Mapping Features to Automatically Identified Object-Oriented Variability Implementations

The case of ArgoUML-SPL

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Variability-Rich Systems with a Single Code Base

16.000 options managed in 25M LoC [Acher2018]

#ifdef

24.000 different platforms in 2015 [Open2015]

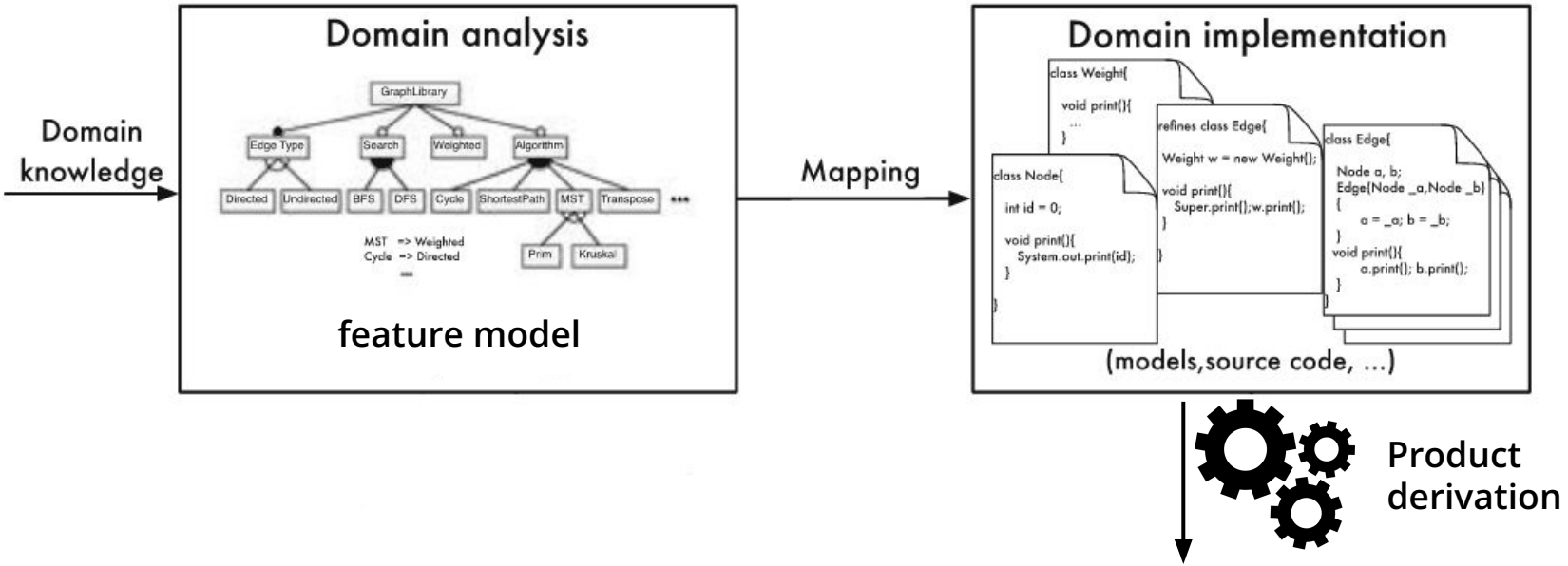
Object-orientation

2.000+ options generating variants for platforms, security levels... [Acher2018]

Object-orientation

and many variability implementation techniques...

Problem: How to master them as SPL?



Source: http://stg-tud.github.io/sedc/Lecture/ws16-17/6-SPL.pdf

How to engineer an SPL?

Forward-engineering:

Feature model ⟶ Domain implementation

Mapping between feature model and features is done **during the implementation**

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Forward-engineering:

Feature model ⟶ Domain implementation

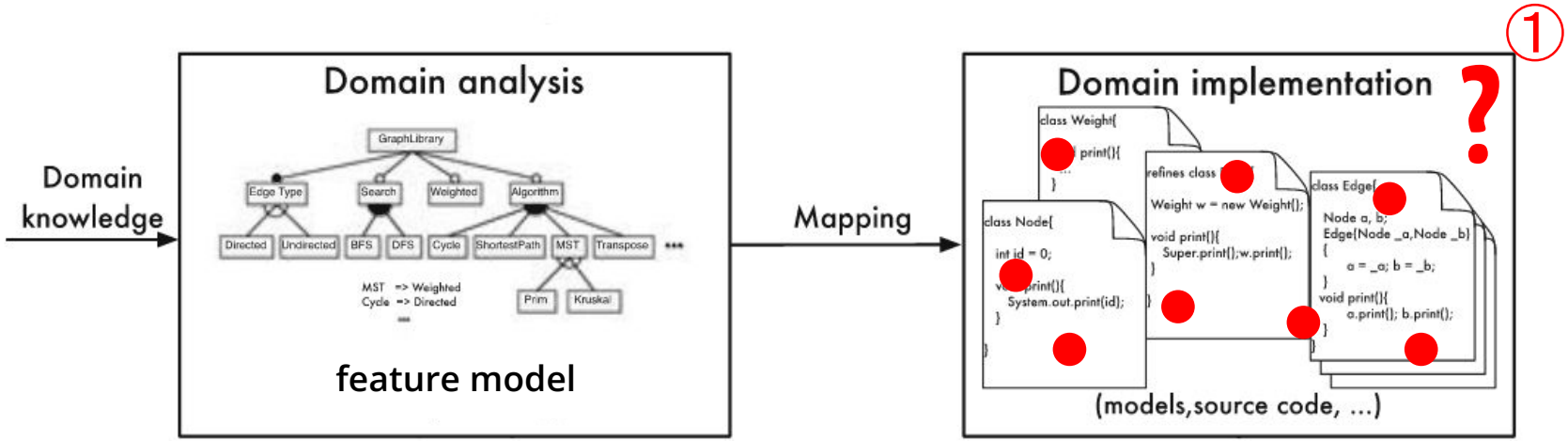
Mapping between feature model and features is done **during the implementation**

Reverse-engineering:

Feature model ⟵ Domain implementation

Need to extract the features and build a mapping with the feature model, or build it

Problem 1: How to identify variability implementations in an existing codebase?



