Detecting Object Usage Anomalies

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Andreas Zeller
Christian Lindig

Saarland University



Some AspectJ method

```
private boolean verifyNIAP (…) {
    …
    Iterator iter = …;
    while (iter.hasNext()) {
        … = iter.next();
        …
        return verifyNIAP (…);
    }
    return true;
}
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Never loops!

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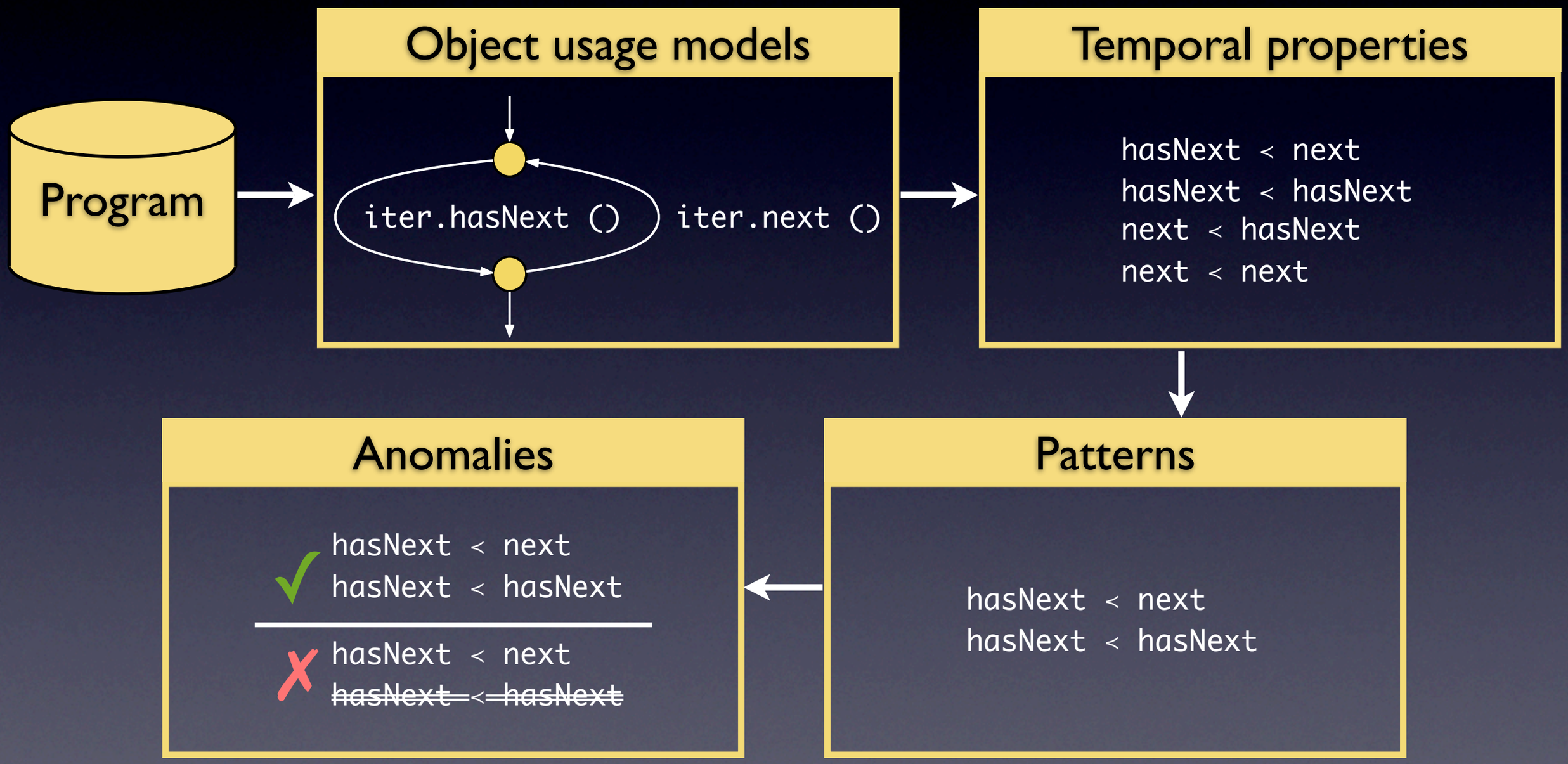
Never loops!

Violates typical iterator usage pattern

JADET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iter.hasNext ()
iter.next ()
Temporal properties
hasNext ≺ next
hasNext ≺ hasNext
next ≺ hasNext
next ≺ next
Patterns
hasNext ≺ next
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Anomalies
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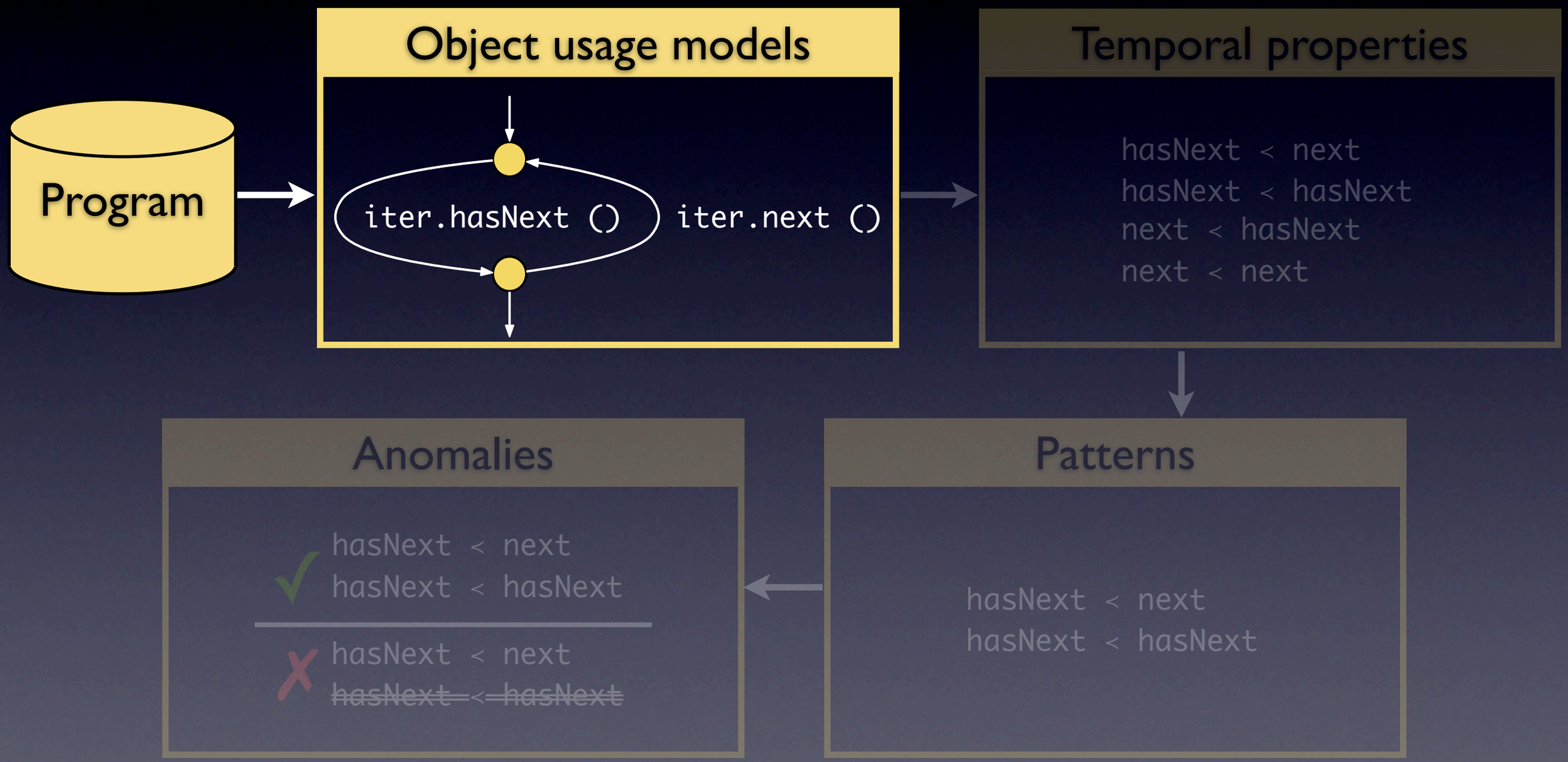
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Creating a method model

```
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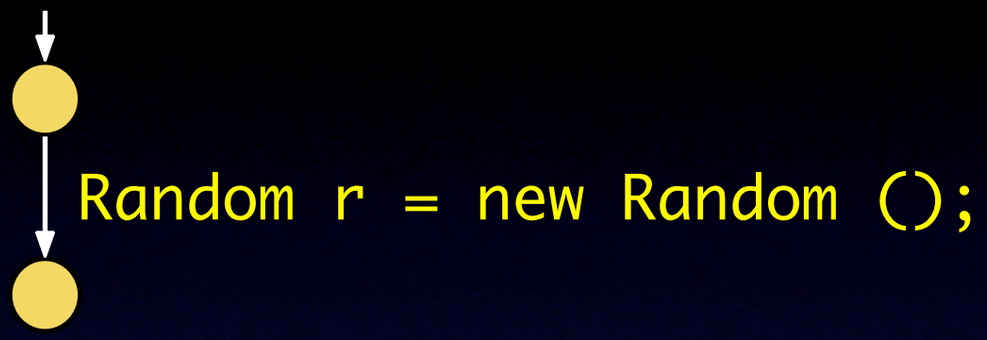


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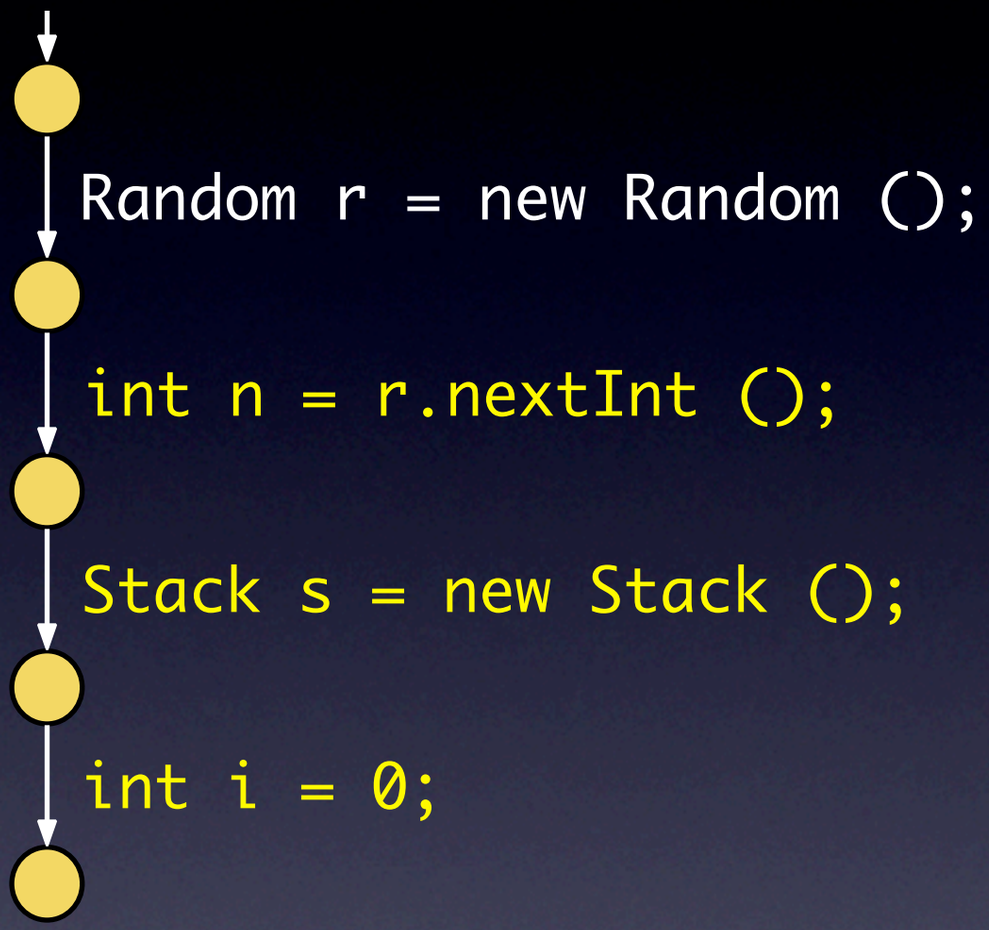

