Technische Universität Braunschweig

ISF

Structural Feature Interaction Patterns - Case Studies and Guidelines

VaMoS 2014, January 22–24, Nice, France

Sven Schuster, Sandro Schulze, Ina Schaefer, January 23, 2014

Feature Interactions

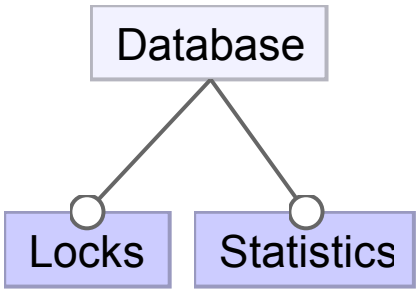
Behavioral Feature Interactions

- Fire & Flood Control

Feature Interactions

Structural Feature Interactions

- Database Locks & Statistics



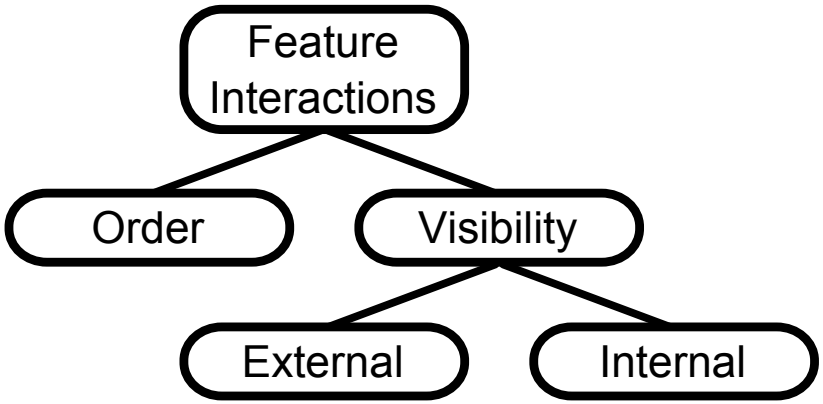
- Locks (blue), Statistics (red)
- Overlapping (violet)
  - Locking the calculation of Statistics
  - Statistics of Locking
- Optional Feature Problem

```
1  class Database {
2    List locks;
3    void lock() { /*...*/ }
4    void unlock() { /*...*/ }
5    void put(Object key, Object data) {
6      lock();
7      /*...*/
8      unlock();
9    }
10   Object get(Object key) {
11     lock();
12     /*...*/
13     unlock();
14   }
15   int getOpenLocks() {
16     return locks.size();
17   }
18   int getDbSize() {
19     return calculateDbSize();
20   }
21   static int calculateDbSize() {
22     lock();
23     /*...*/
24     unlock();
25   }
26 }
```

Problem Statement

Categorization by Apel et al.

- Which FIs exist?
- How do they manifest?



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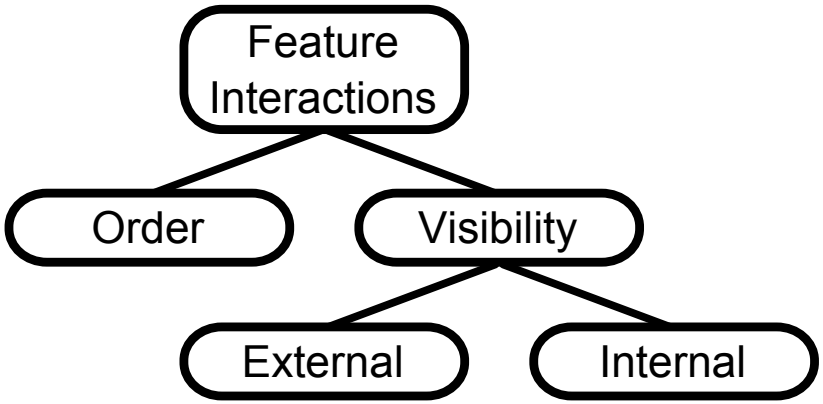

What about...

