Aspectual Feature Modules

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Aspects vs. Feature Modules

- Aspects and feature modules are powerful mechanisms
  - They have different strengths and weaknesses
- We need guidelines about when to use which mechanism
  - Programmers should use the best of the two worlds

Comparison in Two Dimensions

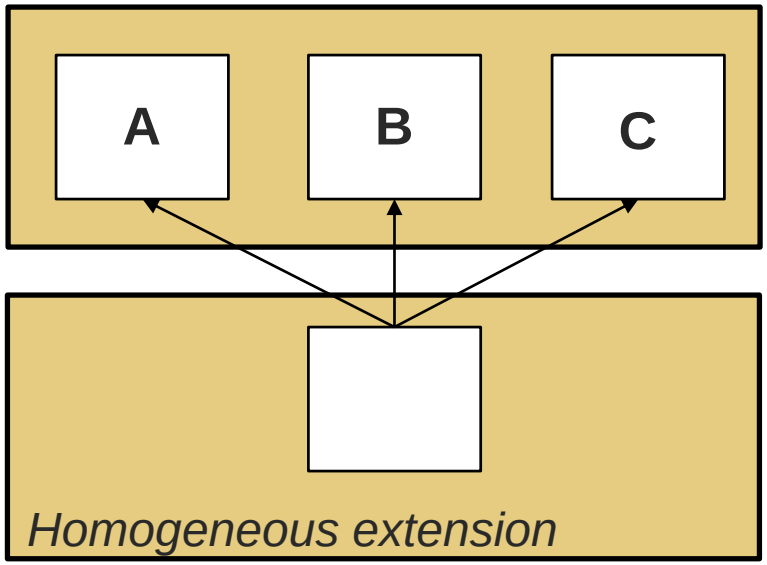
- Homogeneous or Heterogeneous
  - They depend on the uniformity of the program extensions
- Static or Dynamic
  - They depend on the temporal pattern of extensions

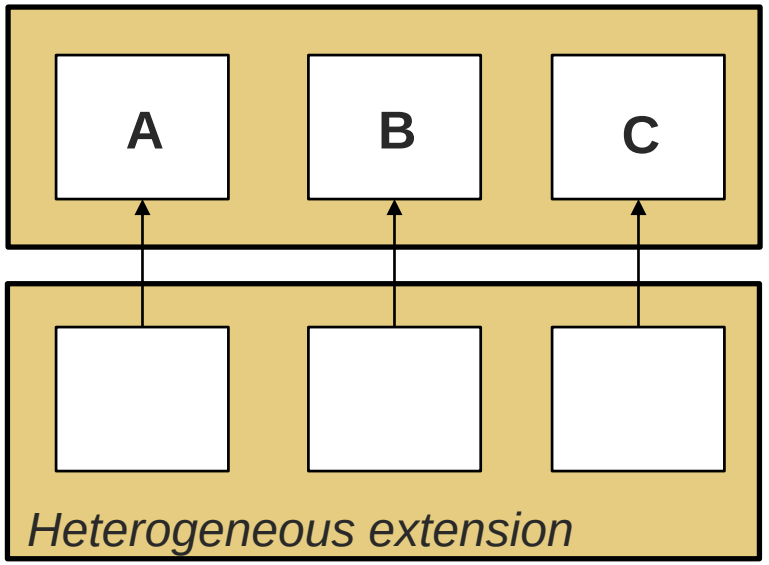
Homogeneous and Heterogeneous Concerns

Definitions

- A homogeneous crosscutting concern extends a program at multiple join point by applying a single extension
- A heterogeneous crosscutting concern extends multiple join points by adding multiple extensions
  - Each extension targets one join point

Examples






```
public aspect FooAspect {
  after(): execution(void A.foo()) ||
           execution(void B.foo()) ||
           execution(void C.foo()) {
    // do something
  }
}
```

```
public aspect FooAspect {
  after(): execution(void A.foo()) ||
    // do something
  }
  after(): execution(void B.foo()) ||
    // do something
  }
  ...
}
```

When to use heterogeneous?

- Collaborations of classes are typically heterogeneous
  - Classes add to a program different functionality
- Feature modules are also designed to implement heterogeneous concerns

When to use homogeneous?

