FHistorian: Locating Features in Version Histories

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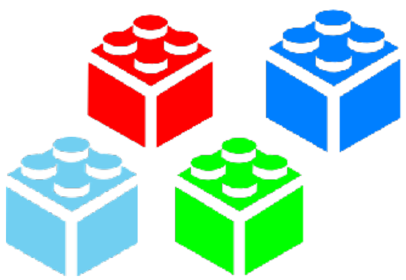
Feature Location

"Feature location is the activity of identifying an initial location in the source code that implements functionality in a software system."

Dit, B., Revelle, M., Gethers, M. and Poshyvanyk, D. (2013), Feature location in source code: a taxonomy and survey. J. Softw. Evol. and Proc., 25: 53–95. doi:10.1002/smr.567

Feature Location for SPLE

The "top-down" approach



core assets (features)

configurations + feature model

product outputs

Feature Location for SPLE

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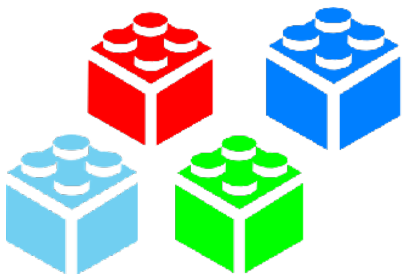

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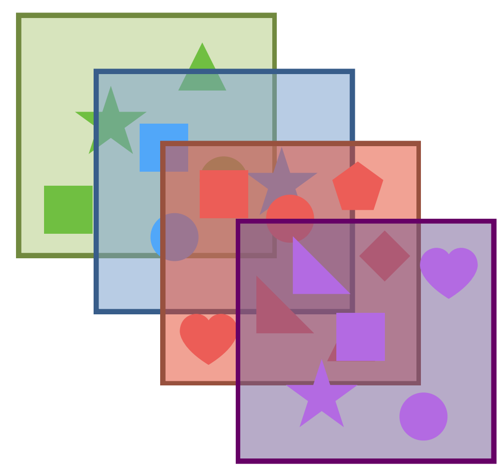
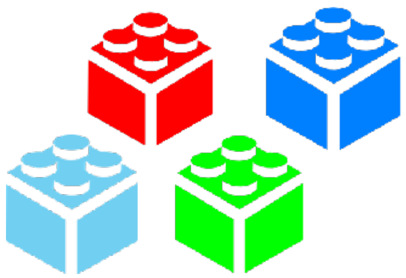


product variants

The "bottom-up" approach

Feature Location for SPLE

The "top-down" approach



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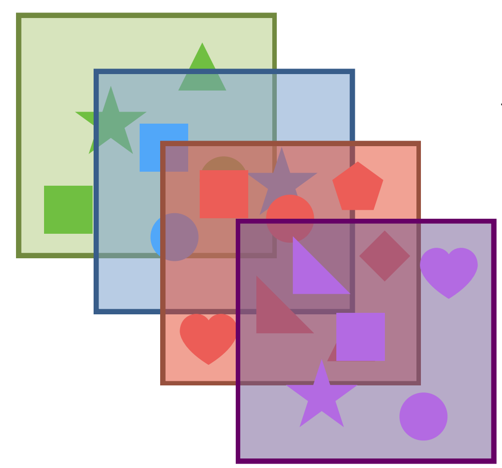
From "ad-hoc" to "systematic"



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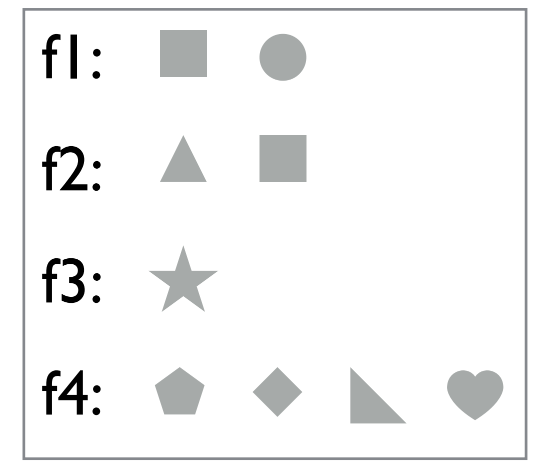
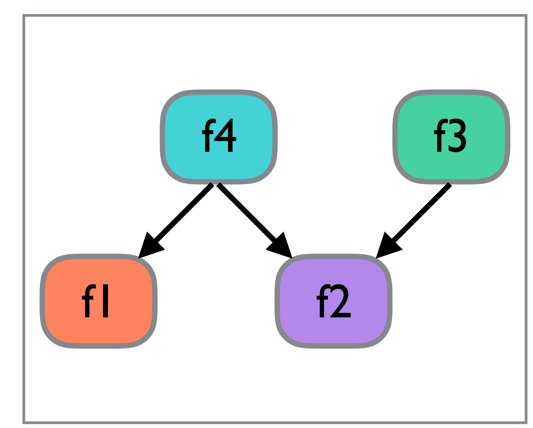


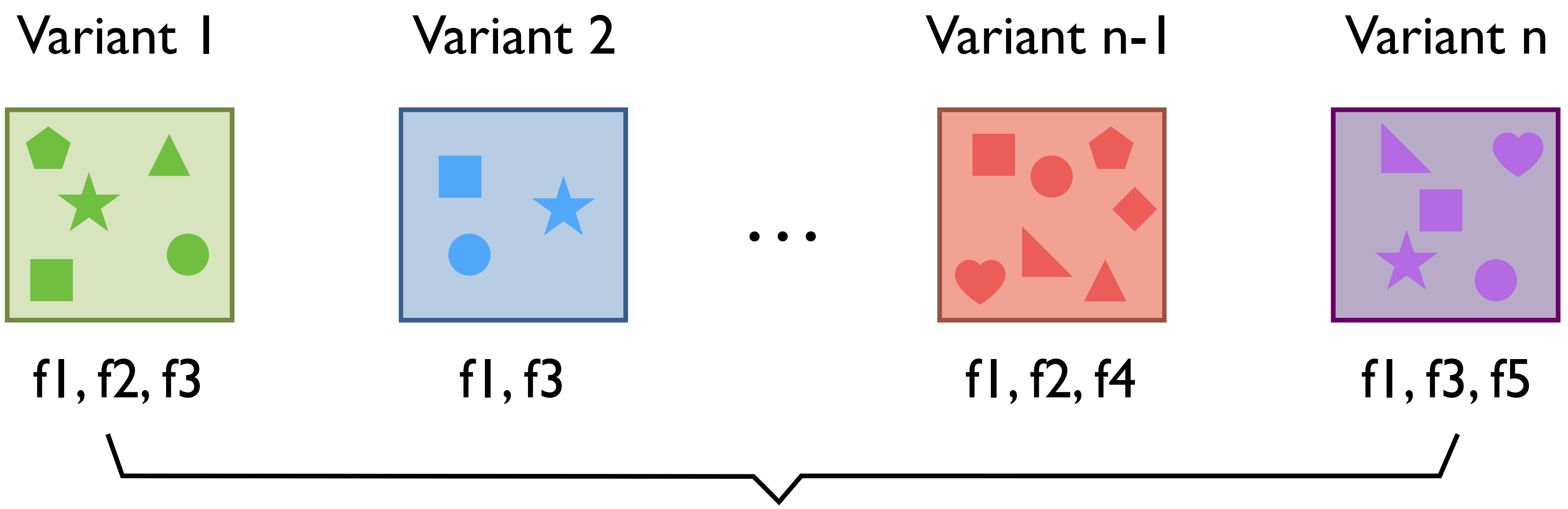
1. feature implementations (assets)



The "bottom-up" approach

2. feature relationships (feature models)

Feature Location from Product Variants



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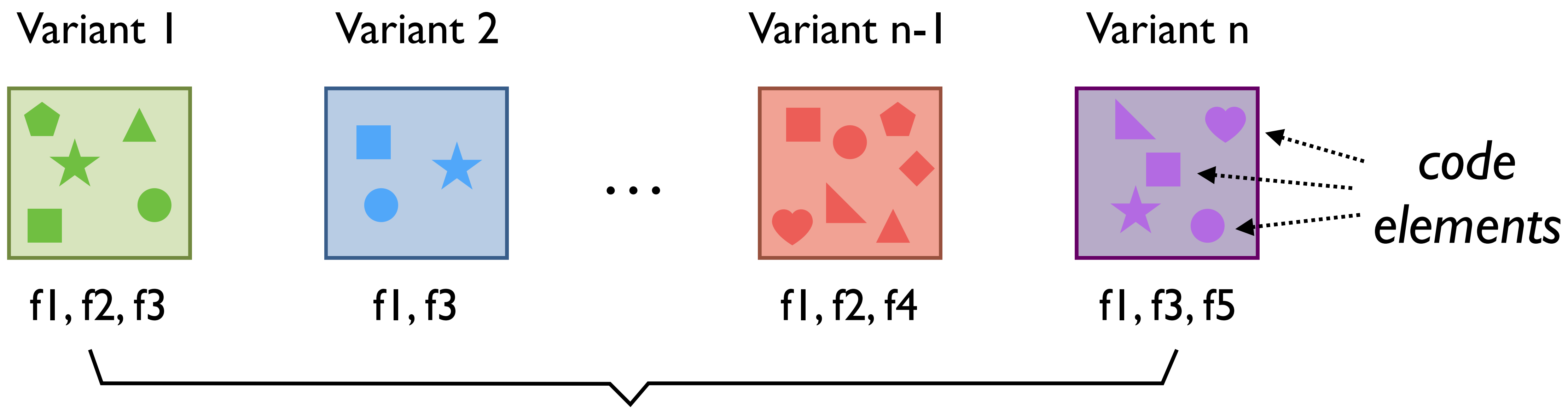

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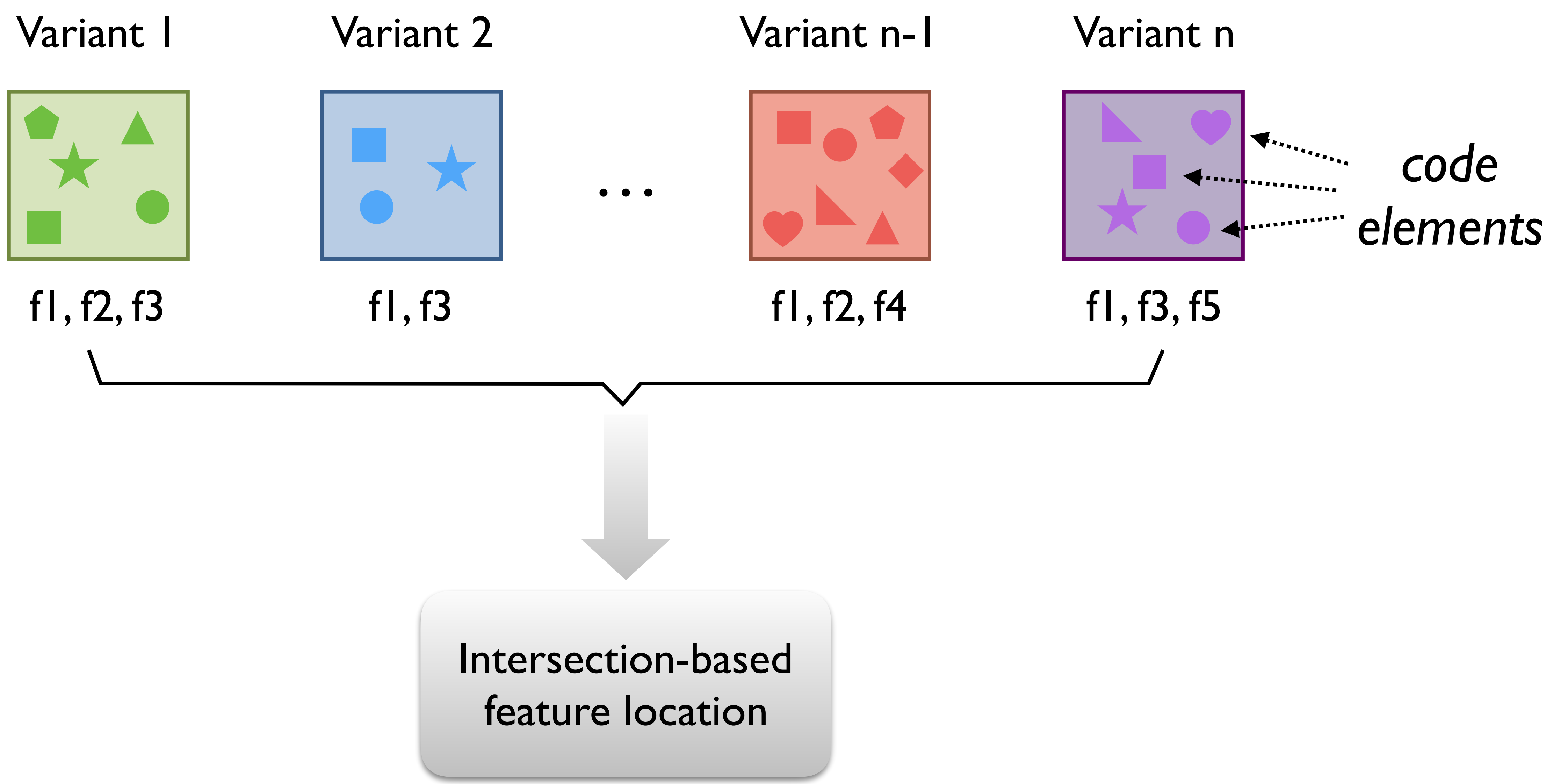

