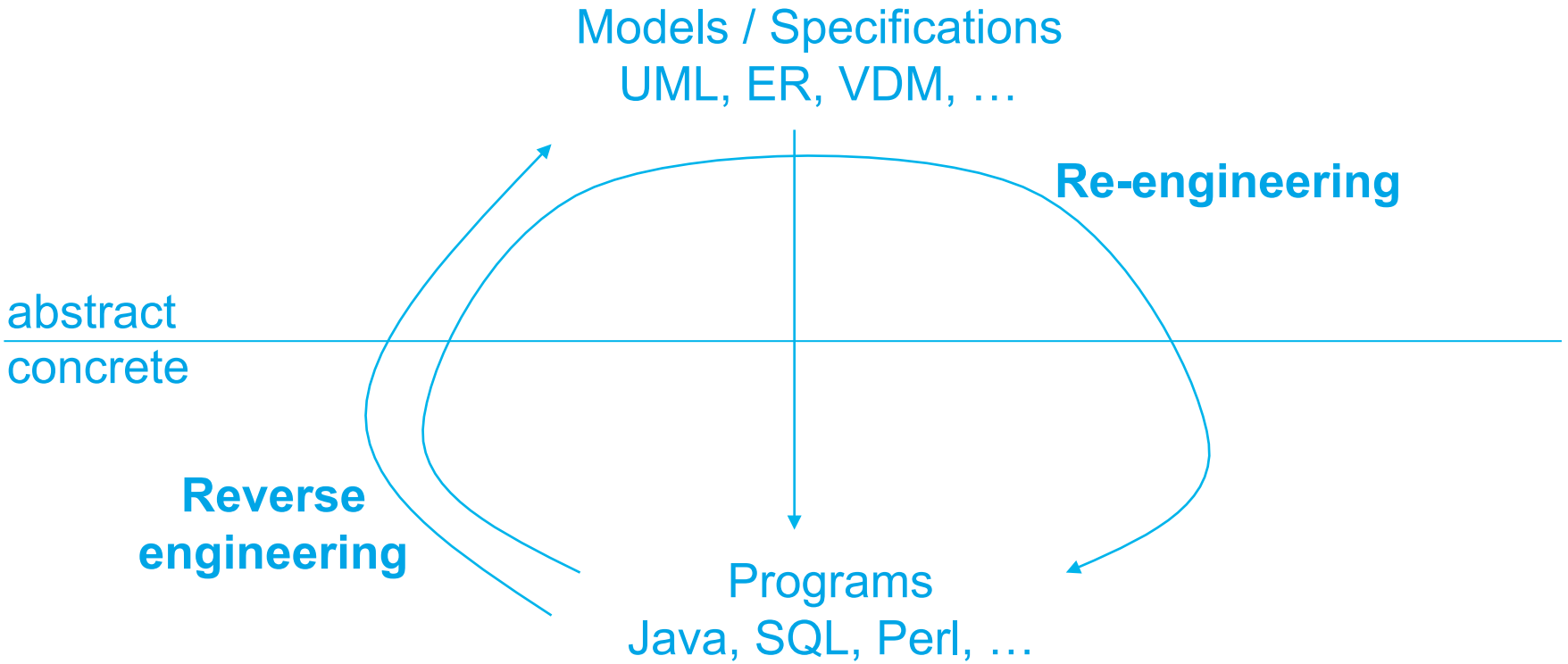
REVERSE ENGINEERING

Terminology



Reverse engineering

Dependencies and graphs

- Extraction, manipulation, presentation
- Graph metrics
- Slicing

Advanced

- Type reconstruction
- Concept analysis
- Programmatic join extraction

Reverse engineering trinity

Extraction

From program sources, extract basic information into an initial source model.

