Mining framework concepts from application code

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Outline

Problem - Java Applet

```
import java.applet.Applet;


public class HelloApplet extends  Applet {









}
```

Problem - Java Applet

```
import javax.swing.JApplet;

public class HelloApplet extends JApplet {









}
```

Problem - Java Applet

```
import javax.swing.JApplet;

public class HelloApplet extends JApplet {




    public void init() {
        showStatus("Hello, world!");

    }



}
```

Problem - Java Applet

```
import javax.swing.JApplet;
import java.awt.event.KeyListener;

public class HelloApplet extends JApplet {

    KeyListener keyList = new KeyListener() {
        public void keyTyped(KeyEvent e) { /* Do something */ }
        public void keyPressed(KeyEvent e) {}
        public void keyReleased(KeyEvent e) {}
    }

    public void init() {
        showStatus("Hello, world!");

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    public void init() {
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        addKeyListener(keyList);
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}
```

Problem - Java Applet

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import javax.swing.JApplet;
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public class HelloApplet extends JApplet {

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        removeKeyListener(keyList);

}
```

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```
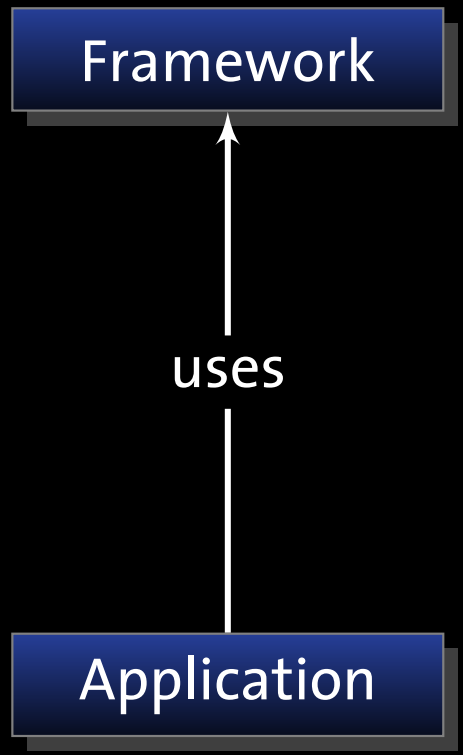
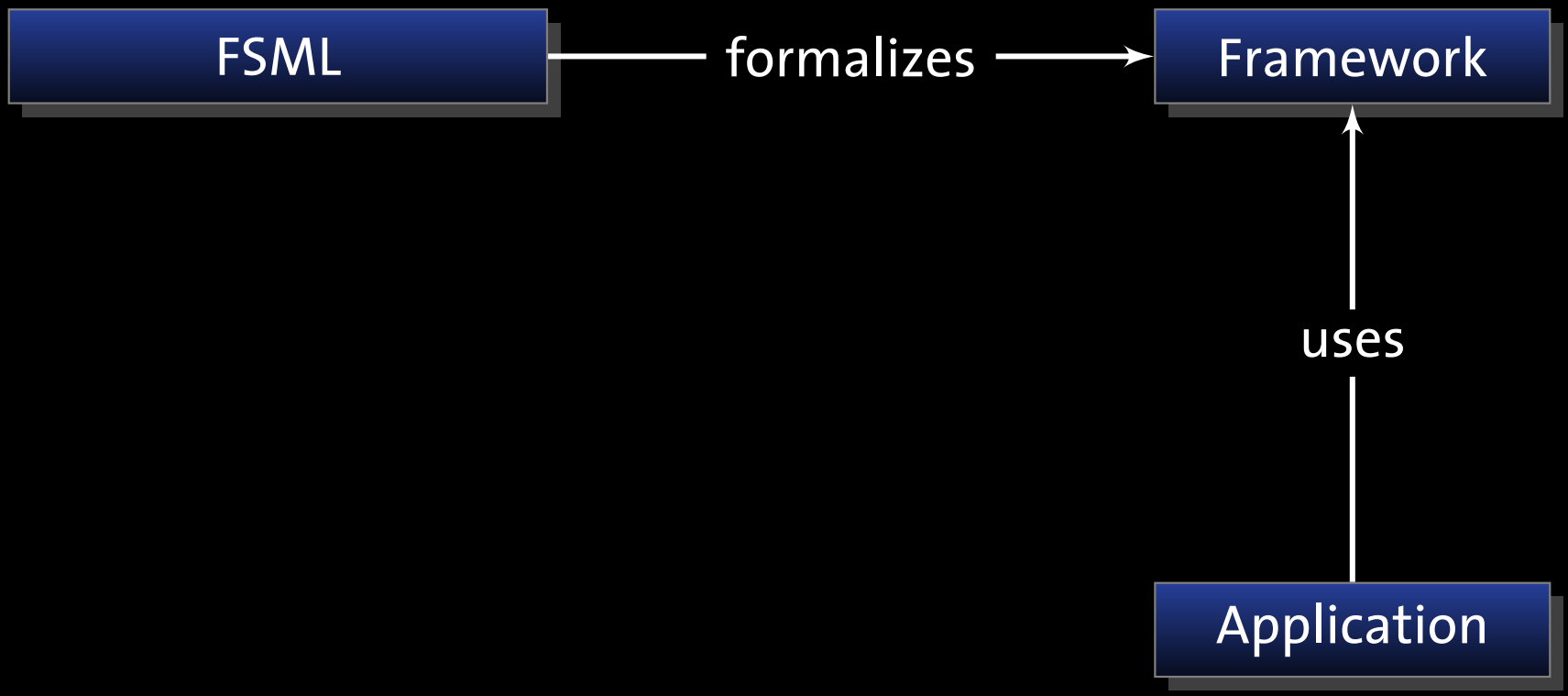