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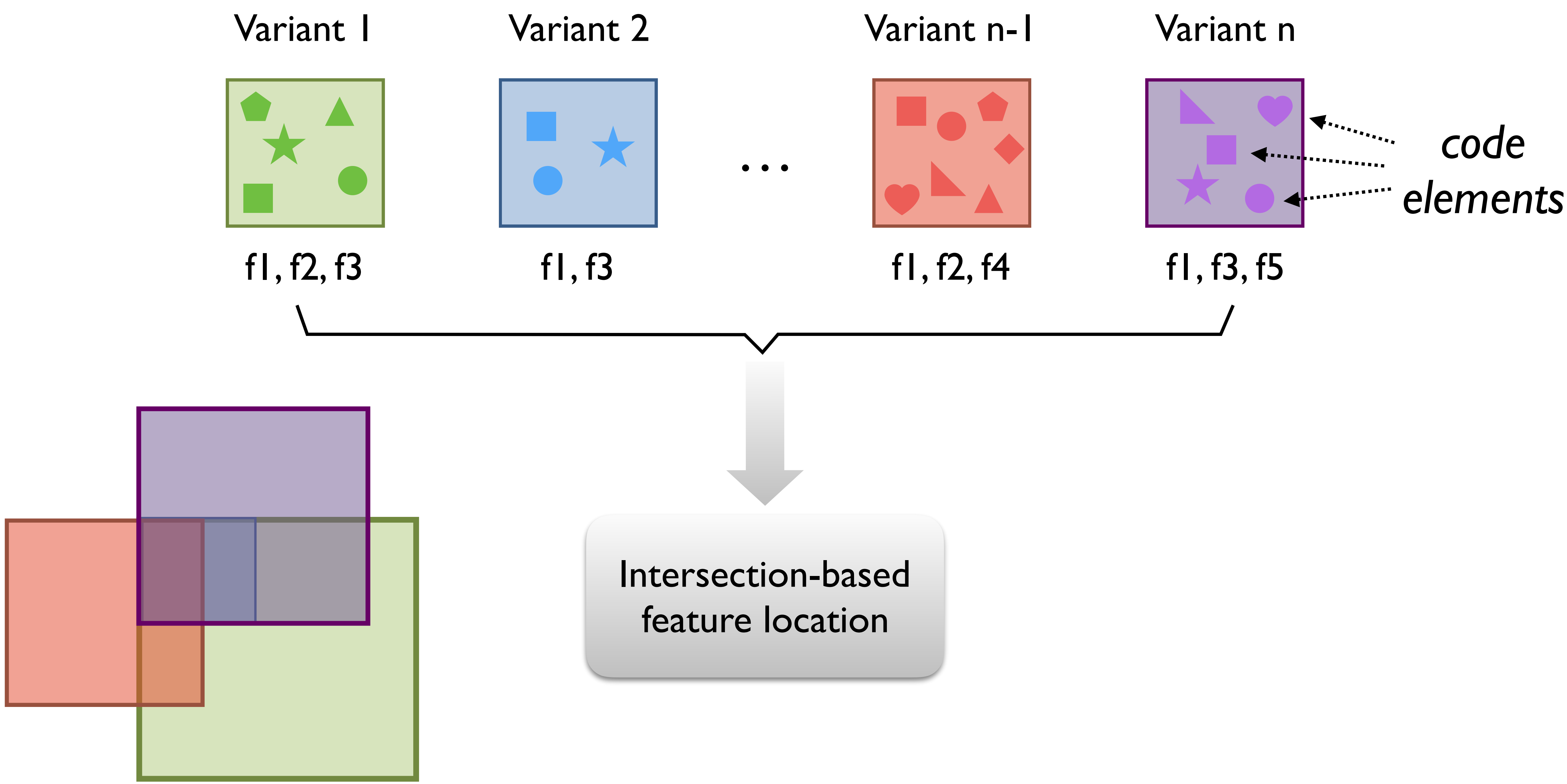

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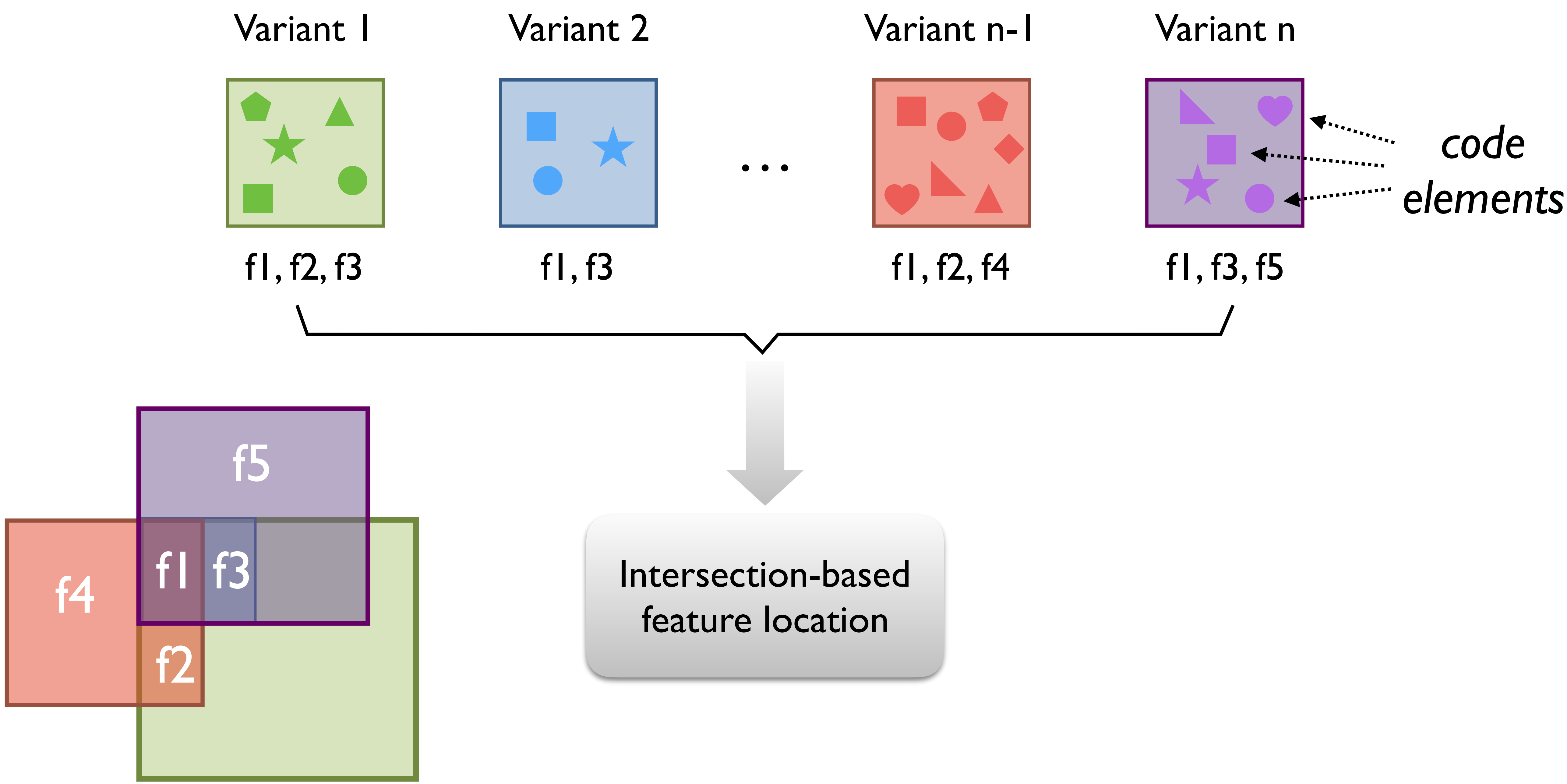

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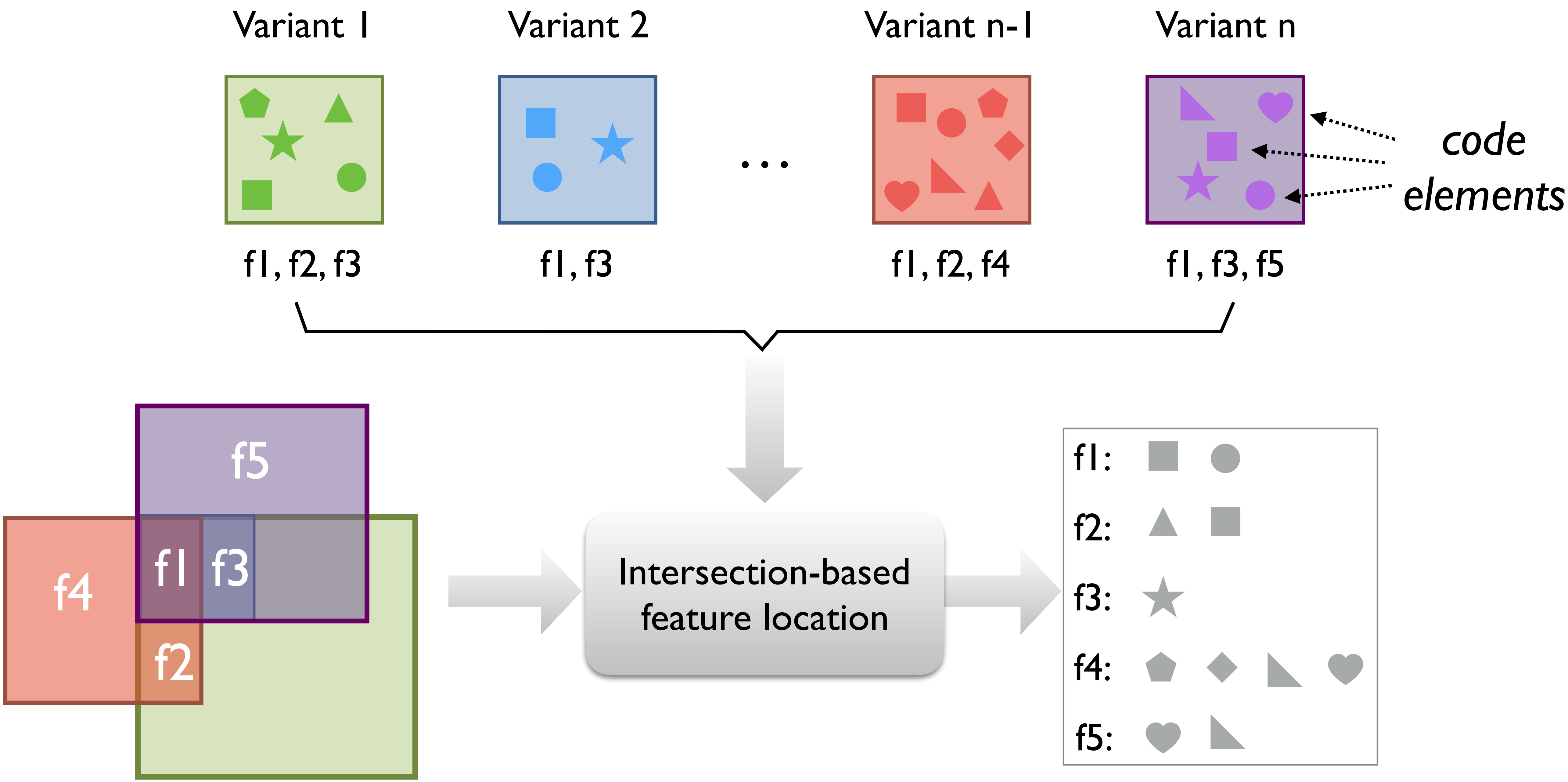

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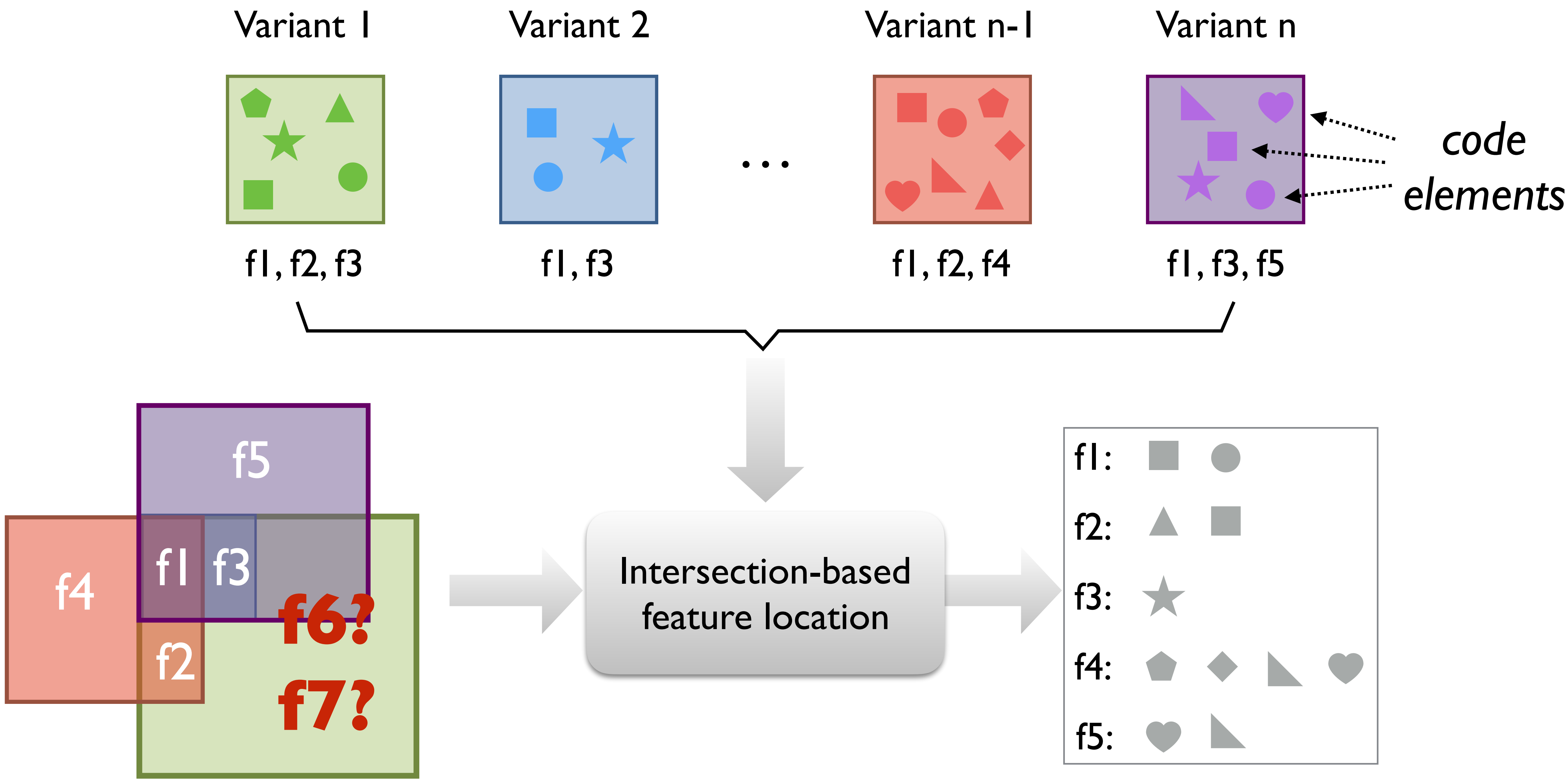

What if: Variant 1 also has f6 and f7?