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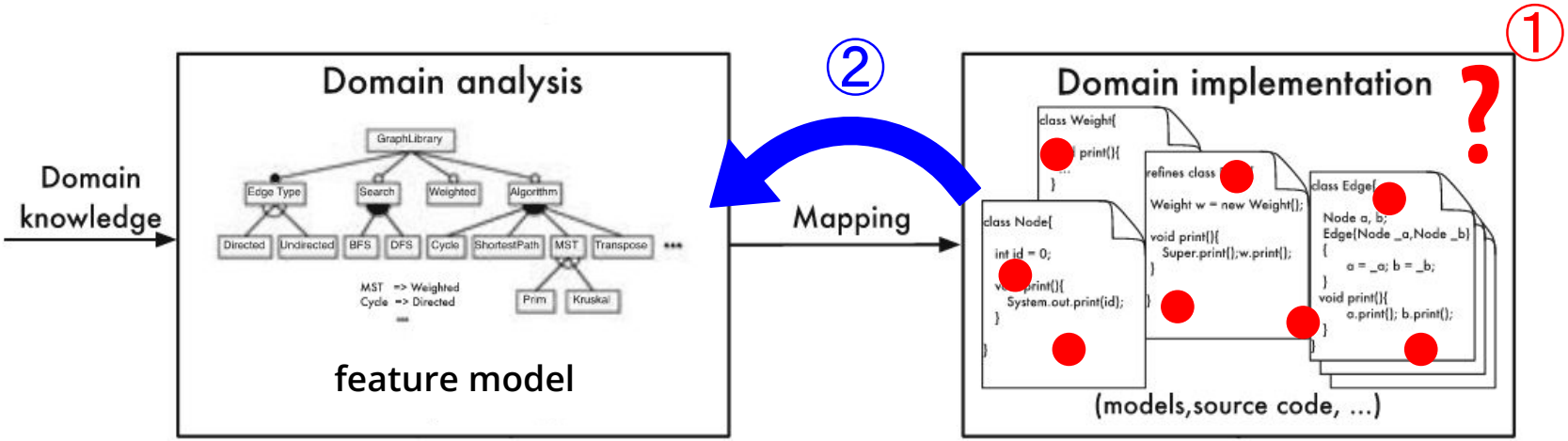
Problem 1: How to identify variability implementations in an existing codebase?

Problem 2: How to map these variability implementations to domain features?



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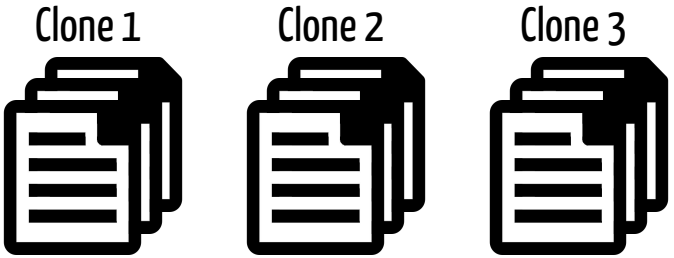
State of the art on variability implementations detection

Context: projects clones

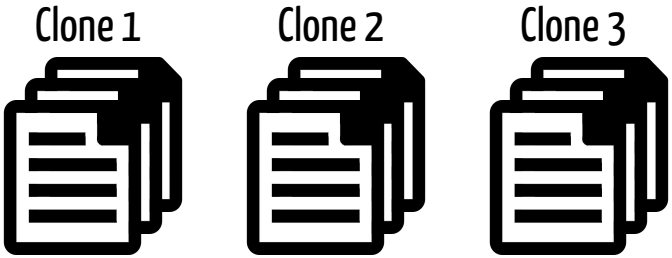


Detection method:

Comparison between clones and mapping with the domain features [Wesley2017]

State of the art on variability implementations detection

Context: projects clones

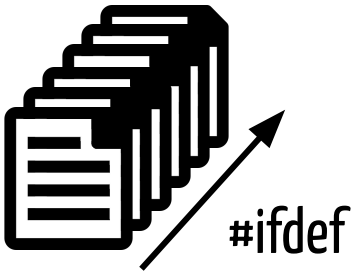


Detection method:

Comparison between clones and mapping with the domain features [Wesley2017]

Context: unique codebase and preprocessing directives

#ifdef ⟶ variant



Detection method:

Determining the consistency of directives [Liebig2010]

State of the art on variability implementations detection

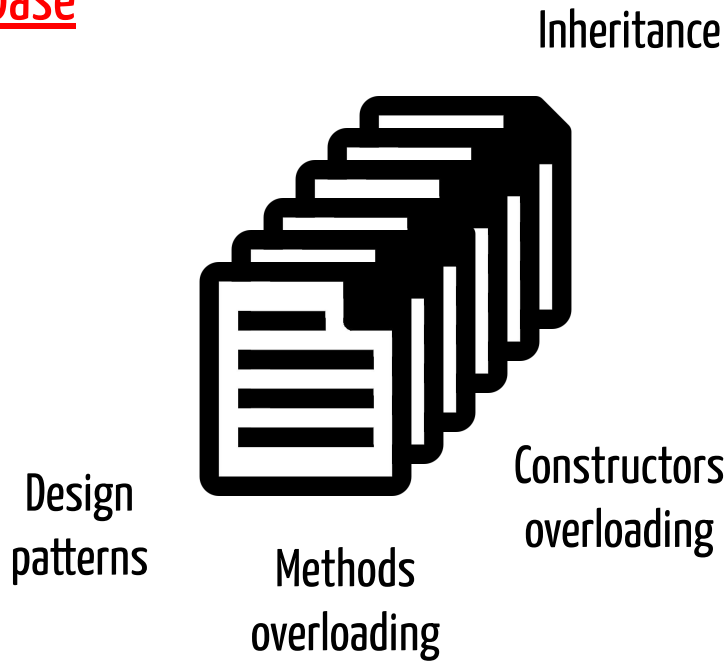
Our context: large and unique object-oriented codebase