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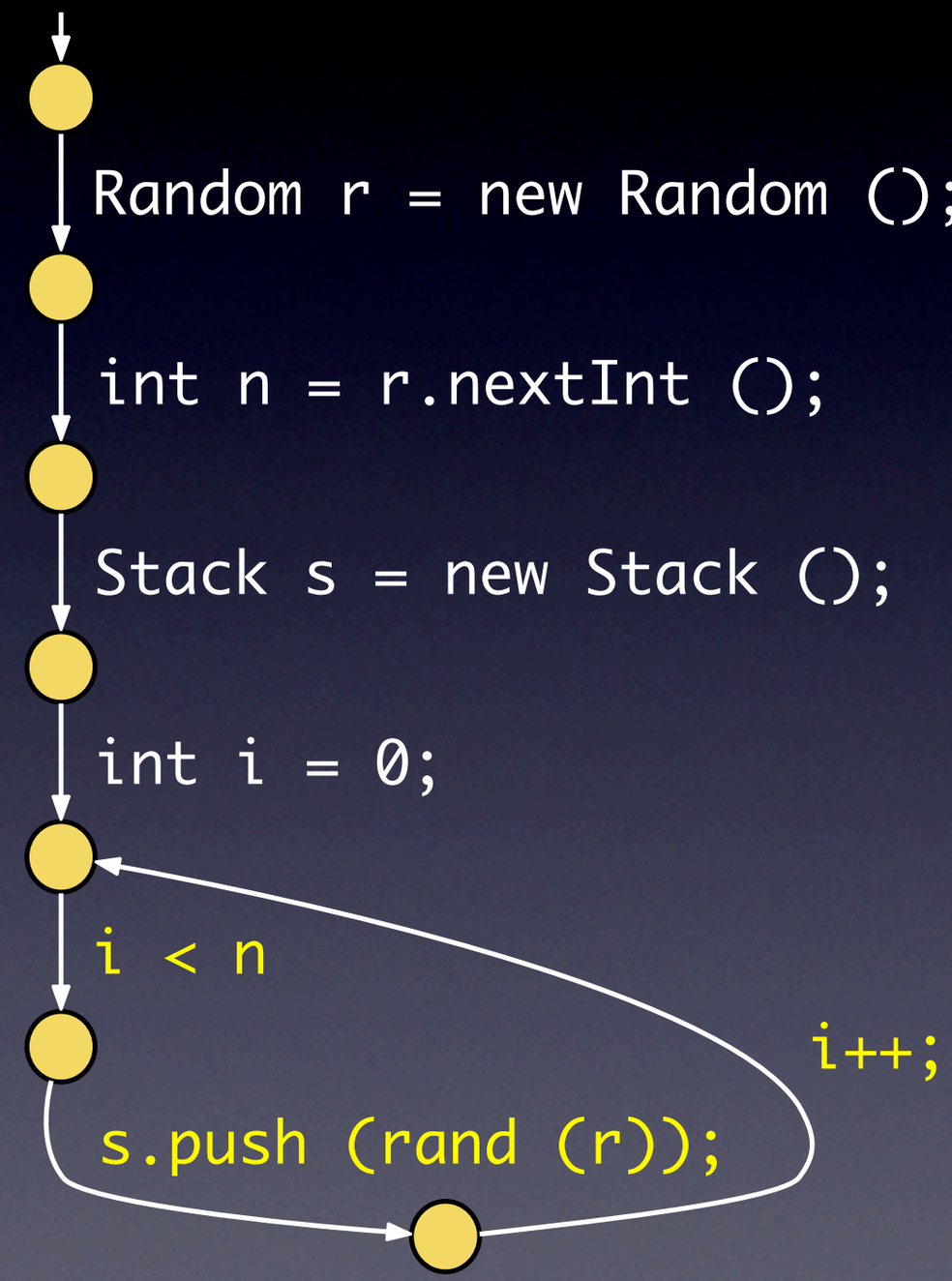

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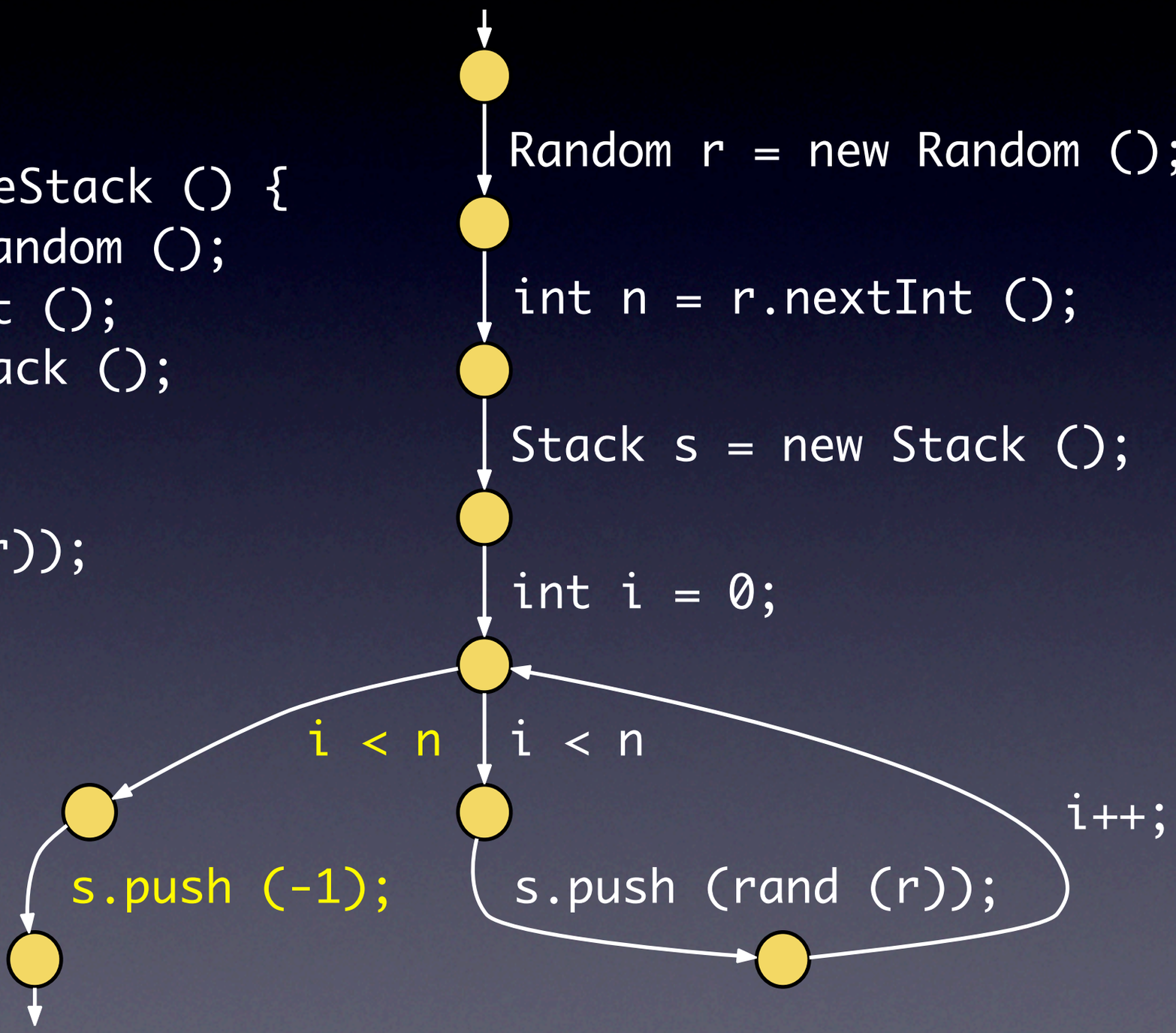

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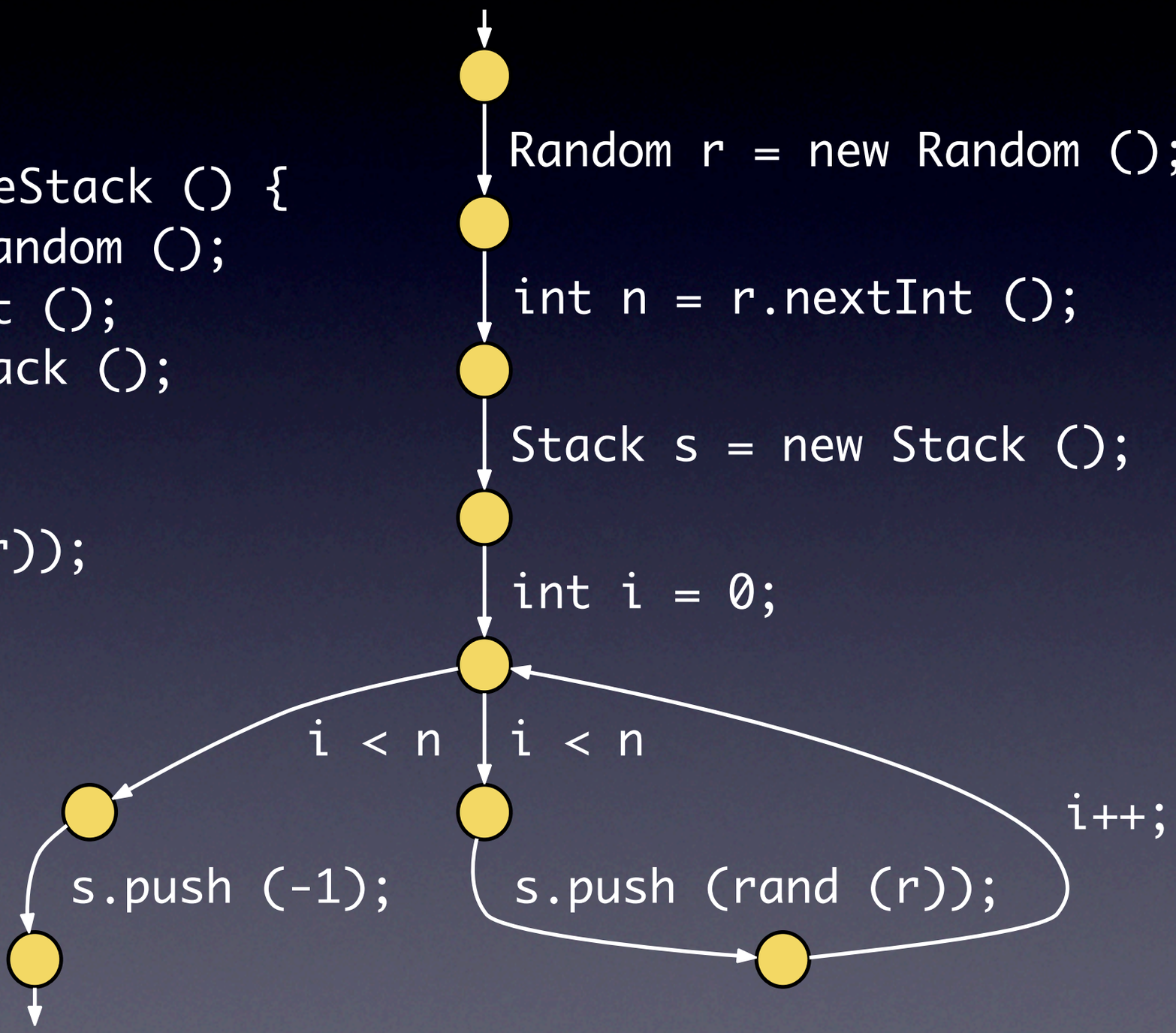

