Verification Strategies for Feature-Oriented Software Product Lines

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Motivation

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- **Verification of feature-oriented SPLs**

Problem: Scalable Verification

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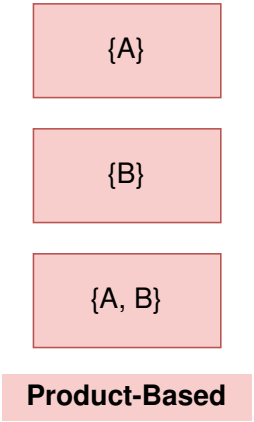

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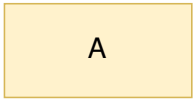
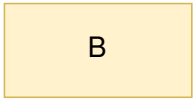
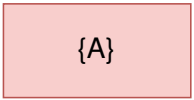
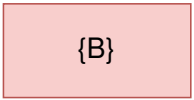
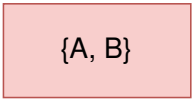




Feature-Based







Product-Based

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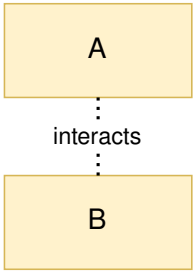

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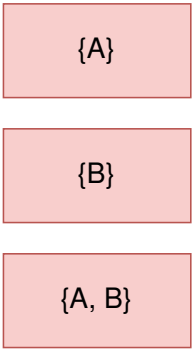

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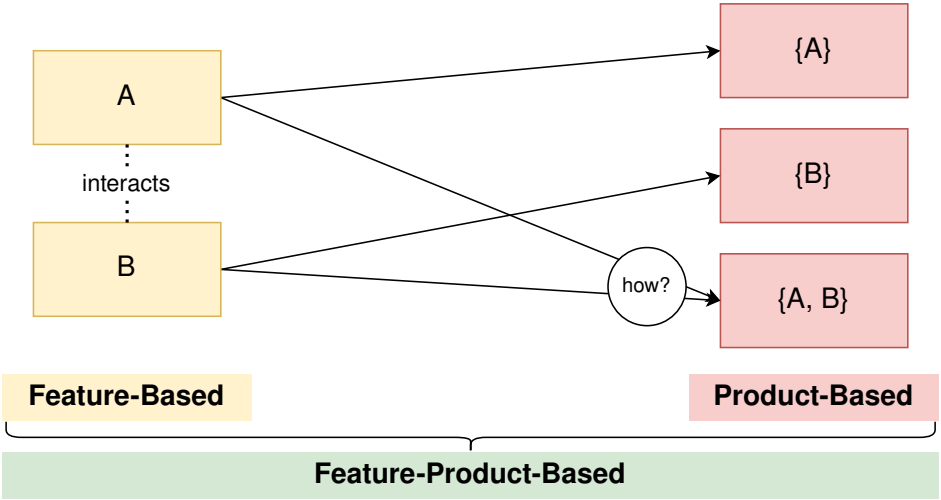

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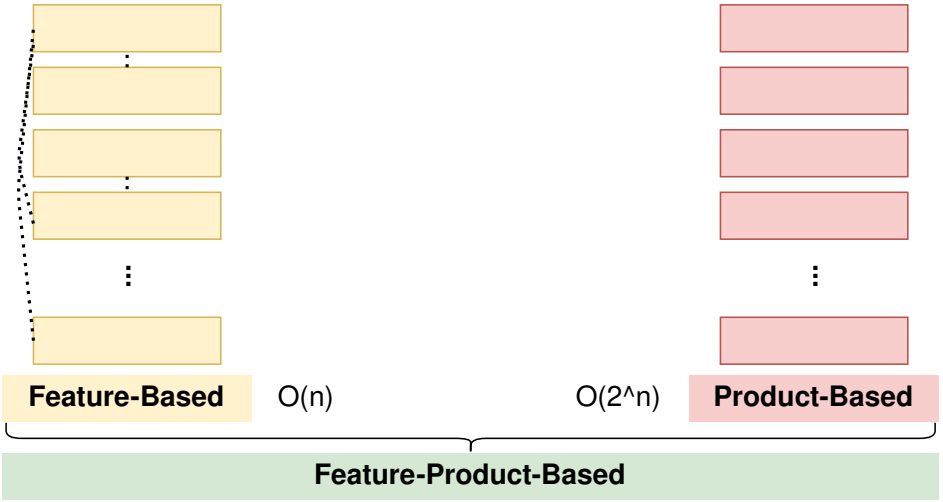