- Several implementation mechanisms
- Variability buried in the code (variation points)

Detection method:

Currently no method

[Lozano2011], [Metzger2014], [Tërnava2017]



Variation points and variants

```java
public abstract class Shape {
  public abstract double area();
  public abstract double perimeter(); /*...*/
}
```

```java
public class Circle extends Shape {
  private final double radius;
  // Constructor omitted
  public double area() {
    return Math.PI * Math.pow(radius, 2);
  }
  public double perimeter() {
    return 2 * Math.PI * radius;
  }
}
```

```java
public class Rectangle extends Shape {
  private final double width, length;
  // Constructor omitted
  public double area() {
    return width * length;
  }
  public double perimeter() {
    return 2 * (width + length);
  }
  public void draw(int x, int y) {
  // rectangle at (x, y, width, length)
  }
  public void draw(Point p) {
  // rectangle at (p.x, p.y, width, length)
  }
}
```

Variation points and variants

vp_shape

```
1  public abstract class Shape {
2    public abstract double area();
3    public abstract double perimeter(); /*...*/
4  }
```

v_circle

```
5  public class Circle extends Shape {
6    private final double radius;
7    // Constructor omitted
8    public double area() {
9      return Math.PI * Math.pow(radius, 2);
10   }
11   public double perimeter() {
12     return 2 * Math.PI * radius;
13   }
14 }
```

v_rectangle

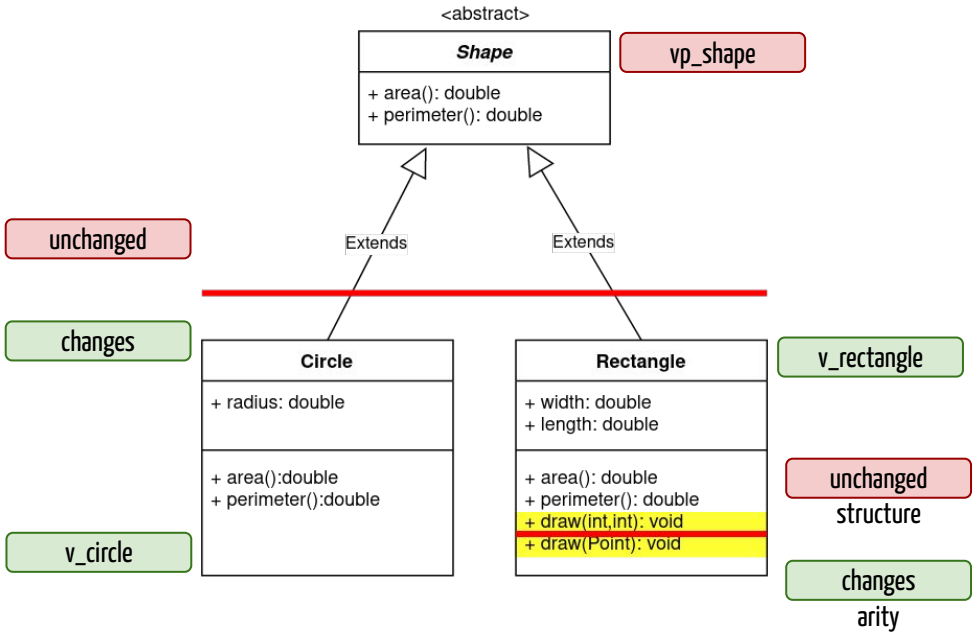
```
15 public class Rectangle extends Shape {
16   private final double width, length;
17   // Constructor omitted
18   public double area() {
19     return width * length;
20   }
21   public double perimeter() {
22     return 2 * (width + length);
23   }
24   public void draw(int x, int y) {
25   // rectangle at (x, y, width, length)
26   }
27   public void draw(Point p) {
28   // rectangle at (p.x, p.y, width, length)
29   }
30 }
```

vp_draw

Use of symmetries to detect variability implementations?

Intuition:

- Presence of **symmetries in object-oriented codebases** [Coplien2019] inspired from the theory of centres [Alexander2002]
- Symmetries present in **mechanisms implementing variability**