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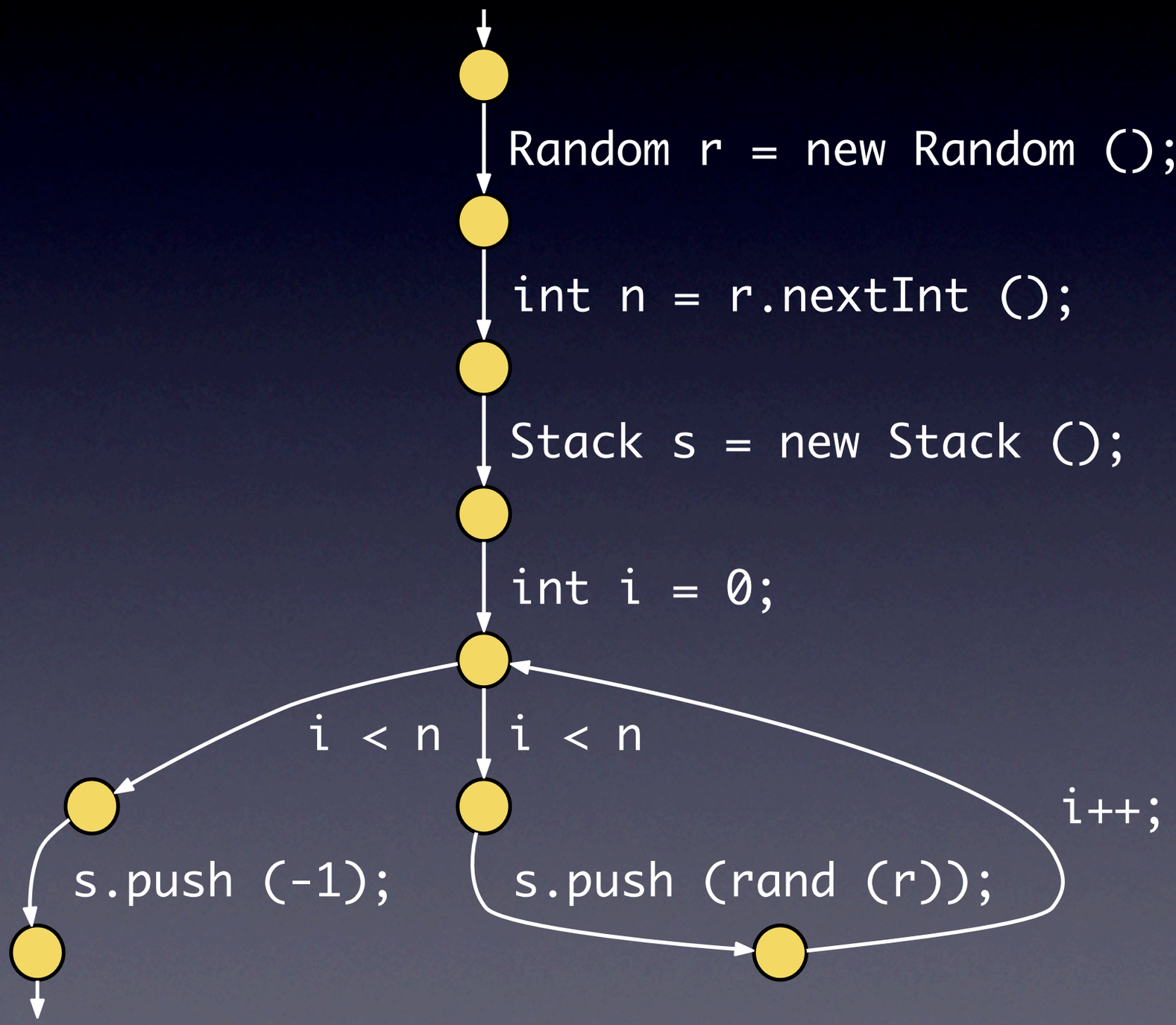

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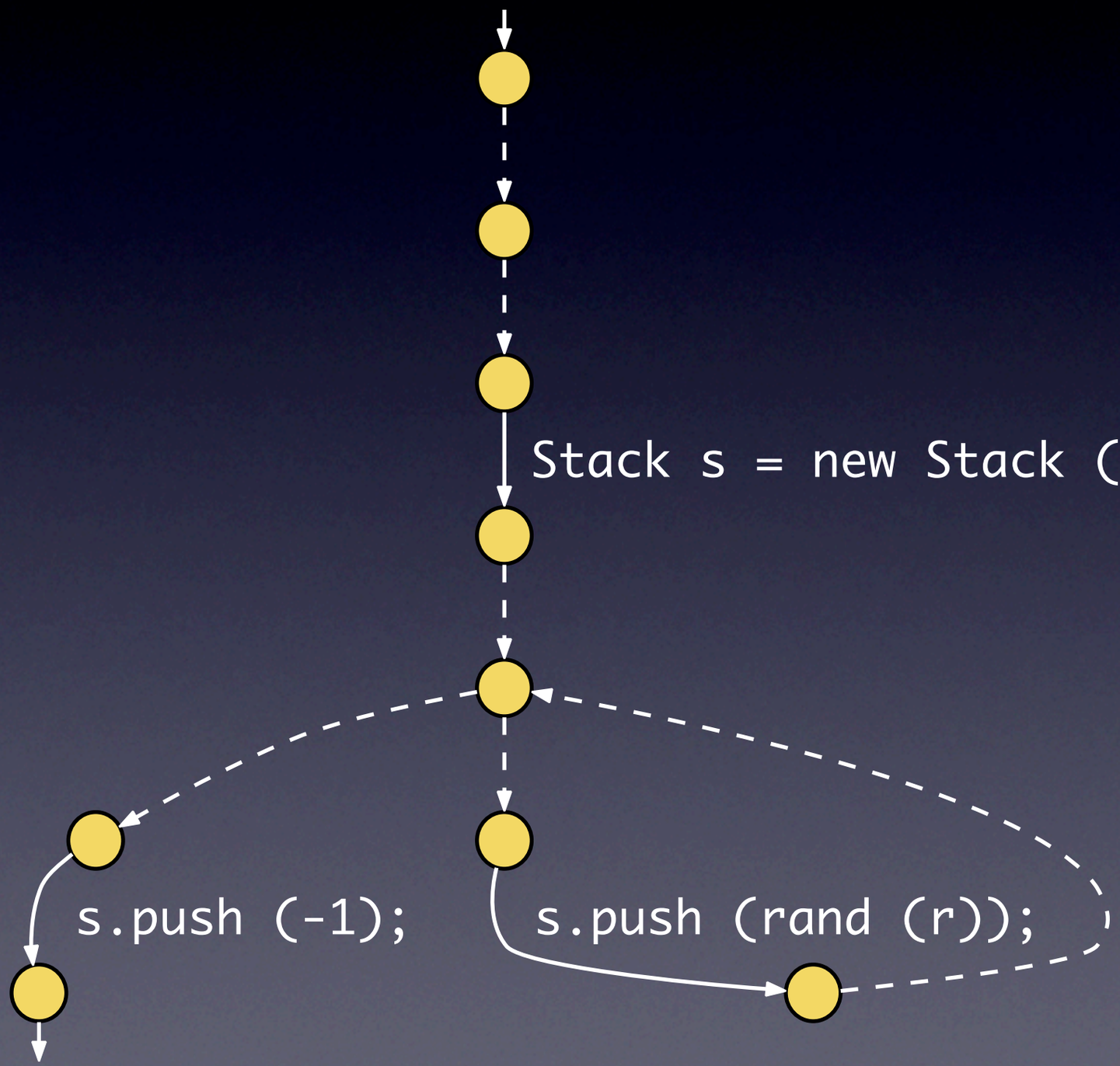

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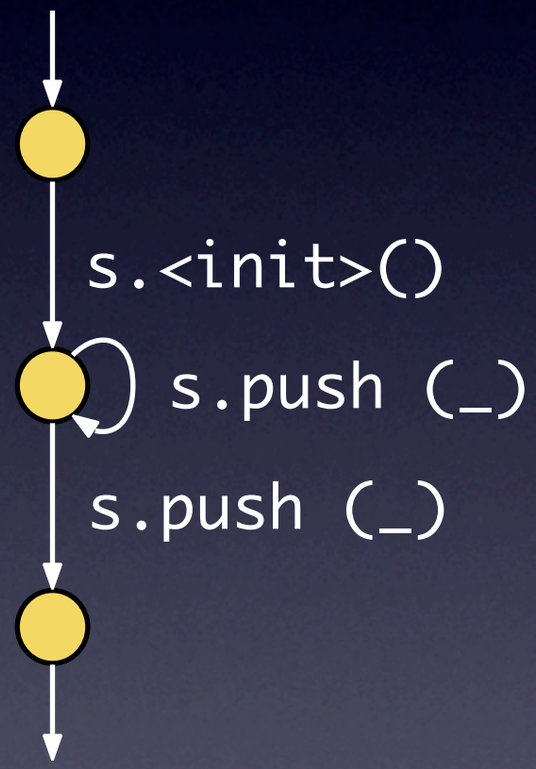