- Why do they exist?
- Are they intentional?

Focussing on...

- Internal Interactions
  - Structural Interactions

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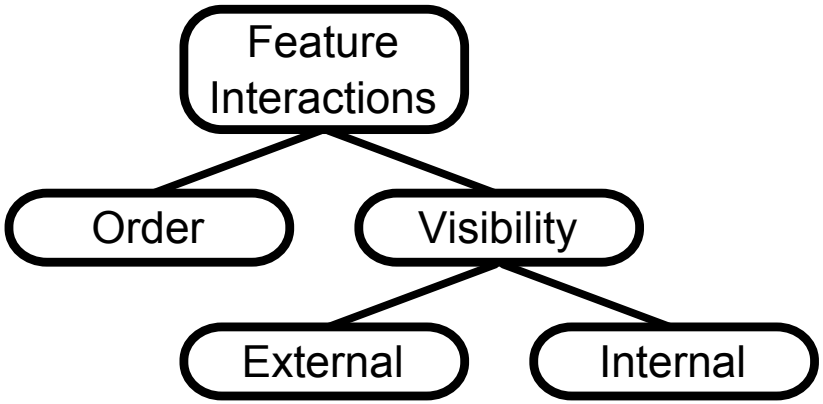

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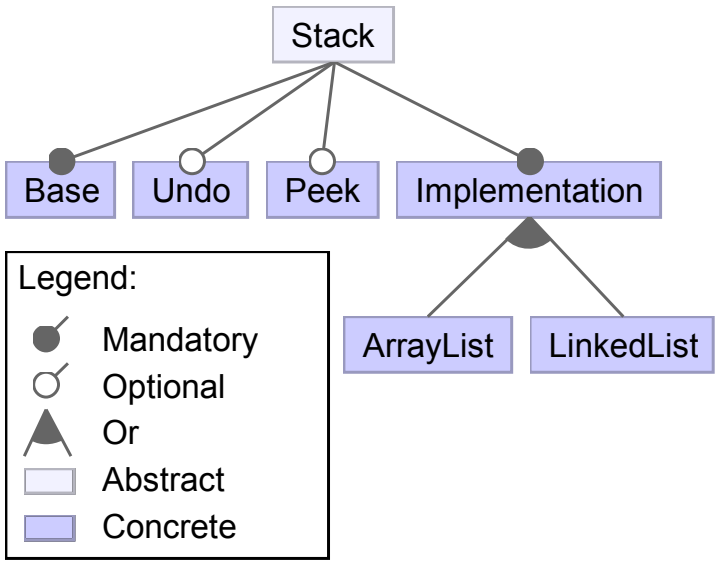
$\Rightarrow$ Structural Feature Interaction Patterns

SPLs & FOP



Feature Base

```
class Stack
  void push(int v)
    { /* ... */ }
  int pop() { /* ... */ }
}
```

Feature Undo

```
class Stack { /* ... */
  int backupPush;
  void undo() { /* ... */ }
  void push(int v) {
    backupPush=v;
    original(v);
  }
}
```