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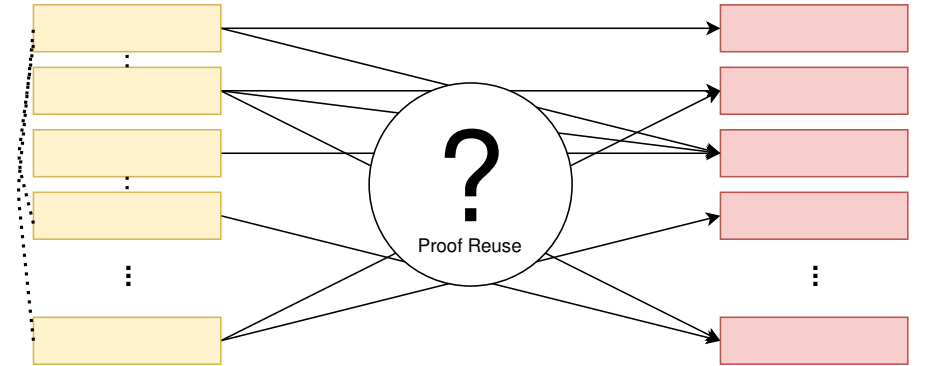

Two Opposing Solutions

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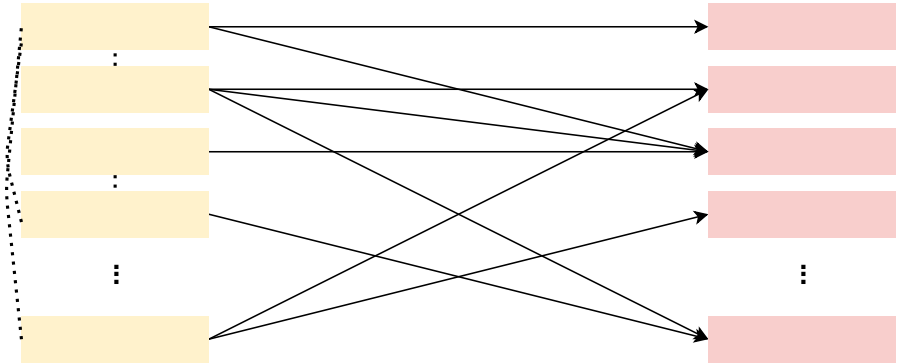

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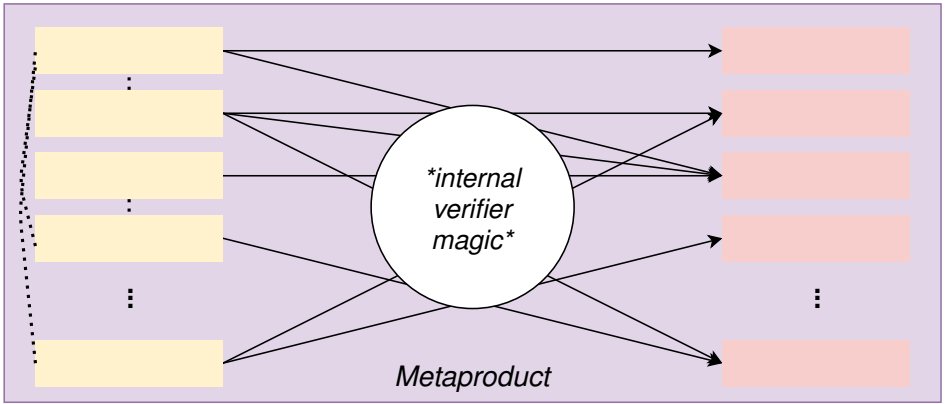
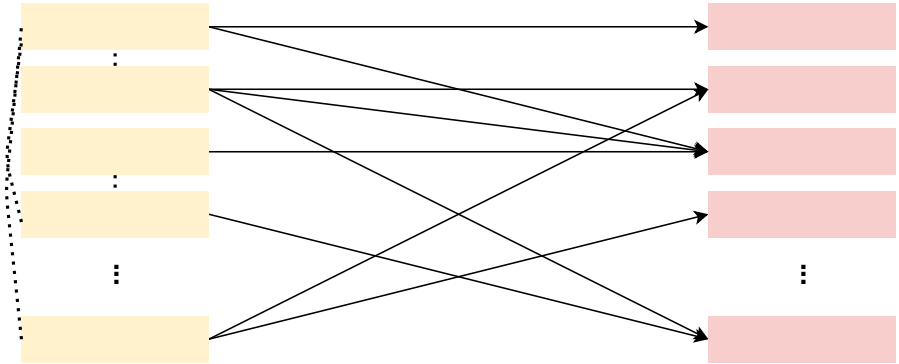