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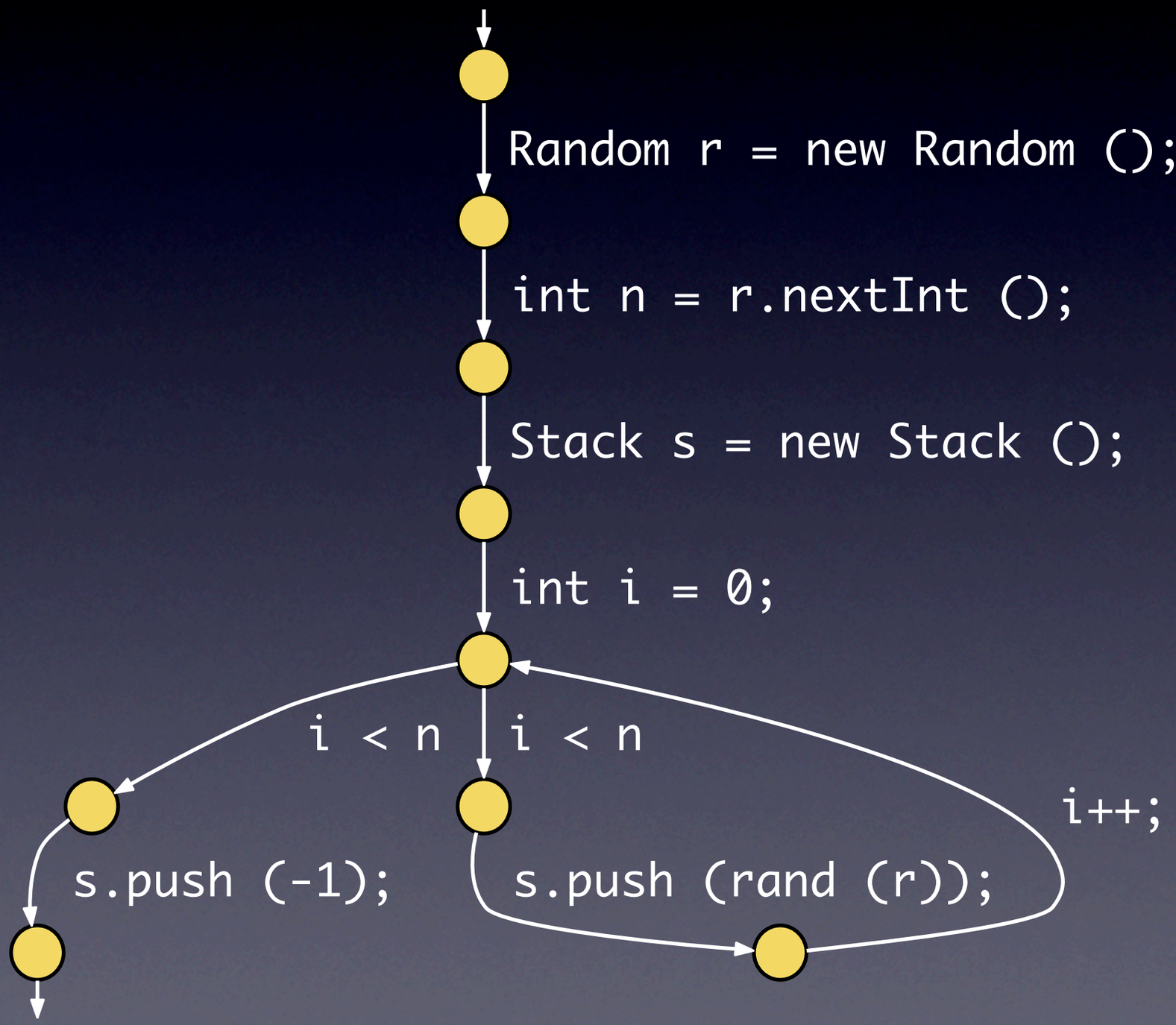

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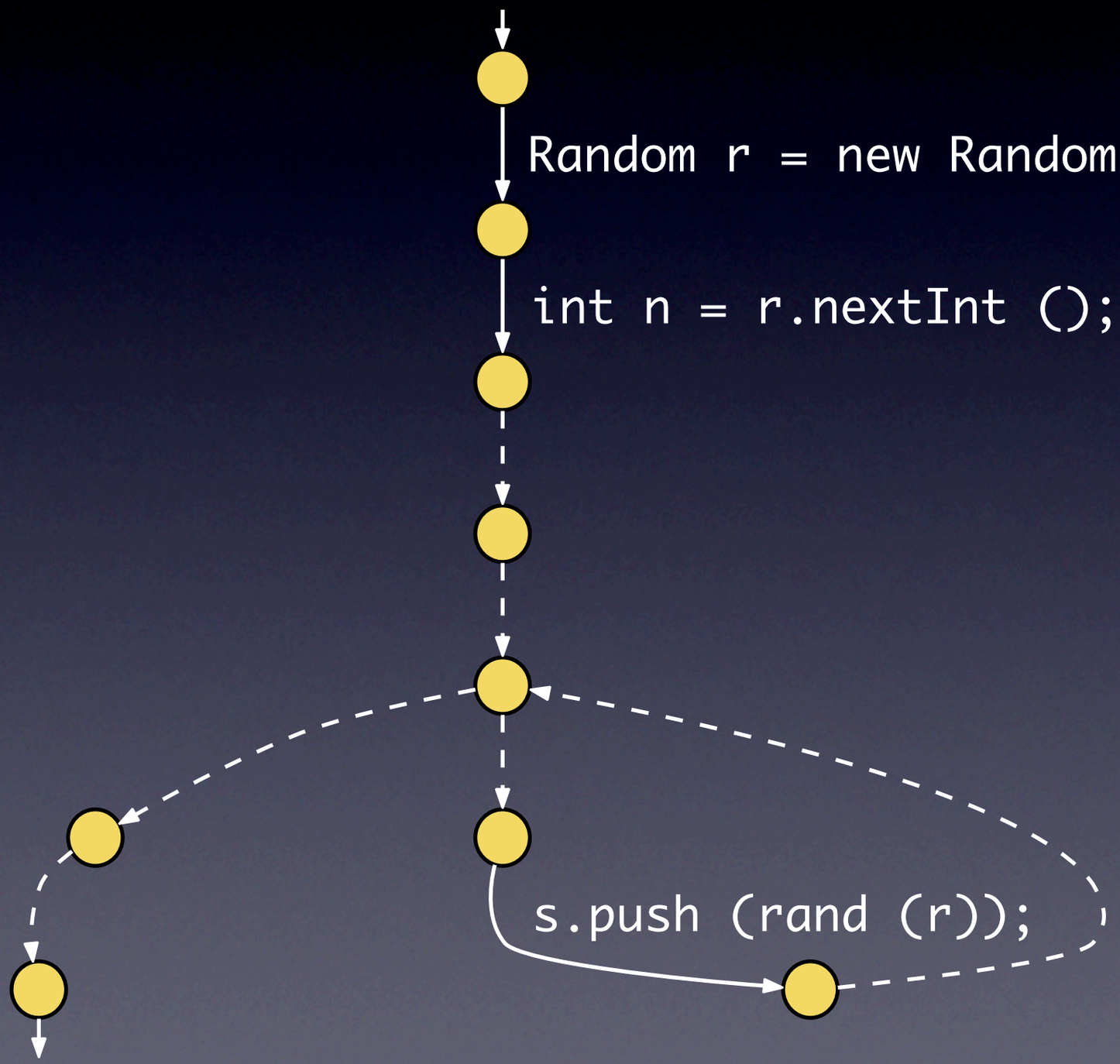

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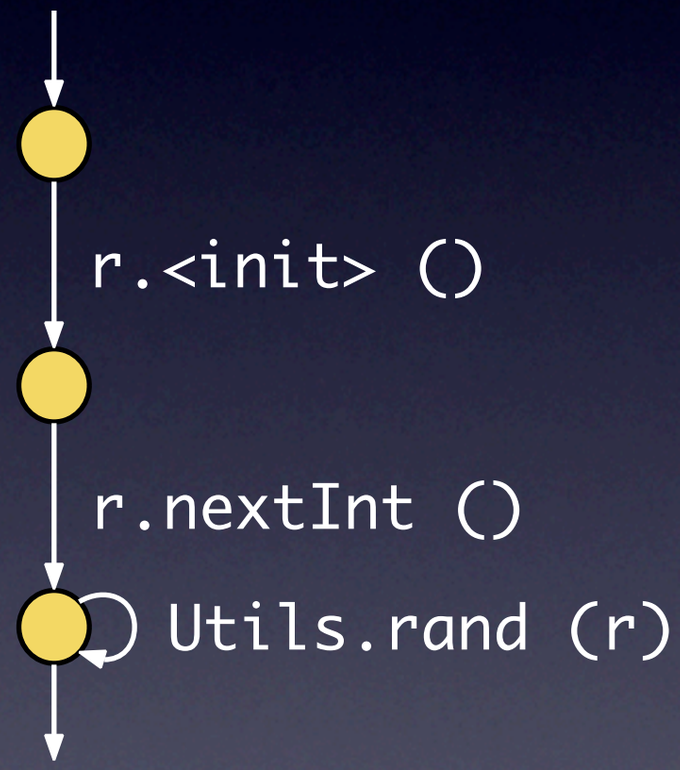
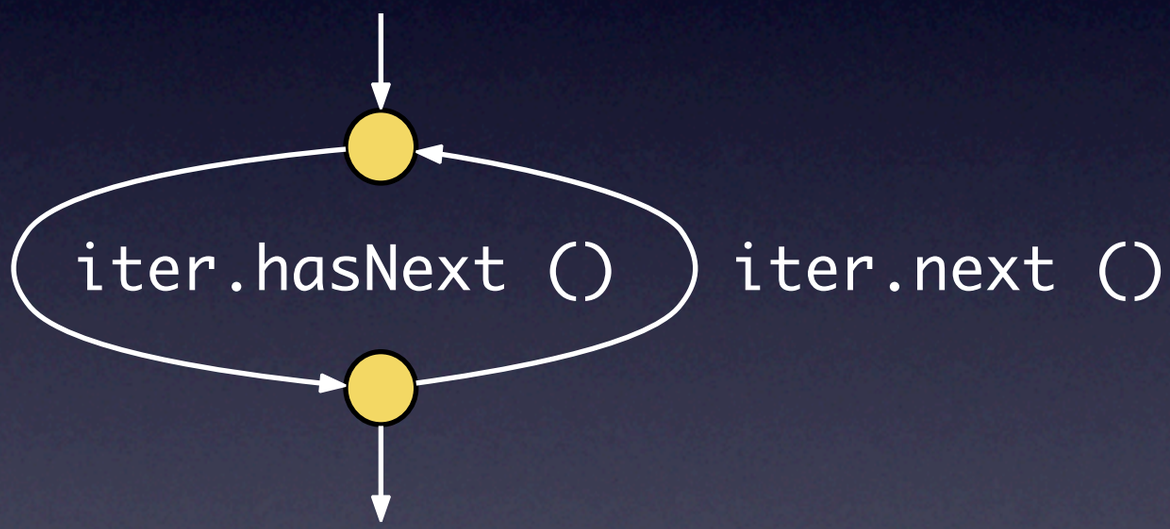