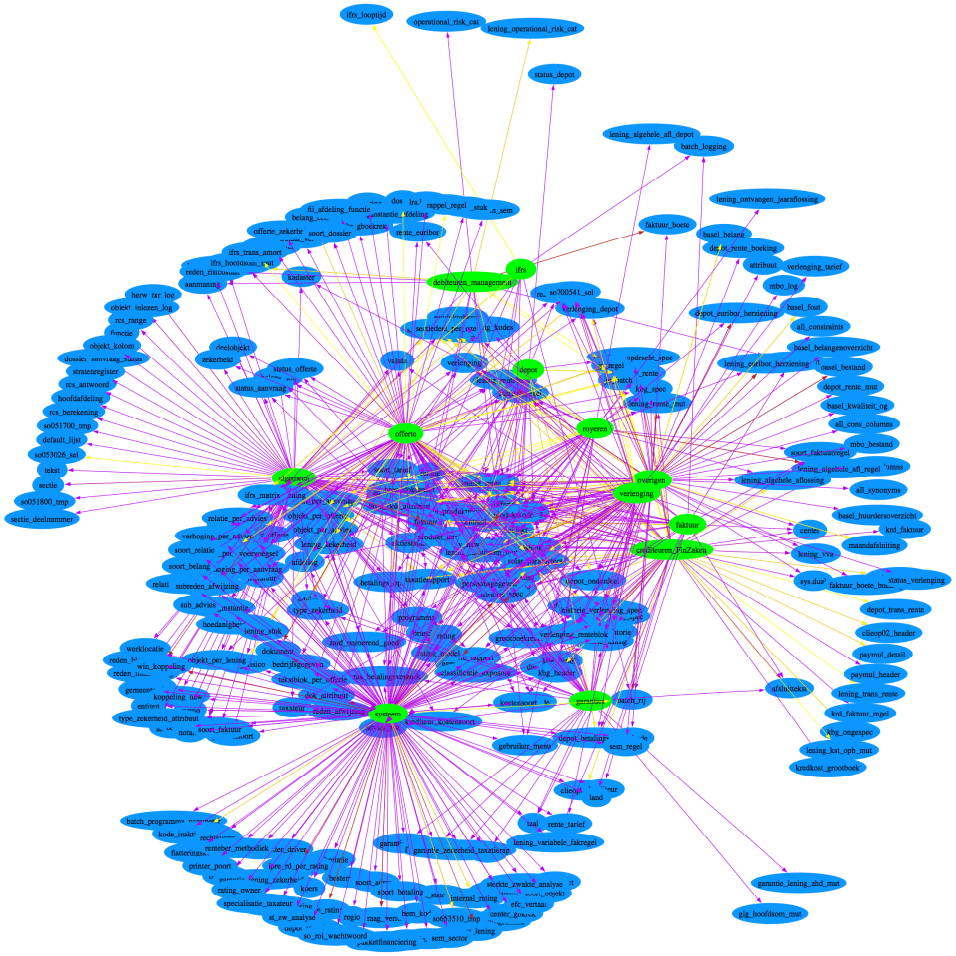
Manipulation

Combine, condense, aggregate, or otherwise process the basic information to obtain a derived source model.

Presentation

Visualize or otherwise present source models to a user.