Family-Based

Two Opposing Solutions

Solution 2



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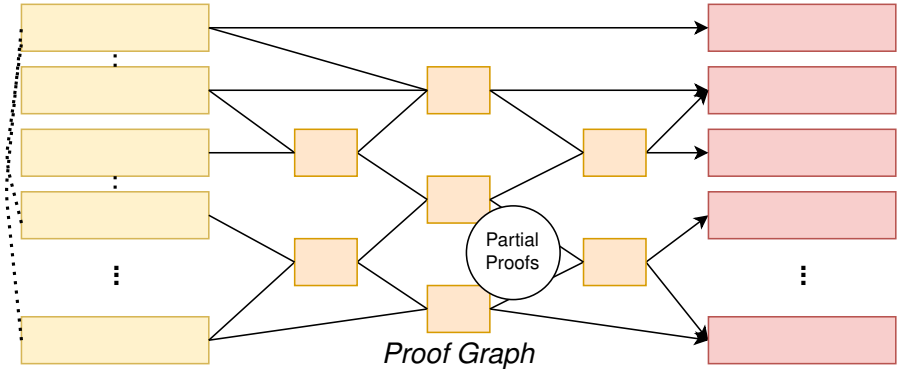

Feature-Family-Based

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- **Implement** proof plans in KeY
- **Evaluate** proof plans on a case study
- **Goals:**
  $\Longrightarrow$ Align proof reuse with software reuse by small, modular proofs
  $\Longrightarrow$ Position proof plans as manipulatable, first-class objects

Proof Reuse with Partial Proofs

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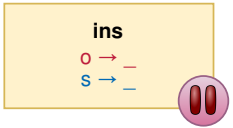

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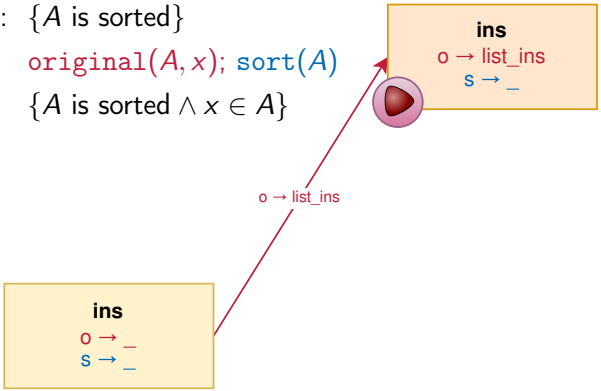

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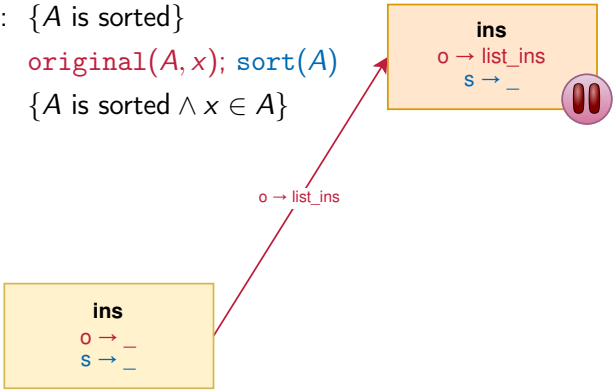