Framework-Specific Modelling Languages



[o] M. Antkiewicz, T. Tonelli Bartolomei, K. Czarnecki

Framework-Specific Modelling Languages



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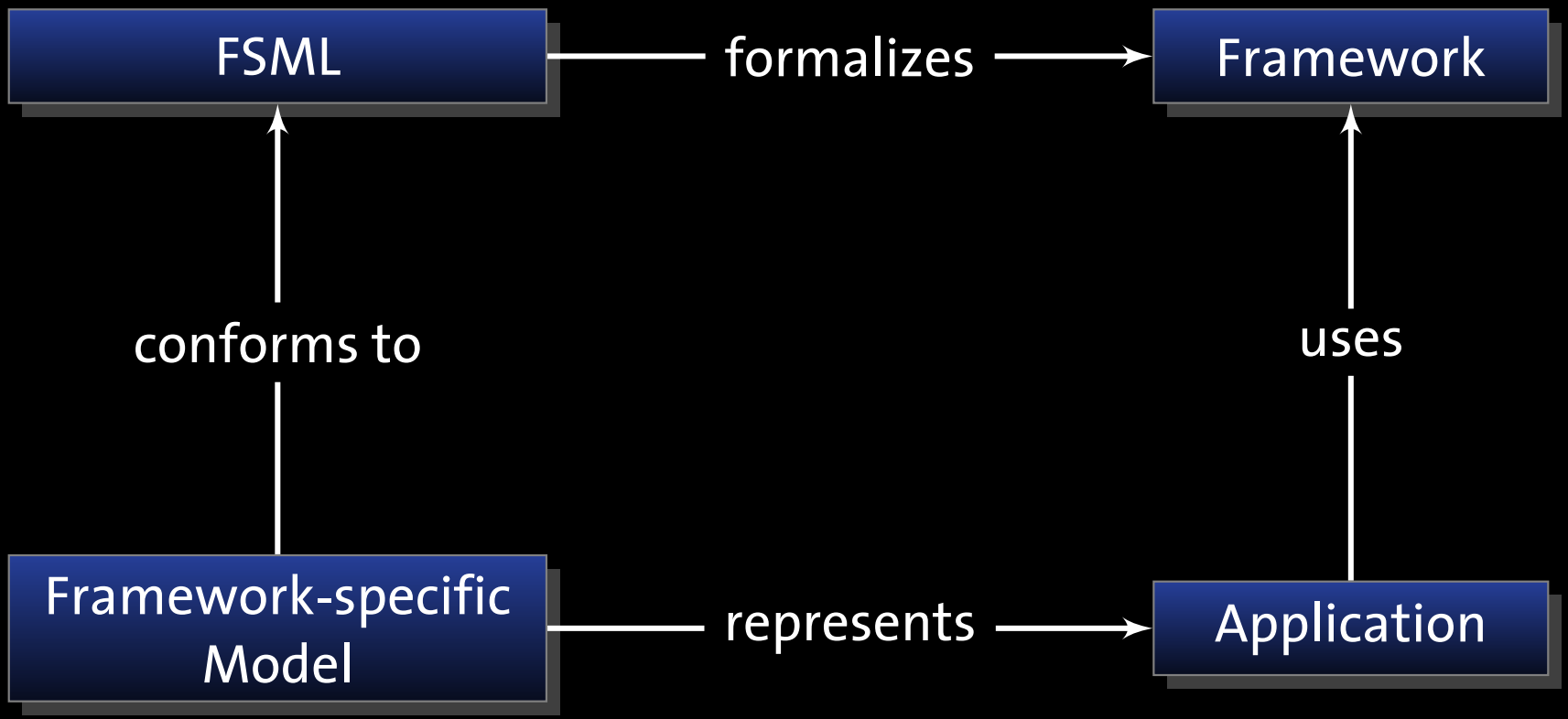

[o] M. Antkiewicz, T. Tonelli Bartolomei, K. Czarnecki

Applet FSML

Applet FSML
- [1..1] name (String) — **class** name
- **!**[1..1] extendsApplet — **extends** Applet
  - [0..1] extendsJApplet — **extends** JApplet
- [0..*] registersKeyListener — **calls** addKeyListener(...)
  - **!**⟨**1 - 1**⟩
    - [0..1] asThis
      - ...
    - [0..1] asAField — **parameter** is a field
      - [1..1] listenerField (String) — **field** name
      - [1..1] typedKeyListener — **typed** KeyListener(...)
      - [1..1] initialized — **assigned** an object
      - [1..1] deregisters — **calls** removeKeyListener(...)
- [0..*] showsStatus — **calls** showsStatus(...)
  - [1..1] message (String) — **parameter** value

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Forward & Reverse

Model

Applet Instance
- name ← ``HelloApplet''
- extendsApplet ← ✓
  - extendsJApplet ← *x*
- registersKeyListener ← *x*
  - ⟨group⟩
    - asThis ← *x*
      - ...
    - asAField ← *x*
      - listenerField (String) ← *x*
      - typedKeyListener ← *x*
      - initialized ← *x*
      - deregisters ← *x*
- showsStatus ← ✓
  - message ← ``Hello, world!''

Code

Forward & Reverse

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Code

```
public class HelloApplet extends Applet {



  public void init() {
    showStatus("Hello, world!");