Identifying variation points with variants

Variability implementation technique ⟷ local symmetry

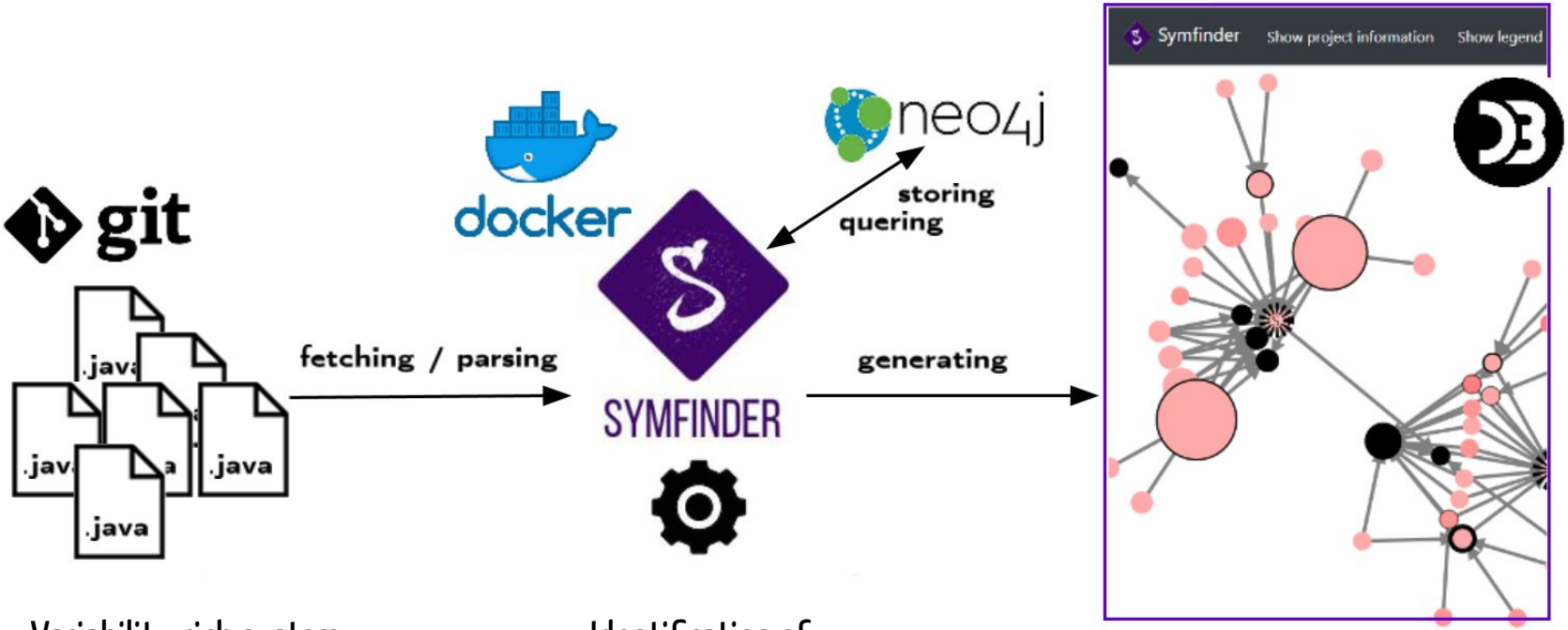
- variation point (commonality) ⟷ unchanged
- variant (variability) ⟷ changes

Identification through local symmetries in core assets

High density of symmetries ⟶ variability intense places

Xhevahire Tërnava, Johann Mortara, and Philippe Collet. 2019. Identifying and Visualizing Variability in Object-Oriented Variability-Rich Systems. In 23rd International Systems and Software Product Line Conference - Volume A (SPLC '19), September 9–13, 2019, Paris, France. ACM, New York, NY, USA, 12 pages.

symfinder



Variability-rich system in a single code base

Identification of symmetries

Visualization of *vp-s*

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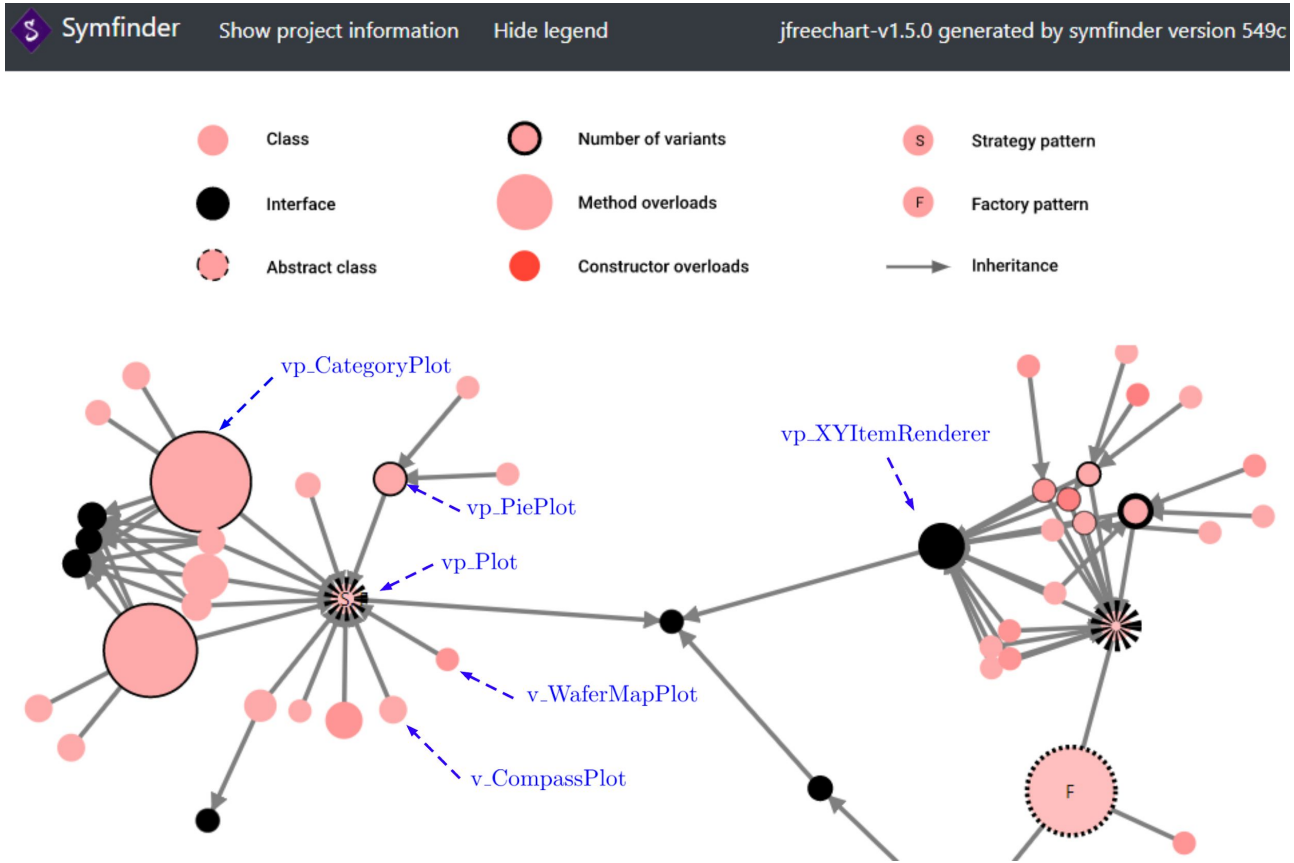
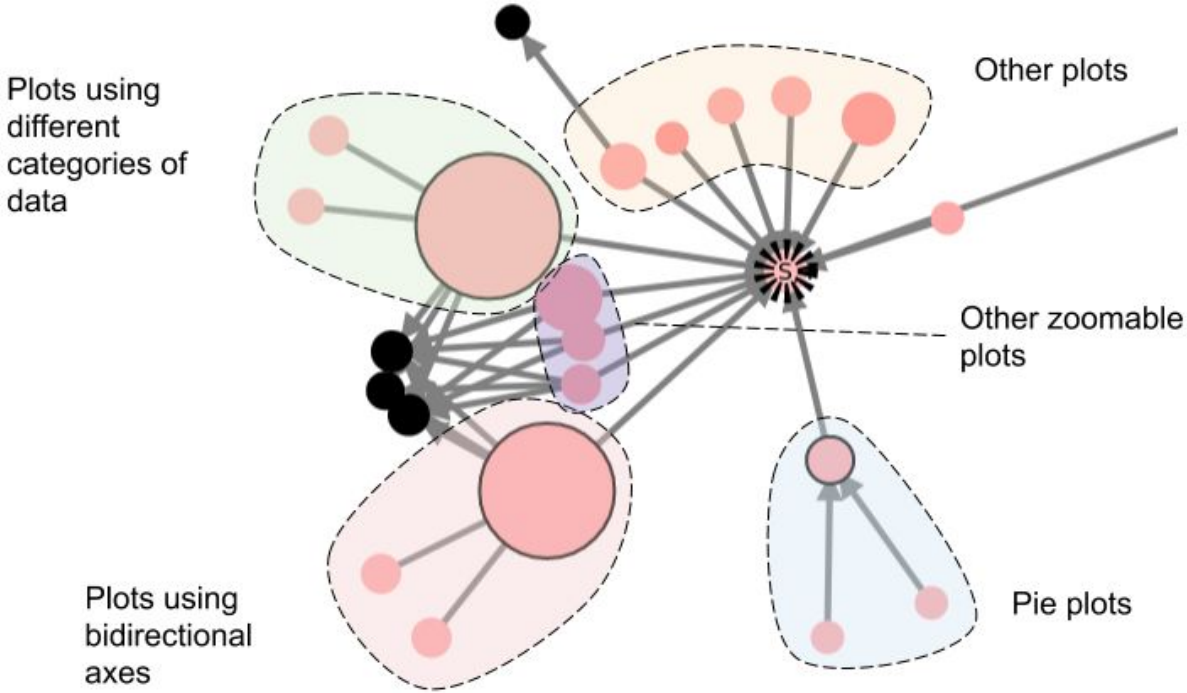
Automatic visualization of *vp-s* with variants