Iterator models

Typical



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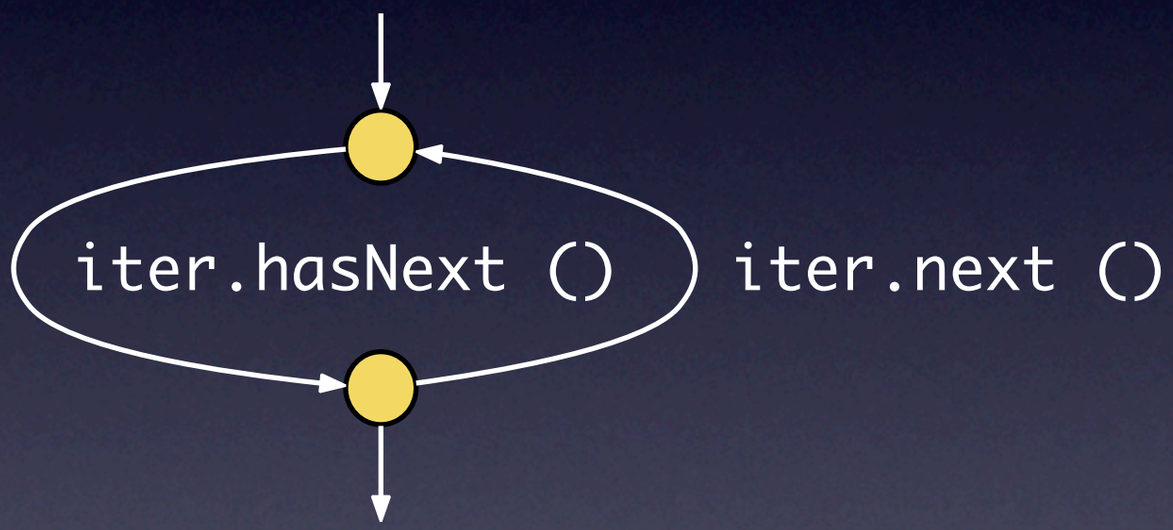


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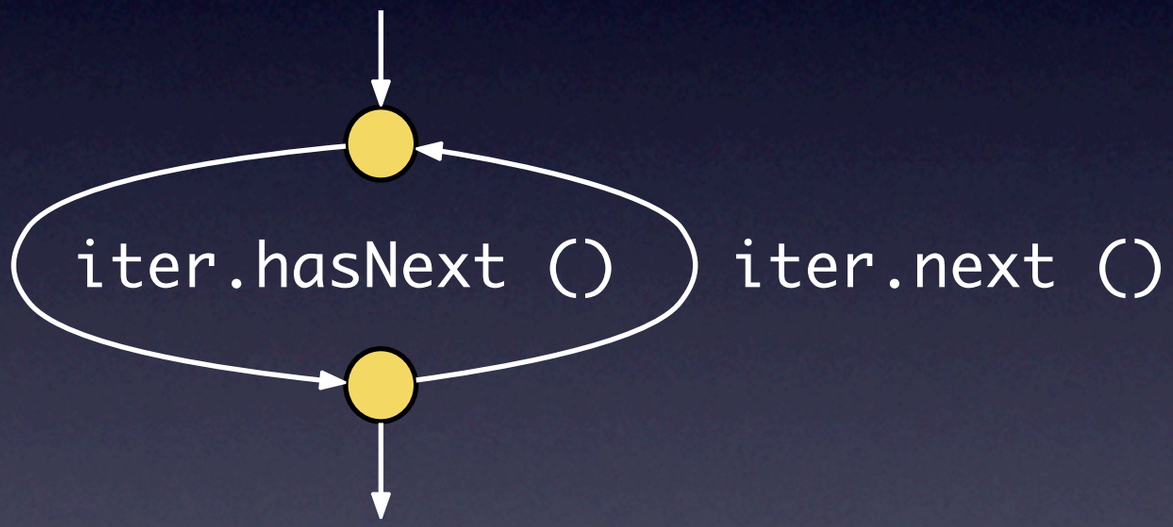
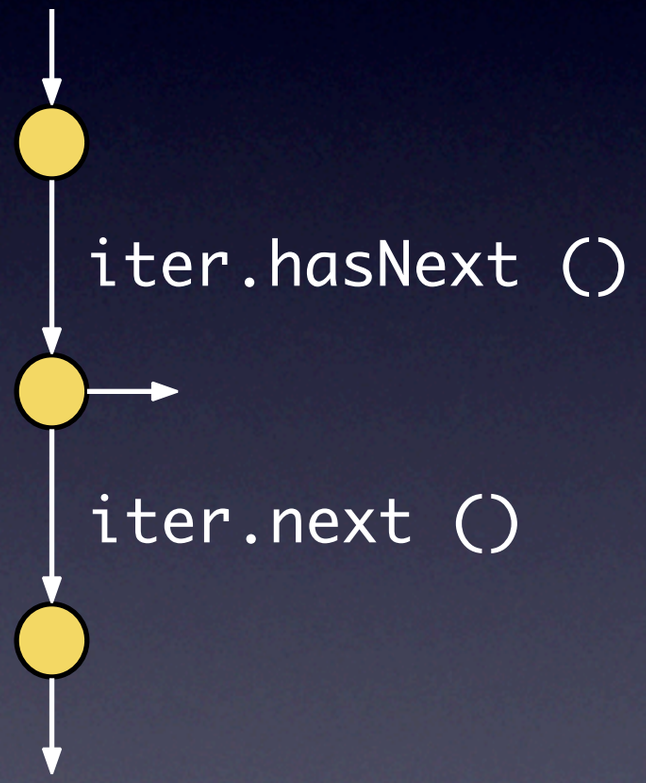


Anomalous



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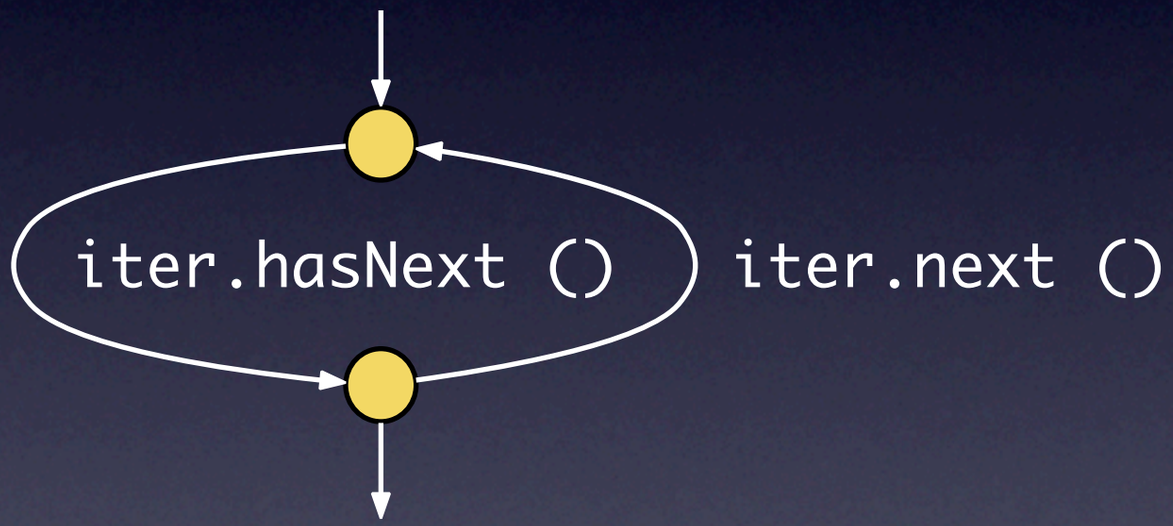

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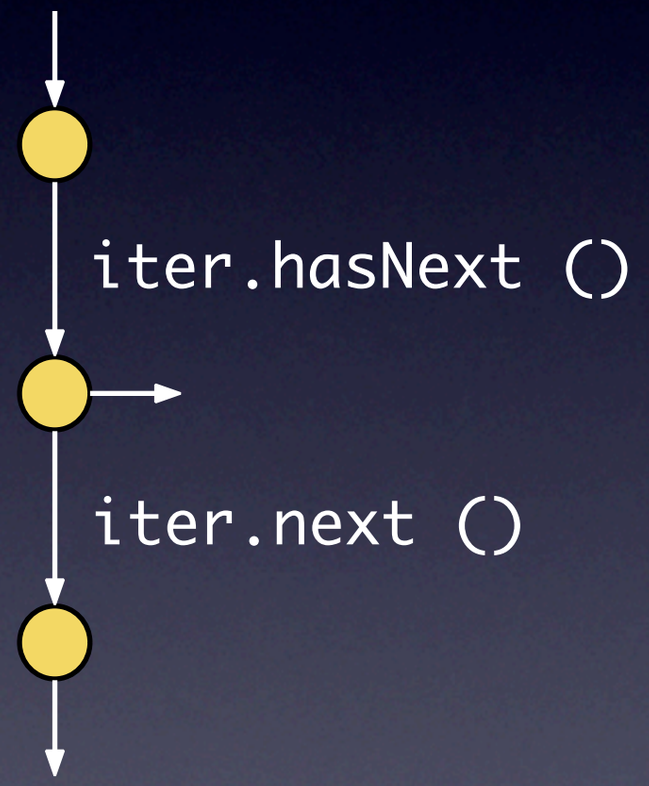
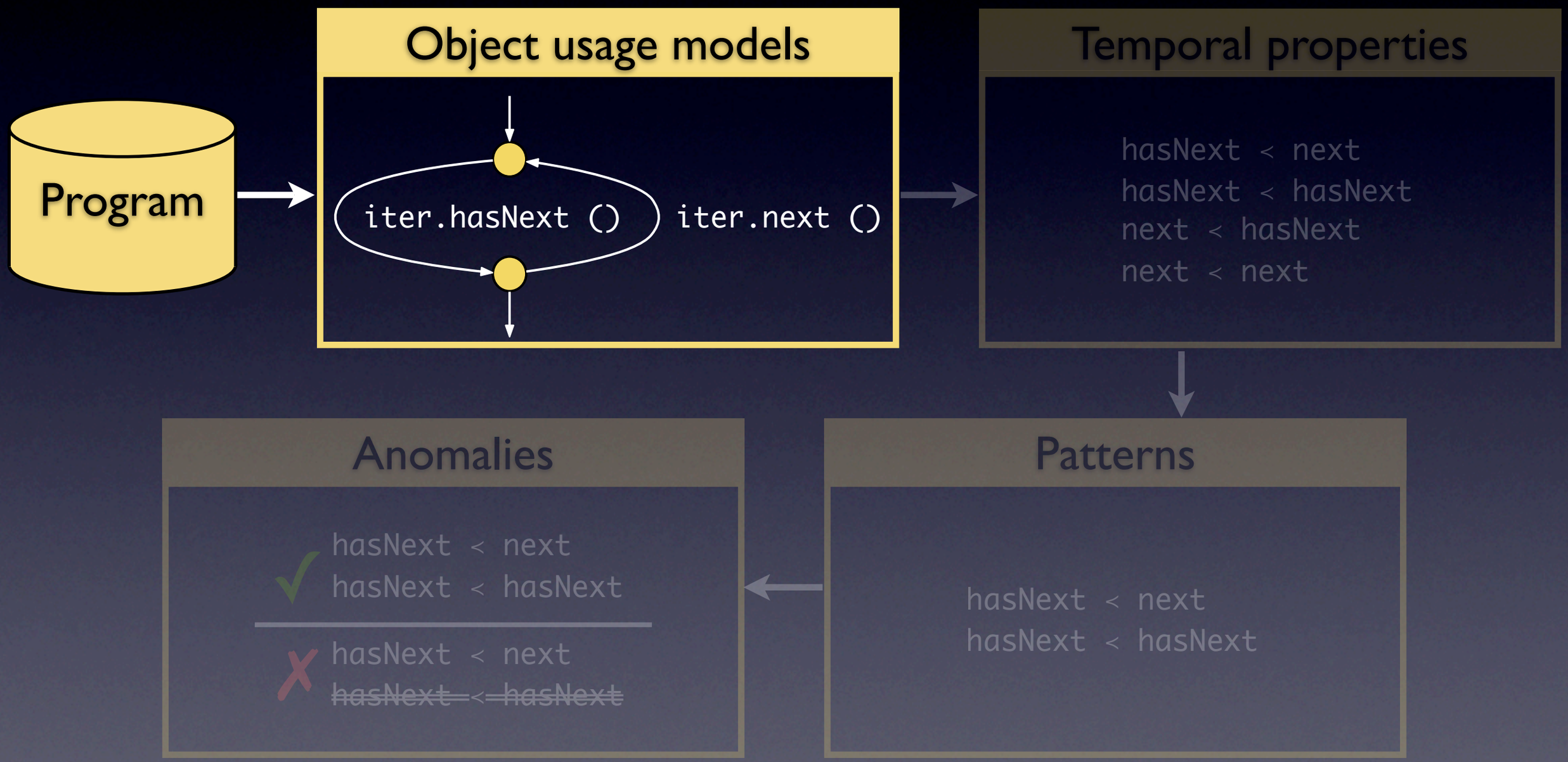


How do we quantify such difference?