  }



}
```

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- name ← ``HelloApplet''
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    - listenerField (String) ← ...
    - typedKeyListener ← ✓
    - **initialized** ← *x*
    - **deregisters** ← *x*
- showsStatus ← ✓
  - message ← ``Hello, world!''

Code

```
public class HelloApplet extends Applet {

  KeyListener keyList                                    ;

  public void init() {
    showStatus("Hello, world!");
    addKeyListener(keyList);
  }



}
```

Forward & Reverse

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- name ← ``HelloApplet''
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Code

```
public class HelloApplet extends Applet {

  KeyListener keyList = new KeyListener() { … };

  public void init() {
    showStatus("Hello, world!");
    addKeyListener(keyList);
  }

  public void destroy() {
    removeKeyListener(keyList);
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```
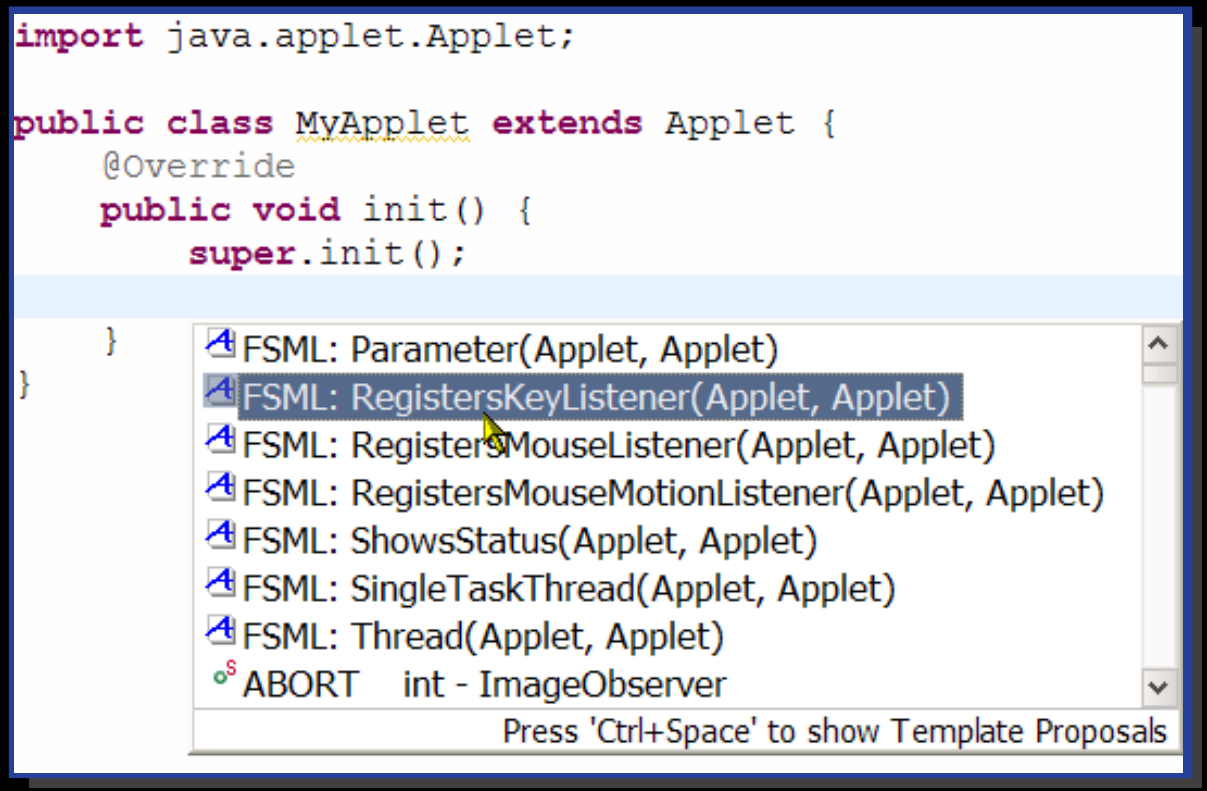
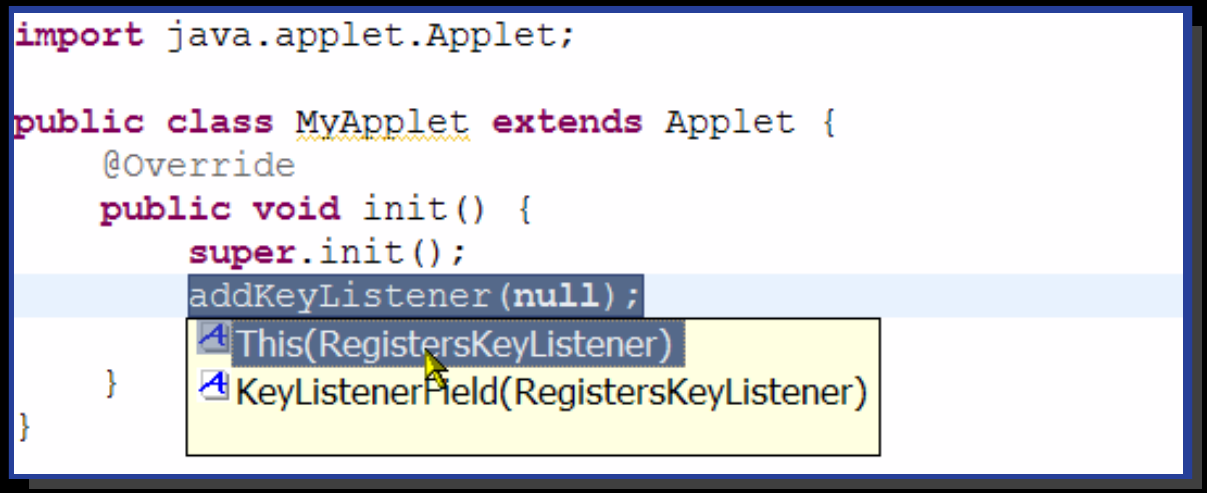

Tool Support: Forward Eng.