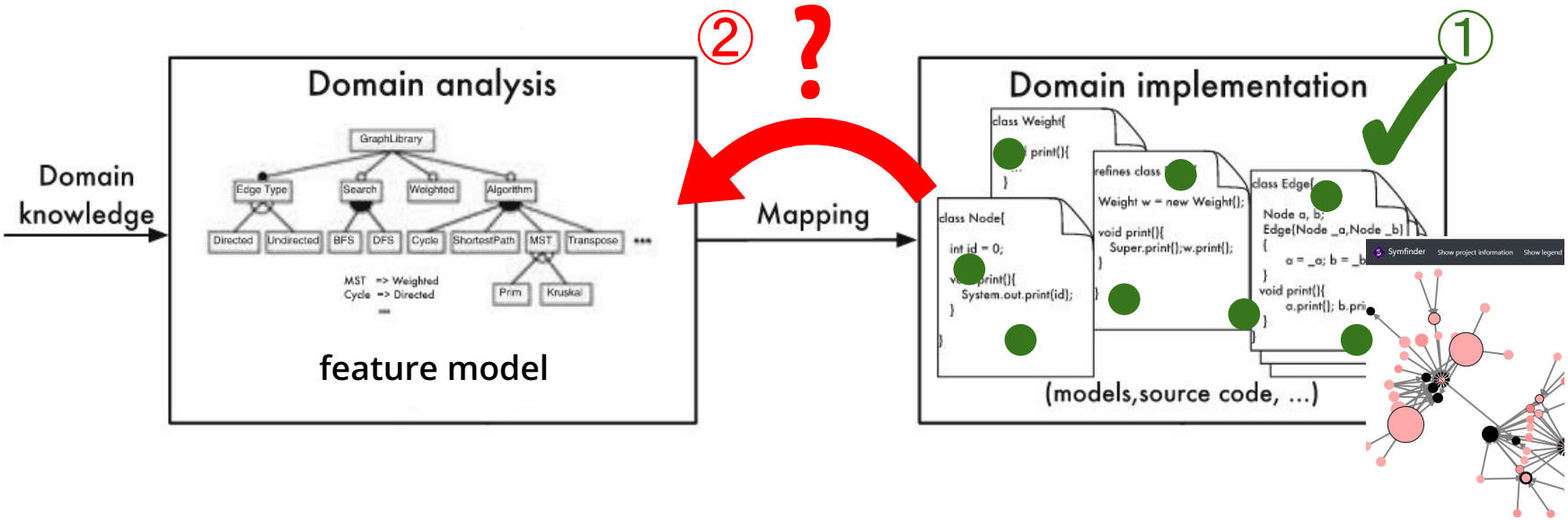


What can be manually found: an example



Problem 1: How to identify variability implementations in an existing codebase?

Problem 2: How to map these variability implementations to domain features?