JADET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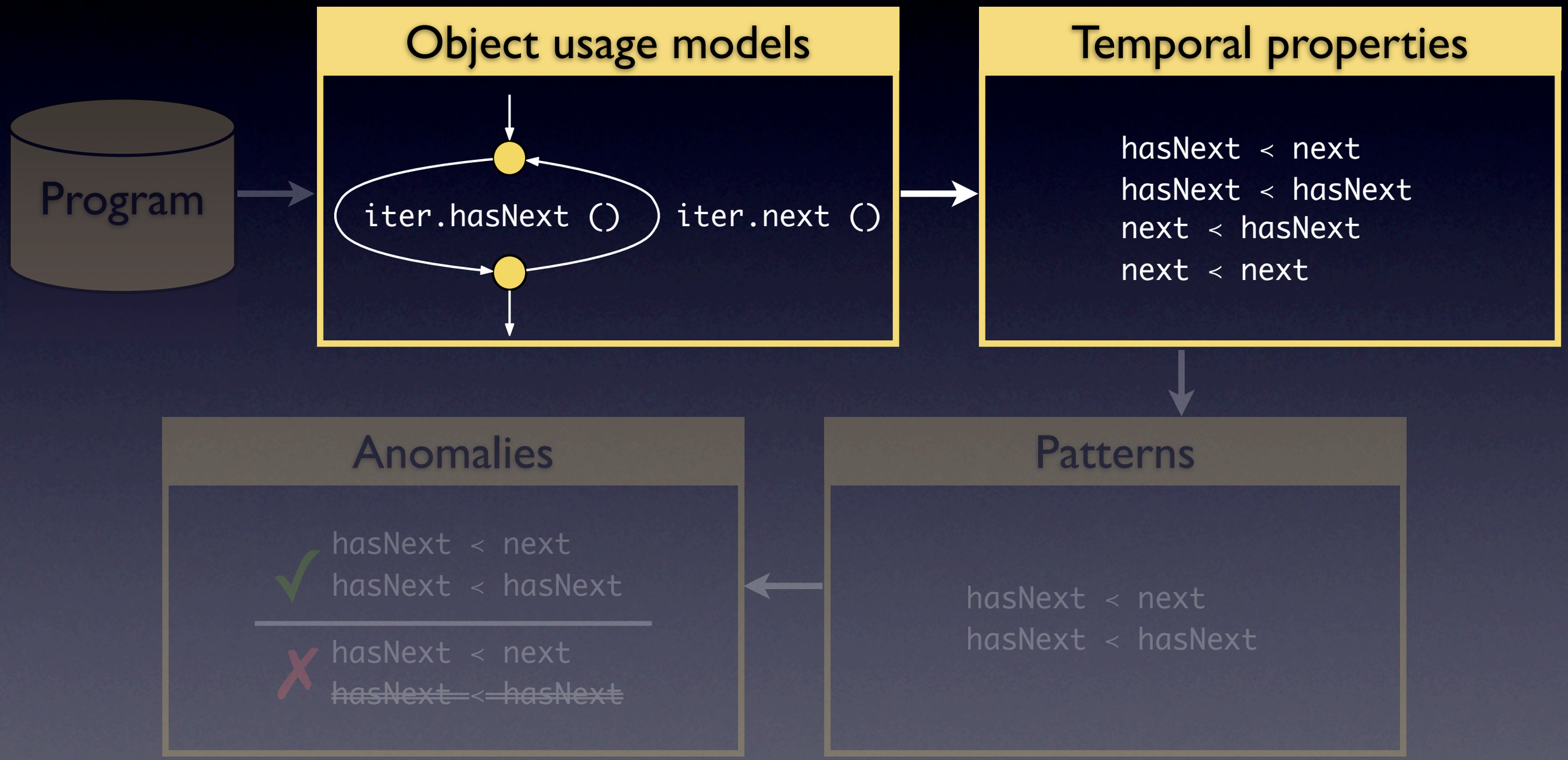
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Extracting temporal properties

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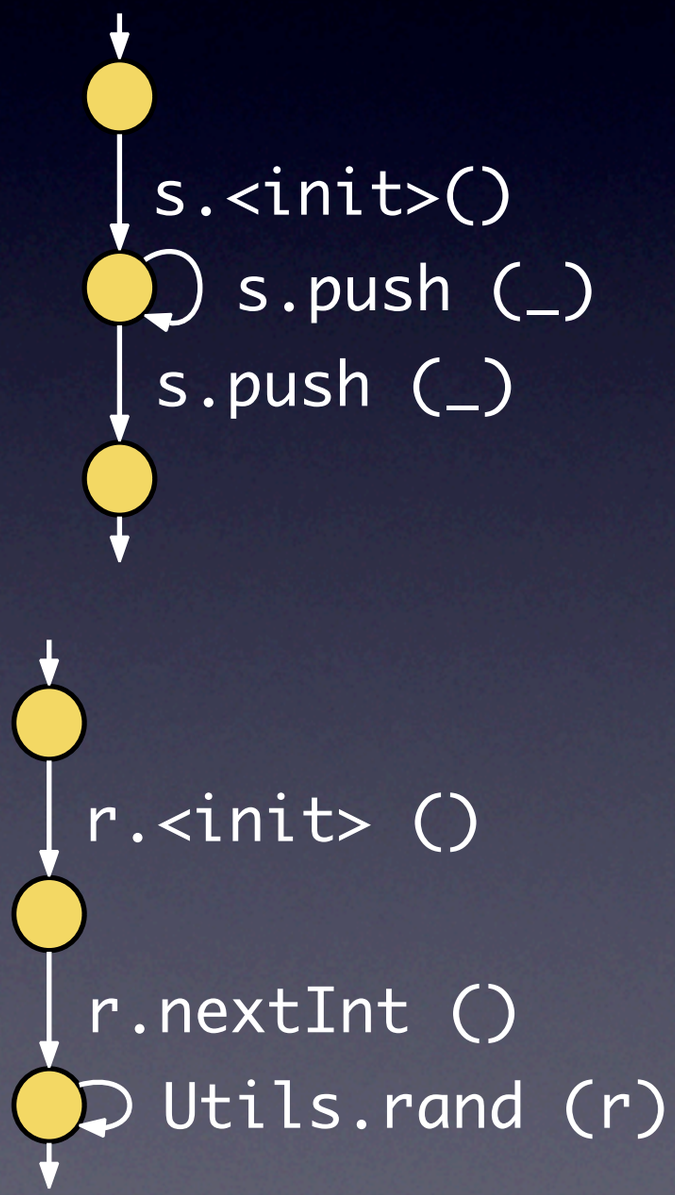

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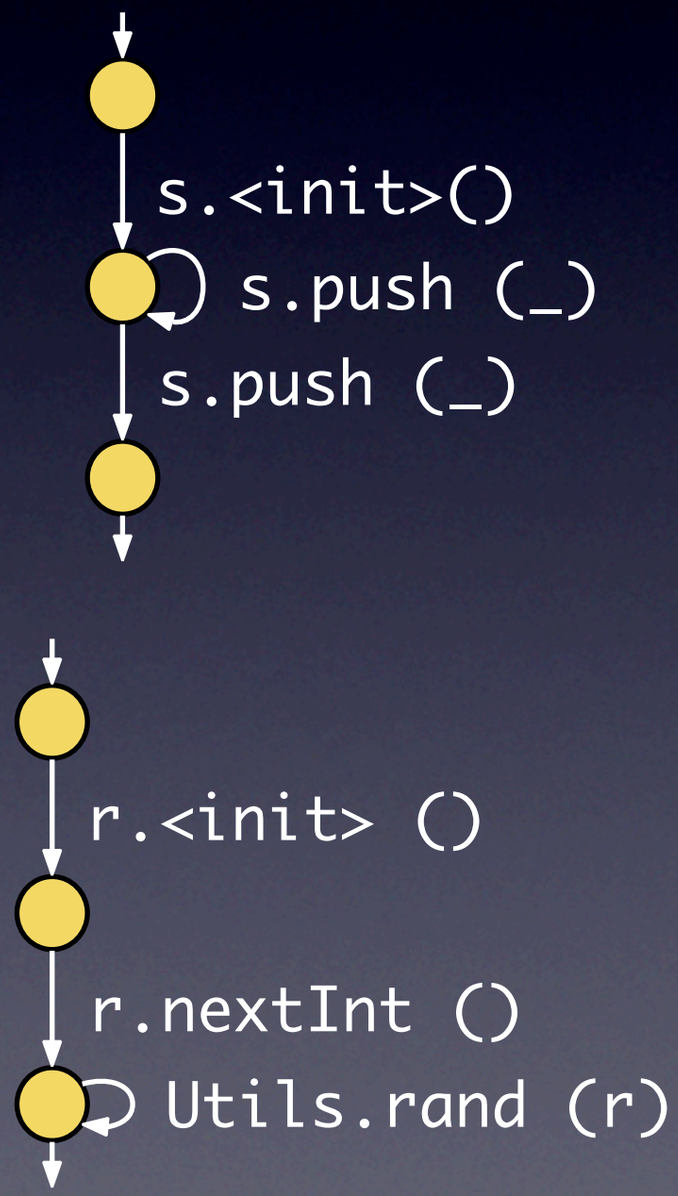
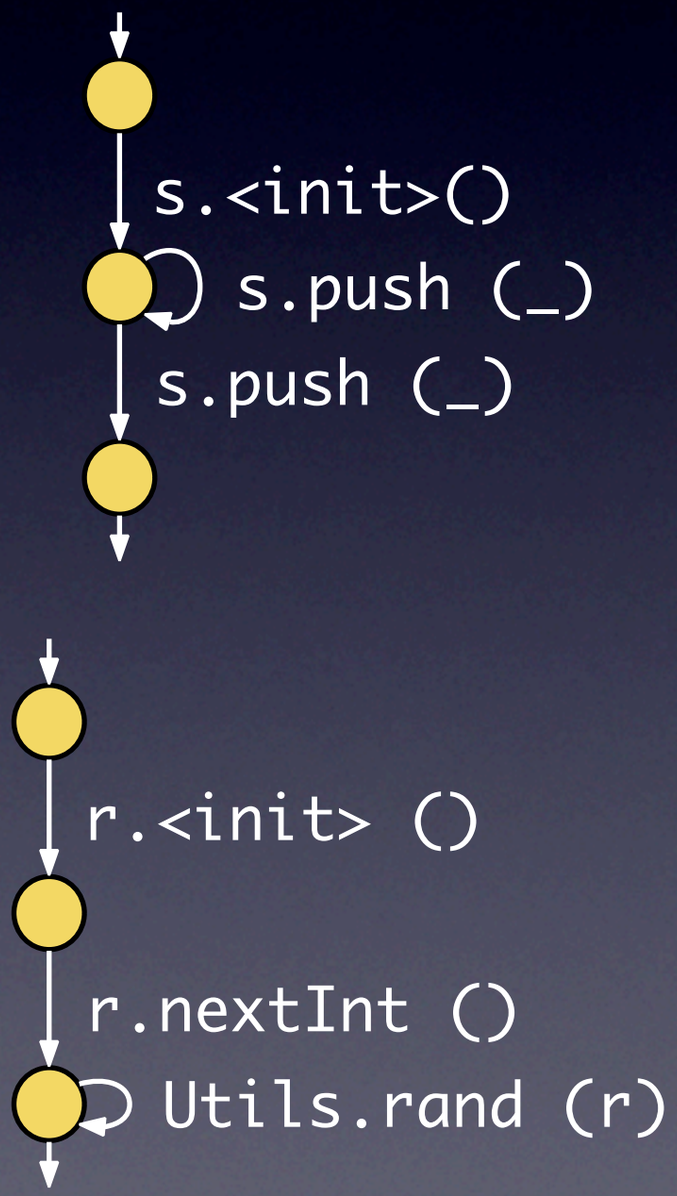



```
Stack.<init> ≺ Stack.push
Stack.push ≺ Stack.push
```