[o] H. M. Lee. Model-guided Code Assistance for Framework Application Development.

Tool Support: Forward Eng. (cont.)



[9] H. M. Lee. Model-guided Code Assistance for Framework Application Development.

Tool Support: Forward Eng. (cont.)

```
import java.applet.Applet;
import java.awt.event.KeyListener;
import java.awt.event.KeyEvent;

public class MyApplet extends Applet implements KeyListener {
    @Override
    public void init() {
        super.init();
        addKeyListener(this);

    }

    public void destroy() {
        super.destroy();
        removeKeyListener(this);
    }

    public void keyTyped(KeyEvent keyEvent) {
    }

    public void keyPressed(KeyEvent keyEvent) {
    }

    public void keyReleased(KeyEvent keyEvent) {
    }
}
```

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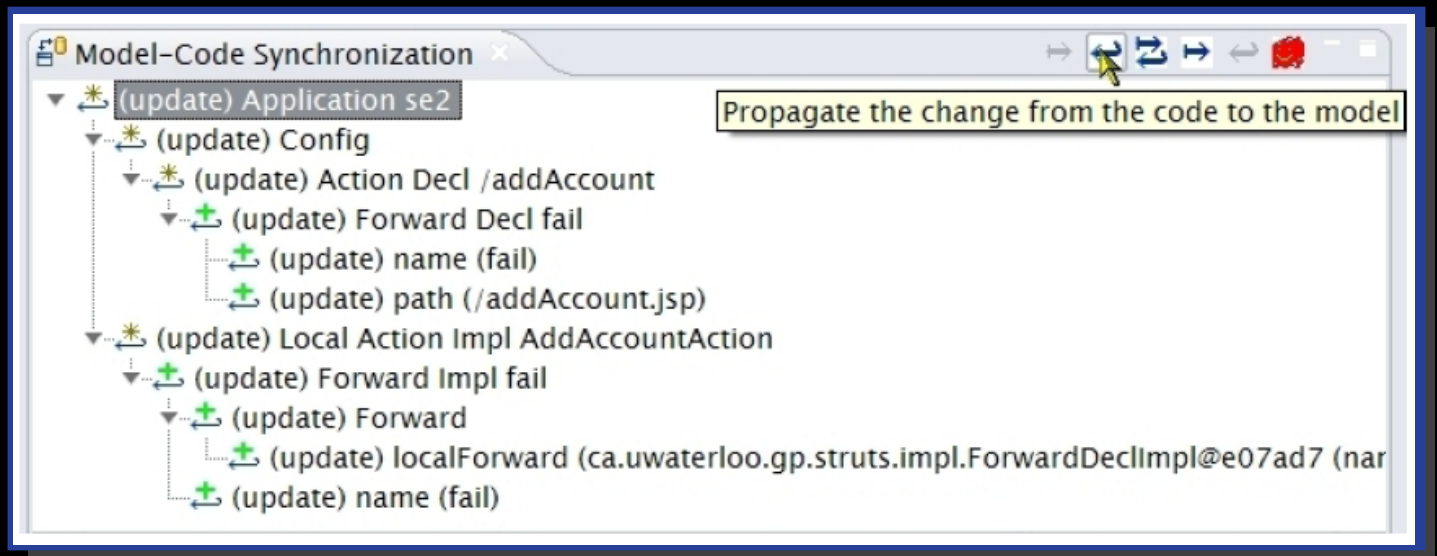
Tool Support: Reverse Engineering



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Constructing FSMLs

FSMLs are great!

But, how are they constructed?

- Creator must have an in-depth understanding of the framework.
- Examine tutorials and documentation.
- Examine boiler-plate code and example applications.

...currently an entirely **manual** process.

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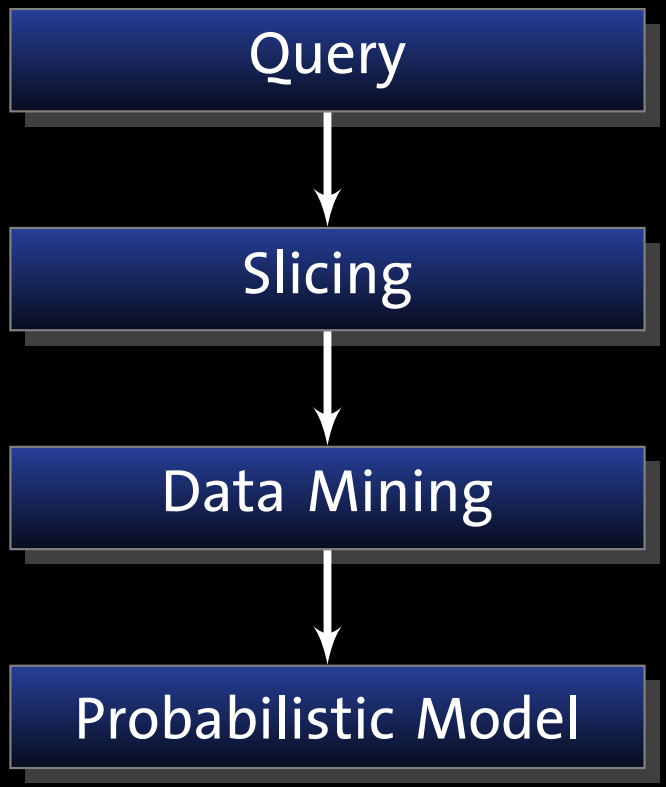
Mining for Framework Concepts



Provide hints for finding concept statements.