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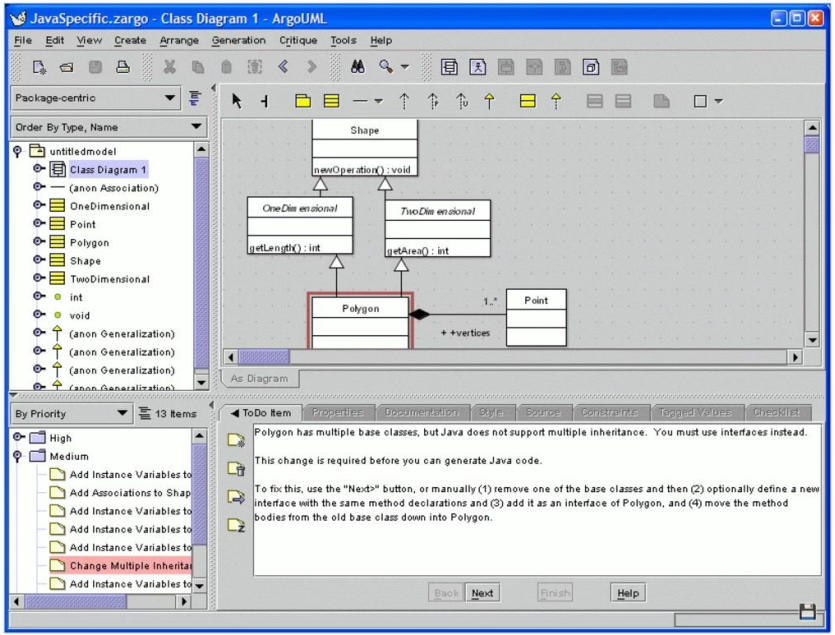
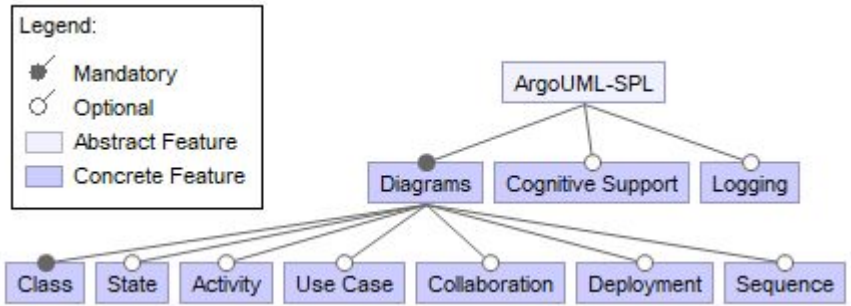
ArgoUML-SPL [Couto2011]

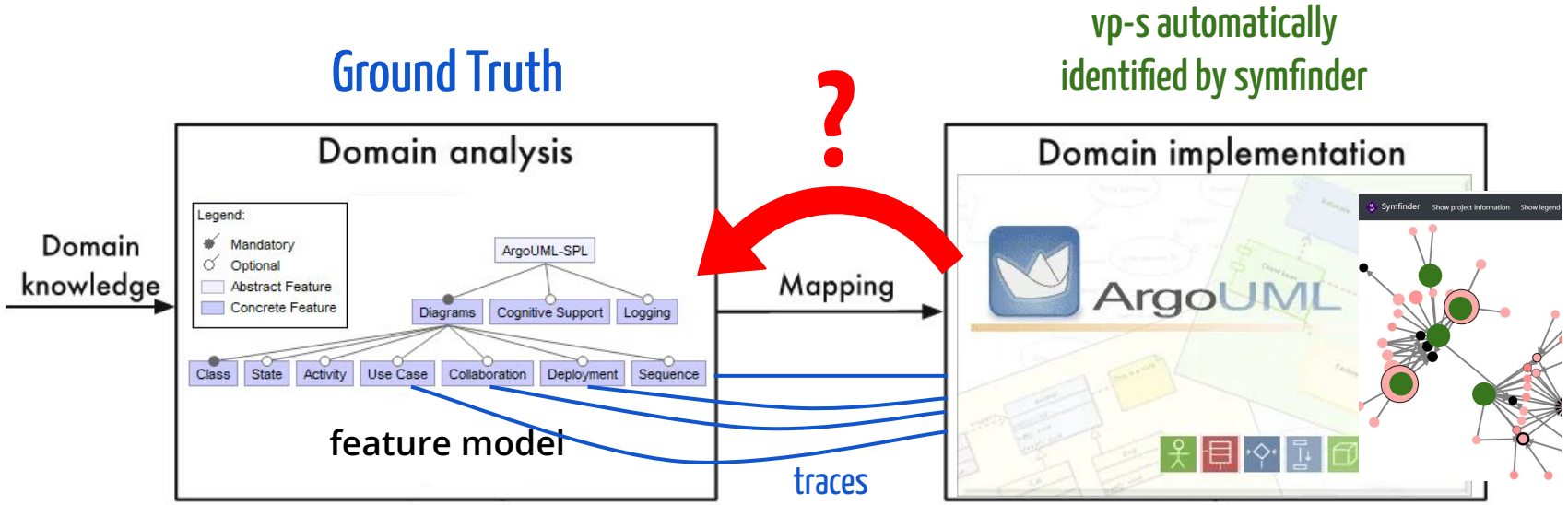


ArgoUML editor



Feature model of ArgoUML-SPL

Question: Are the identified *vp-s* from ArgoUML relevant for a feature mapping?



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Experimental setup

Ground Truth

Excerpt of traces for USECASE feature

org.argouml.uml.diagram.use_case.ui.FigActor

```
//#if defined(USECASEDIAGRAM)
//@#$LPS-USECASEDIAGRAM:GranularityType:Package
public class FigActor extends FigNodeModelElement
```

org.argouml.uml.diagram.use_case.ui.FigClassifierRole

```
//#if defined(SEQUENCEDIAGRAM)
//@#$LPS-SEQUENCEDIAGRAM:GranularityType:Package
public class FigClassifierRole extends FigNodeModelElement
```

.