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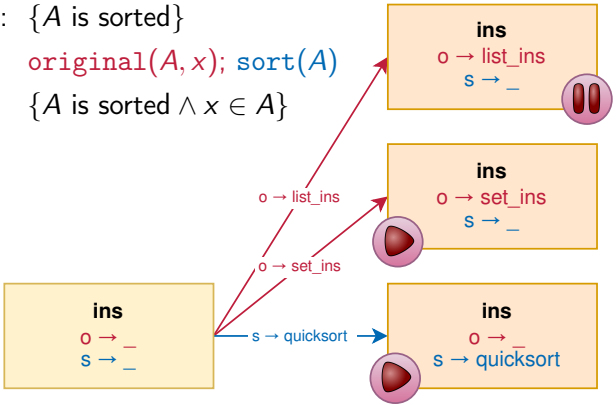

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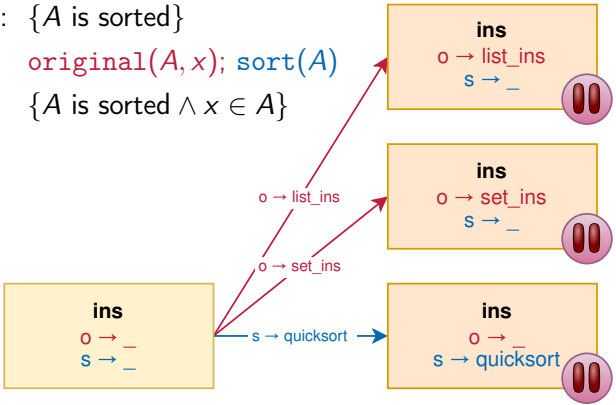

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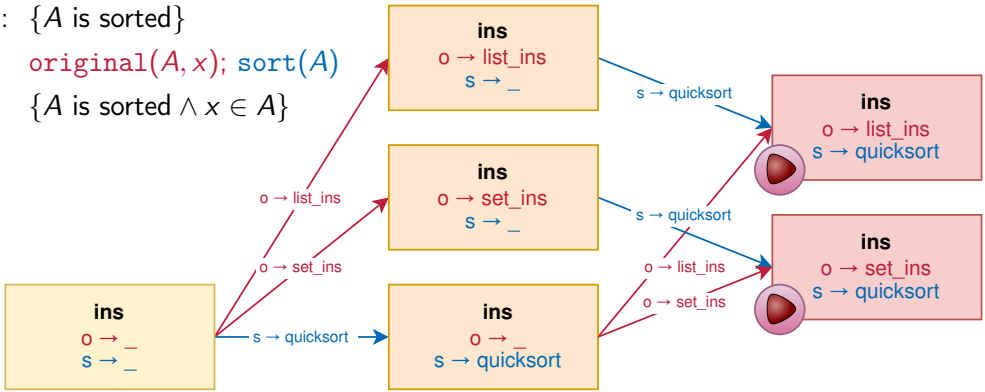

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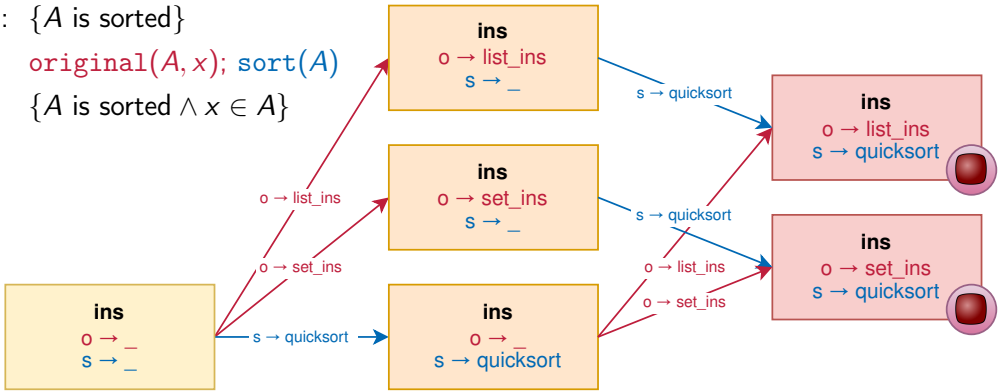