Example



Green oval = module

Blue oval = table

Purple arrow = select operation

Yellow arrow = insert/update operation

Brown arrow = delete operation

Example

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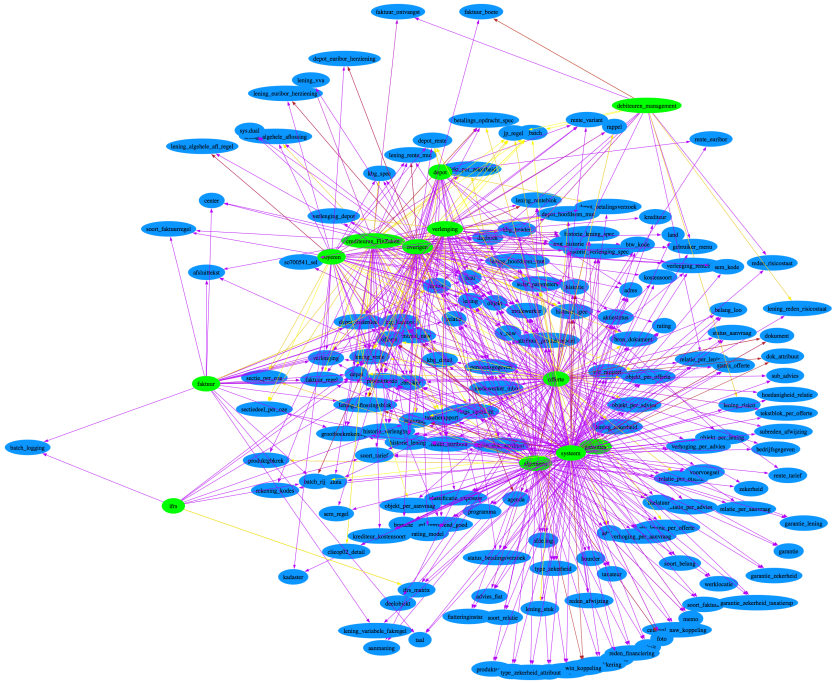
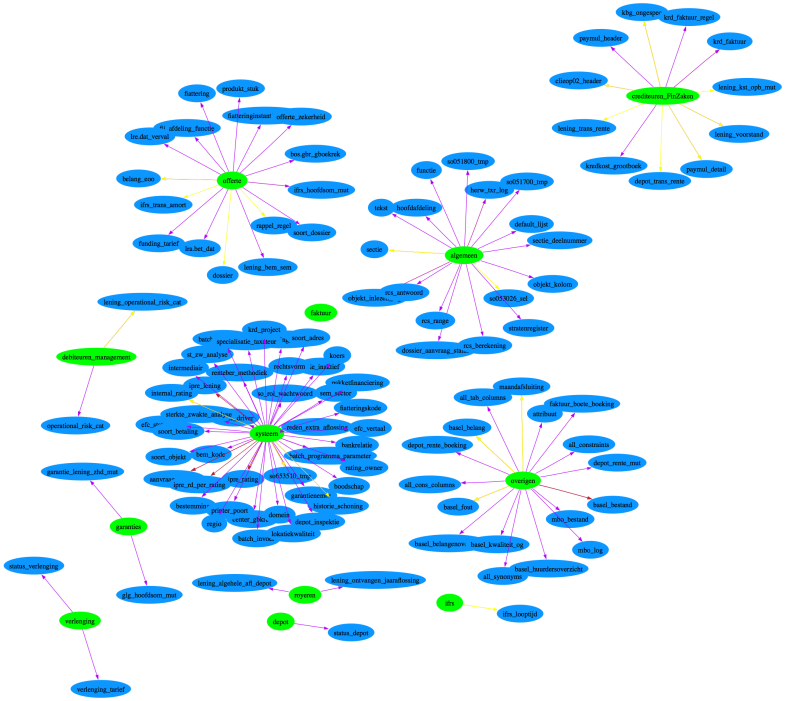


Tables used by multiple modules.



Tables used by a single module.

Relations and graphs

Relation

```
type Rel a b = Set (a,b)
```

set of pairs

Graph

```
type Gph a = Rel a a
```

endo-relation

Labeled relation

```
type LRel a b l = Map (a,b) l
```

map from pairs

Note

```
Rel a b = Set(a,b)= Map(a,b)()= LRel a b ()
```

Slicing (forward)