.

.

Experimental setup

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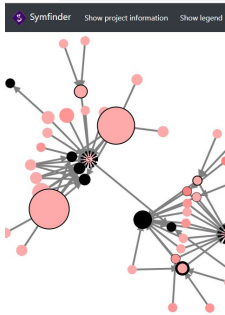
public class FigClassifierRole extends FigNodeModelElement
```

.
.
.

Excerpt of *symfinder* JSON output




```
{
  "nodes": [
    {
      "types": [
        "CLASS", "METHOD_LEVEL_VP", "VARIANT"
      ],
      "constructorVPs": 1,
      "methodVariants": 0,
      "classVariants": 0,
      "methodVPs": 0,
      "constructorVariants": 3,
      "name":
"org.argouml.uml.diagram.use_case.ui.FigActor"
    },...
  ],
  "links": [
    {
      "type": "EXTENDS",
      "source":
"org.argouml.uml.diagram.ui.FigNodeModelElement",
      "target":
"org.argouml.uml.diagram.use_case.ui.FigActor"
    },...
  ]
}
```

Experimental setup

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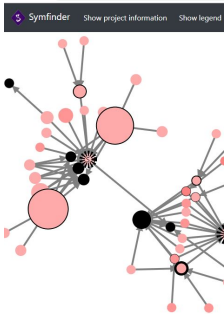
.
.
.

Manual mapping using Excel formulae

Excerpt of *symfinder* JSON output




```
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  "nodes": [
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      "types": [
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      ],
      "constructorVPs": 1,
      "methodVariants": 0,
      "classVariants": 0,
      "methodVPs": 0,
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    },...
  ],
  "links": [
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      "target":
"org.argouml.uml.diagram.use_case.ui.FigActor"
    },...
  ]
}
```

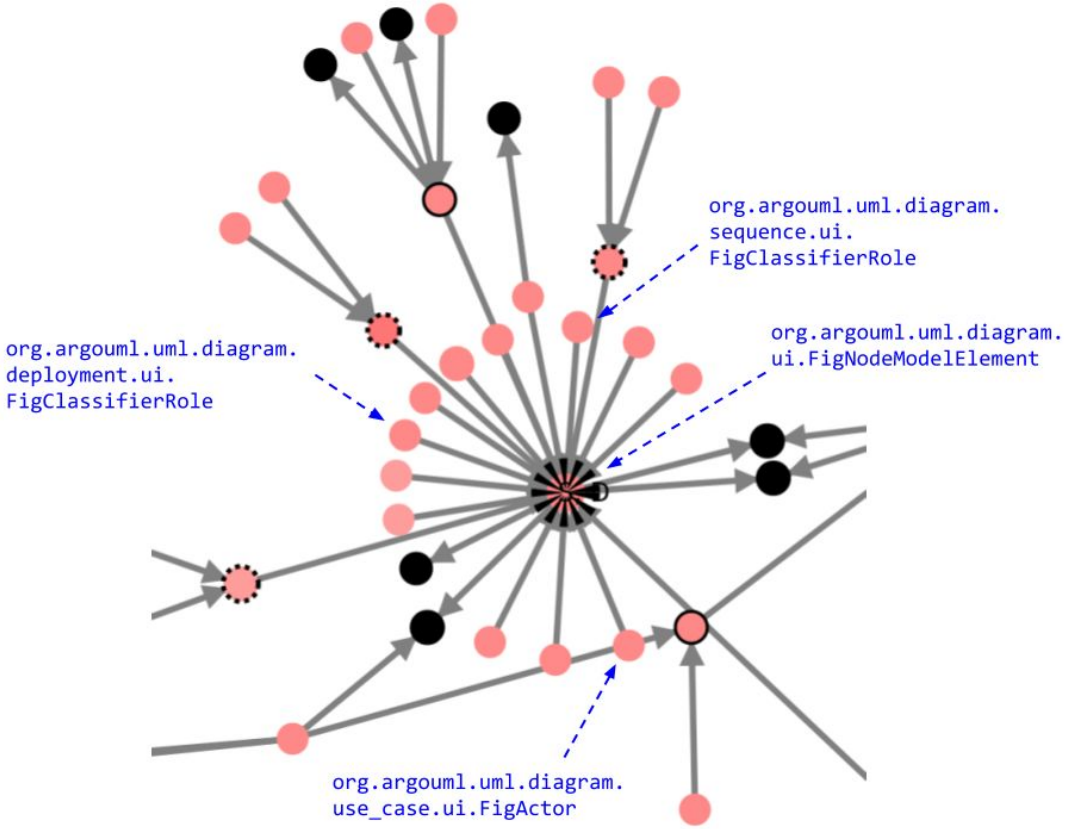
Validation

Feature: Use Case

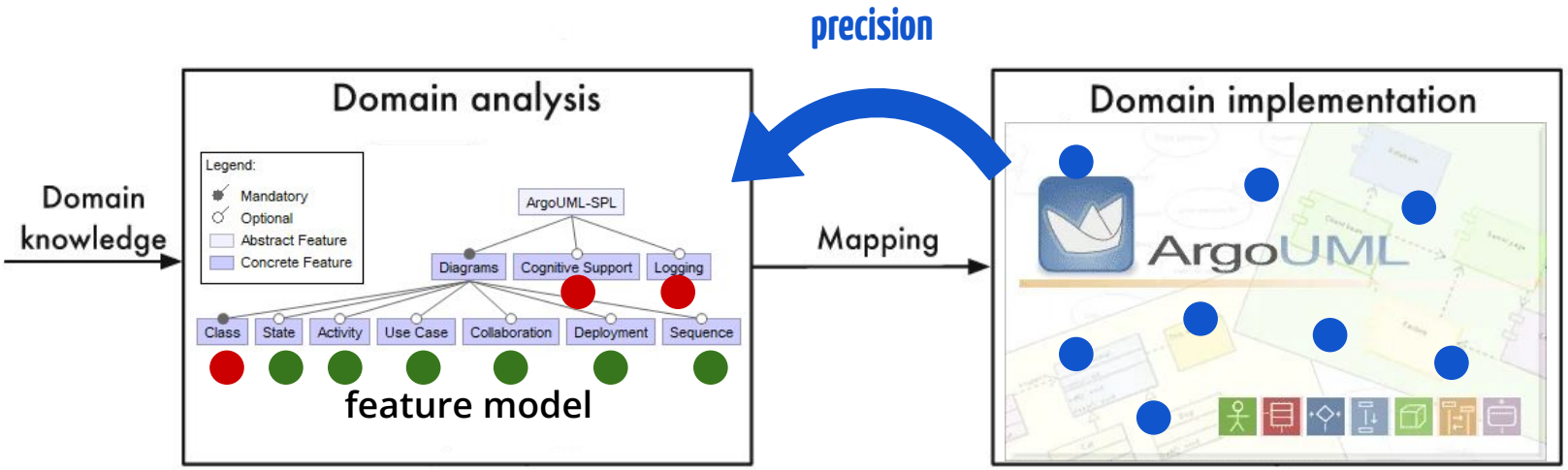
```
//#if defined(USECASEDIAGRAM)
//@#$LPS-USECASEDIAGRAM:GranularityType:Package
public class FigActor extends FigNodeModelElement
```

Feature: Sequence

