Reverse Engineering

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UvA, MSc SE, 9 November 2015

Roadmap

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W46	Reverse Engineering	V.Zaytsev
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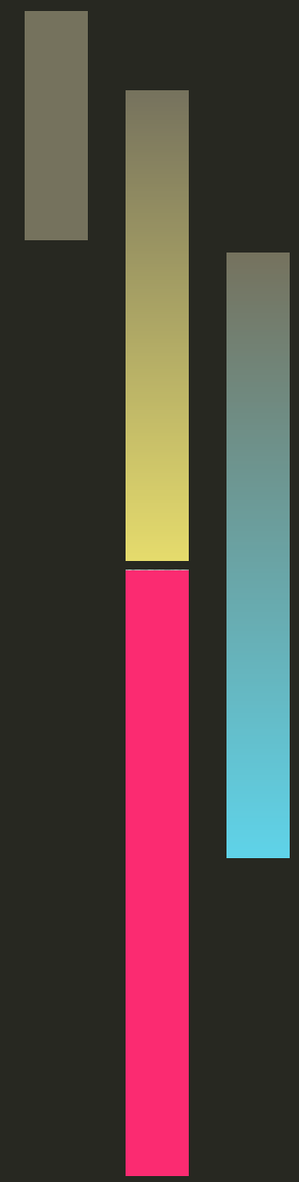
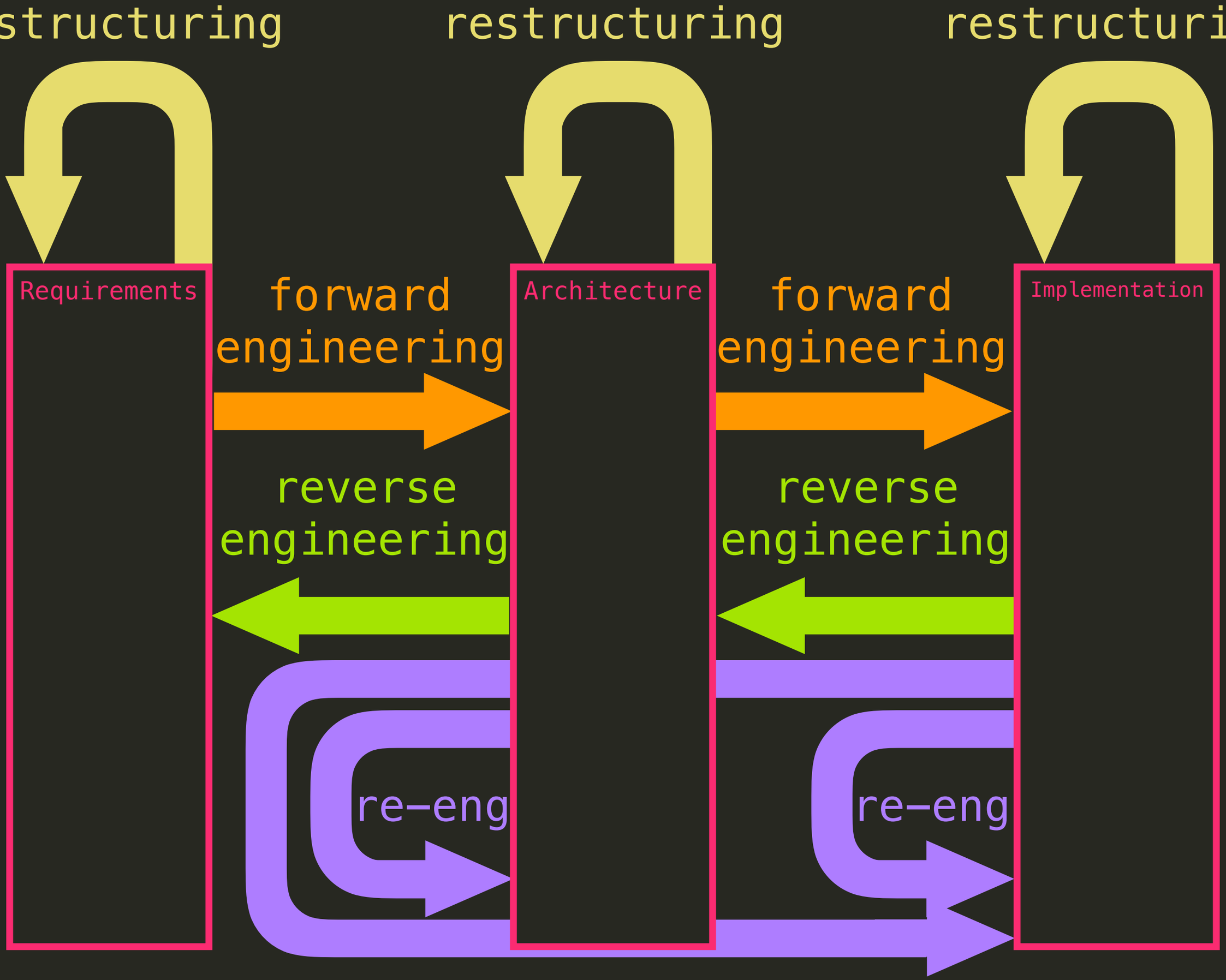
W49	Source Code Manipulation	V.Zaytsev
W50	Legacy and Renovation	TBA
W51	Conclusion	V.Zaytsev





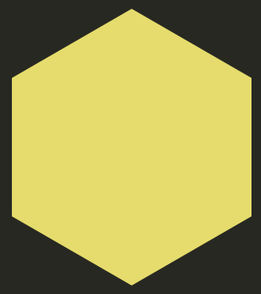
E.Chikofsky, J.H.Cross II, Reverse Engineering and Design Discovery: A Taxonomy. IEEE Software 7:1, 1990.