Superimposition

```
class Stack { /* ... */
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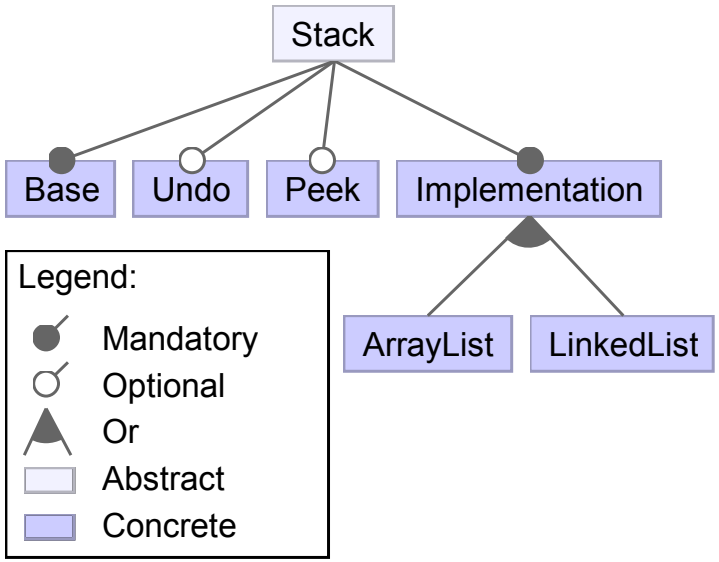
SPLs & FOP



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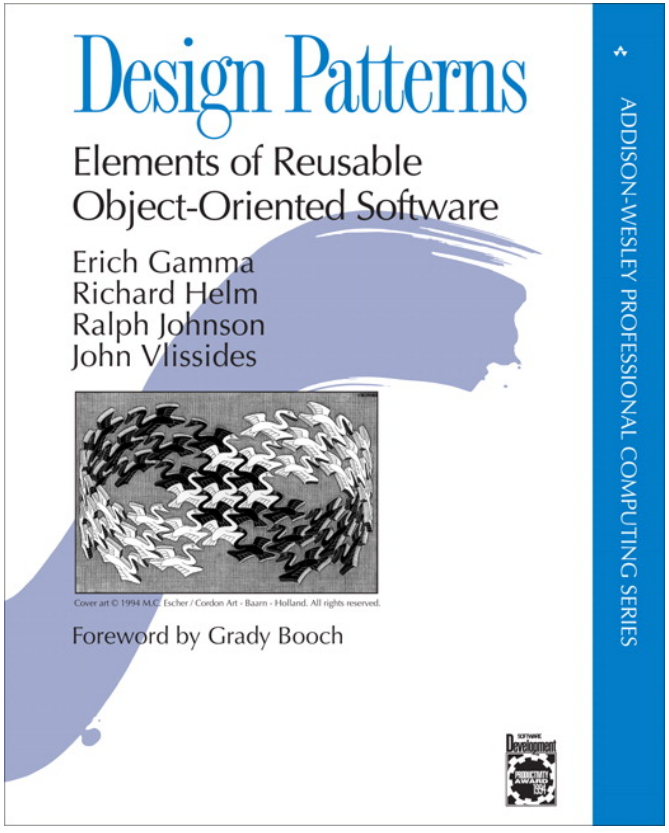
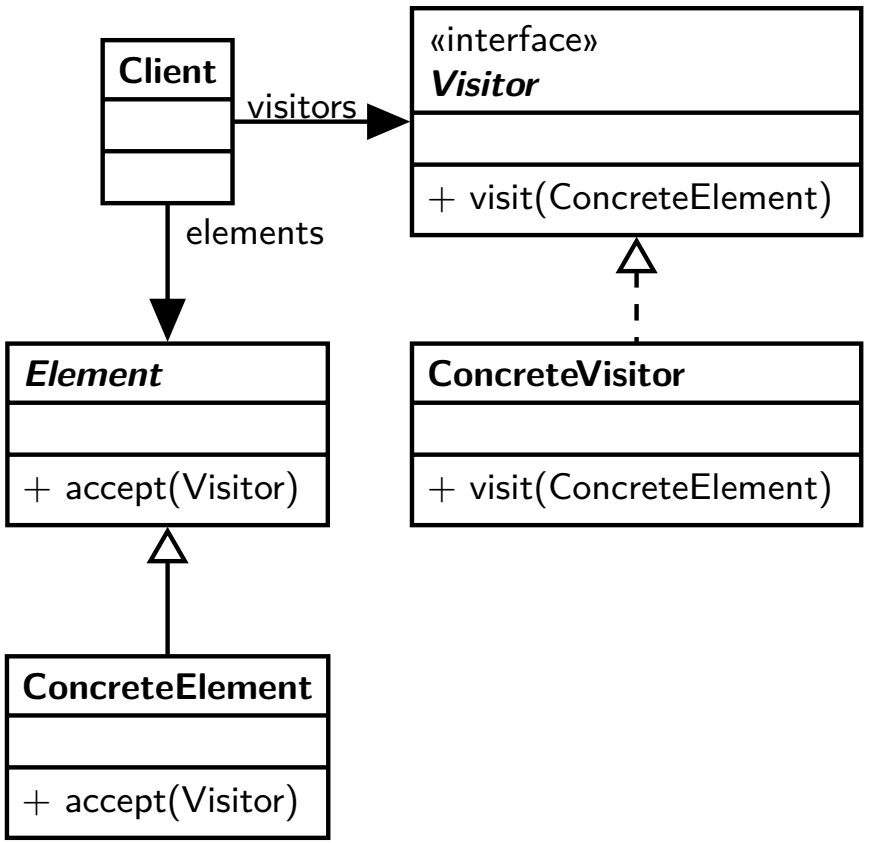
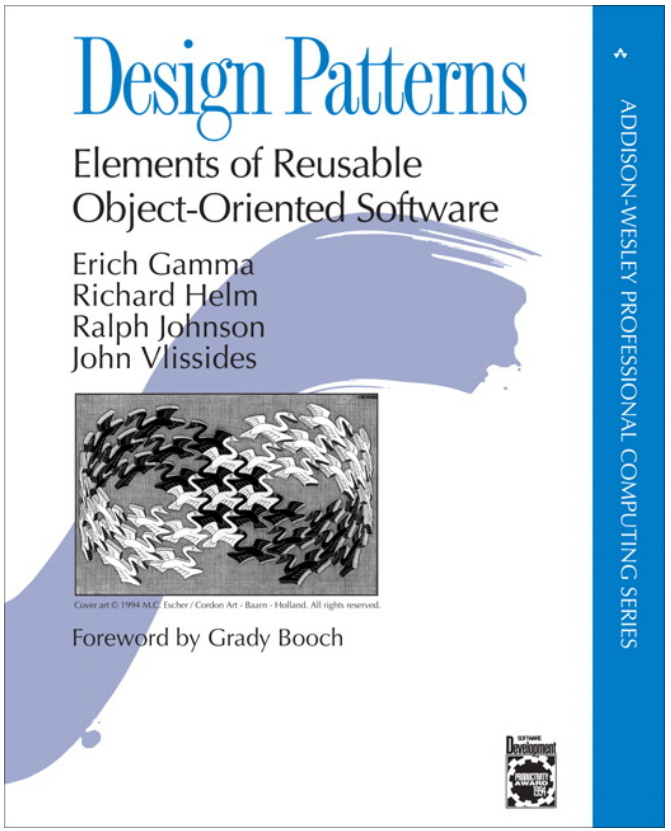
⇒ FeatureHouse / Fuji

Design Patterns