```
//#if defined(SEQUENCEDIAGRAM)
//@#$LPS-SEQUENCEDIAGRAM:GranularityType:Package
public class FigClassifierRole extends FigNodeModelElement
```



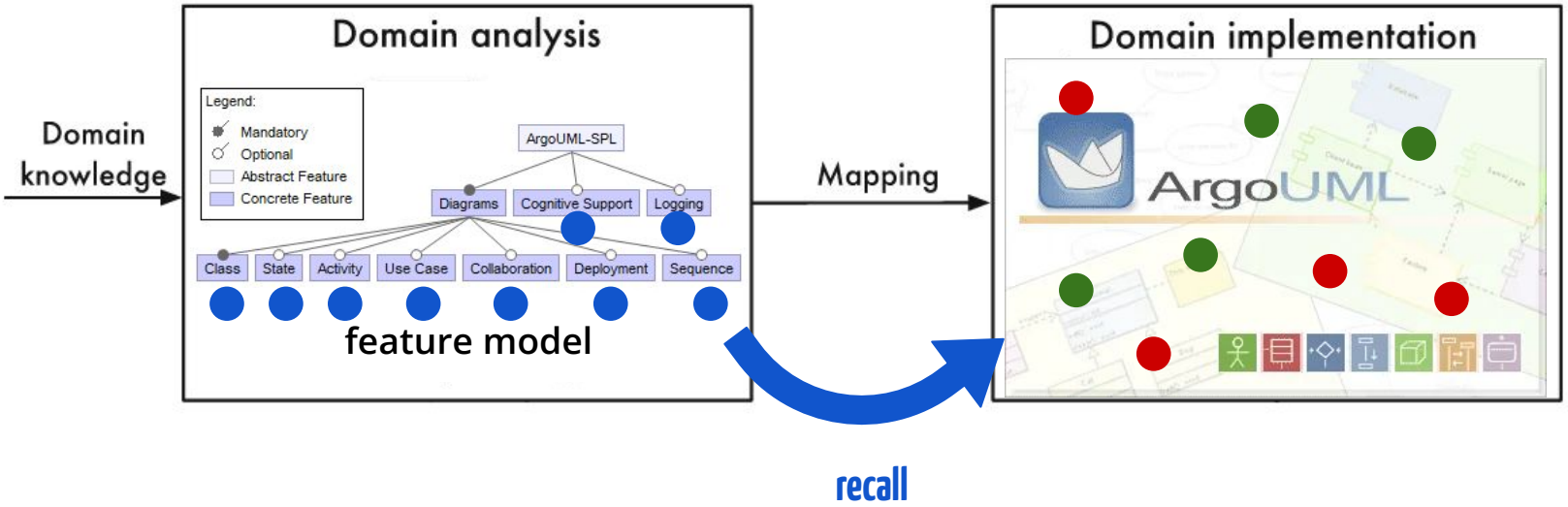
Relevance of the *vp-s*



Precision:

Percentage of identified vp-s and variants that could be mapped to domain features

Relevance of the *vp-s*



Recall:

Percentage of features' traces that could be mapped to identified vp-s and variants

Relevance of the *vp-s*

Calculating precision

$$precision = \frac{TP}{TP + FP} = \frac{|T_{gt} \cap I_{vp-v}|}{|I_{vp-v}|} = \frac{593}{1560} = 38\%$$

Low precision was **expected**:

- coarse grain features based on superficial domain knowledge
- not all identified places with a symmetry are related to variability

Relevance of the *vp-s*

Calculating recall

$$recall = \frac{TP}{TP + FN} = \frac{|T_{gt} \cap I_{vp-v}|}{|T_{gt}|} = \frac{593}{712} = 83\%$$

The missing 17% of traces are **not variability related**:

- initialization classes
- external libraries

Future work

Map the identified *vp-s* with variants to #ifdef directives

Take into account *vp-s* with variants at method level

Extend symfinder to be able to analyse projects in other languages

Mapping Features to Automatically Identified Object-Oriented Variability Implementations

The case of ArgoUML-SPL

Successful mapping to preexisting domain features

vp-s detection method is **little precise** but **highly robust** on ArgoUML-SPL

symfinder identifies ***vp-s*** **with variants relevant** for feature mapping

Availability:

- Public release: tag **vamos2020**
  https://github.com/DeathStar3/symfinder
- symfinder demonstration
  https://deathstar3.github.io/symfinder-demo/

Get the paper:

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