Find related statements.

Find usage patterns among multiple examples.

Output a probabilistic model describing usage.

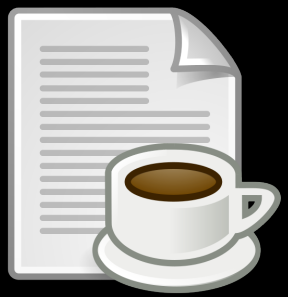
Input Query

```
public class HelloWorldPresentation extends JApplet {
  public static final String HELLO_WORLD = "Hello World!";
  public HelloWorldPresentation() {
    Container contentPane = getContentPane();
    JLabel hwLabel = new JLabel(HELLO_WORLD);
    StringBuilder builder = new StringBuilder(HELLO_WORLD);
    Formatter fmt = new Formatter(builder);
    fmt.format("%s %s", HELLO_WORLD, HELLO_WORLD);
    contentPane.add(hwLabel);
  }
}
```

User selects lines of code in a framework application.

Concept Slicing

Reduce an example to a minimal set of statements that retains the specified behaviour.



Source code with Query

Concept Slicing

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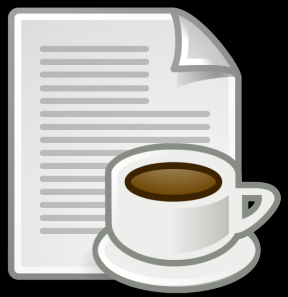
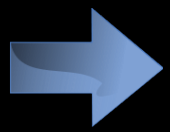


Source code with Query



Program Slicer

Concept Slicing

Reduce an example to a minimal set of statements that retains the specified behaviour.

Source code with Query

Program Slicer

Relevant Statements

Concept Slicing

```
public class HelloApplet extends JApplet {
    KeyListener keyList = new KeyListener() { … }
    Image smiley;

    public void init() {
        smiley = getImage(getCodeBase(), "images/smile.gif");
        showStatus("Hello, world!");
        addKeyListener(keyList);
        play(getCodeBase(), "audio/woohoo.wav");
    }

    public void destroy() {
        removeKeyListener(keyList);
    }
}
```

Concept Slicing

```
public class HelloApplet extends JApplet {
    KeyListener keyList = new KeyListener() { … }
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        smiley = getImage(getCodeBase(), "images/smile.gif");
        showStatus("Hello, world!");
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    }

    public void destroy() {
        removeKeyListener(keyList);
    }
}
```
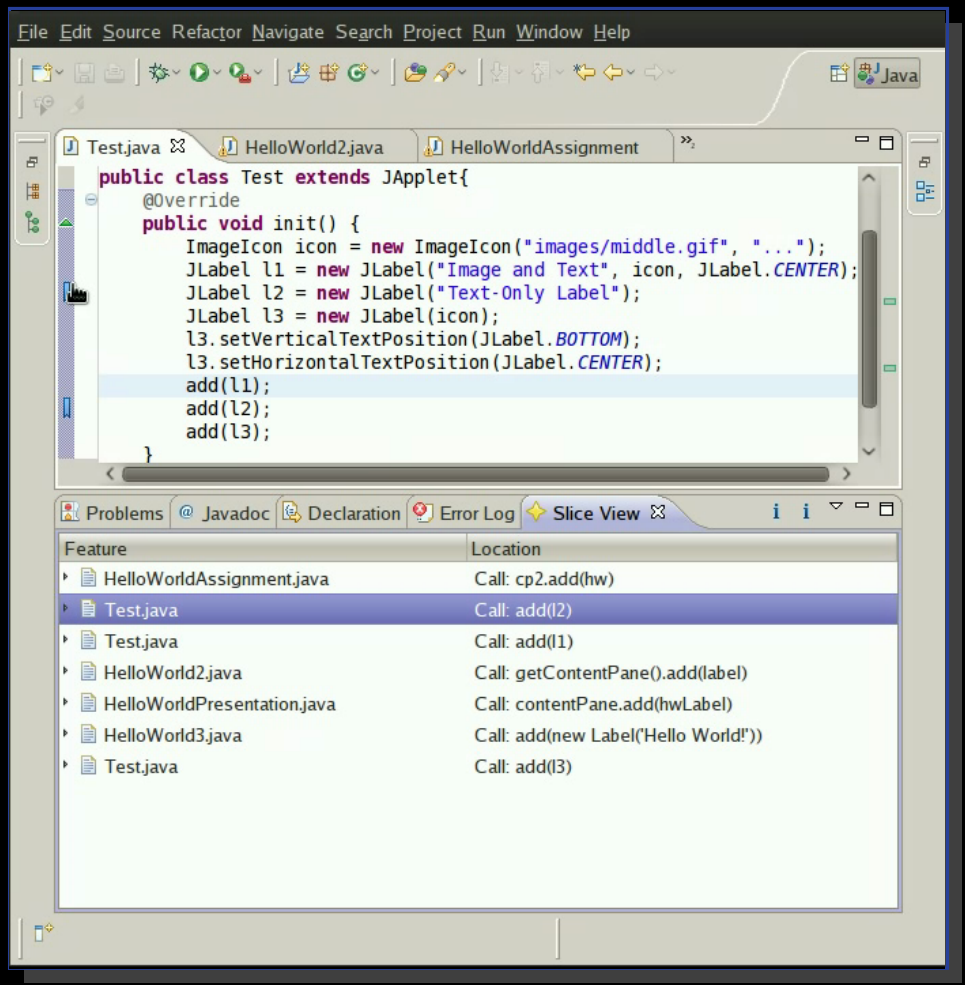