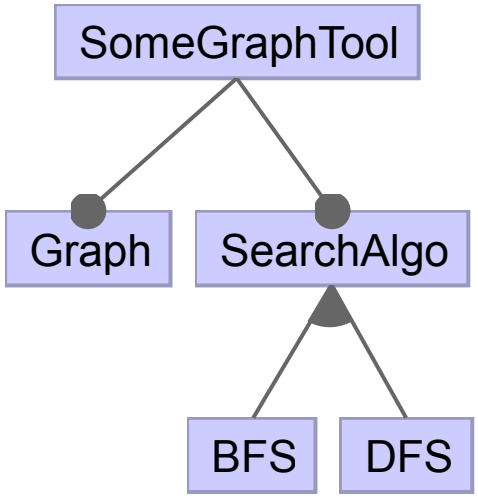


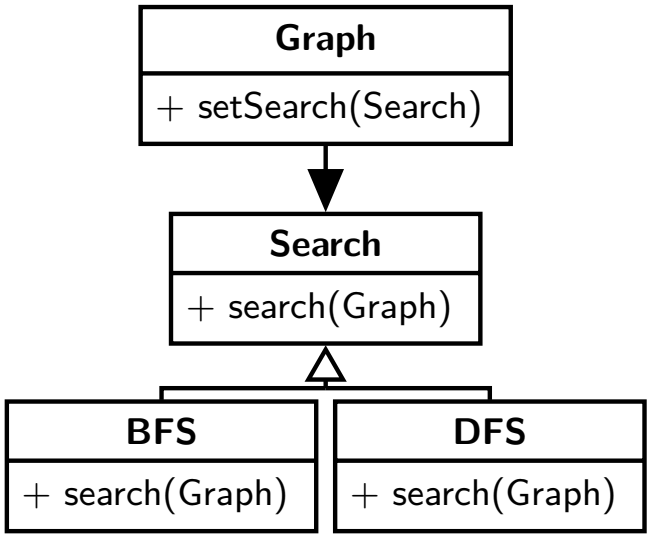
Design Patterns





Feature-Oriented Design Patterns





⇒ One-to-one mapping between Features & Strategies[1]

[1] Sven Schuster, Sandro Schulze, *Object-Oriented Design in Feature-Oriented Programming*, FOSD'12

Feature Template Method

Feature *DirectedOnlyVertices*