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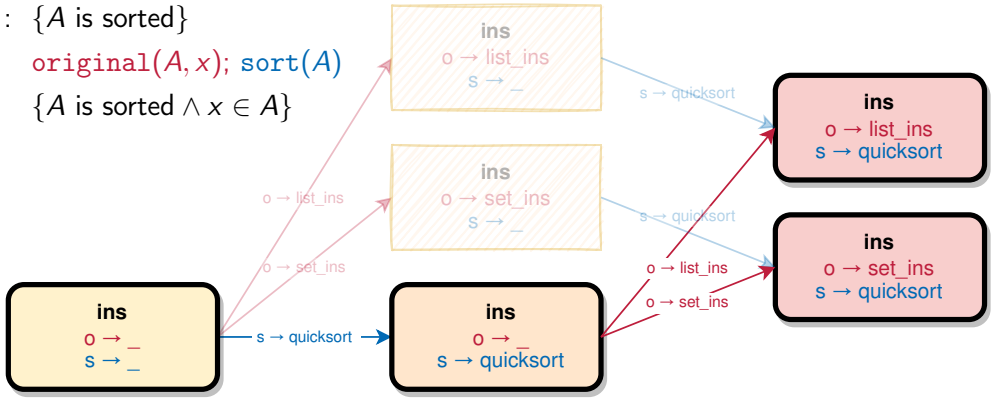

Proof Plan with Reuse

An SPL and its Proof Graph

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	List	Set	Ord
ins	●	○	○
find	●	×	○
sort	×	×	○

$\{List\}$

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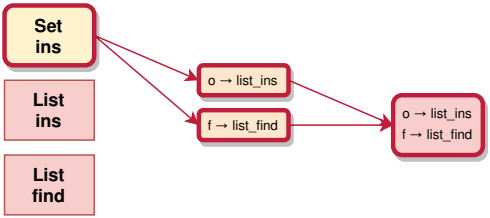

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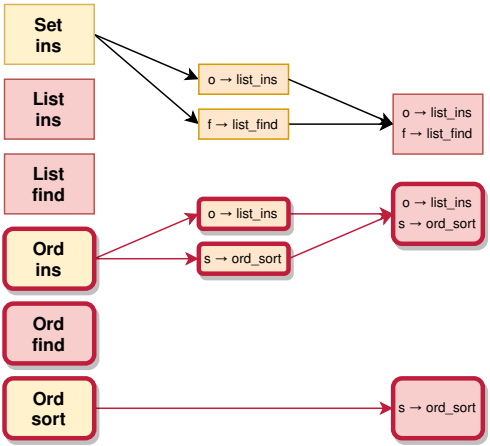

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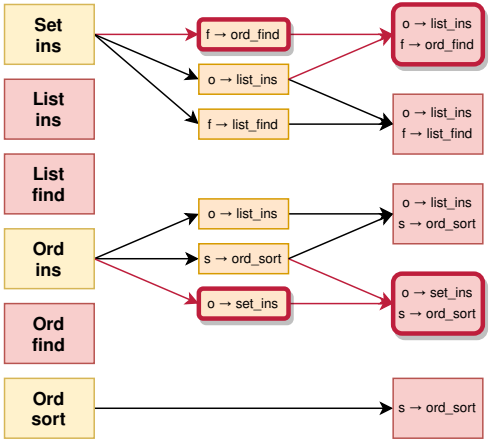

A Spectrum of Verification Strategies

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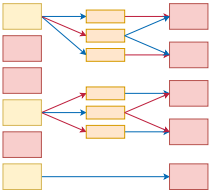

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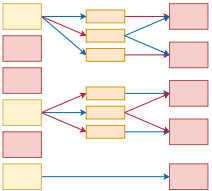

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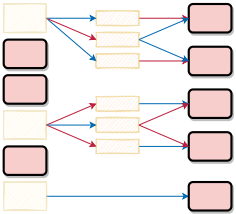

Product-Based

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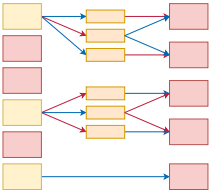

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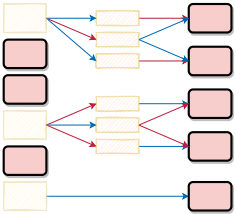