Pitfalls of Intersection-Based Approaches

Intersection-based FL:

- Only works well with a large number of variants
- Operates in *static* manner
- Feature labeling has to be exhaustive

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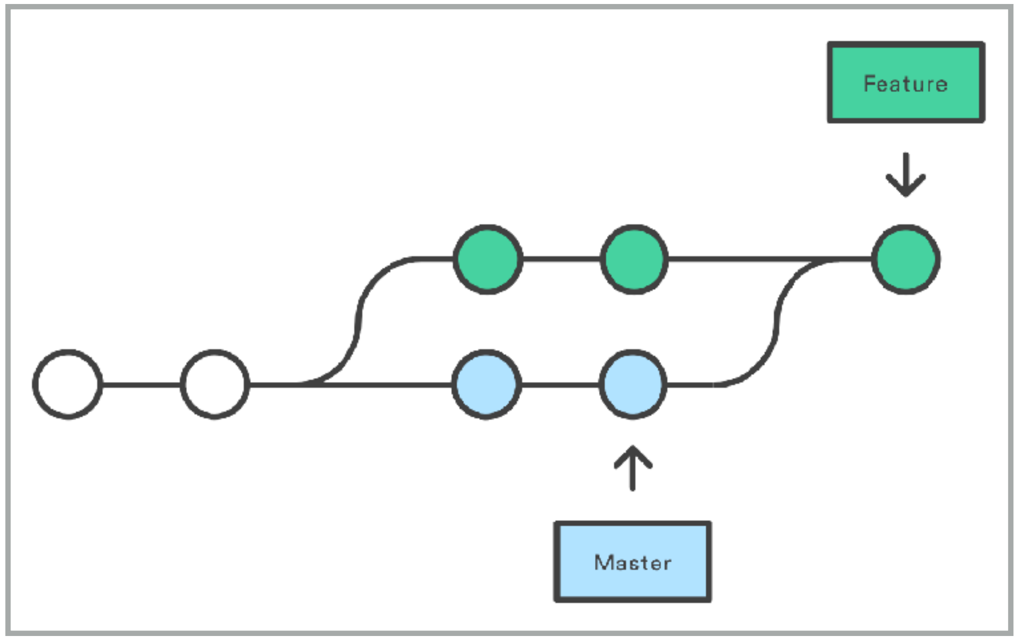
Reality:

- 3~10 products, ~50 features
- Maintained in version control systems (e.g., Git)



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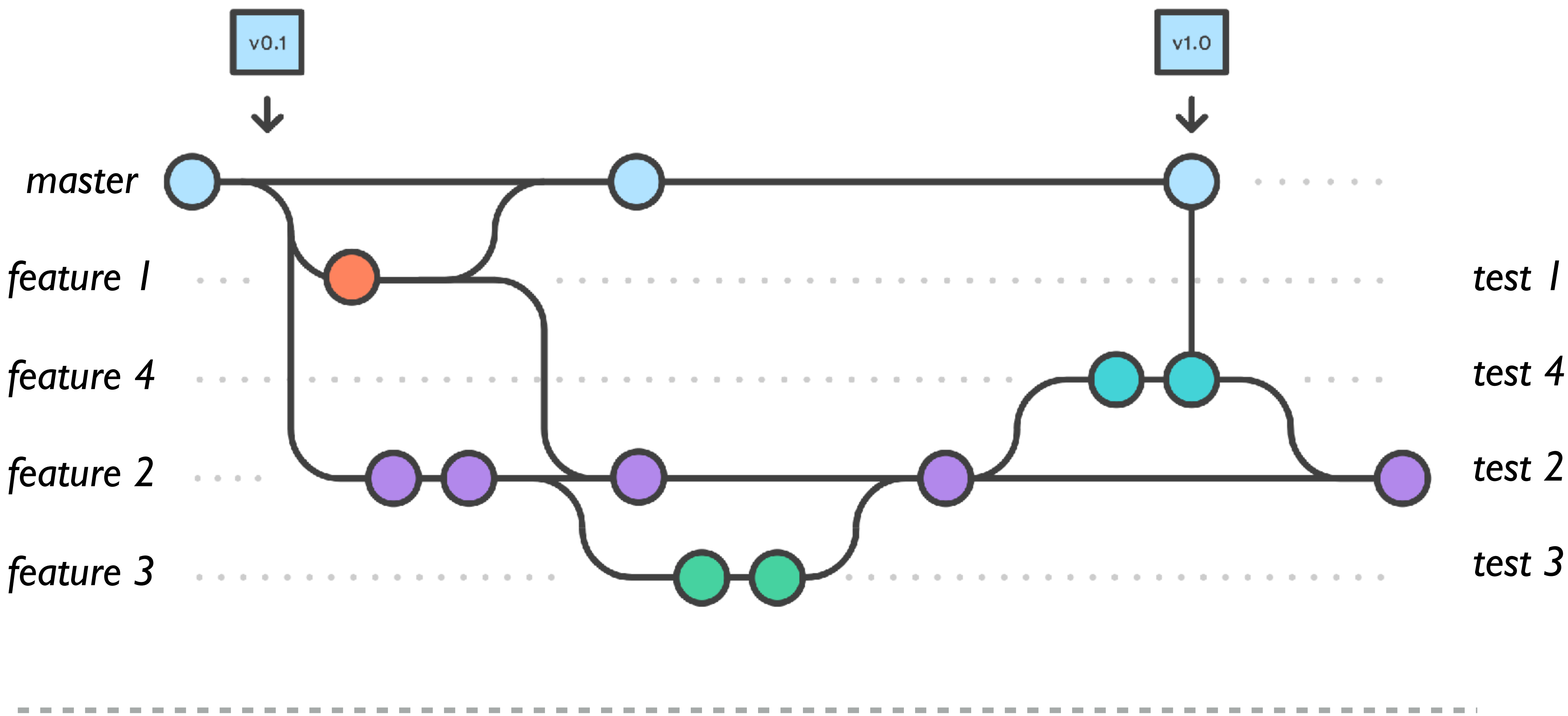

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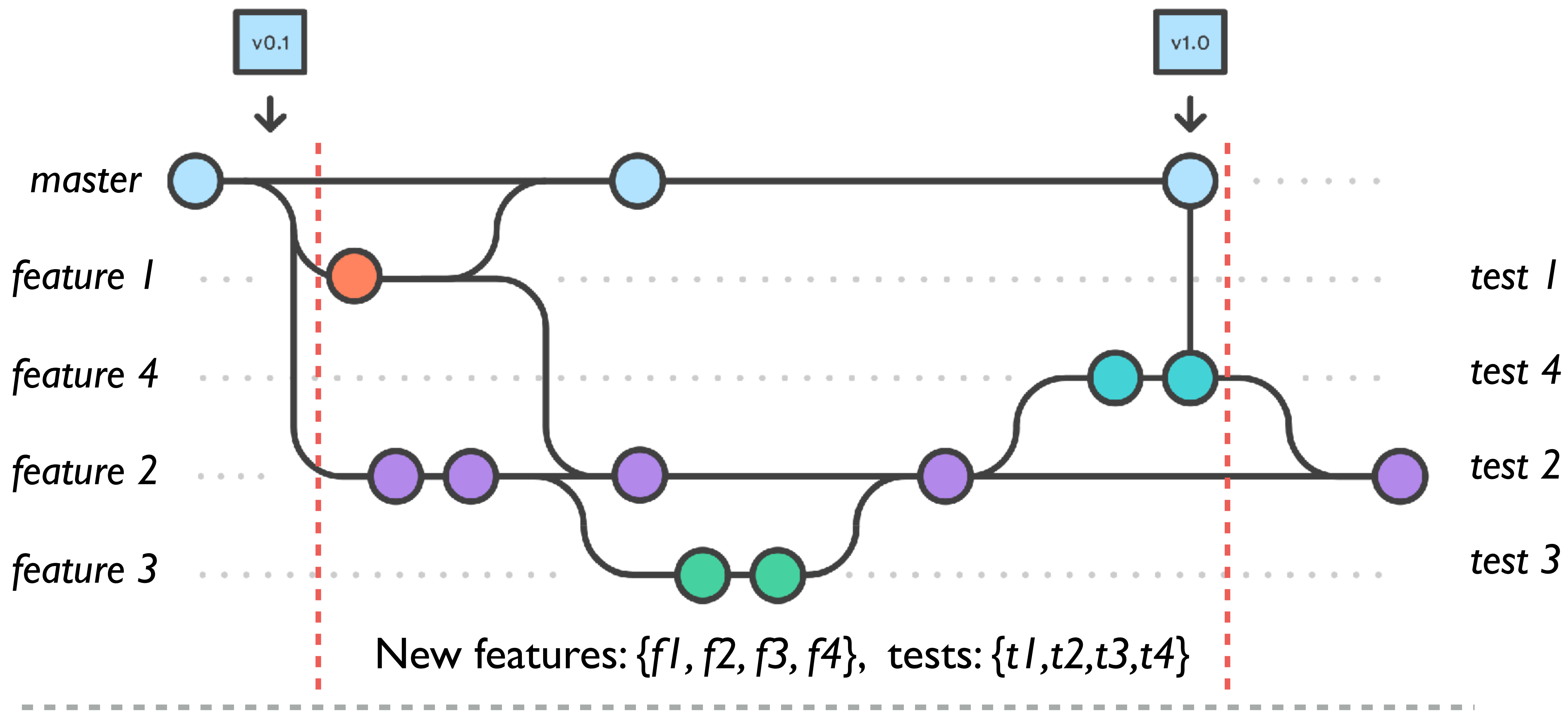

New features: {*f1*, *f2*, *f3*, *f4*}, tests: {*t1*,*t2*,*t3*,*t4*}

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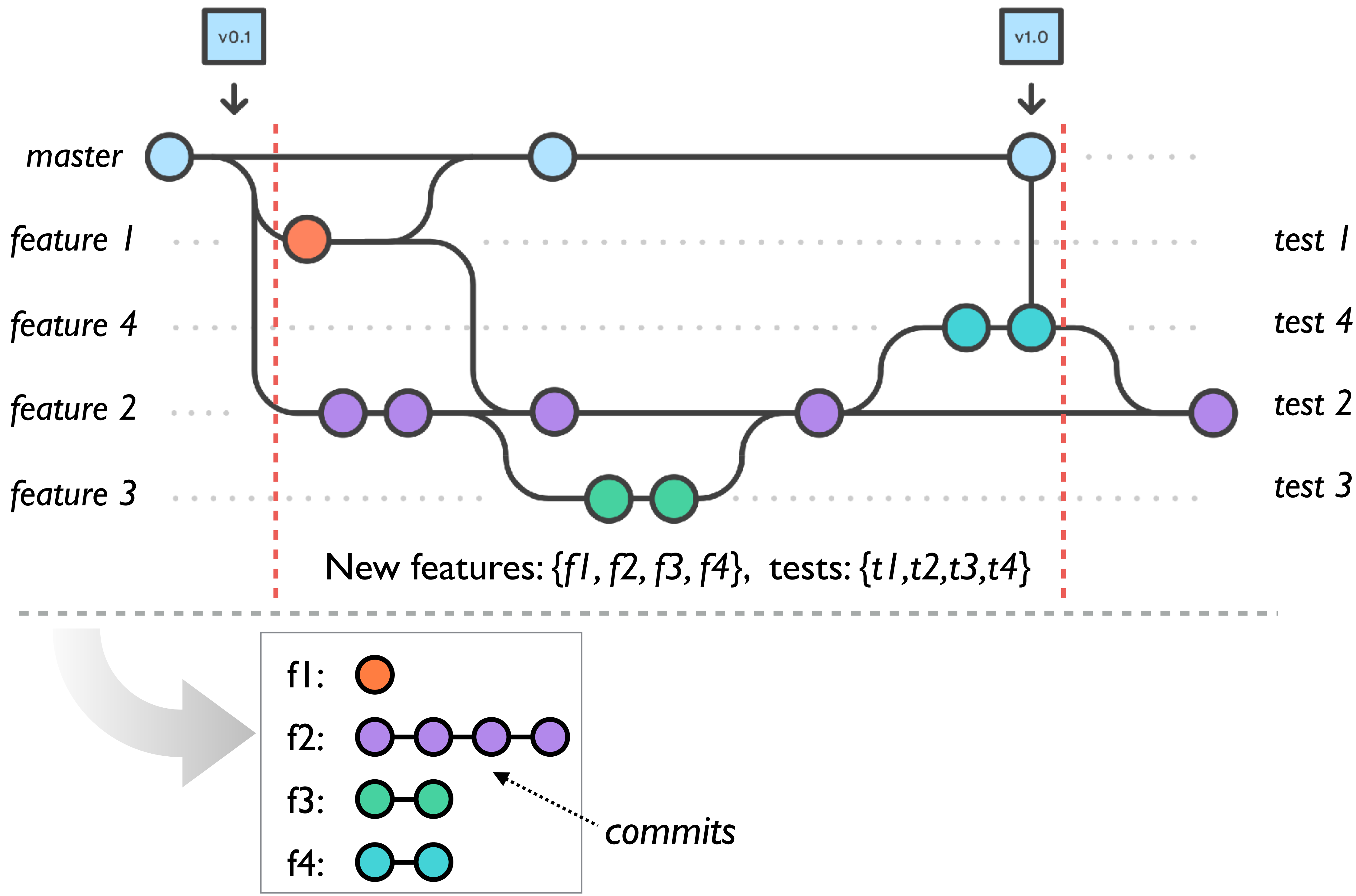