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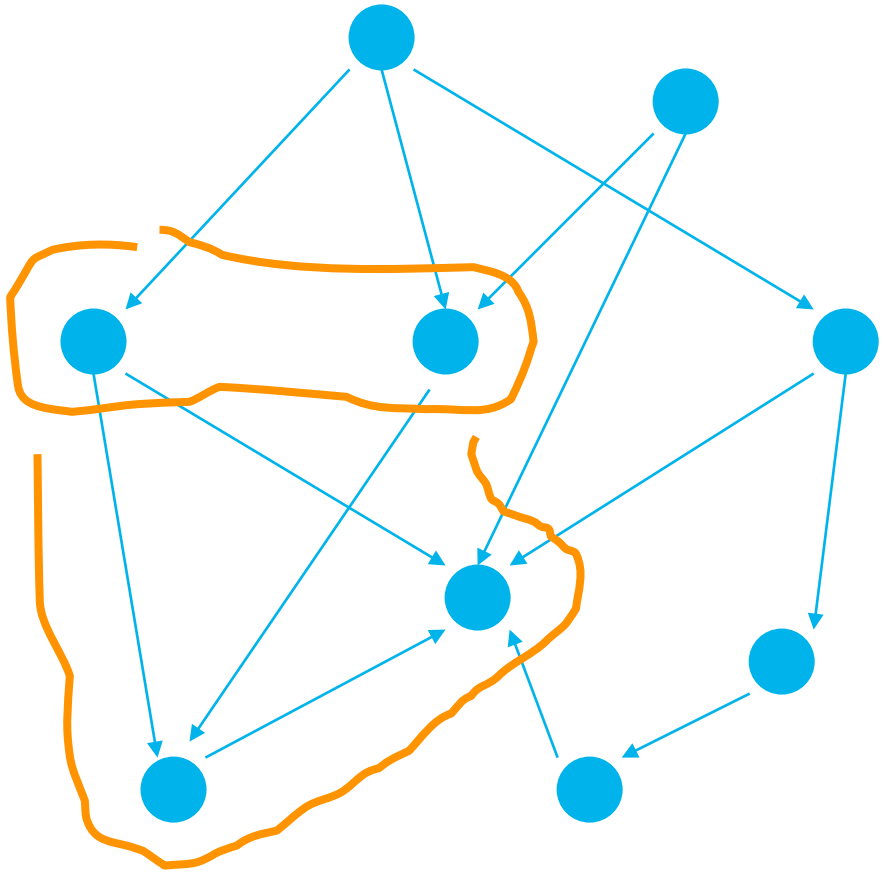
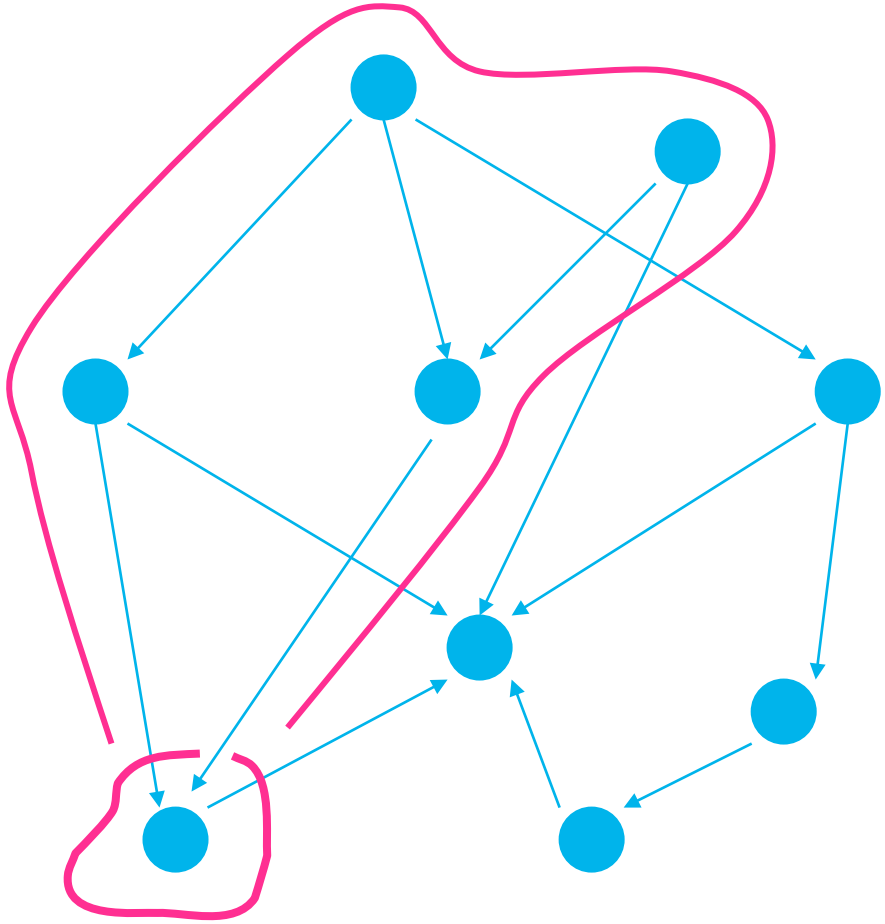