Sliced Statements

Example	Location	Statement
HelloApplet	Class	*field*:keyList (KeyListener)
HelloApplet	initializer	*assigns*:keyList = new KeyListener()
HelloApplet	init()	*calls*:addKeyListener(keyList)
HelloApplet	destroy()	*calls*:removeKeyListener(keyList)

Finding Related Usages

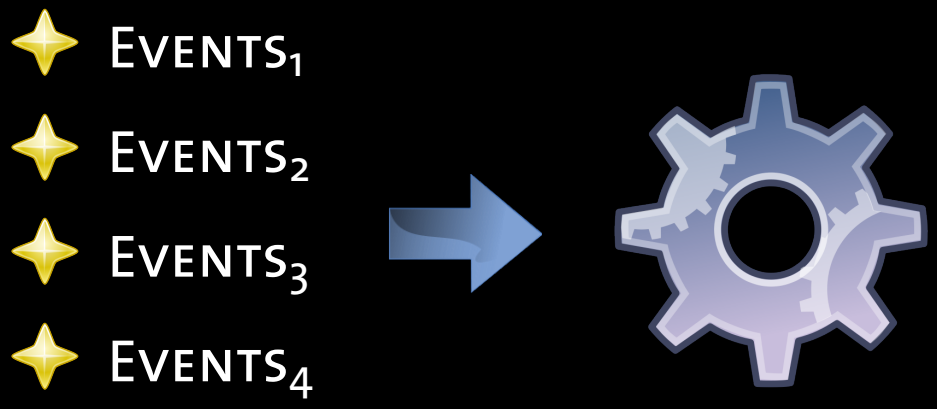


Reverse-Engineering the Model

- EVENTS_1
- EVENTS_2
- EVENTS_3
- EVENTS_4

Sliced Events

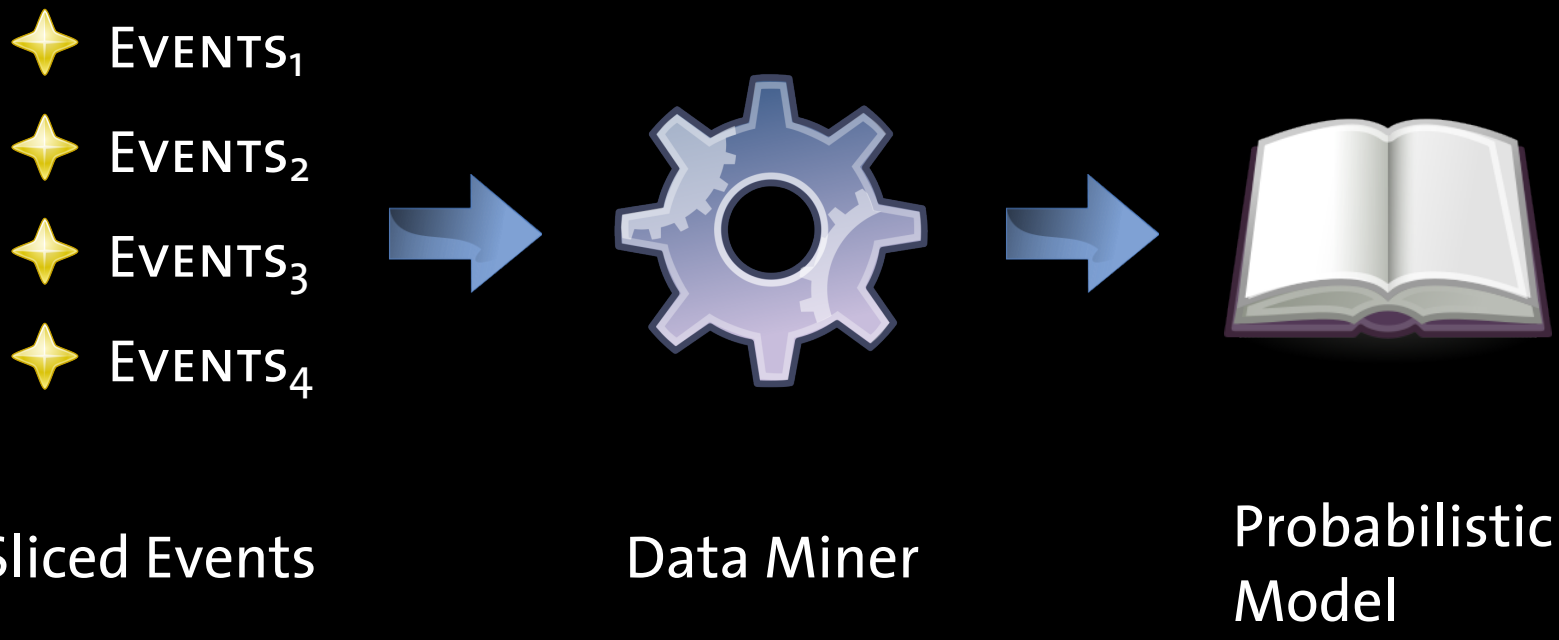
Reverse-Engineering the Model



Sliced Events

Data Miner

Reverse-Engineering the Model



Feature Model Mining

Mine for probabilistic expressions from slices gathered from multiple applications.