```
1 public class Graph {
2   public void run(Vertex s) {
3     /*empty */
4   }
5 }
```

Feature *TestProg*

```
1 class Main {
2   public static void main( String[] args ) {
3     Graph g = new Graph();
4     /* ... */
5     g.run(g.getVertices().next());
6   }
7 }
```

Feature *Number*

```
1  public class Graph {
2    public void run(Vertex s) {
3      System.out.println("Number");
4      NumberVertices();
5      original(s);
6    }
7    public void NumberVertices() {
8      /* ... */
9    }
10 }
```

⇒ Implicit constraint to fill/refine template method in later features[2]

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Research Questions

⇒ **RQ1:** *To what extent do design patterns exist in feature-oriented SPLs?*

⇒ **RQ2:** *Do feature interactions occur in the context of design patterns and if so, how do the features interact?*

Setup & Methodology

Study

- Automated pattern detection technique

Setup & Methodology

Study

- Automated pattern detection technique
- SPLs of different sizes and domains

SPLs

- Ahead
- BerkeleyDB
- GameOfLife
- GPL
- GUIDSL
- TankWar
- Violet

Setup & Methodology

Study

- Automated pattern detection technique
- SPLs of different sizes and domains
- Common design patterns

SPLs

- Ahead
- BerkeleyDB
- GameOfLife
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Patterns

- Visitor
- Observer
- Strategy
- FTM

Design Pattern Detection for FOP

Automated detection approach

- Adapted from Heuzeroth et al.
- Family-based $\Rightarrow$ static analysis

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Automated detection approach

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- Family-based ⇒ static analysis
- Searching for tuples of elements using Fuji AST

Visitor Pattern

```
VisitorCandidate = {
  Visitor.visit(ConcreteElement),
  ConcreteVisitor.visit(ConcreteElement),
  Element.accept(Visitor),
  ConcreteElement.accept(Visitor)
}
```

Design Pattern Detection for FOP

Automated detection approach

- Adapted from Heuzeroth et al.
- Family-based ⇒ static analysis
- Searching for tuples of elements using Fuji AST
- Manual elimination of false positives

Visitor Pattern

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VisitorCandidate = {
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```

Design Pattern Detection - Visitor in GPL

Feature *DFS*

```
1  public class WorkSpace {
2    public void preVisitAction(Vertex v) {}
3  }
4
5  public class Vertex {
6    public void nodeSearch(WorkSpace w) {
7      /*...*/
8      w.preVisitAction(this);
9      /*...*/
10   }
11 }
```

Feature *Number*