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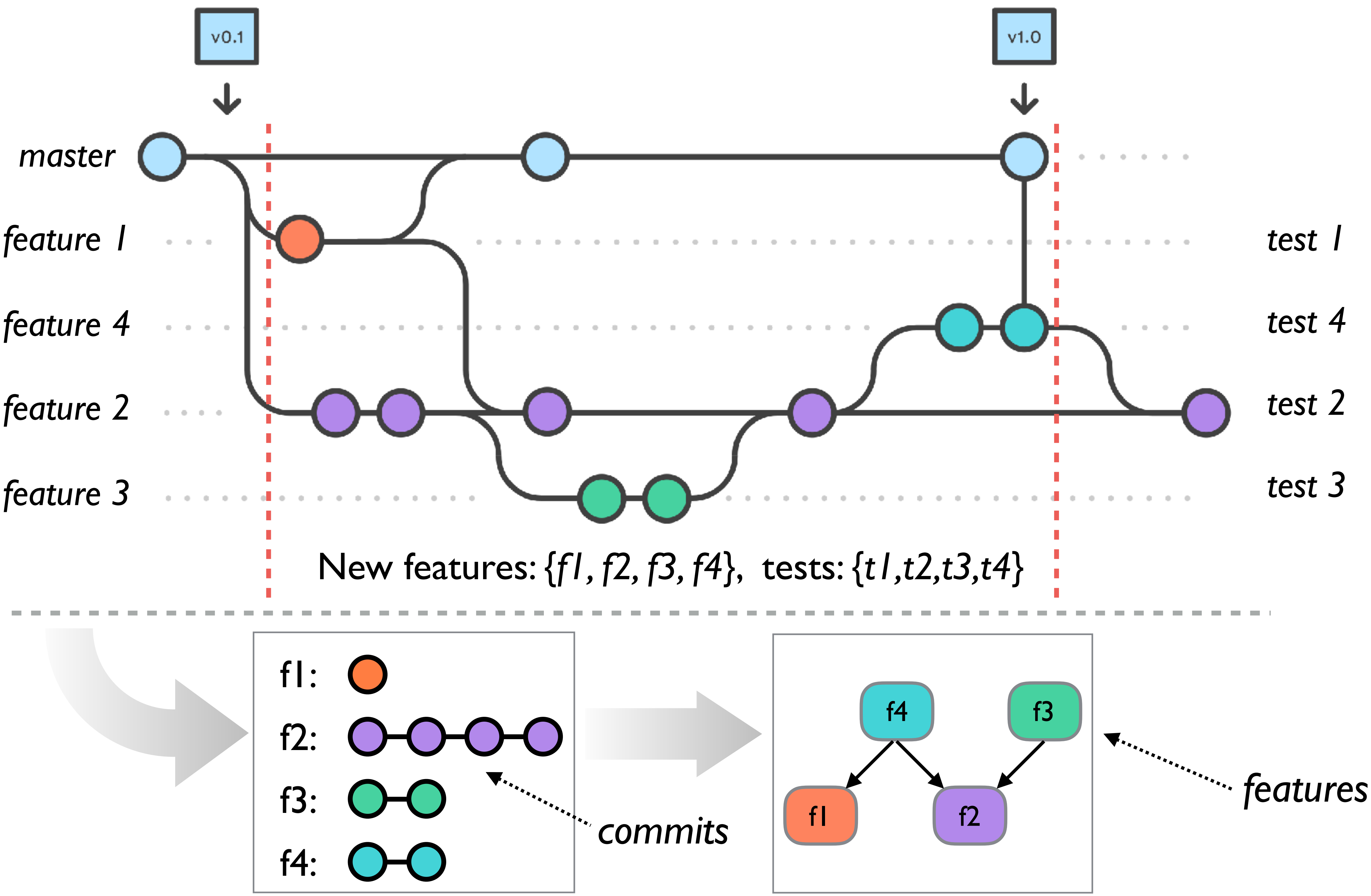

History-Based vs. Intersection-Based

History-based dynamic feature location

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- More flexible:
  1. Implicit feature labeling: release notes
  2. Traceability of evolution information
  3. Effective even with limited numbers of variants

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- More accurate:
  4. Captures runtime dependencies
  5. Focused search space: only considering changes within a history range
  6. Generates Light-weight feature models

Outline

1. Introduction
2. Background
   - *Semantics-Preserving History Slice*
   - *Semantic History Slicing*
3. FHistorian
   - *FLocate: identifying feature implementations in histories*
   - *FHGraph: inferring feature relationships*
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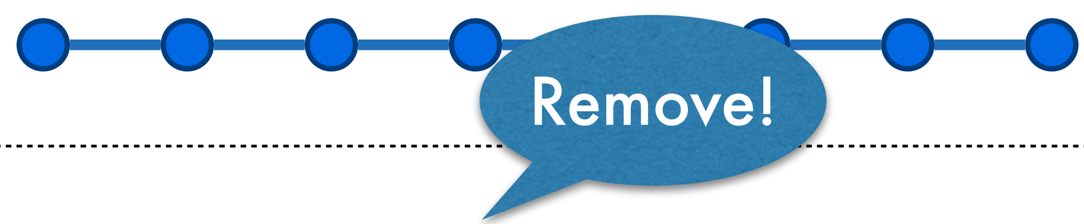
5. Conclusion & Future Work

Semantics-Preserving History Slice

(H)istory	(T)ests	H ⊨ T
	T_1, T_2	✓

Semantics-Preserving History Slice

(H)istory	(T)ests	$H \models T$
	T_1, T_2	✓
	T_1, T_2	✗

Semantics-Preserving History Slice

(H)istory	(T)ests	H ⊨ T
	T_1, T_2	✓
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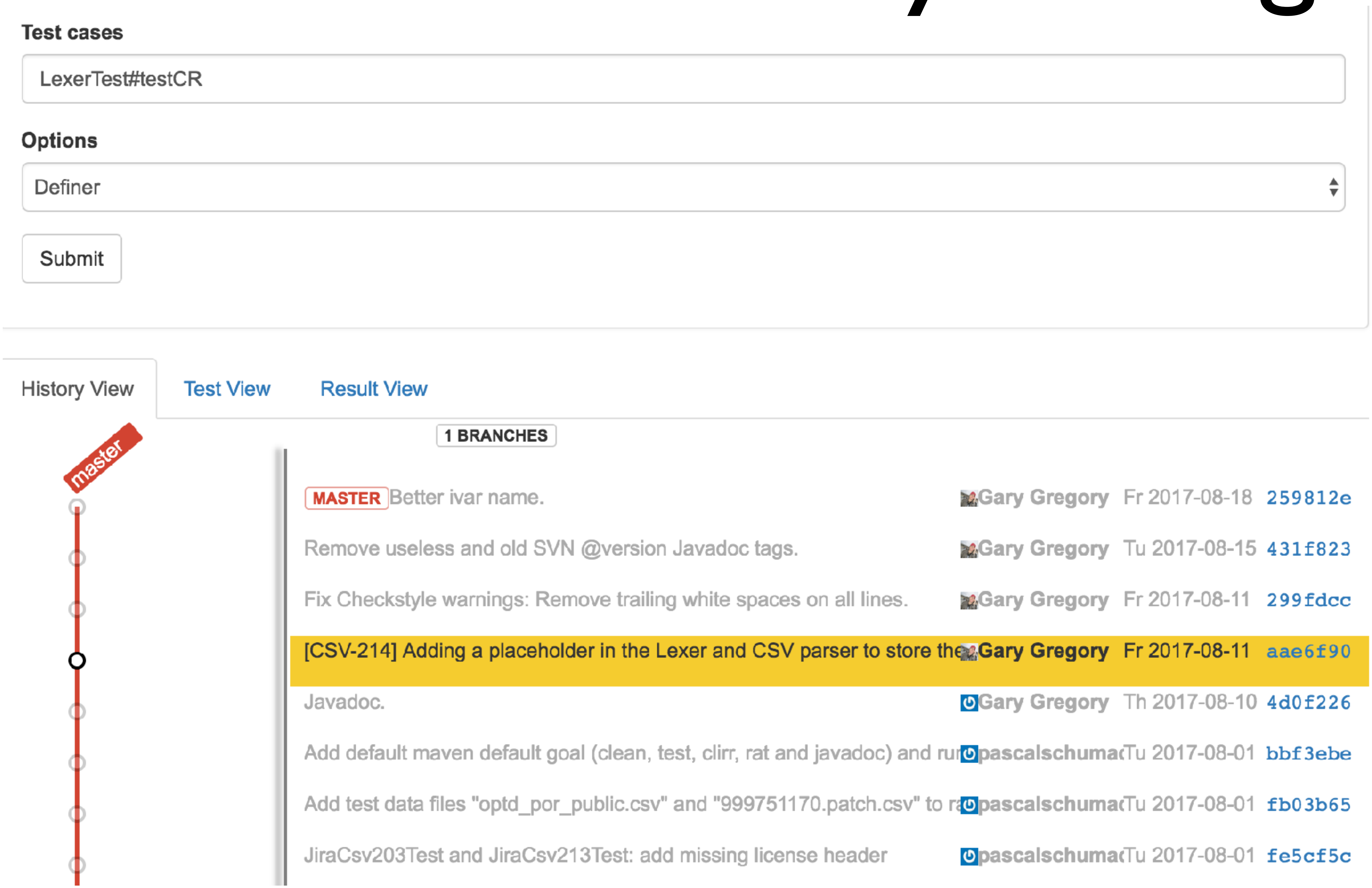
Minimal semantics-preserving slice = feature implementing changes?

Semantic History Slicing



http://www.cs.toronto.edu/~liyi/cslicer [ASE'16]

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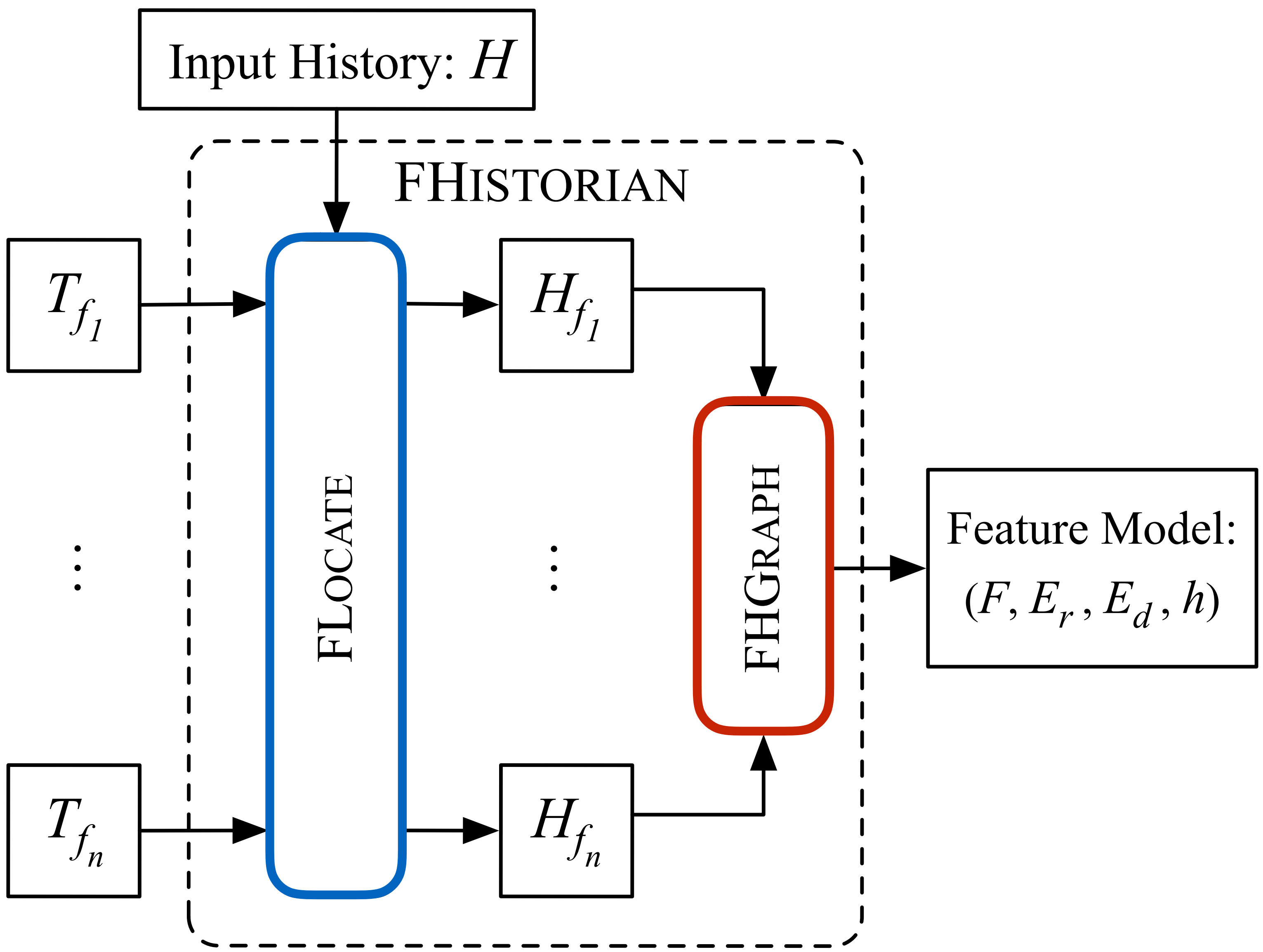
FHistorian = FLocate + FHGraph