Objectives of reverse engineering

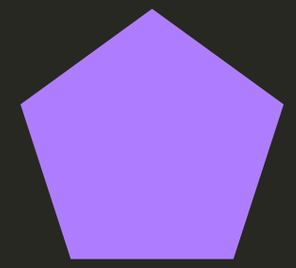
* Cope with complexity
* Generate alternate views
* Recover lost info
* Detect side effects
* Synthesise higher abstractions
* Facilitate reuse

E.Chikofsky, J.H.Cross II, Reverse Engineering and Design Discovery: A Taxonomy. IEEE Software 7:1, 1990.

Code Reverse Engineering



Code reverse engineering

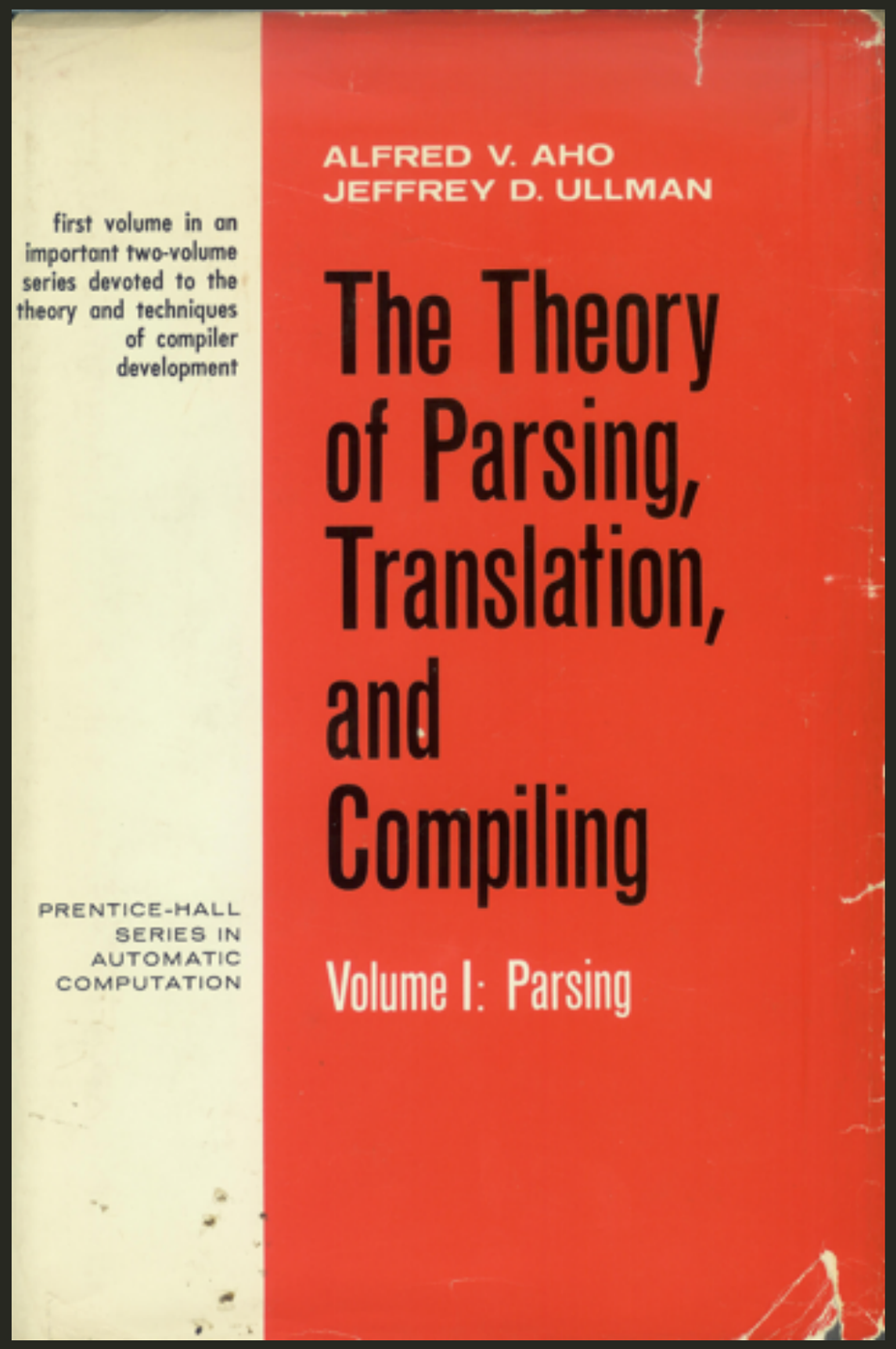


* Parsing
* Fact extraction
* Slicing
* Pattern matching
* Decomposition
* Exploration