Slicing (backward)



Chop
= Forward ∩ Backward

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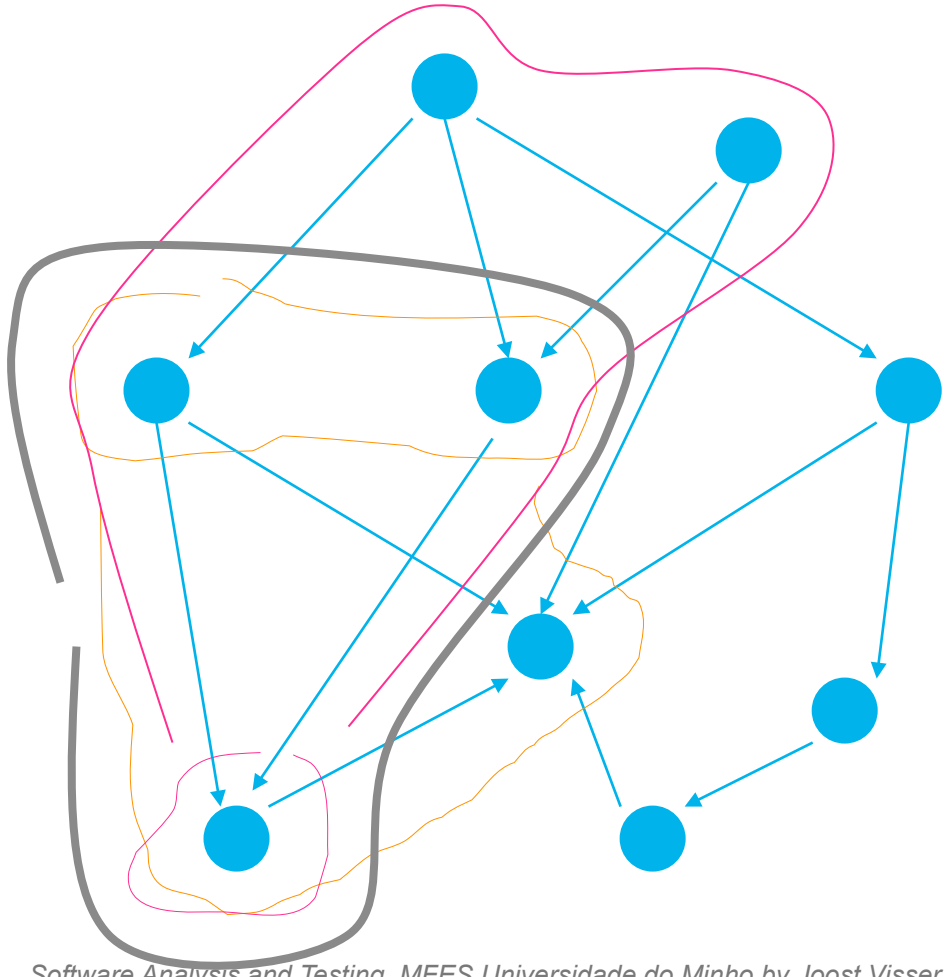
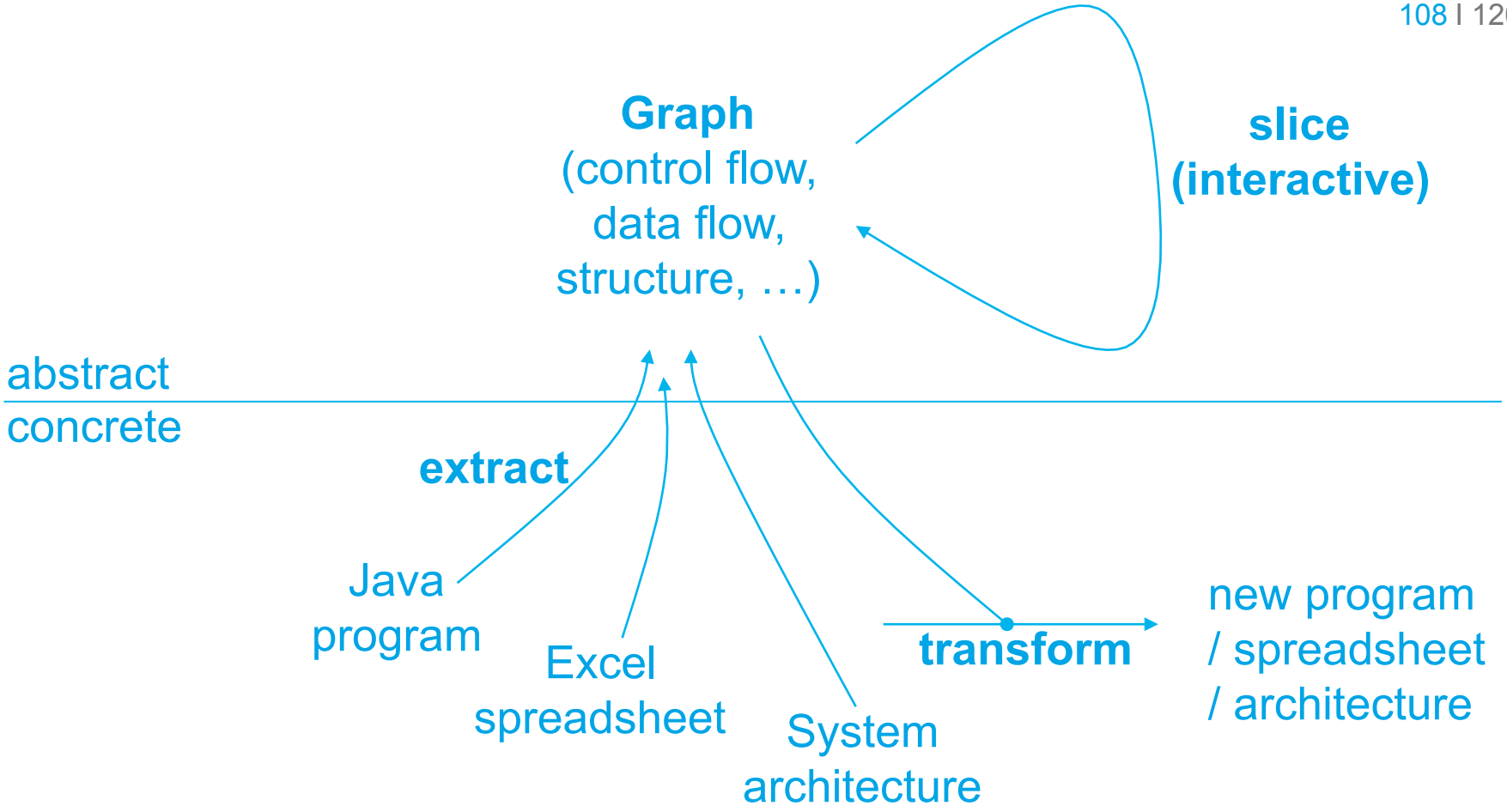