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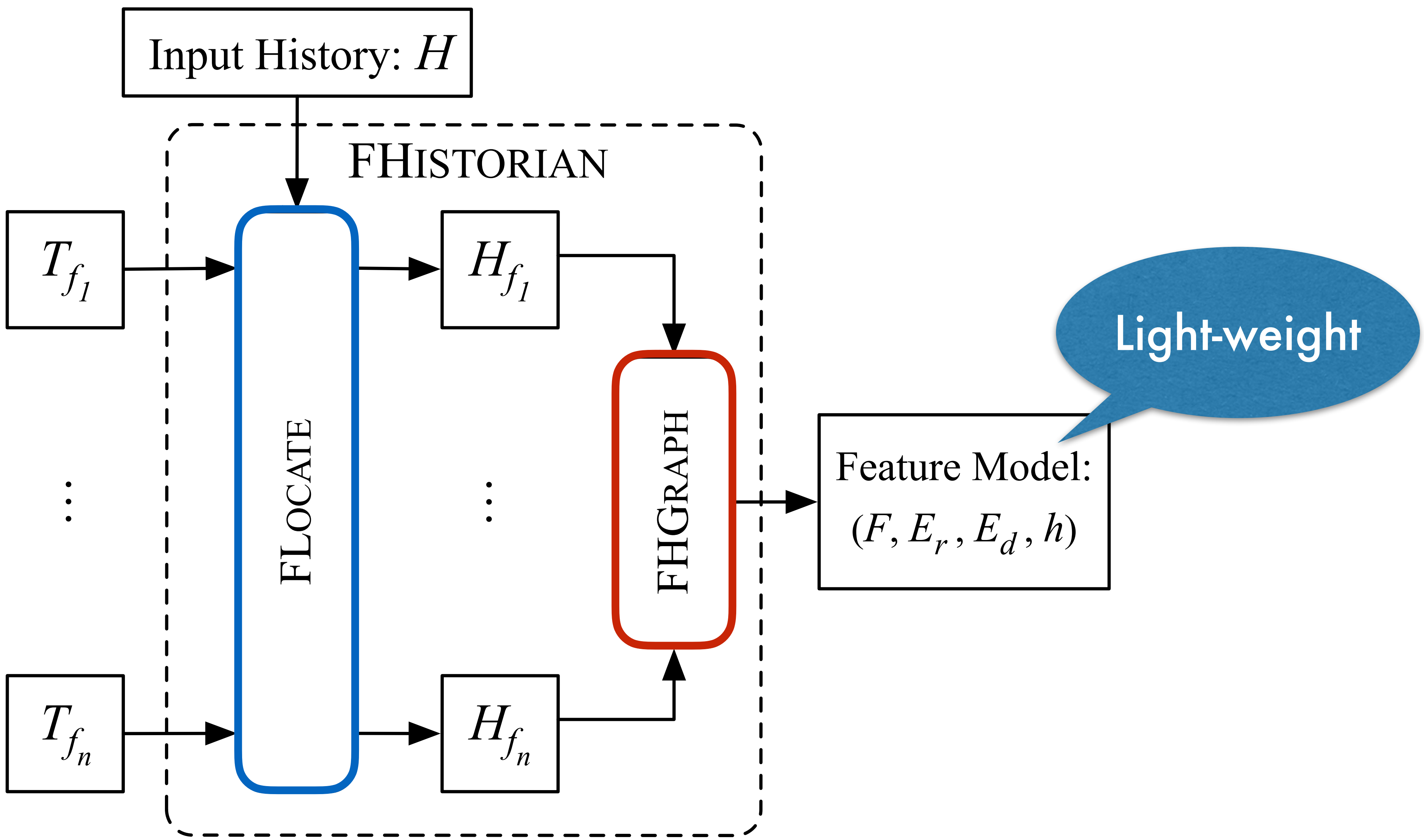

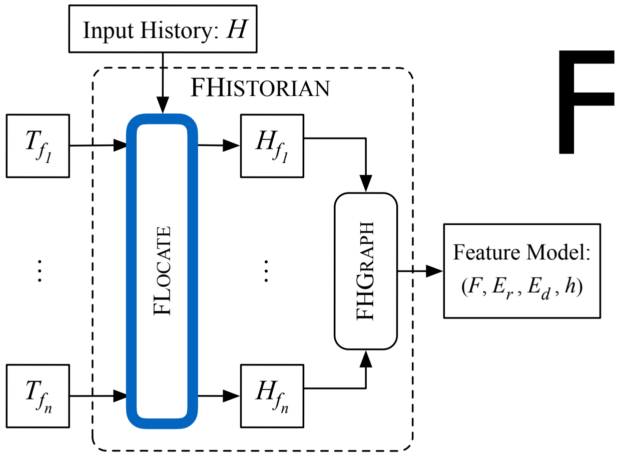

FLocate: Locating Feature Implementations

Based on Definer [ASE'16]