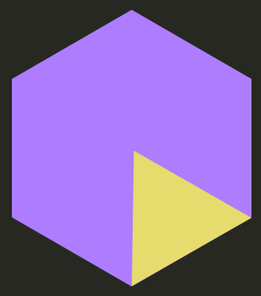
H.A.Müller, J.H.Jahnke, D.B.Smith, M.-A.Storey, S.R.Tilley, K.Wong, Reverse Engineering: A Roadmap, ICSE 2000. http://bibtex.github.io/ICSE-2000-Future-MullerJSSTW.html

Parsing

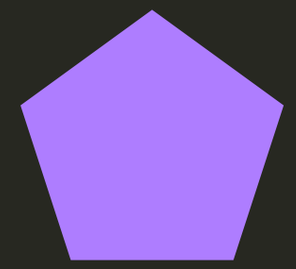
* Well-developed since…
* Recognising structure
  * text → tree
  * parse tree → AST
  * forest disambiguation
  * tokens → list
  * image → visual model



A.V. Aho & J.D. Ullman, The Theory of Parsing, Translation and Compiling, 1972.
V.Zaytsev, A.H.Bagge, Parsing in a Broad Sense, MoDELS 2014.

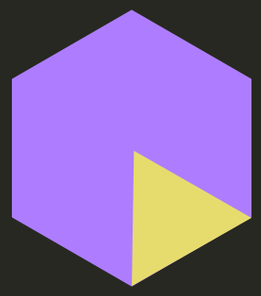


↑ Parsing

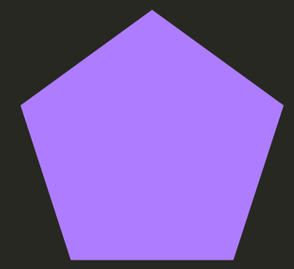


* Reduce the input back to the start symbol
* Recognise terminals
* Replace terminals by nonterminals
* Replace terminals and nonterminals by lhs

* LR(1) ::= yacc | Beaver | Eli | SableCC | Irony;
* GLR ::= bison | DMS | GDK | Tom;
* SGLR ::= ASF+SDF | Spoofax | Stratego;

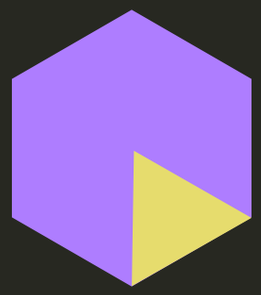


↓ Parsing

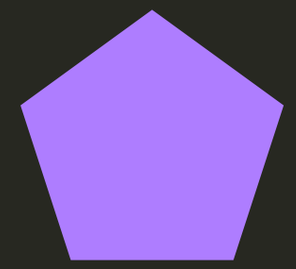


* Imitate production by rederivation
* Each nonterminal is a goal
* Replace each goal by subgoals
* Parse tree is built from top to bottom

* LL(k) ::= JavaCC;
* Earley ::= Marpa | ModelCC;
* GLL ::= Rascal | gll-combinators;
* Packrat ::= Rats! | OMeta | PetitParser;
* LL(*) ::= ANTLR | TXL;
* DCG ::= Prolog;

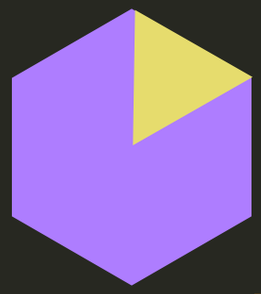


Semiparsing

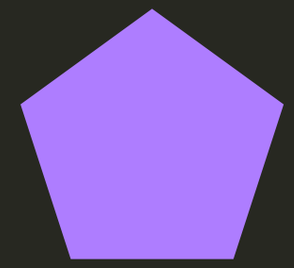


* grep
* anchor terminals
* islands & noise
* skeleton grammars
* relaxation & robustness
* multilanguage

V.Zaytsev, Formal Foundations for Semi-Parsing, CSMR-WCRE ERA, 2014
http://bibtex.github.io/CSMR-WCRE-2014-Zaytsev.html



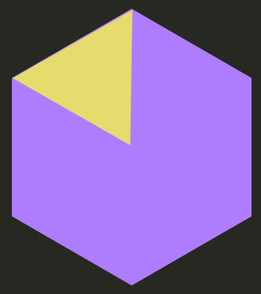
Fact extraction



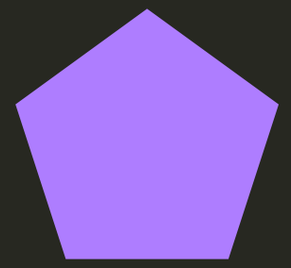
= parsing + generating a factbase
(or, sequence of graph transformations)

* e.g., metrics
* Can be language-parametric!
* Schema
  * describes form of the data
  * ASG = Abstract Semantic Graph
  * call graph
  * dependence graph
  * relations

Y.Lin, R.C.Holt, Formalizing Fact Extraction, ATEM 2003.
http://bibtex.github.io/ATEM-2003-LinH04.html