Extracting temporal properties




```
Stack.<init> ≺ Stack.push
Stack.push ≺ Stack.push
```

```
Random.<init> ≺ Random.nextInt
Random.<init> ≺ Utils.rand
Random.nextInt ≺ Utils.rand
Utils.rand ≺ Utils.rand
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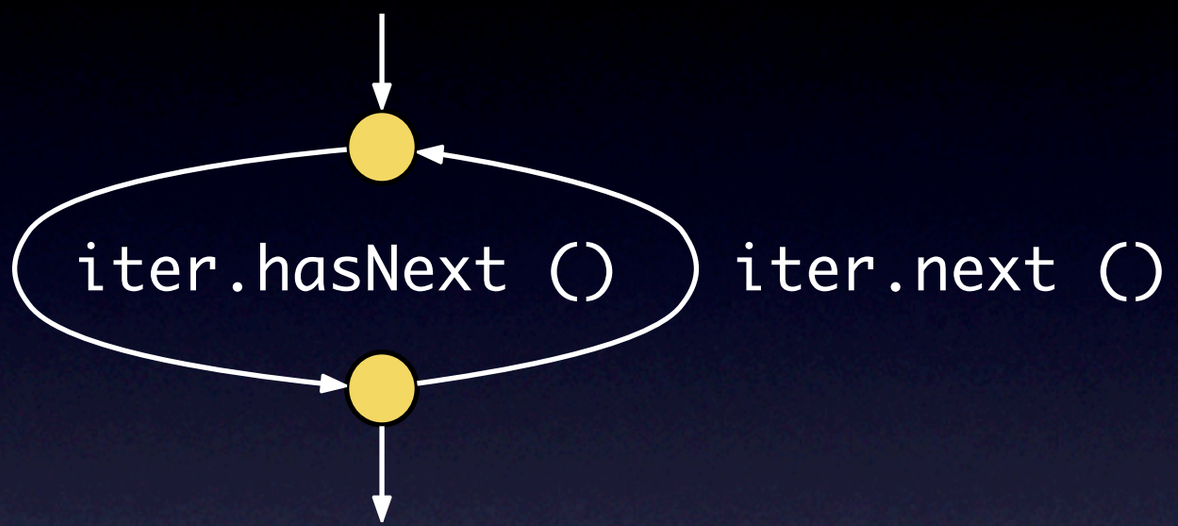
The Iterator properties