- Foreach feature *f*, find a *minimal* slice: H_f s.t. $H_f \vDash T_f$
- Factoring out other features: $f = H_f \setminus H_{f'}$ *for all other f'*
- Hunk minimization (details in paper…)

```
δ1 | i:int f1(){return 1;}
   | ...
δ2 | j:int f2(){return f1()+1;}
   | ...
δ3 | k:int f3(){return f1()-1;}
T_f1 : f1()==1, T_f2 : f2()==2, T_f3 : f3()==0
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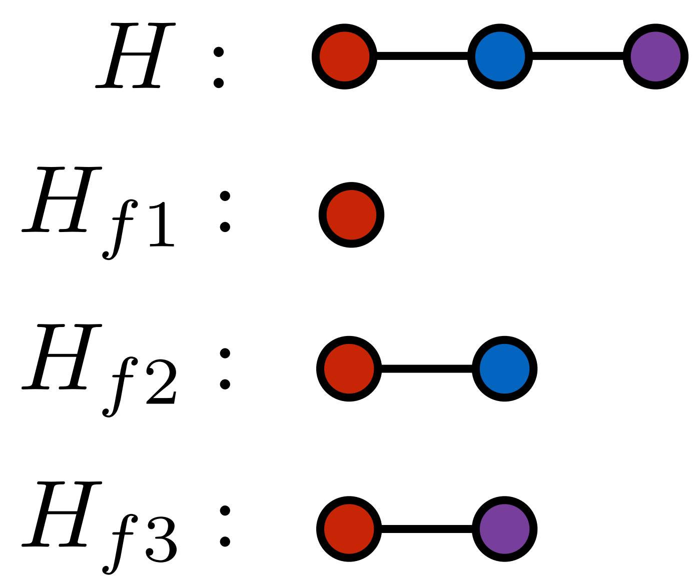

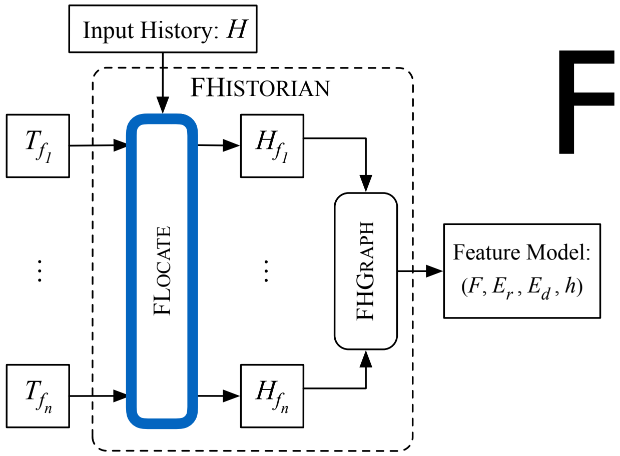

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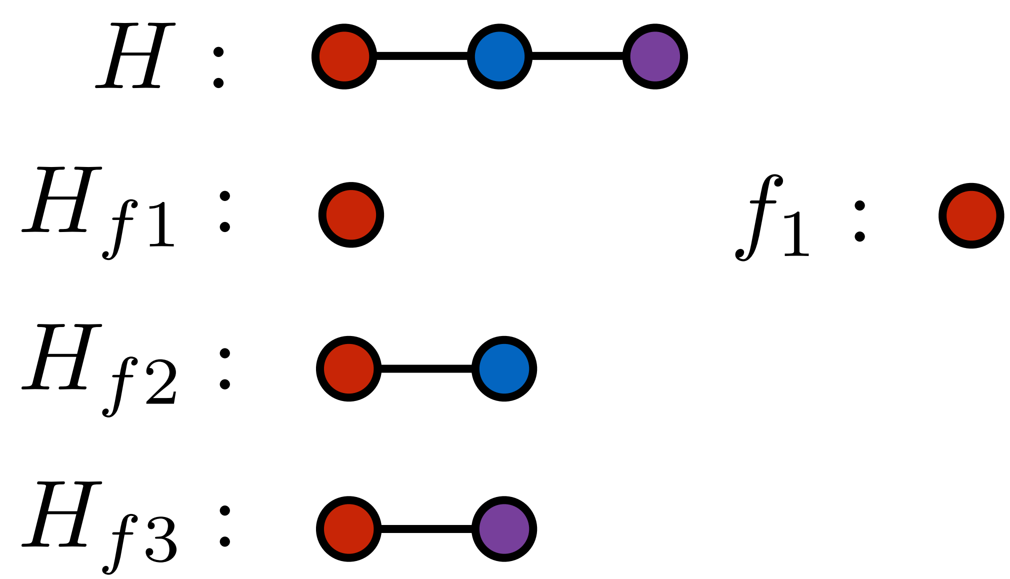

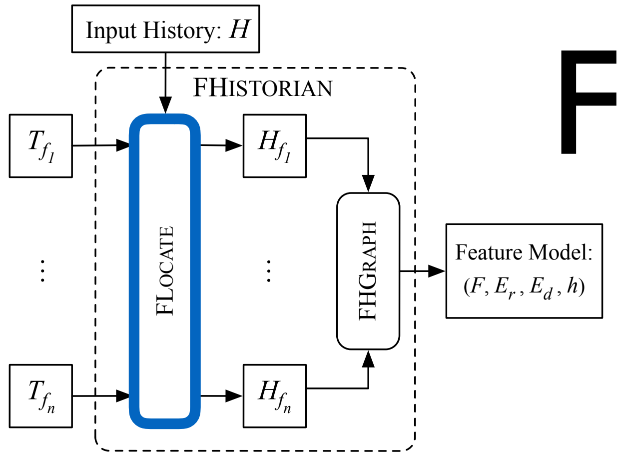

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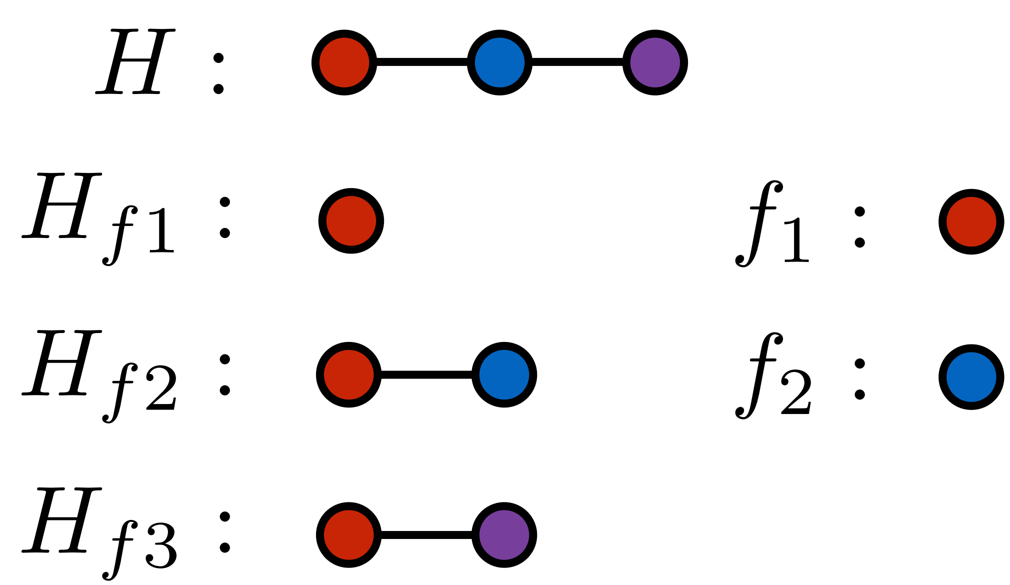

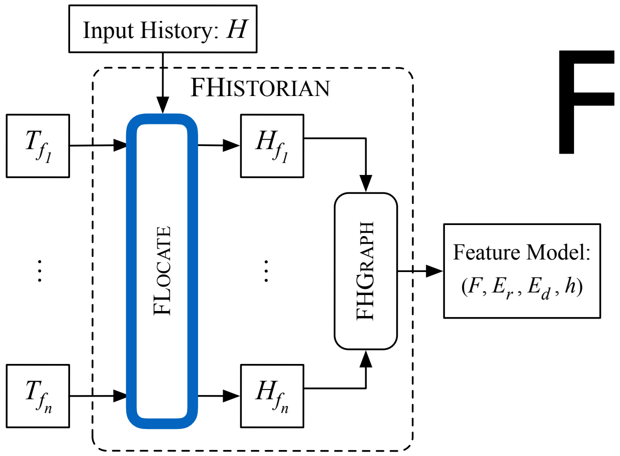

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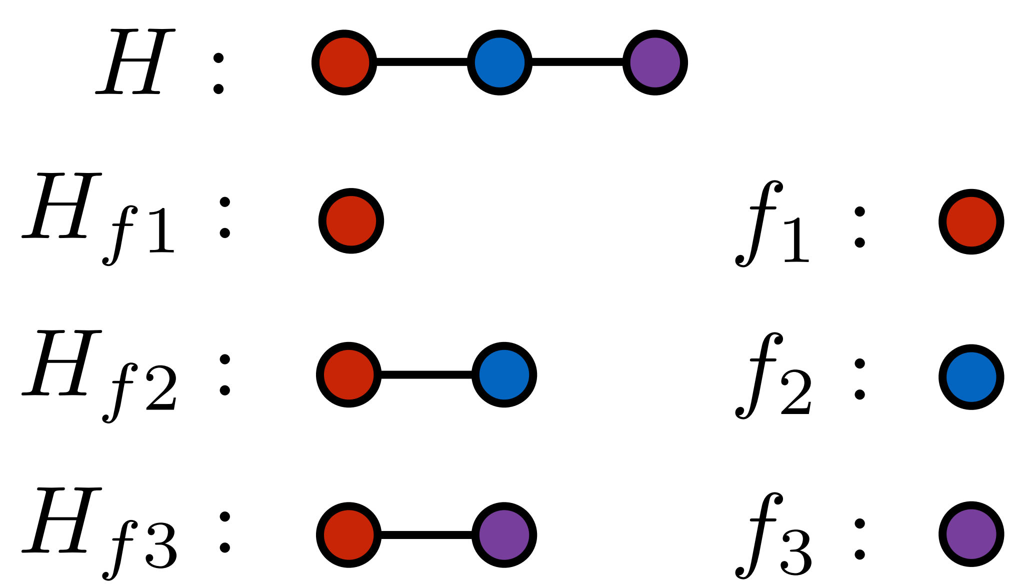
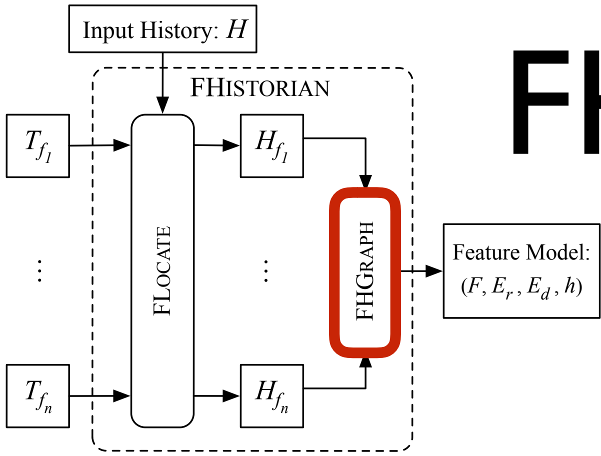




FHGraph: Inferring Feature Relationships

Light-weight feature model:

Depends-on

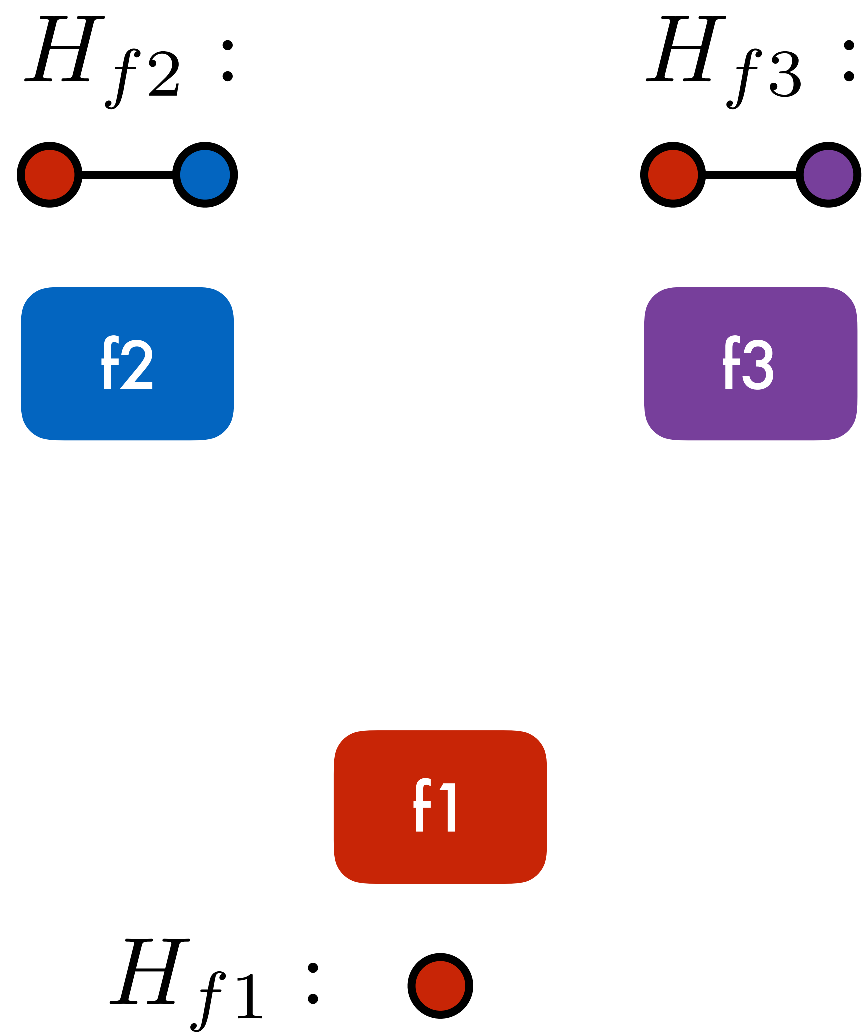
$$(f_2 \rightarrow f_1) \Leftrightarrow (H_{f_1} \subseteq H_{f_2})$$

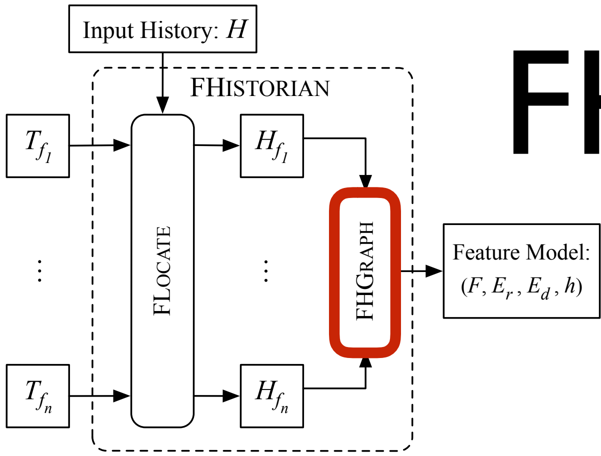
Reflecting runtime dependencies

Relates-to

$$(f_2 \leftrightarrow f_1) \Leftrightarrow (H_{f_1} \cap H_{f_2} \neq \emptyset)$$

Revealing underlying connections