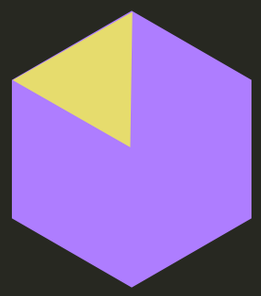


Slicing

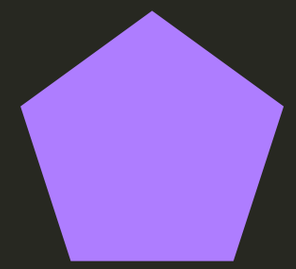


```
read(text);
read(n);
lines = 1;
chars = 1;
subtext = "";
c = getChar(text);
while (c != ‘\eof’)
      if (c == ‘\n’)
      then lines = lines + 1;
           chars = chars + 1;
      else chars = chars + 1;
           if (n != 0)
           then subtext = subtext ++ c;
                n = n – 1;
      c = getChar(text);
write(lines);
write(chars);
write(subtext);
```

J. Silva, A Vocabulary of Program Slicing-Based Techniques, CSUR, 2012.

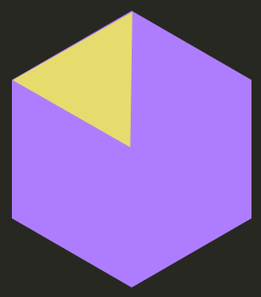


Slicing

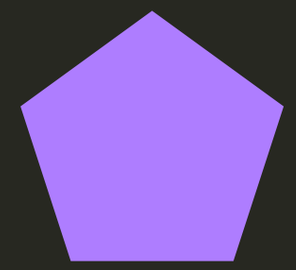


* Forward/backward slicing
* Dynamic/conditioned slicing
  * constraints on input
* Chopping
  * discover connection between I & O
* Amorphous slicing
* . . .

J. Silva, A Vocabulary of Program Slicing-Based Techniques, CSUR, 2012.

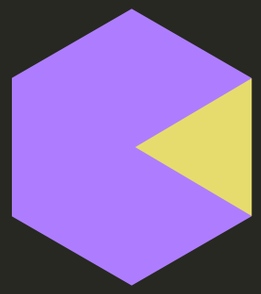


Slicing

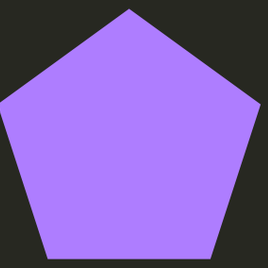


* Debugging
  * cf. Weiser CACM 1982
* Cohesion measurement
  * cf. Ott&Bieman IST 1998
* Comprehension
  * cf. De Lucia&Fasolino&Munro IWPC 1996
* Maintenance
  * e.g. reuse
* Re-engineering
  * e.g. clone detection

http://www0.cs.ucl.ac.uk/staff/mharman/sf.html

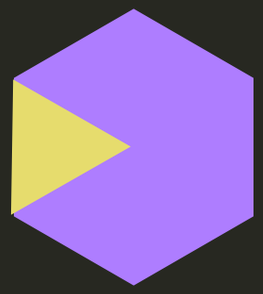


Pattern matching

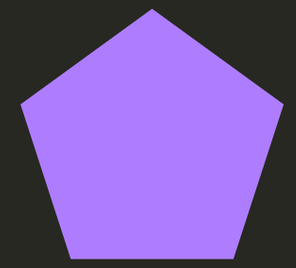


* Easy to formulate on ADTs
* In Rascal:
  * visit(){case}
  * := and !:=
  * functions
* Need traversal strategies
  * depth-first (pre-, in-, post-order)
  * breadth-first
  * topdown, bottomup, downup
  * innermost, outermost
  * . . .

E.Visser, Z.Benaissa, A.P.Tolmach, Building Program Optimizers with Rewriting Strategies, ICFP 1998.
http://bibtex.github.io/ICFP-1998-VisserBT.html



Decomposition



* Recall partitioning & equiv. classes
* Simplest form: modularisation
* Usually: some graph + SCCs
  * Given granularity
    * make a valid decomposition
    * maximising benefit
  * Applicable to packages, build targets, automata, tasks, formulae, processes, rels…

M.Vakilian, R.Sauciuc, J.D.Morgenthaler, V.Mirrokni, Automated Decomposition of Build Targets, ICSE 2015
http://bibtex.github.io/ICSE-v1-2015-VakilianSMM.html