```
1  public class NumberWorkSpace extends WorkSpace {
2    int vertexCounter;
3    public NumberWorkSpace() {
4      vertexCounter = 0;
5    }
6    public void preVisitAction(Vertex v) {
7      if (v.visited != true) {
8        v.VertexNumber = vertexCounter++;
9      }
10   }
11 }
```

Design Pattern Detection - Visitor in GPL

`Visitor.visit(ConcreteElement)`

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`ConcreteVisitor.visit(ConcreteElement)`

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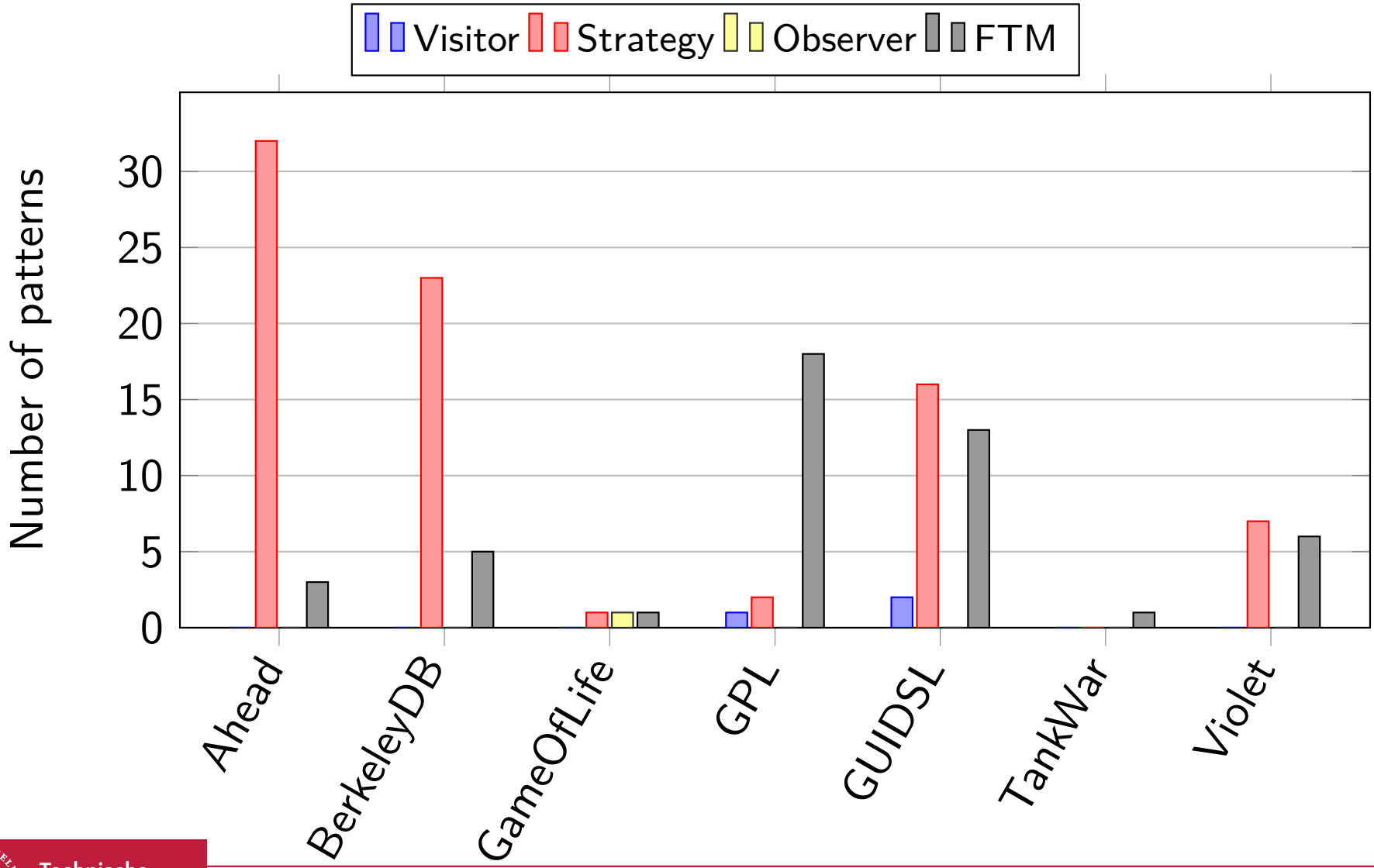
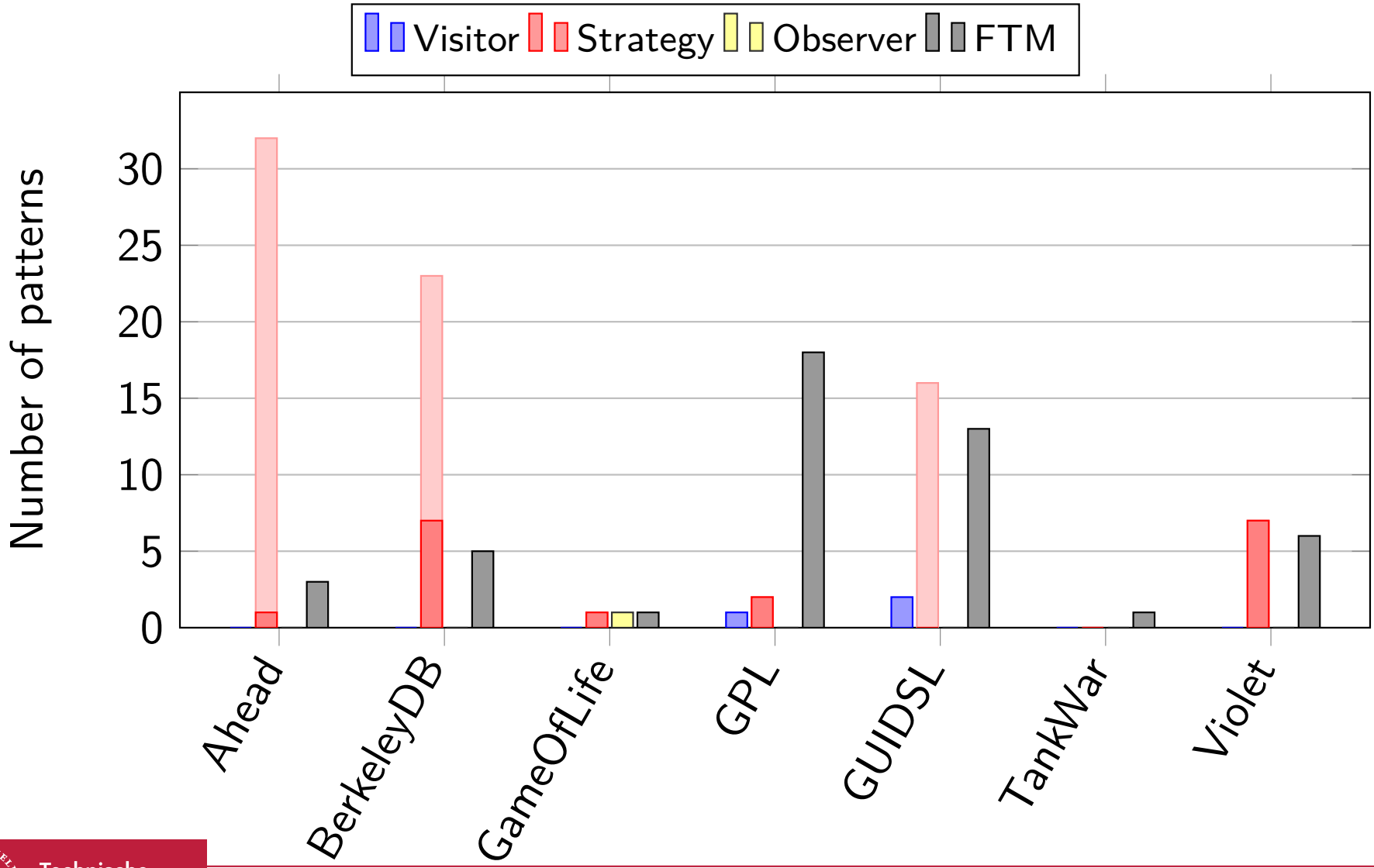
11 }
```