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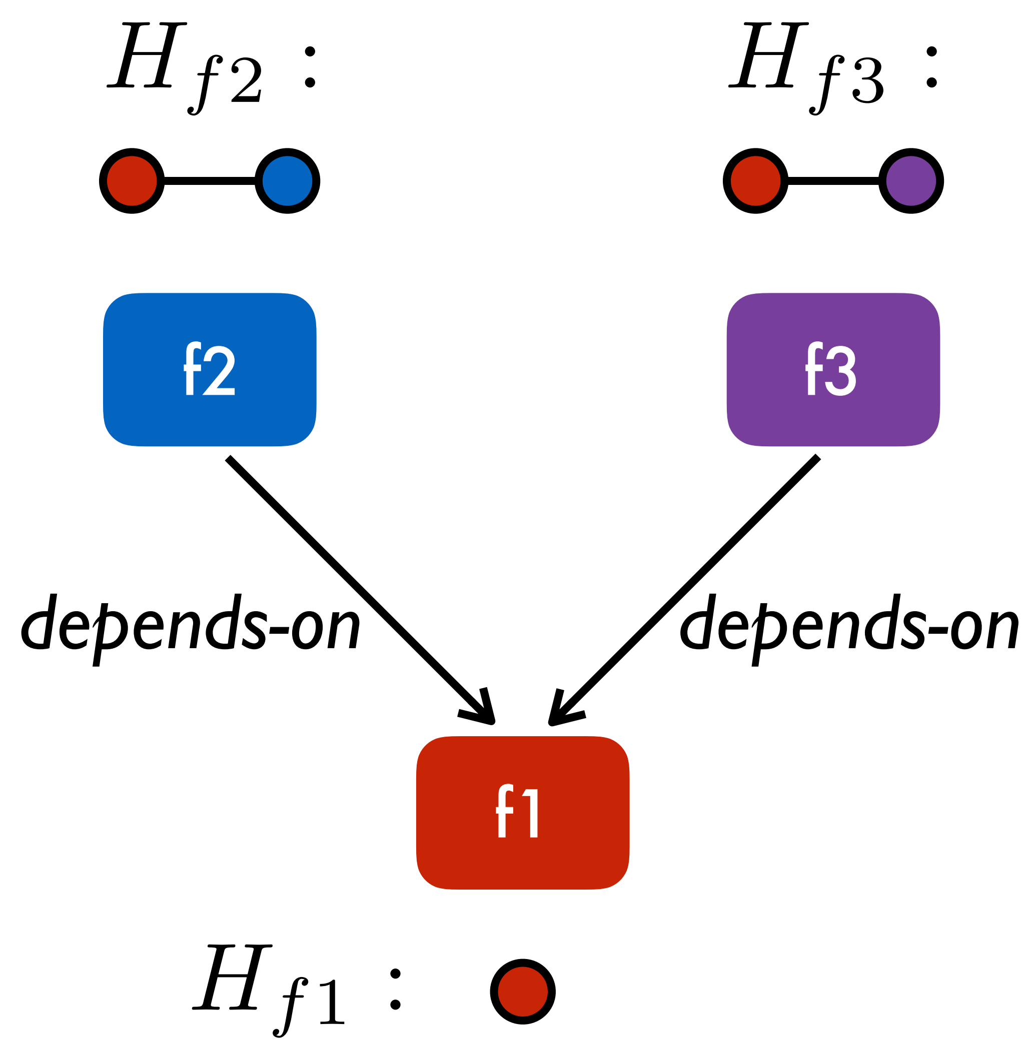

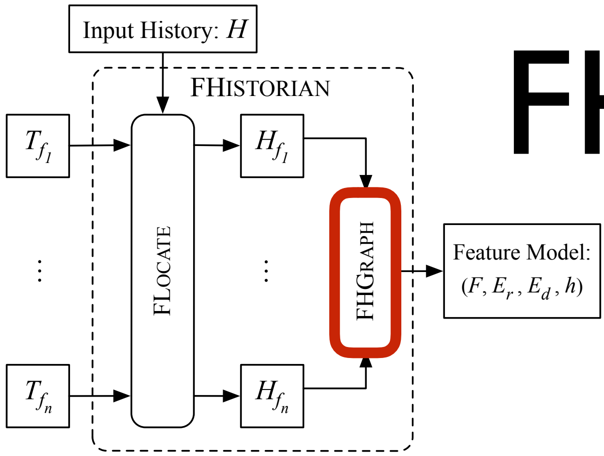

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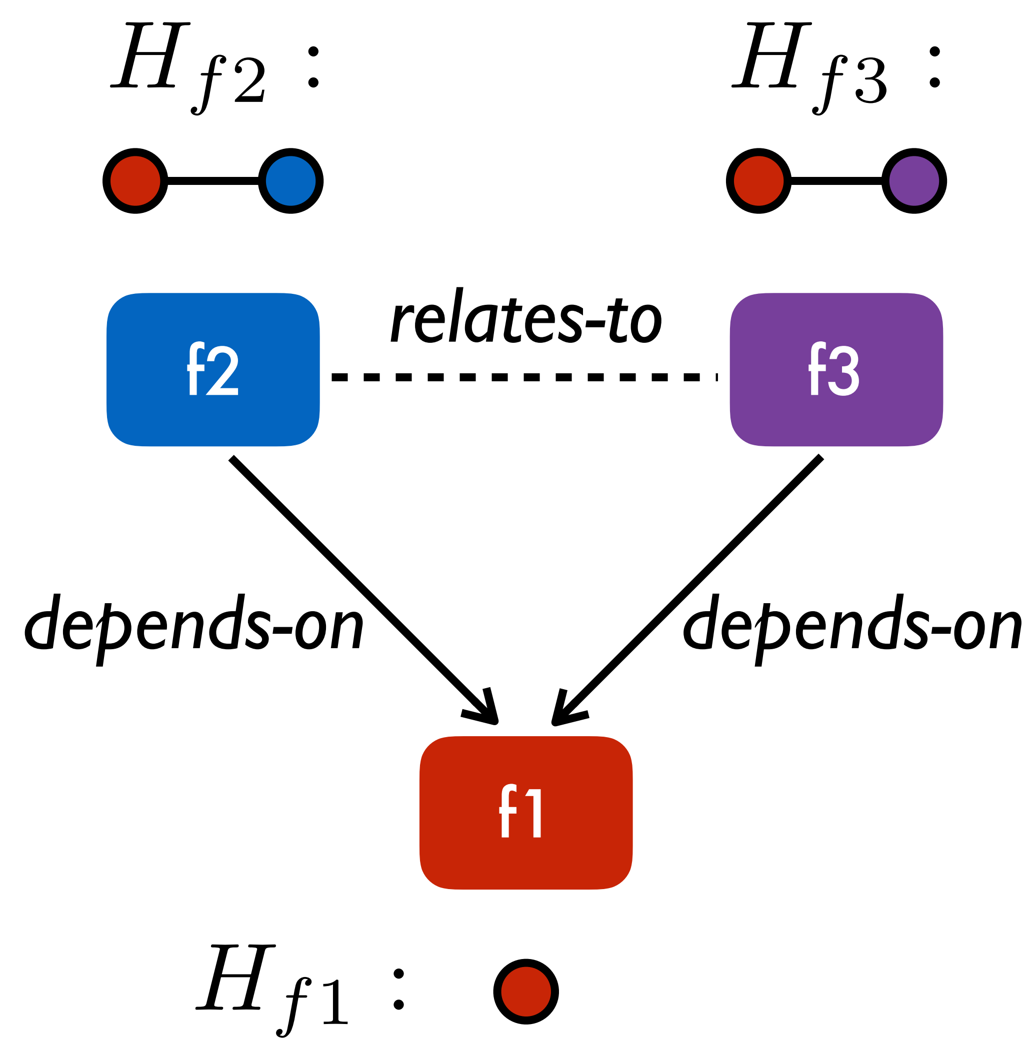

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Evaluation

FHistorian:

- Implementation: [*bitbucket.org/liyistc/gitslice*](bitbucket.org/liyistc/gitslice)
- Data set [MSR'17]: [*github.com/Chenguang-Zhu/DoSC*](github.com/Chenguang-Zhu/DoSC)

Research questions:

- *How accurate are the feature location results?*
- *Are the inferred feature relationships useful?*

Evaluation Subjects

Preparing subjects:

- Take a release history (ideally with JIRA issue tracking)
- Go through each feature (64)
- Identify feature tests (36)

Project & Release	Features	
	#New	#Tested
`commons-csv v1.3`	7	4
`commons-compress v1.13`	7	6
`commons-io v1.4`	18	9
`commons-io v2.2`	15	7
`commons-lang v3.4`	17	10

release notes

New Feature $\{f_1, f_2, \ldots, f_n\}$

- [MATH-814] - Kendalls Tau Implementation
- [MATH-851] - Add convolution
- [MATH-968] - Pareto distribution is missing
- [MATH-977] - Add Halton sequence generator
- [MATH-978] - StorelessCovariance to be map/reducable
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features

Commons Math / MATH-814

Kendalls Tau Implementation f_1