Exploration

Software visualisation

Algorithm visualisation

Static algorithm visualisation

Algorithm animation

Program visualisation

Data animation

Static code visualisation

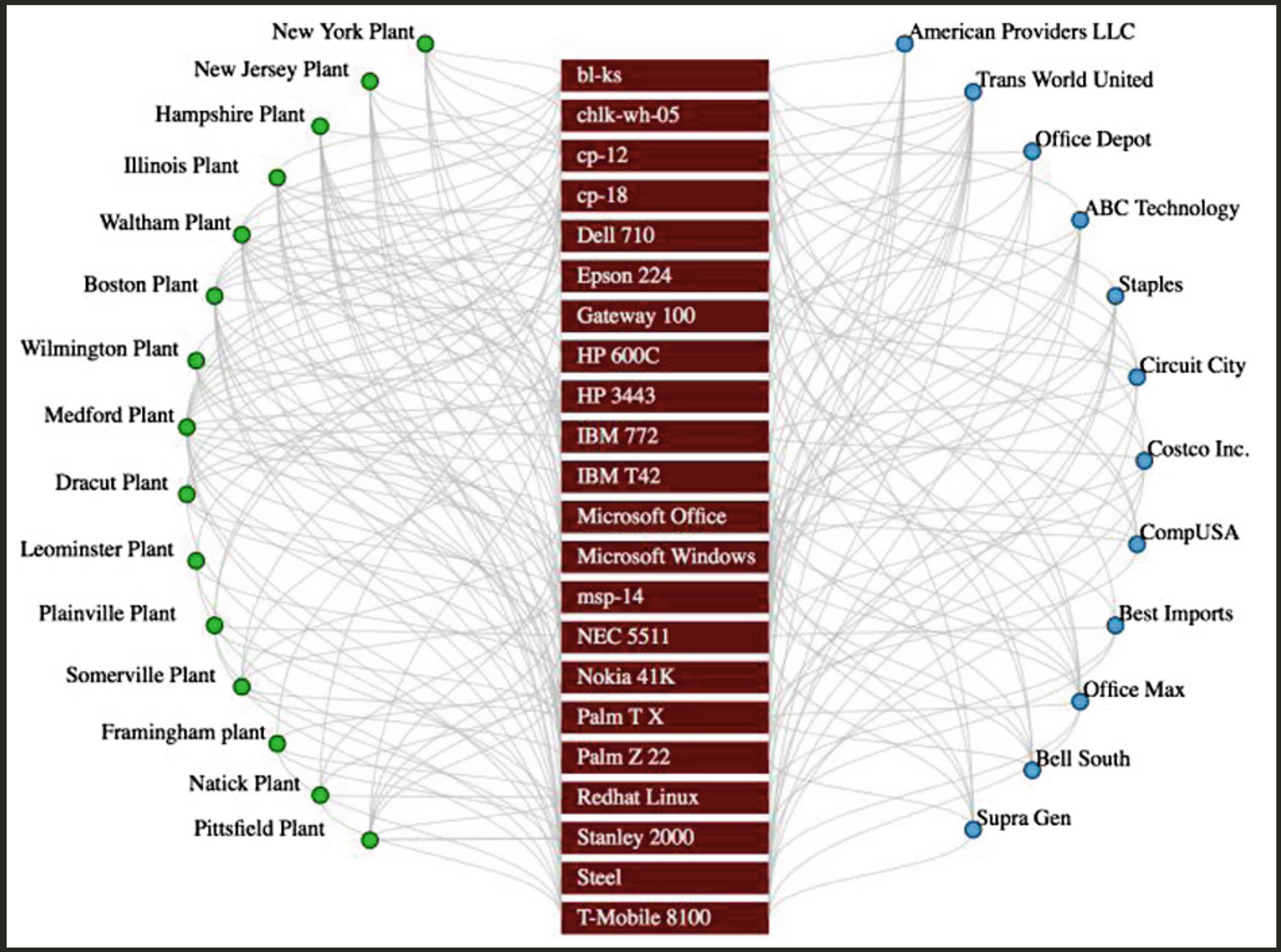
Static data visualisation

Visual programming

Code animation

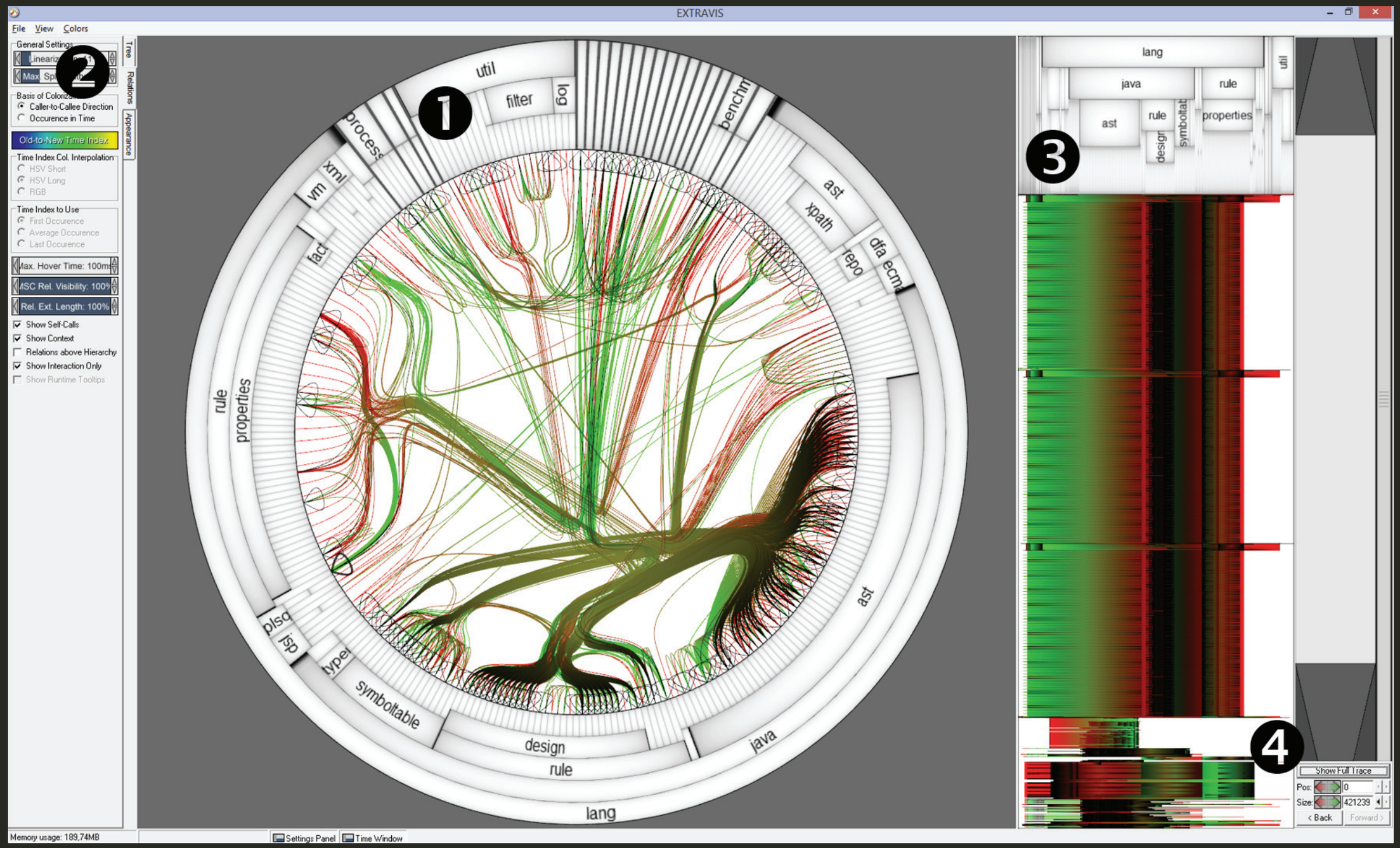
B.A.Price, R.M.Baecker, I.S.Small, A Principled Taxonomy of Software Visualization, JVLC 1993