Results - Complete Number of Patterns



Results - Number of decomposed Patterns



Results - Decomposition of Visitor

Feature *Number*

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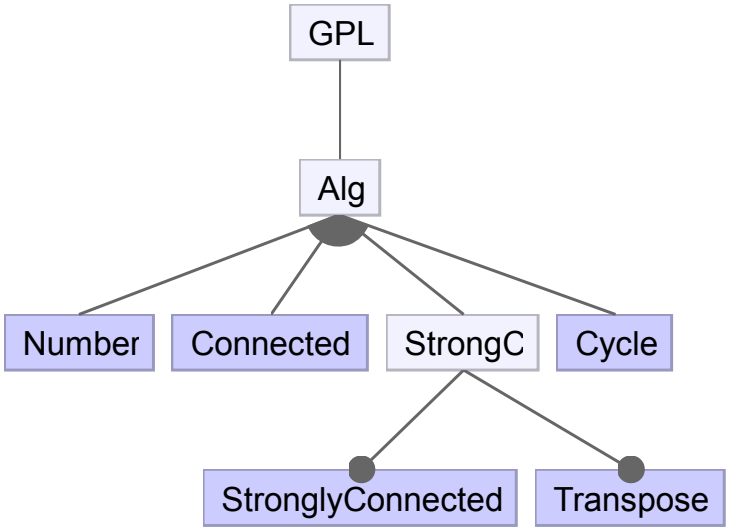

Feature *Cycle*

```
1  public class CycleWorkSpace extends WorkSpace {
2    public void preVisitAction(Vertex v) {
3      /* ... */
4    }
5  }
```

Feature *Connected*

```
1  public class ConnectedWorkSpace extends WorkSpace {
2    public void preVisitAction(Vertex v) {
3      /* ... */
4    }
5  }
```

Results - Feature Template Method

Feature *DFS*

```
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3  }
4  public class Vertex {
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6      /*...*/
7    }
8  }
9  public class Graph {
10   public void GraphSearch(WorkSpace w) {
11     /*...*/
12     v.nodeSearch(w);
13     /*...*/
14   }
15 }
```

Feature *DirectedOnlyVertices*

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13 public class Graph {
14   public void run(Vertex s) {
15     System.out.println("Number");
16     NumberVertices();
17     original(s);
18   }
19   public void NumberVertices() {
20     GraphSearch(new NumberWorkSpace());
21   }
22 }
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Results - Summary

Design Patterns in SPLs

- Design Patterns do occur in feature-oriented SPLs...
  - ... frequently.
  - ... across several features.

Feature Interactions within Design Patterns

- Addition of concrete pattern classes in sibling features
- No refinements of the actual pattern implementation
- Feature Template Method to register/call new objects

Towards Guidelines

Application Scenarios

- Similar to design patterns in OOP
  - Visitor to traverse through grammar
  - Observer to realize MVC
  - Strategy to interchange similar algorithms

Feature Structure

- Concrete classes of decomposed patterns introduced by sibling features
- Design patterns are encapsulated by feature group

$\Rightarrow$ Reflection of design pattern in feature model

$\Rightarrow$ Synergy of modularity of variability model and Implementation

Conclusion & Future Work

We have...

... introduced the idea of structural feature interaction patterns

... proposed a detection technique for design patterns in FOP

... conducted a case study detecting structural feature interaction within design patterns

... introduced ideas for guidelines

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We should...

... improve and extend the detection technique

... conduct more studies do derive more detailed guidelines

... reason about how to apply such guidelines (automatically)?