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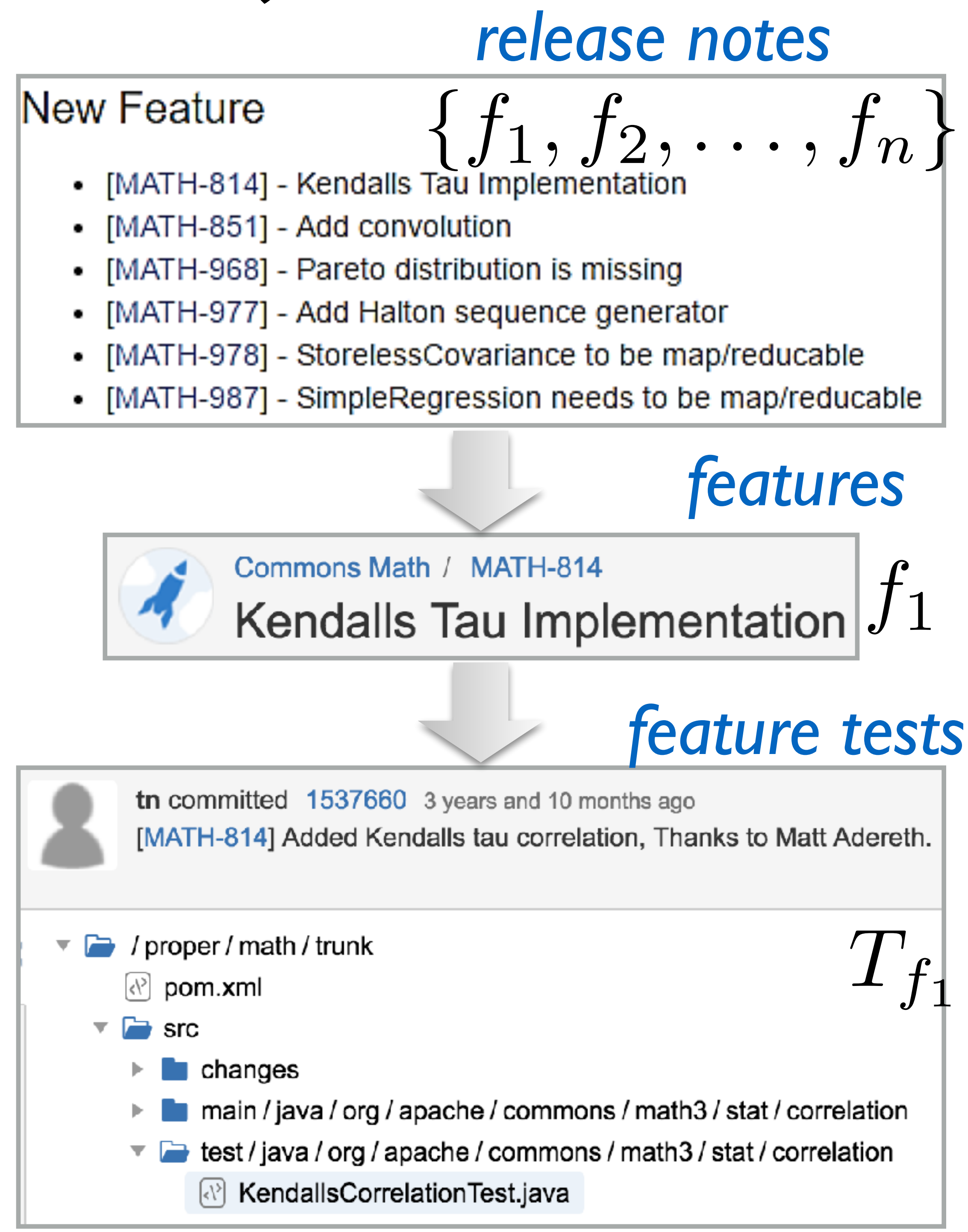

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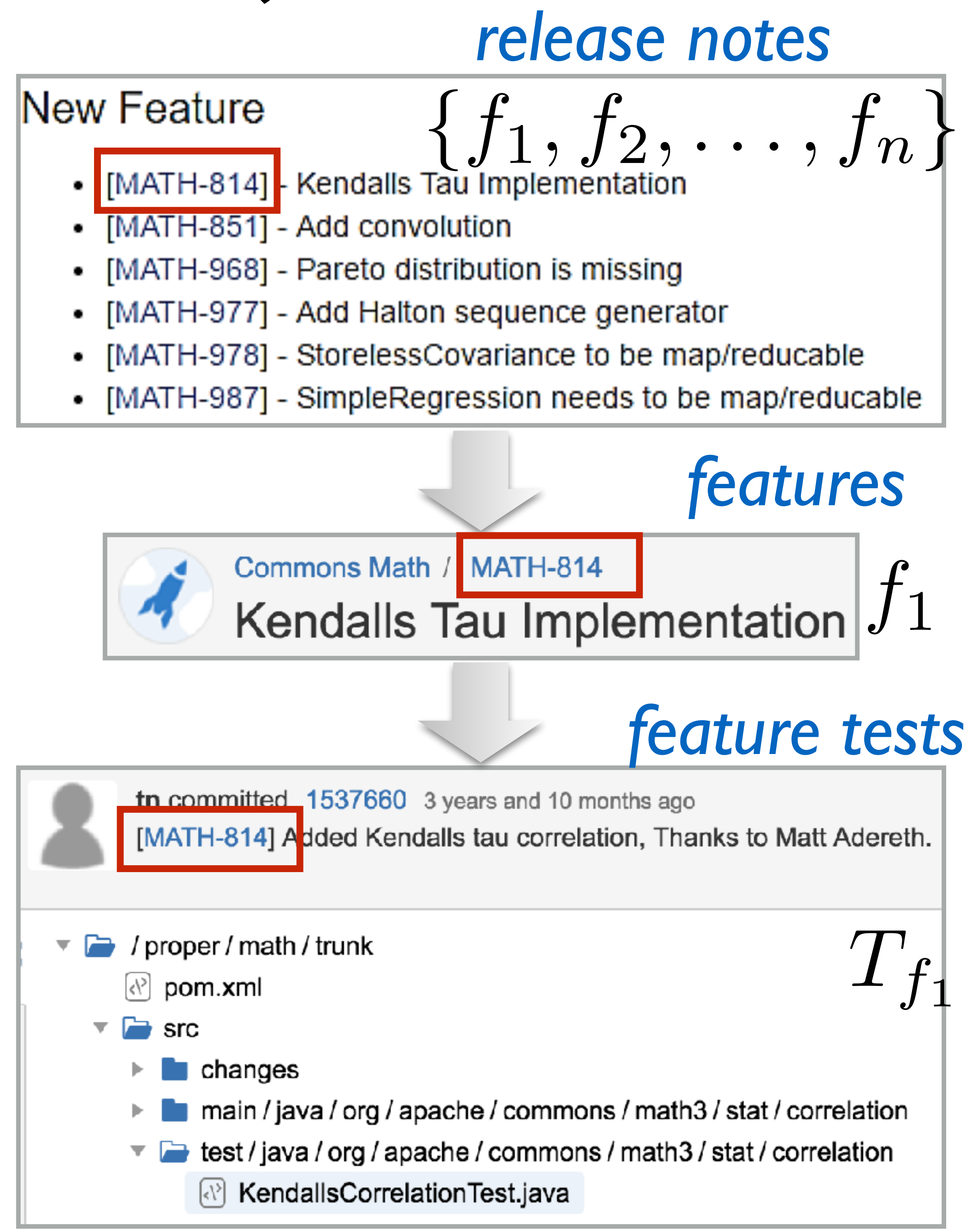

Results

Comparing with developer annotations:

- *Ground truth*: extracted from change logs and release notes (not always perfect)
- Perfect match on 15/36 features
- Finding more changes, occasionally missing changes

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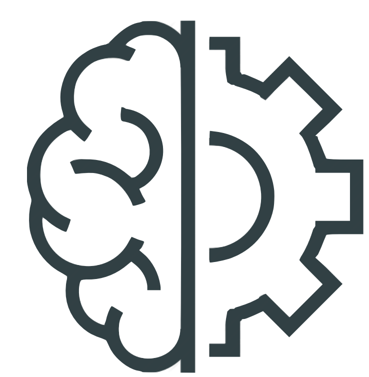
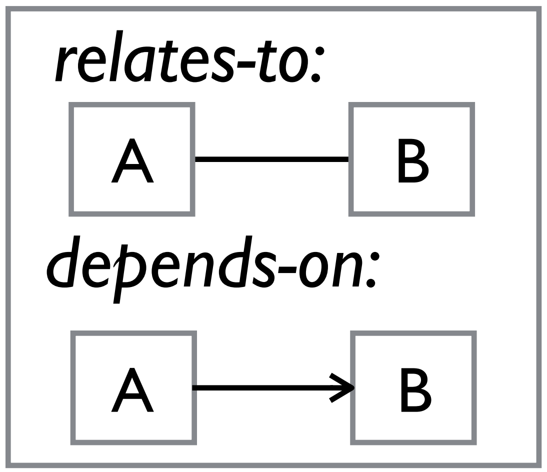
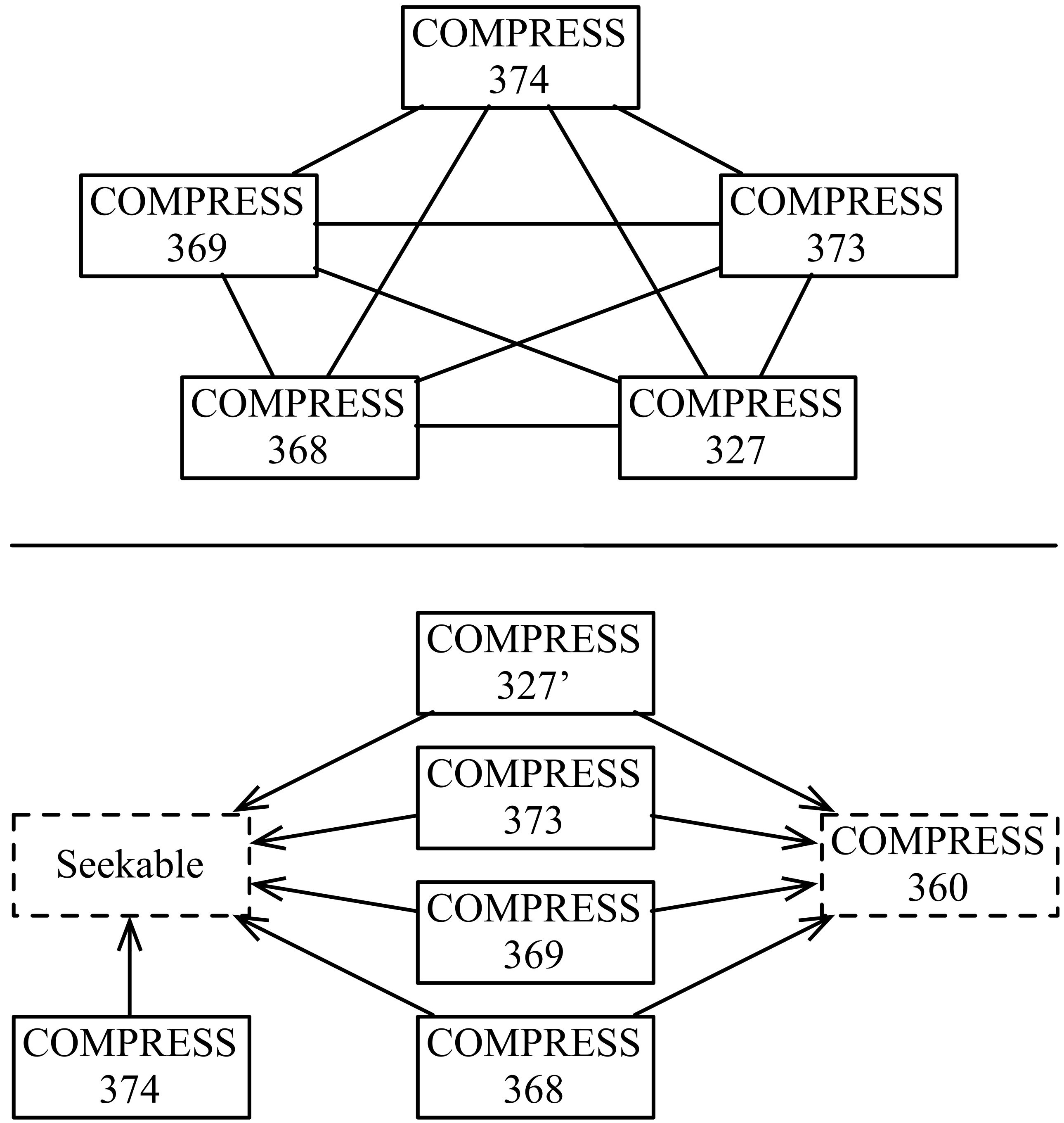
Reasons for the differences:

- *Conceptual* vs. *operational*
- Missing minor optimizations: not affecting tests
- Discovering *hidden dependencies*

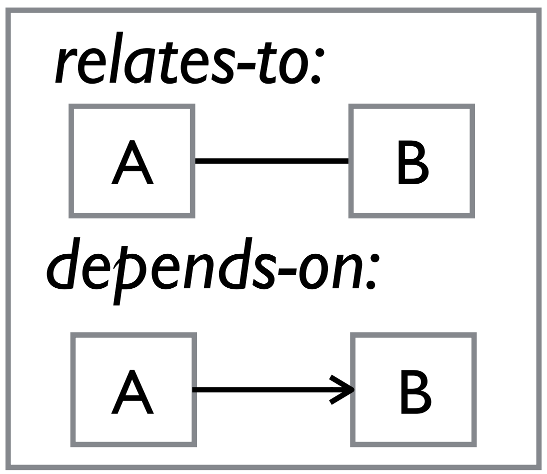


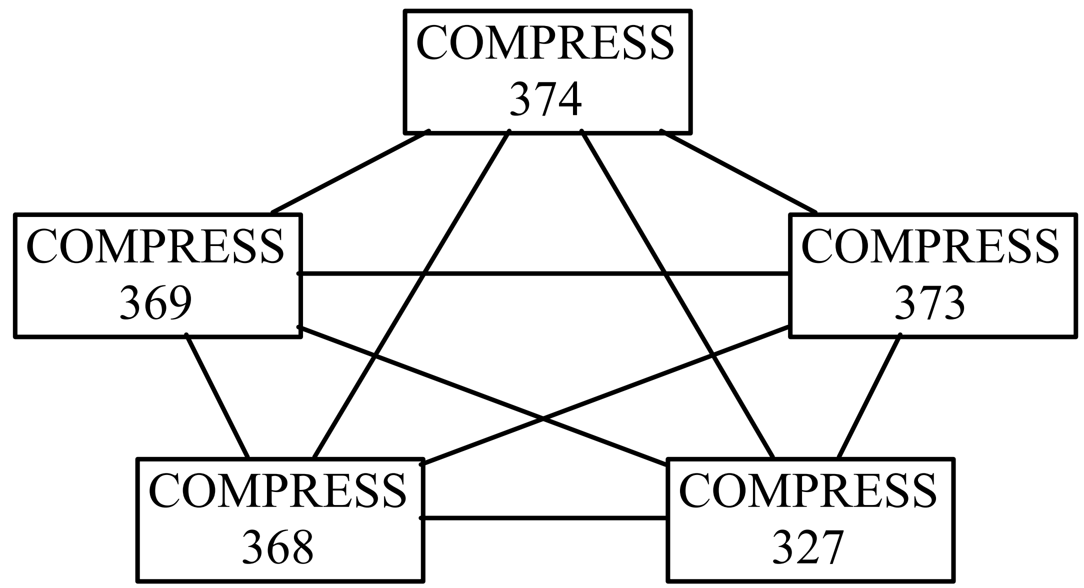
Results: Feature Relationships

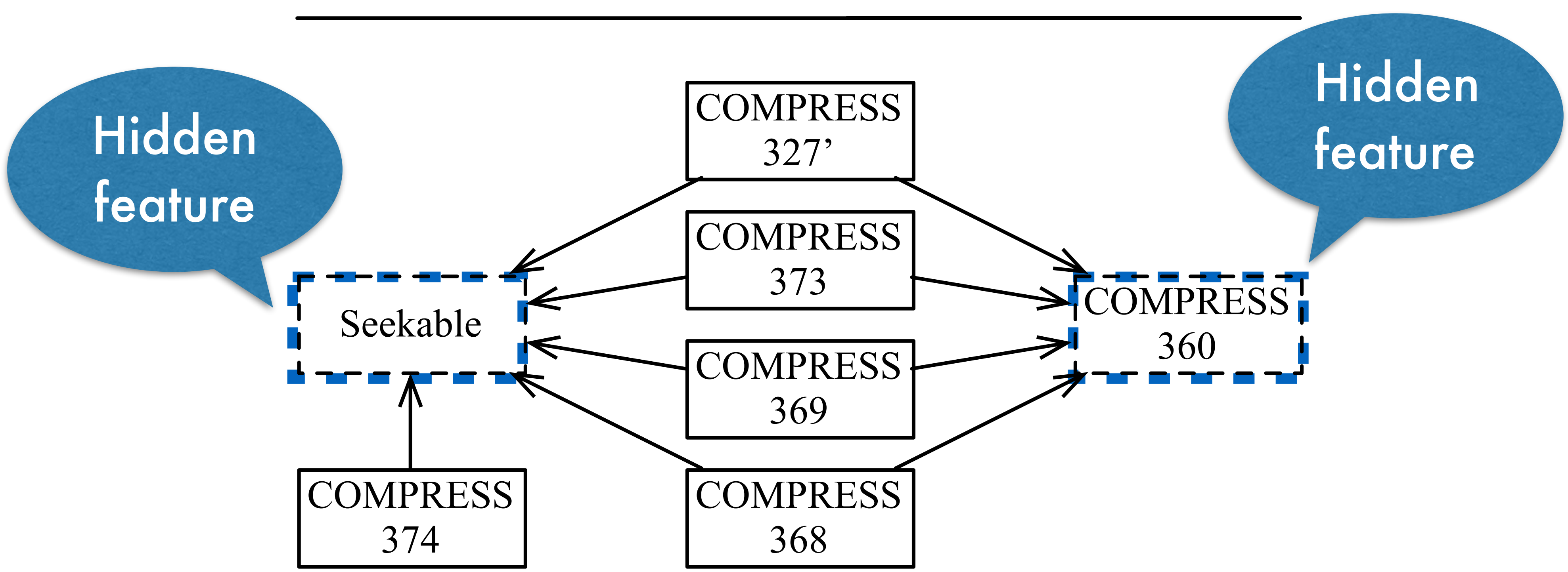




Results: Feature Relationships







Conclusion & Future Work

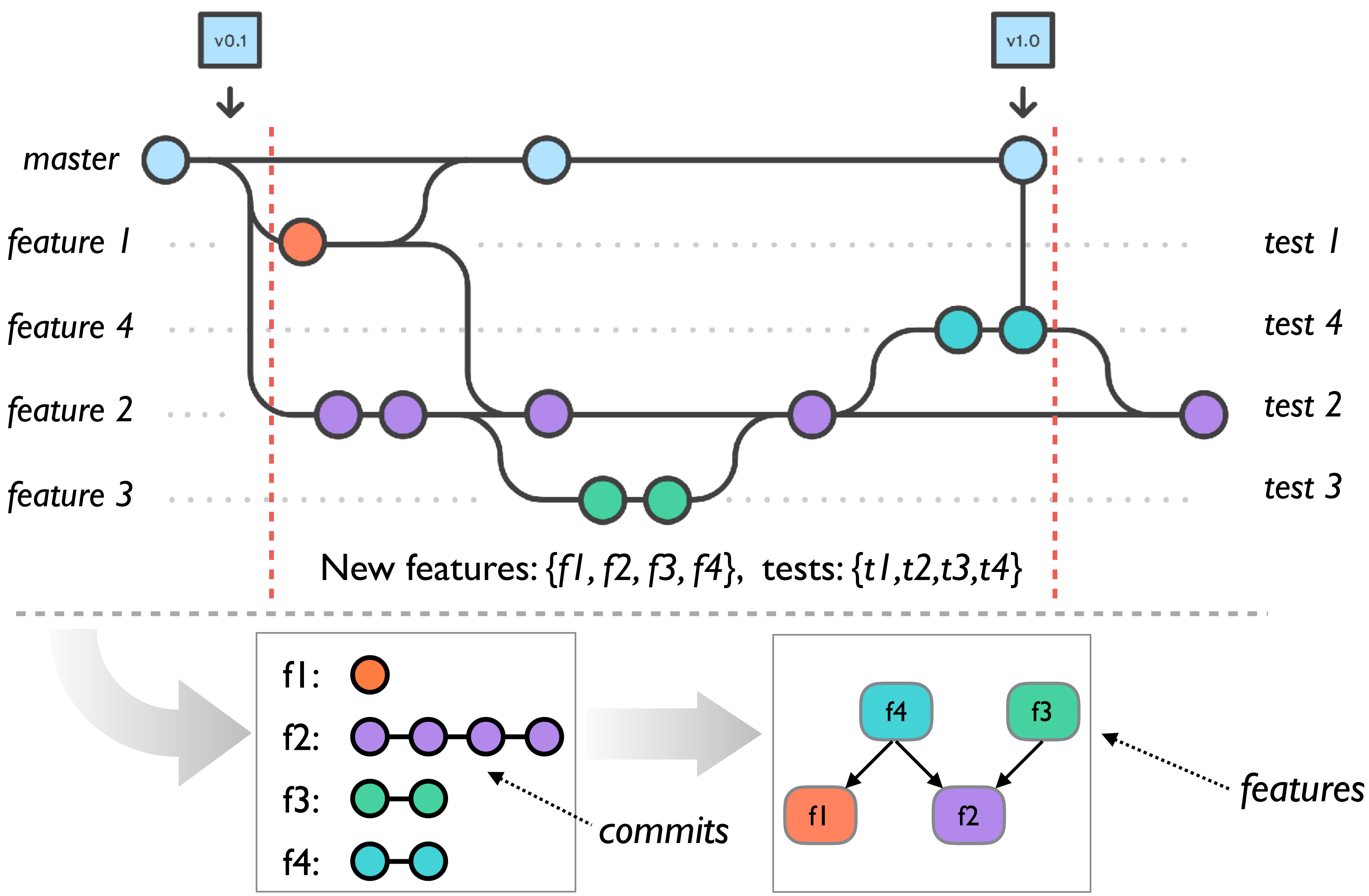
FHistorian: History-based feature location

- More *flexible* and more *accurate*
- Exploiting version control data
- Identifying feature implementations dynamically
- Inferring light-weight feature models

What's next?

- Extracting feature meta information automatically
- Generating richer feature models

Questions?



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