[9] K. Czarnecki, A. Wasowski, S. She.

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Association Rule	conf
KeyListener $\Rightarrow$ asThis $\vee$ asAField	100%

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Association Rule	conf
KeyListener $\Rightarrow$ asThis $\vee$ asAField	100%
asAField $\Rightarrow \neg$ asThis	100%

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Feature Model Mining

Mine for probabilistic expressions from slices gathered from multiple applications.

Association Rule	conf
KeyListener $\Rightarrow$ asThis $\vee$ asAField	100%
asAField $\Rightarrow \neg$ asThis	100%
KeyListener $\Rightarrow$ asAField	70%
KeyListener $\Rightarrow$ asThis	30%

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Feature Model Mining

Mine for probabilistic expressions from slices gathered from multiple applications.

Association Rule	conf
KeyListener $\Rightarrow$ asThis $\vee$ asAField	100%
asAField $\Rightarrow \neg$ asThis	100%
KeyListener $\Rightarrow$ asAField	70%
KeyListener $\Rightarrow$ asThis	30%
asAField $\Leftrightarrow$ new KeyListener()	100%

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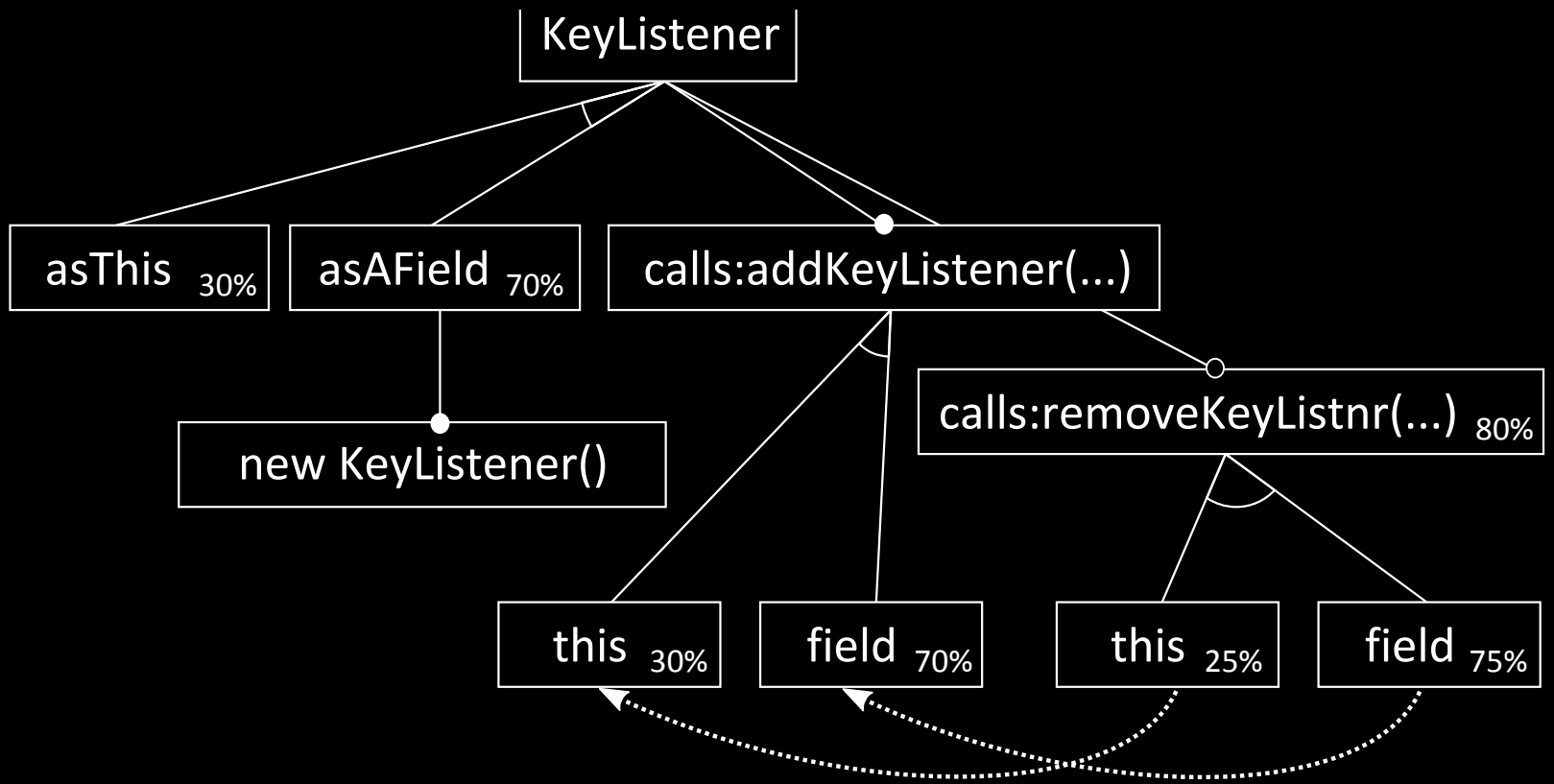
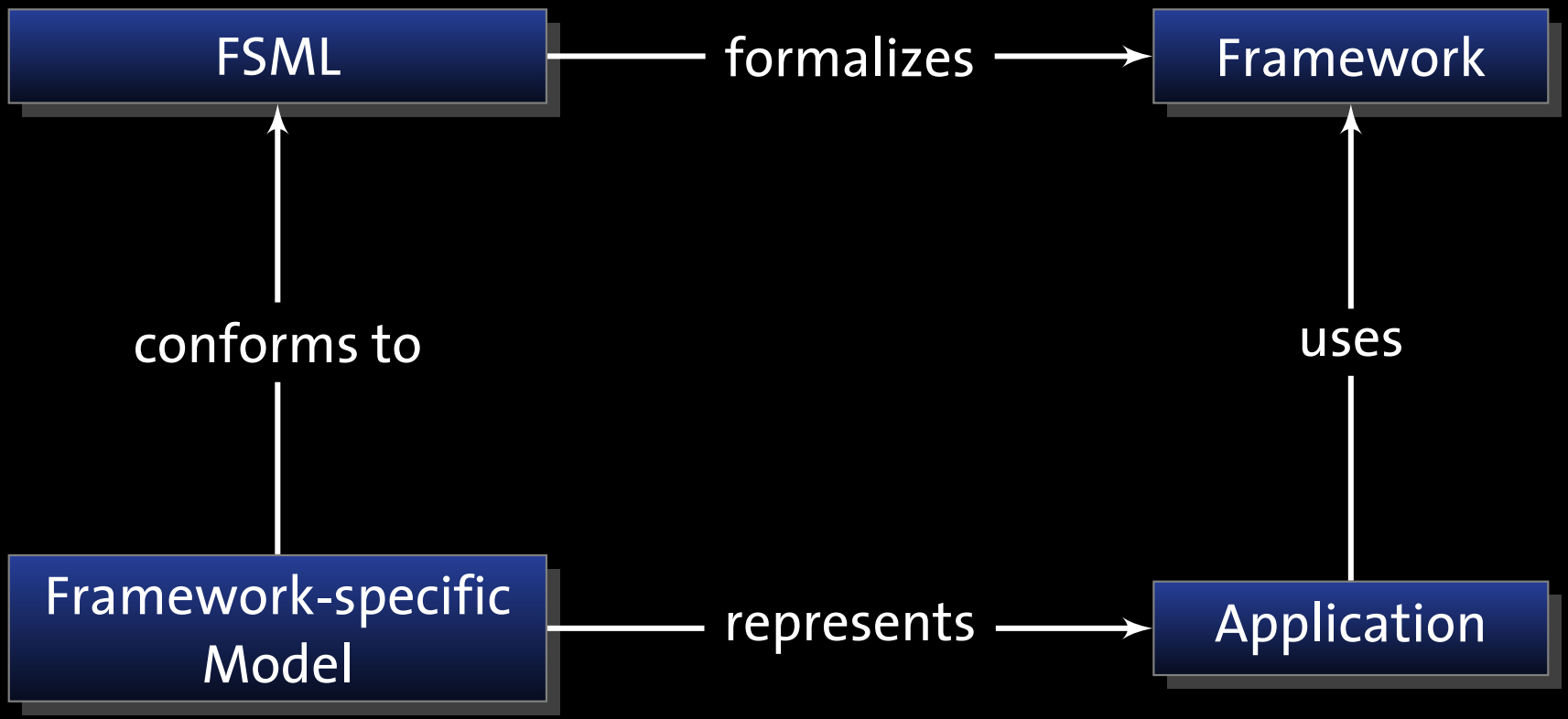
Mined Feature Model