Visualisation



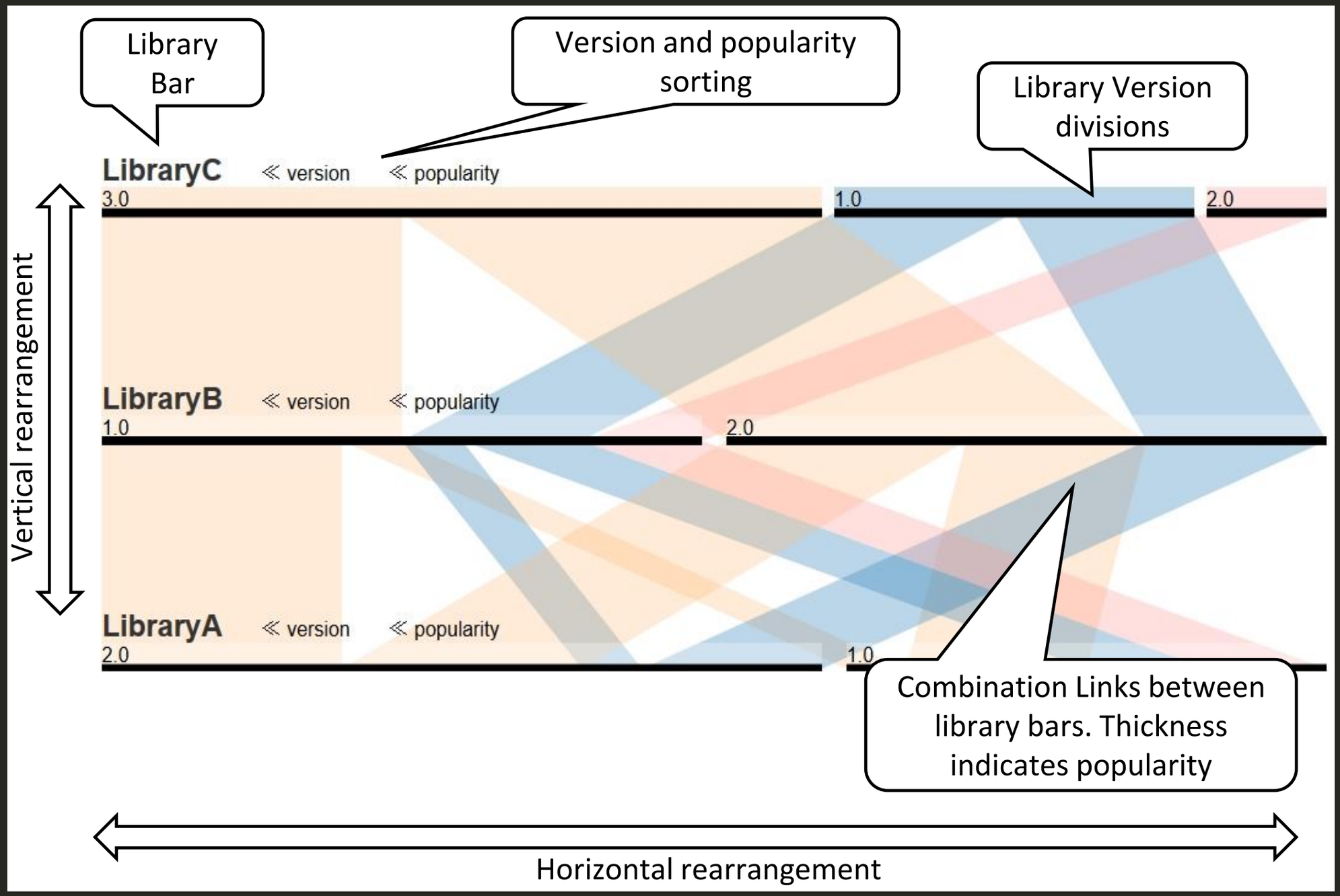
T.Babaian, W.T.Lucas, M.Li, Modernizing Exploration and Navigation in Enterprise Systems with Interactive Visualizations, HCI 2015. http://bibtex.github.io/HIMI-IKD-2015-BabaianLL.html