Generic slicing



Further reading

See

Arun Lakhotia.
Graph theoretic foundations of program slicing and integration.
The Center for Advanced Computer Studies, University of Southwestern Louisiana.
Technical Report CACS TR-91-5-5, 1991.

Type reconstruction (from type-less legacy code)

See

- Arie van Deursen and Leon Moonen. *An empirical Study Into Cobol Type Inferencing*. Science of Computer Programming **40**(2-3):189-211, July 2001

Basic idea

1. Extract basic relations (entities are variables)
   - assign: ex. `a := b`
   - expression: ex. `a <= b`
   - arrayIndex: ex. `A[i ]`
2. Compute derived relations
   - typeEquiv: variables belong to the same type
   - subtypeOf: variables belong to super/subtype
   - extensional notion of type: set of variables

Type reconstruction (from type-less legacy code)

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Pseudo code from paper

$$arrayIndexEquiv := arrayIndex^{-1} \circ arrayIndex$$

$$typeEquiv := arrayIndexEquiv \cup expression$$

$$subtypeOf := assign$$

repeat

$$subtypeEquiv := equiv(subtypeOf+ \cap (subtypeOf+)^{-1})$$

$$typeEquiv := equiv(typeEquiv \cup subtypeEquiv)$$

$$subtypeOf := subtypeOf \setminus typeEquiv$$

$$subtypeOf := subtypeOf \cup subtypeOf \circ typeEquiv \cup typeEquiv \circ subtypeOf$$

until fixpoint of (typeEquiv, subtypeOf)

Type reconstruction (from type-less legacy code)

Data

```
type VariableGraph v array
  = (Rel v v, Rel v array, Rel v v)

type TypeGraph x
  = (Rel x x, Rel x x)  -- subtypes and type equiv
```

Operation

```
typeInference
  :: (Ord v, Ord array) =>
     VariableGraph v array -> TypeGraph v
```

Formal concept analysis

See

- Christian Lindig. *Fast Concept Analysis*. In Gerhard Stumme, editors, *Working with Conceptual Structures - Contributions to ICCS 2000*, Shaker Verlag, Aachen, Germany, 2000.

Basic idea

1. Given formal context
   - matrix of objects vs. properties
2. Compute concept lattice
   - a concept = (extent,intent)
   - ordering is by sub/super set relation on intent/extent

Used in many fields, including program understanding.

Formal concept analysis pseudo-code (1/2)

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NEIGHBORS $((G, M), (\mathcal{G}, \mathcal{M}, \mathcal{I}))$

```
1   min ← 𝒢 \ G
2   neighbors ← ∅
3   foreach g ∈ 𝒢 \ G do
4      M1 ← (G ∪ {g})′
5      G1 ← M1′
6      if ((min ∩ (G1 \ G \ {g})) = ∅) then
7         neighbors ← neigbors ∪ {(G1, M1)}
8      else
9         min ← min \ {g}
10  return neighbors
```

Note that _′ operation denotes computation of intent from extent, or vice versa, implicitly given a context.

Formal concept analysis pseudo-code (2/2)

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```
LATTICE (G, M, I)
 1  c ← (∅'', ∅')
 2  insert (c, L)
 3  loop
 4     foreach x in NEIGHBORS (c, (G, M, I))
 5        try x ← lookup (x, L)
 6        with NotFound → insert (x, L)
 7        x* ← x* ∪ {c}
 8        c* ← c* ∪ {x}
 9     try c ← next (c, L)
10     with NotFound → exit
11  return L
```

Transposition to Haskell?

Formal concept analysis

Representation

```
type Context g m = Rel g m
type Concept g m = (Set g, Set m)
type ConceptLattice g m
   = Rel (Concept g m) (Concept g m)
```

Algorithm

```
neighbors :: (Ord g, Ord m)
          => Set g                -- extent of concept
          -> Context g m          -- formal context
          -> [Concept g m]        -- list of neighbors

lattice :: (Ord g, Ord m)
        => Context g m            -- formal context
        -> ConceptLattice g m     -- concept lattice
```

Ongoing projects at SIG

Quality and metrics

- Metrics for architectural quality and evolution
- Quality models for BPEL, SAP, Sharepoint, Spreadsheets,…
- Models for Reliability, Technical Debt

Repository mining

- Analyze relationships between code/commits/issues/tests through time
- Calibration and validation of quality indicators

Large-scale source code analysis

- Detection of “events” in data streams
- Using the Amazon cloud
- Metrics warehouse

Possible MFES projects at SIG

Improvement of metrics event detection

- Evaluation of current event detection has revealed weaknesses
- Some improvements have been proposed
- Improvements must be implemented and evaluated

Analysis of OSS projects

- Select 5 high-profile OSS projects
- Analyse code, issues, tests, community structure
- Current status as well as evolution through time
- Assess each project and compare all projects

Metrics for architectural evolution

- Find different types of change (local, simultaneous, de-phased, structural, ..)
- Quantify in metrics
- Case study on two proprietary and two OSS systems

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