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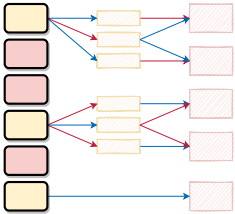

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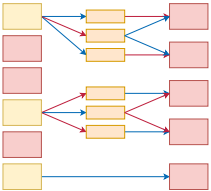

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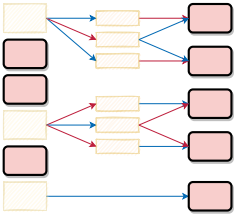

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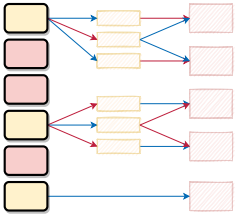

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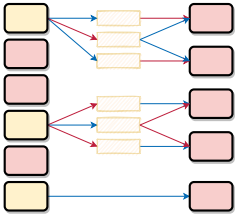

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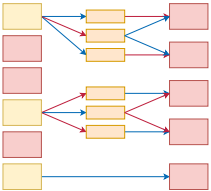

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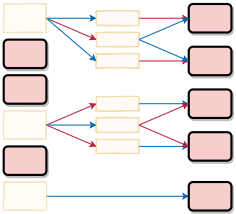

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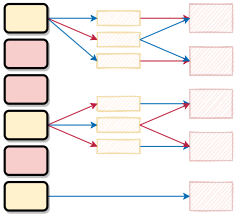

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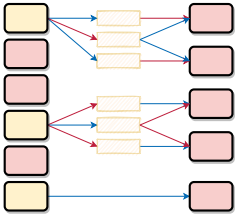

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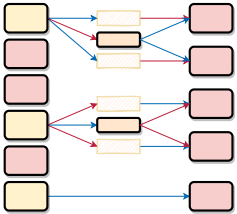

Feature-Family-Based*

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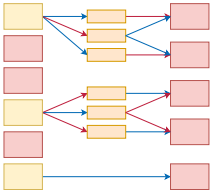
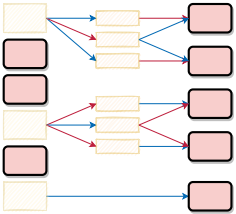


Proof Graph

* *How to choose well?*



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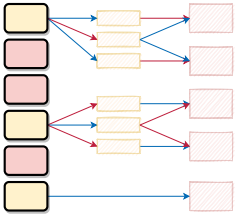
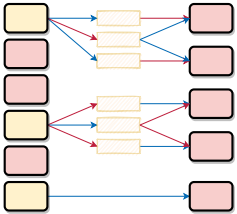
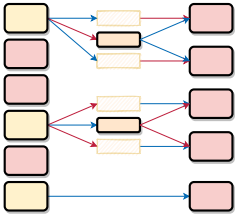


Feature-Based



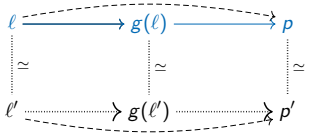
Feature-Product-Based



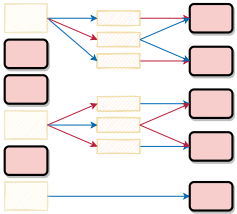
Feature-Family-Based*

A Spectrum of Verification Strategies

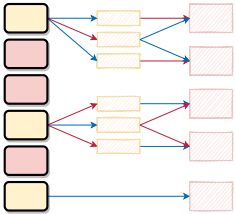
Applications



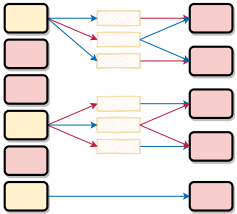
** How to choose well?*



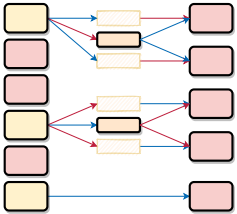
Product-Based



Feature-Based



Feature-Product-Based

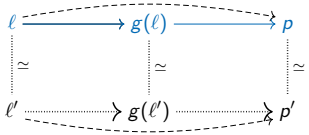


Feature-Family-Based*

A Spectrum of Verification Strategies

Applications

- Post-Hoc Verification



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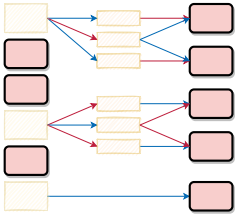
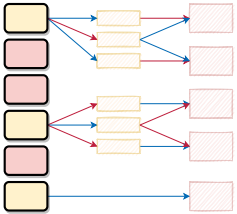
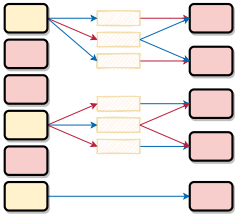