Trace vis



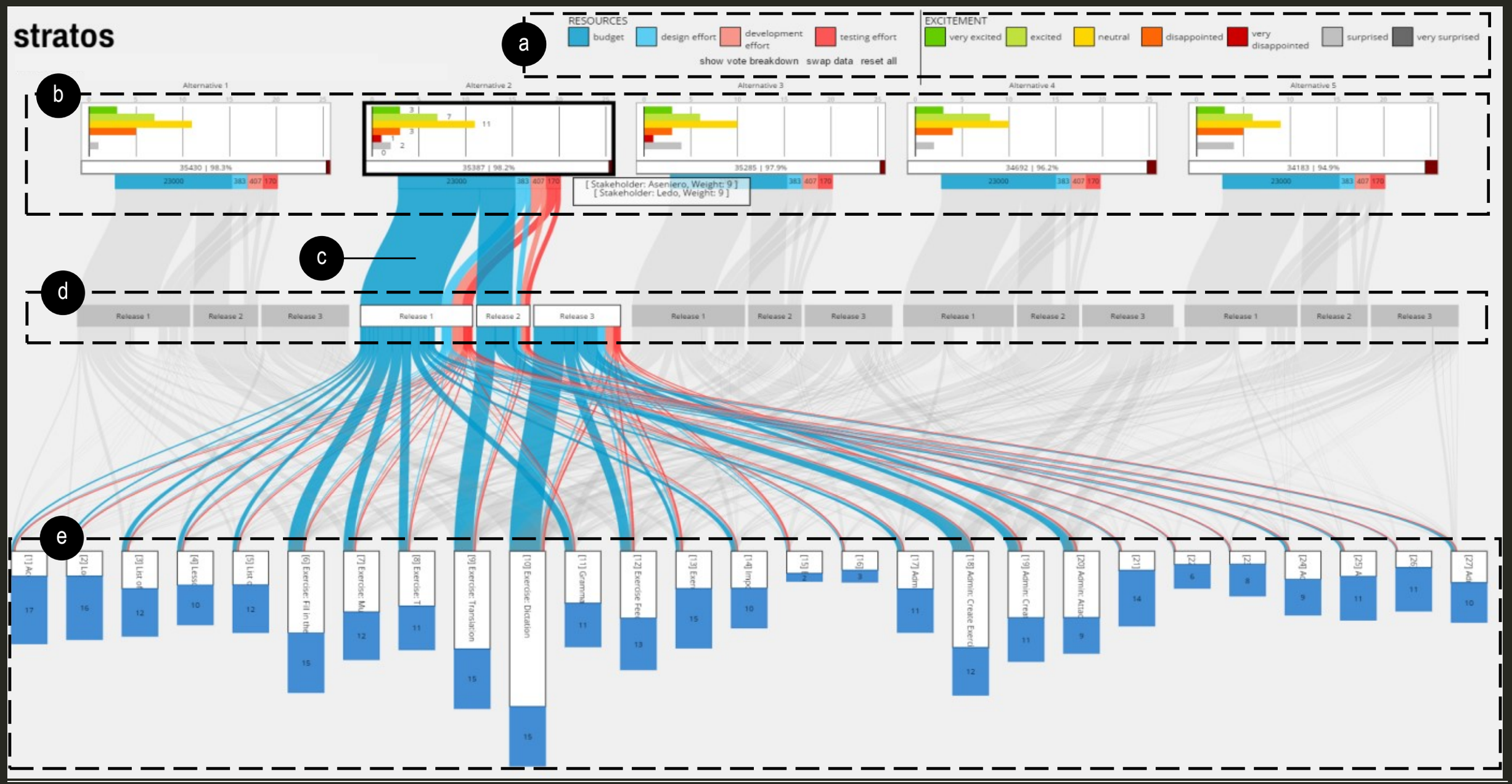
F.Fittkau, S.Finke, W.Hasselbring, J.Waller, Comparing trace visualizations for program comprehension through controlled experiments, ICPC 2015. http://bibtex.github.io/ICPC-2015-FittkauFHW.html

Versioning vis



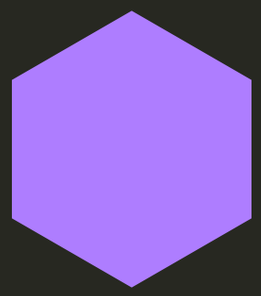
Y.Yano, R.G.Kula, T.Ishio, K.Inoue, VerXCombo: an interactive data visualization of popular library version combinations, ICPC 2015. http://bibtex.github.io/ICPC-2015-YanoKII.html

Release vis



B.A.Aseniero, T.Wun, D.Ledo, G.Ruhe, A.Tang, S.Carpendale, STRATOS: Using Visualization to Support Decisions in Strategic Software Release Planning, CHI 2015. http://bibtex.github.io/CHI-2015-AsenieroWLRTC.html