Framework-Specific Modelling Languages



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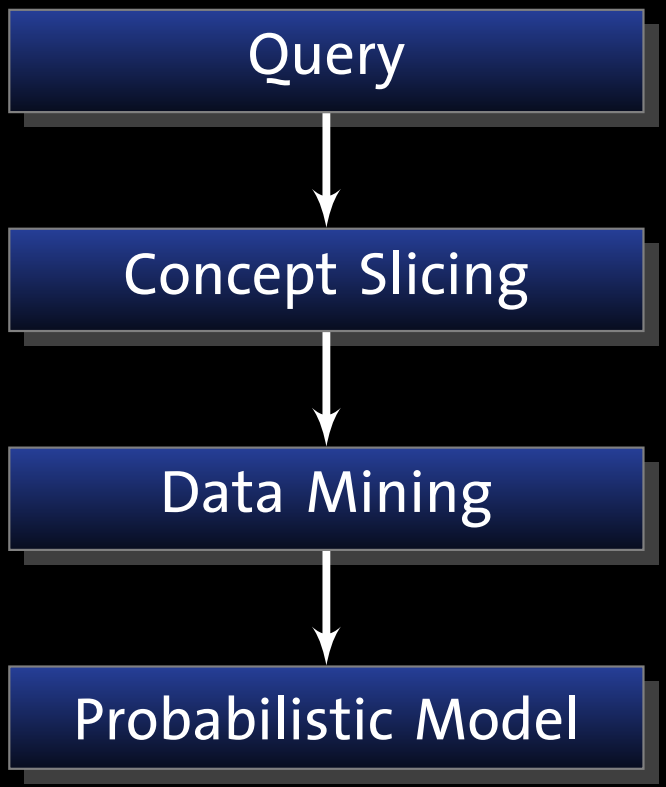
Conclusions



- Constructs a **recipe** from a set of examples.
- **Slicing** finds related statements given a query.
- **Data mining** finds patterns in sliced statements to form a probabilistic model.