Product-Based



Feature-Based



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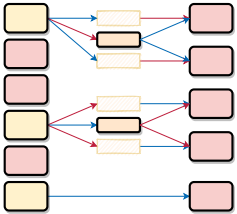
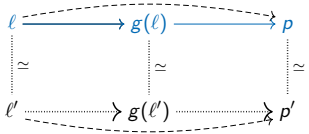


Feature-Family-Based*

A Spectrum of Verification Strategies

Applications

- Post-Hoc Verification
- Evolution Scenarios



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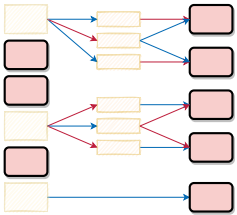
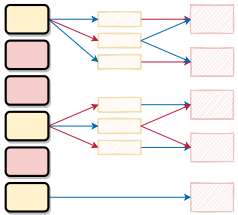
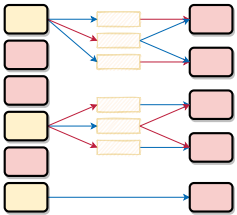


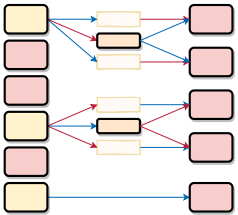
Product-Based



Feature-Based



Feature-Product-Based

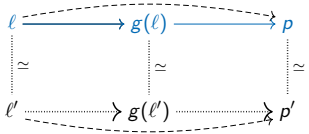


Feature-Family-Based*

A Spectrum of Verification Strategies

Applications

- Post-Hoc Verification
- Evolution Scenarios
- Lazy Exploration*



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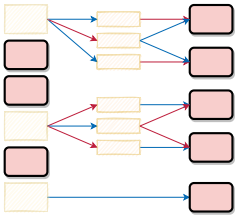

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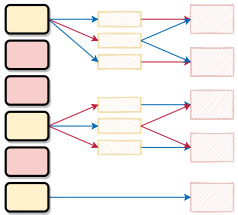

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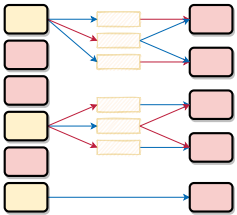

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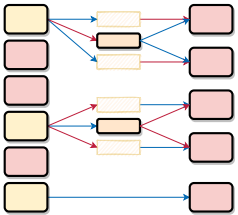

Feature-Family-Based*

Evaluation

[1] https://github.com/ekuiter/KeYPl

Evaluation

- **Subject**: *List* case study[1]
  $\Longrightarrow$ Java + JML + FeatureHouse, 5 features, 13 methods

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Verification strategy	*Time [s]*
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Product-Based (~~dup~~)	23.7
Feature-Family-Based	26.2
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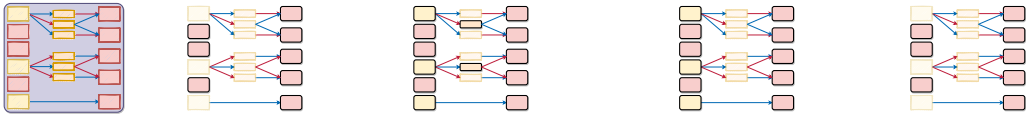

Family-Based > Product-Based (~~dup~~) > Feature-Family-Based > Feature-Product-Based ≫ Product-Based (dup)

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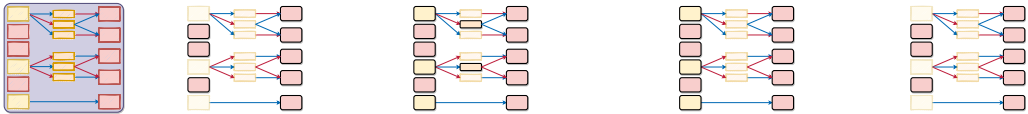

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Threats to Validity?