Data Reverse Engineering



Data reverse engineering

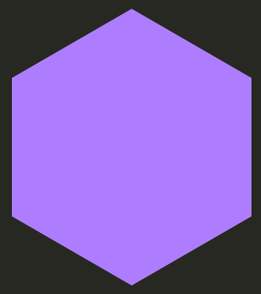
* Database design recovery
* Pattern recognition
* Information retrieval
* Clustering
* Mining unstructured data

H.A.Müller, J.H.Jahnke, D.B.Smith, M.-A.Storey, S.R.Tilley, K.Wong, Reverse Engineering: A Roadmap, ICSE 2000. http://bibtex.github.io/ICSE-2000-Future-MullerJSSTW.html

Database design recovery

* Forward database engineering
  * Conceptual design
  * Logical design
    * Simplification
    * Optimisation
    * Translation
  * Physical design
  * View design

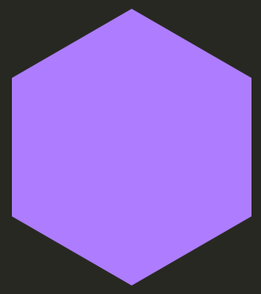
J.-L.Hainaut, J.Henrard, J.-M.Hick, D.Roland, V.Englebert, Database Design Recovery, CAiSE, 1996.
http://bibtex.github.io/CAiSE-1996-HainautHHRE.html



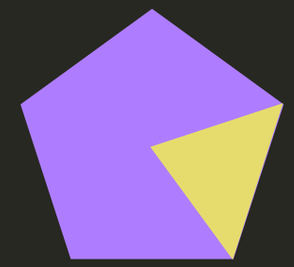
Database design recovery

* Data structure extraction
  * Program analysis
  * Data analysis
    * Schema integration
* Data structure conceptualisation
  * Untranslation
  * Deoptimisation
  * Conceptual normalisation

J.-L.Hainaut, J.Henrard, D.Roland, V.Englebert, J.-M.Hick, Structure Elicitation in Database Reverse Engineering, WCRE 1996
http://bibtex.github.io/WCRE-1996-HainautHREH.html



Pattern recognition



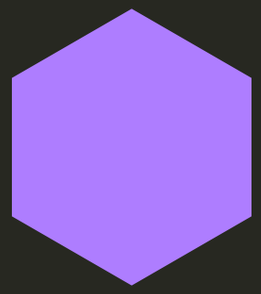
* Pattern = feature vector
* Quantitative features
  * continuous / discrete / interval
* Qualitative features
  * nominal / ordinal
* Find most descriptive/discriminatory

K.C.Gowda, E.Diday, Symbolic clustering using a new dissimilarity measure. IEEE TSMC 22, 1992.

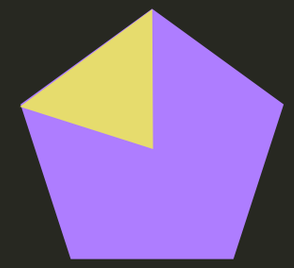
Information retrieval

- Knowledge discovery
- Data mining
- Usually statistical methods
  - = require training
- WEKA = Waikato Environment for Knowledge Analysis
  - Java, 1992–2015
  - http://www.cs.waikato.ac.nz/ml/weka/
  - good with Groovy, Scala, Jython…

M.Hall, E.Frank, G.Holmes, B.Pfahringer, P.Reutemann, I.H.Witten, The WEKA data mining software: an update, SIGKDD Explorations Newsletter 11:1, 2009.

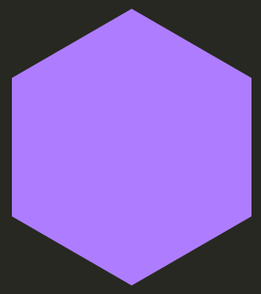


Clustering



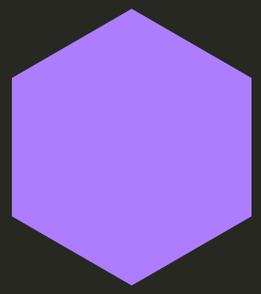
* Pattern recognition & representation
  * similarity/proximity measure
    * Minkowski / edit / statistical
  * Clustering techniques
    * hierarchical / partitional
    * agglomerative / divisive
    * hard / fuzzy
    * incremental / non-incremental
  * Dendrograms

A.K.Jain, M.N.Murty, P.J.Flynn, Data clustering: a review, CSUR 31:3, 1999.



MUD

* Mixture
  * natural language text
  * technical artefacts
* Unstructured data
  * dev communication
  * issue reports
  * documentation
  * meeting notes



MUD

* Can fish for
  * code fragments
  * class names
  * stack traces
  * patches
  * jargon
* State of the art
  * heuristic-based idiosyncratic tools

N.Bettenburg, B.Adams, A.E.Hassan, M.Smidt, A Lightweight Approach to Uncover Technical Artifacts in Unstructured Data, ICPC 2011. http://bibtex.github.io/ICPC-2011-BettenburgAHS.html

Conclusion

* Besides forward engineering
  * there is reverse engineering
* Software comprehension
  * Code reverse engineering
    * parsing, slicing, matching, visualising
  * Data reverse engineering
    * design recovery, PR, IR, clustering, MUD
* Mature yet active field