- Aspects perform better in extending a set of join points using a single advice
  - That is, modularizing a homogeneous crosscutting concern
  - Aspects avoid code replication
- If feature-oriented programming is applied to homogeneous crosscutting concerns, refinements may introduce the same code (replications)

Static and Dynamic Concerns

Definitions

- A static crosscutting concern extends the structure of a program statically
  - It adds classes, interfaces, fields, and methods
- A dynamic crosscutting concern affects the control flow of a program
  - It runs additional code when predefined events occur during the program execution

Examples of Static Concern

Aspect-oriented programming (AOP)

```
aspect ComparableEdge {
  declare parents: Edge implements Comparable;
  Boolean Edge.compare(Edge e) {
    // ...
  }
}
```

Feature-oriented programming (FOP)

```
refines class Edge implements Comparable {
  boolean compare(Edge e) {
    // ...
  }
}
```

Examples of Dynamic Concern

Aspect-oriented programming (AOP)

```
aspect Weighted {
  after(Edge e): execution(void Edge.print())
      && this(e) {
    e.weight.print();
  }
}
```

Feature-oriented programming (FOP)

```
refines class Edge {
  void print() {
    Super.print();
    weight.print();
  }
}
```

Comparison

- Both aspects and feature modules can extend the structure of a base program statically
- Feature-oriented programming does not provide language support for dynamic concerns
  - In some case, they can be implemented

Summary of Comparison

Crosscutting	**FOP**	**AOP**
Heterogeneous	Good Support	Limited Support
Homogeneous	No Support	Good Support
Static	Good Support	Limited Support
Dynamic	Weak Support	Good Support

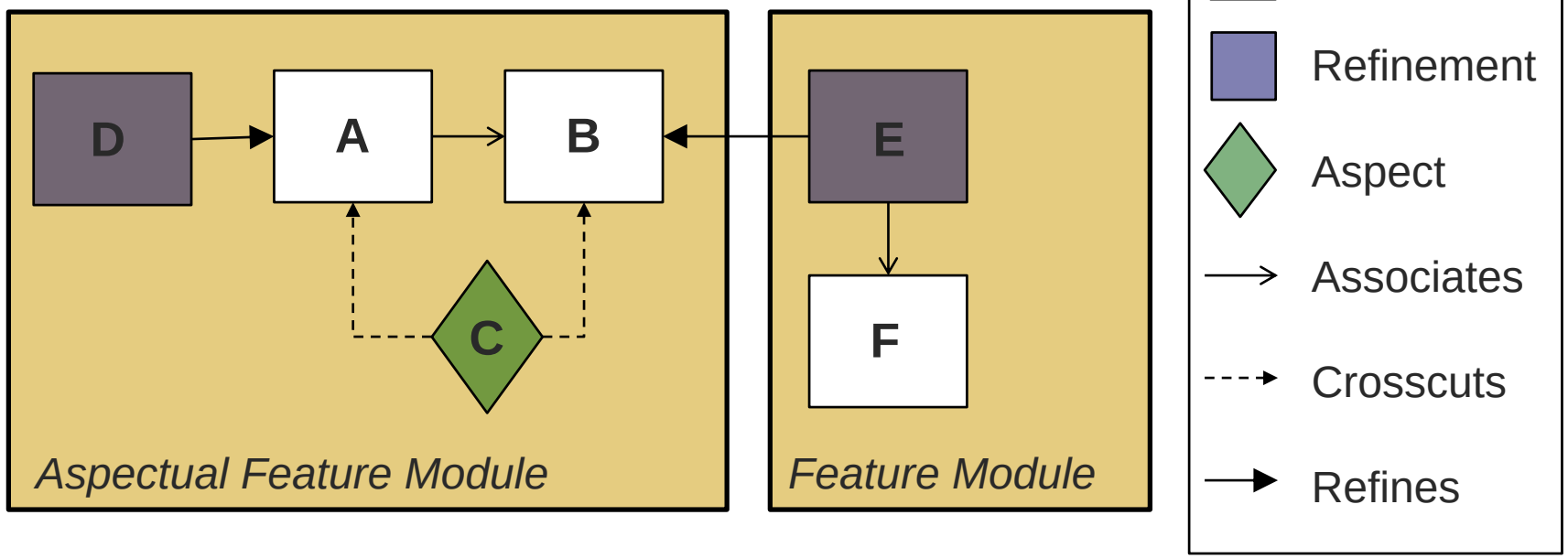
Combining Aspects and Feature Modules

Combining Approaches

- AOP and FOP are not competing approaches
  - They can be combined
- A program can be decomposed in three dimensions
  - Classes and interfaces
  - Features (refinements)
  - Aspects

Aspectual Feature Module

- Feature modules that contain aspects and refinements
- Example:



Bibliography

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- S. Apel, T. Leich, and G. Saake. **Aspectual Feature Modules**. IEEE Transactions on Software (TSE) Engineering, 34(2), 2008.