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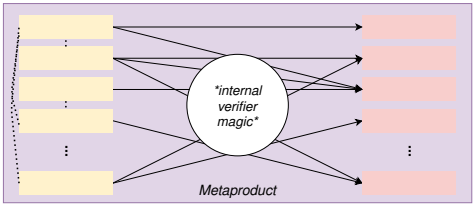
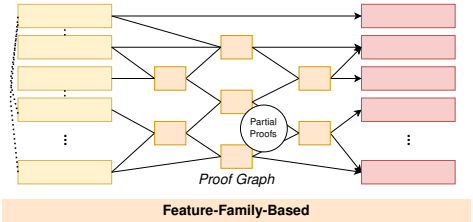
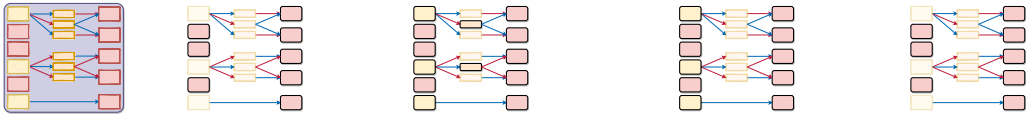
Conclusion







Family-Based > Product-Based > Feature-Family-Based > Feature-Product-Based ≫ Product-Based

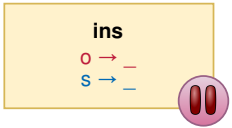
(~~dup~~) (dup)

Abstract Model Methods

$\texttt{ins}(A, x)$: $\{A \text{ is sorted}\}$

$\texttt{original}(A, x); \texttt{sort}(A)$

$\{A \text{ is sorted} \wedge x \in A\}$




```
/*@ requires sorted(A);
  @ ensures sorted(A) && contains(A, x); */
void main(int[] A, int x) {
    original(A, x);
    sort(A);
}

/*@ model boolean original_requires(int[] A, int x);
  @ model boolean original_ensures(int[] A, int x); */
void original(int[] A, int x);

/*@ model boolean sort_requires(int[] A);
  @ model boolean sort_ensures(int[] A); */
void sort(int[] A);
```

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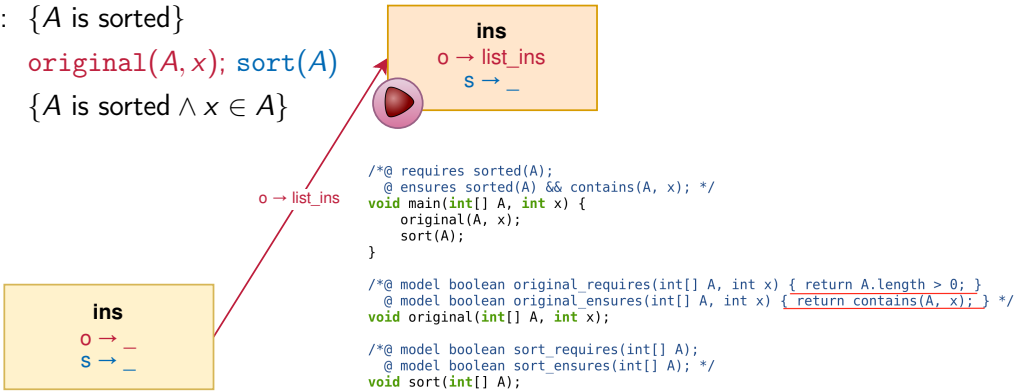


```
/*@ requires sorted(A);
  @ ensures sorted(A) && contains(A, x); */
void main(int[] A, int x) {
    original(A, x);
    sort(A);
}

/*@ model boolean original_requires(int[] A, int x) { return A.length > 0; }
  @ model boolean original_ensures(int[] A, int x) { return contains(A, x); } */
void original(int[] A, int x);

/*@ model boolean sort_requires(int[] A);
  @ model boolean sort_ensures(int[] A); */
void sort(int[] A);
```