```
hasNext < next
hasNext < hasNext
next < hasNext
next < next
```

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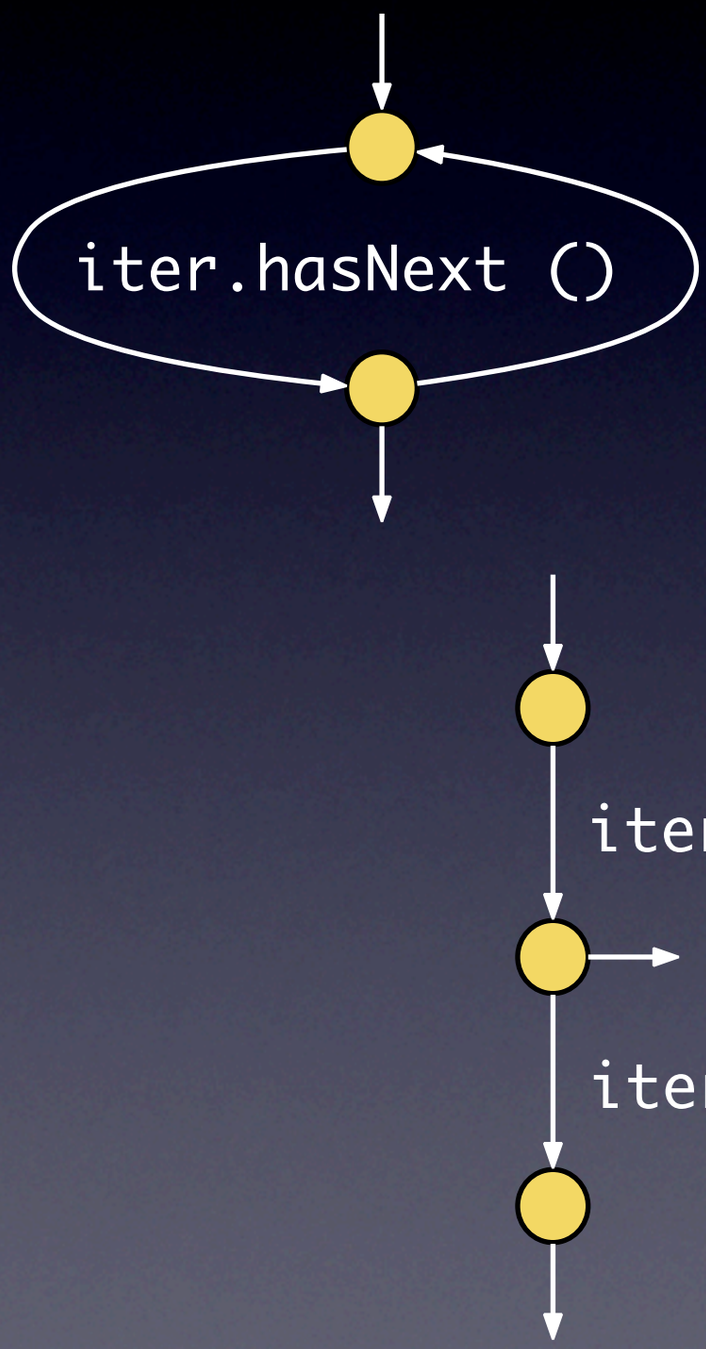


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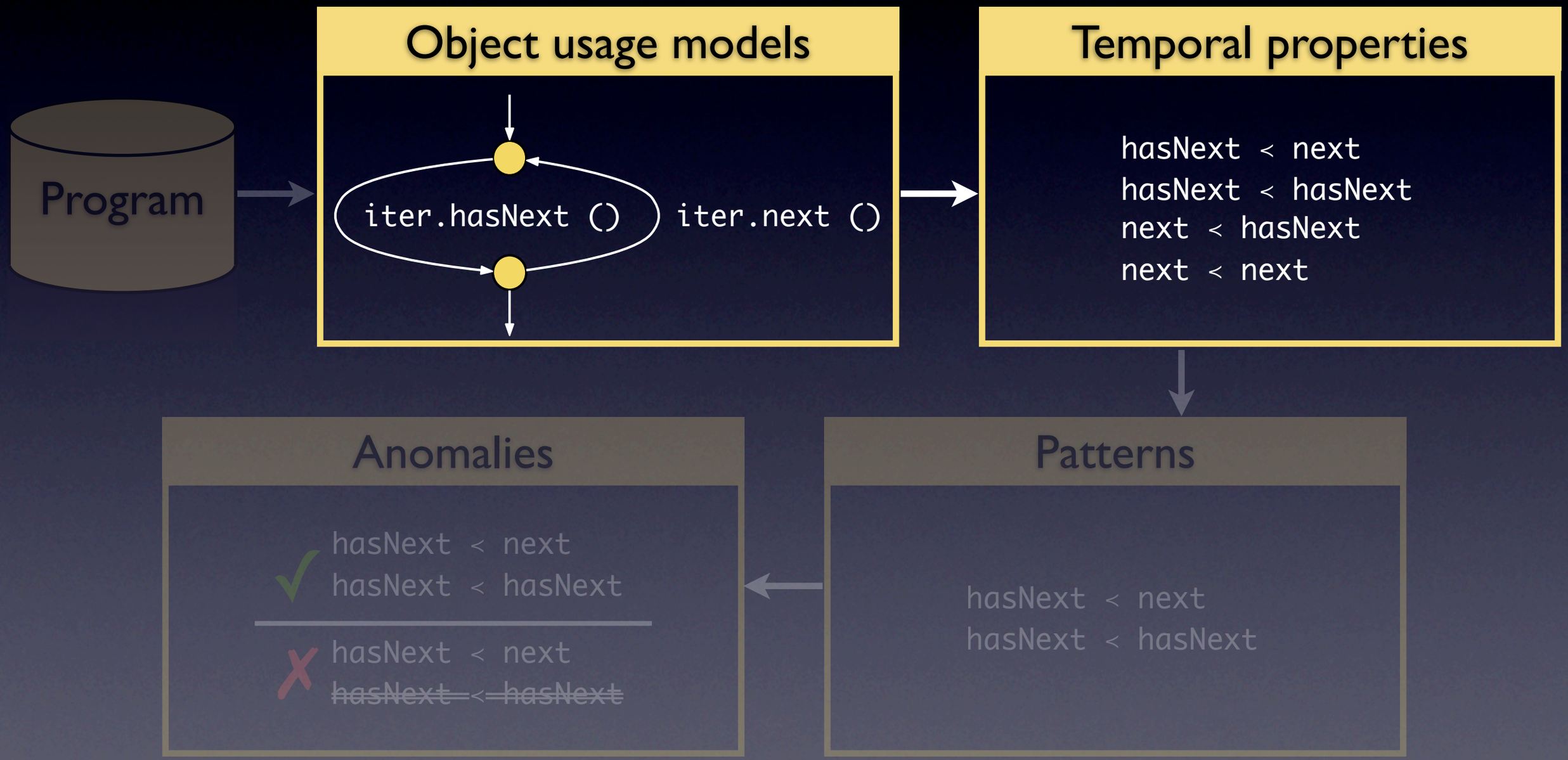
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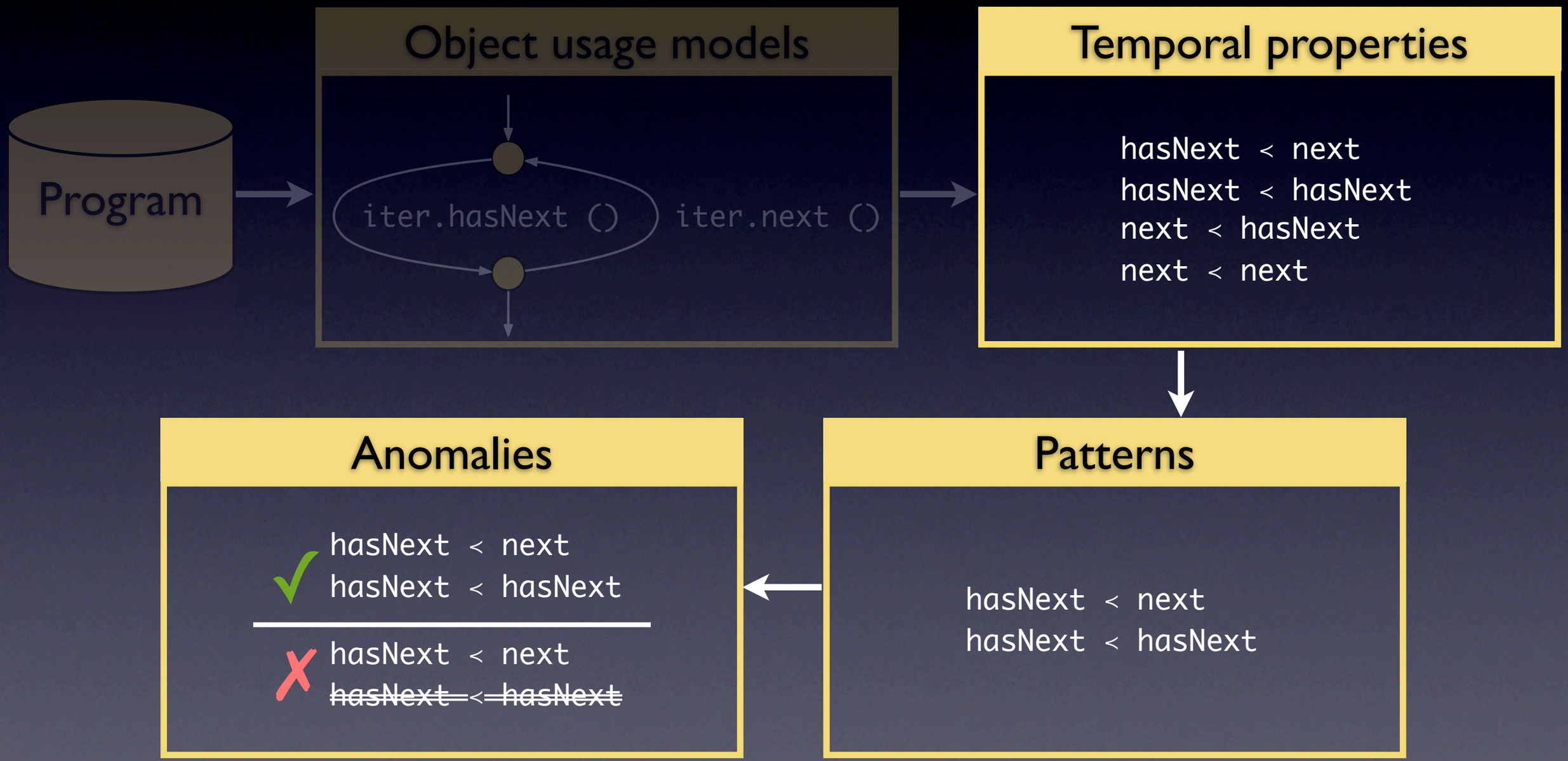
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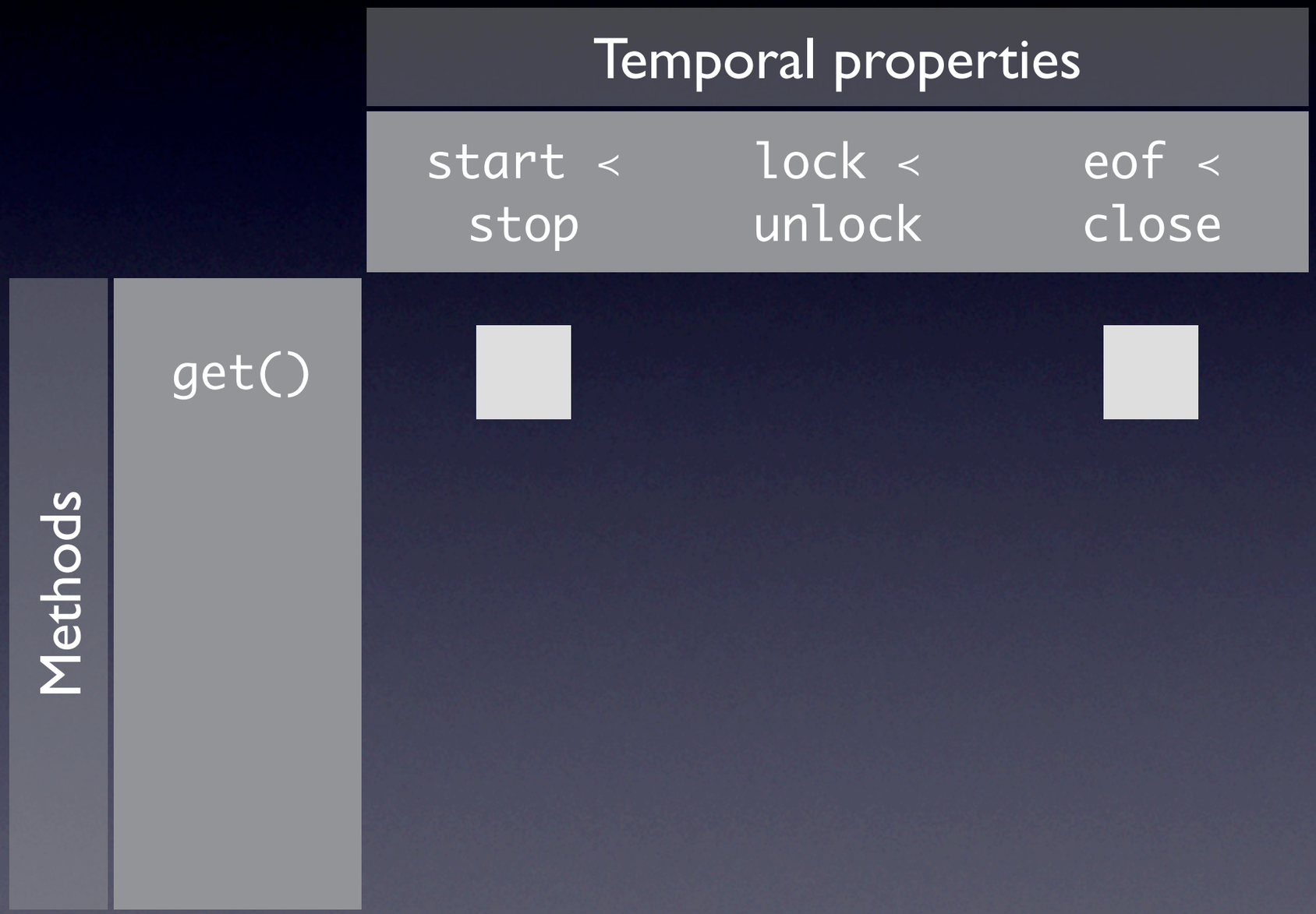
Methods vs. properties

Temporal properties		
`start <` `stop`	`lock <` `unlock`	`eof <` `close`

Methods

Methods vs. properties



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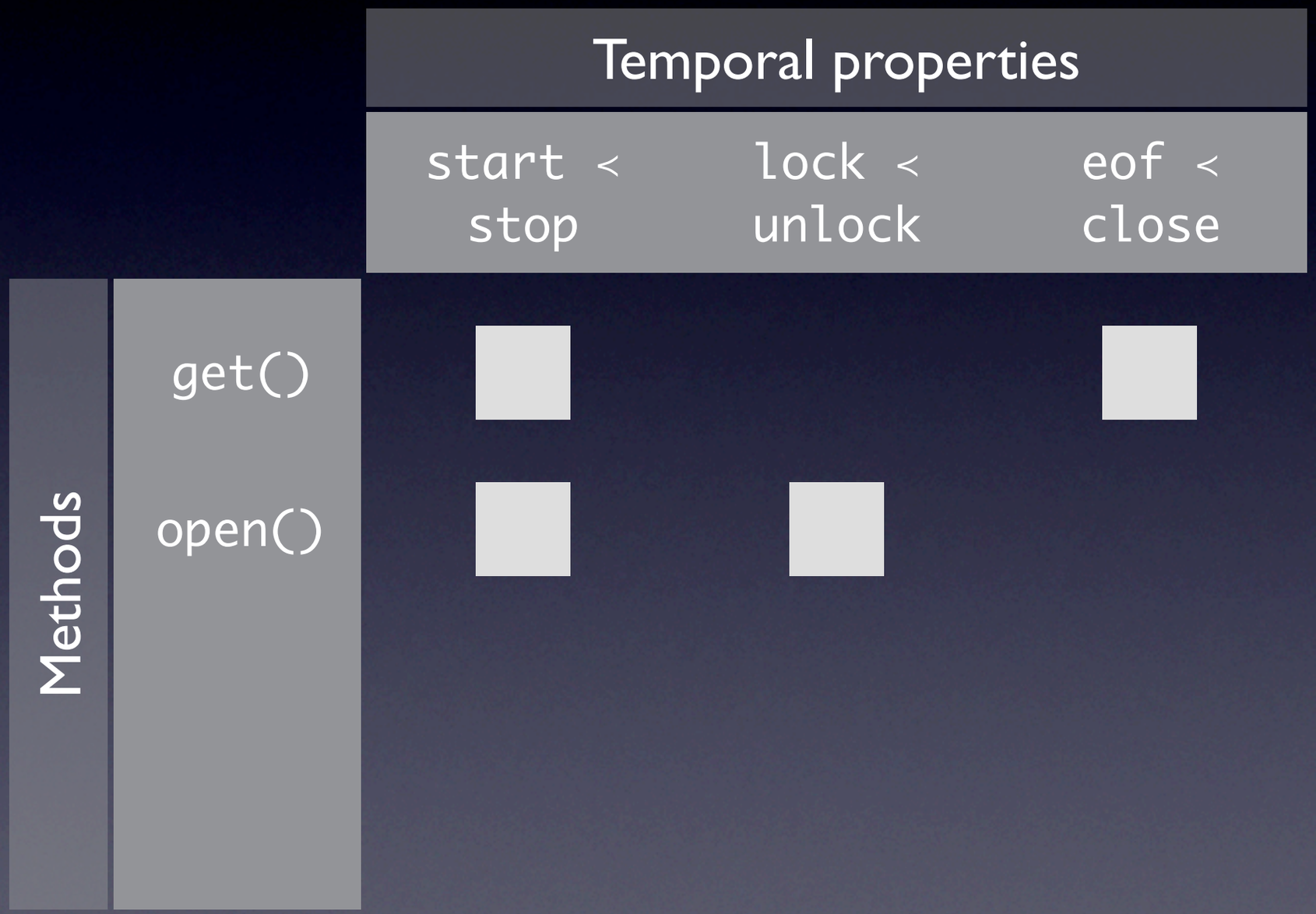

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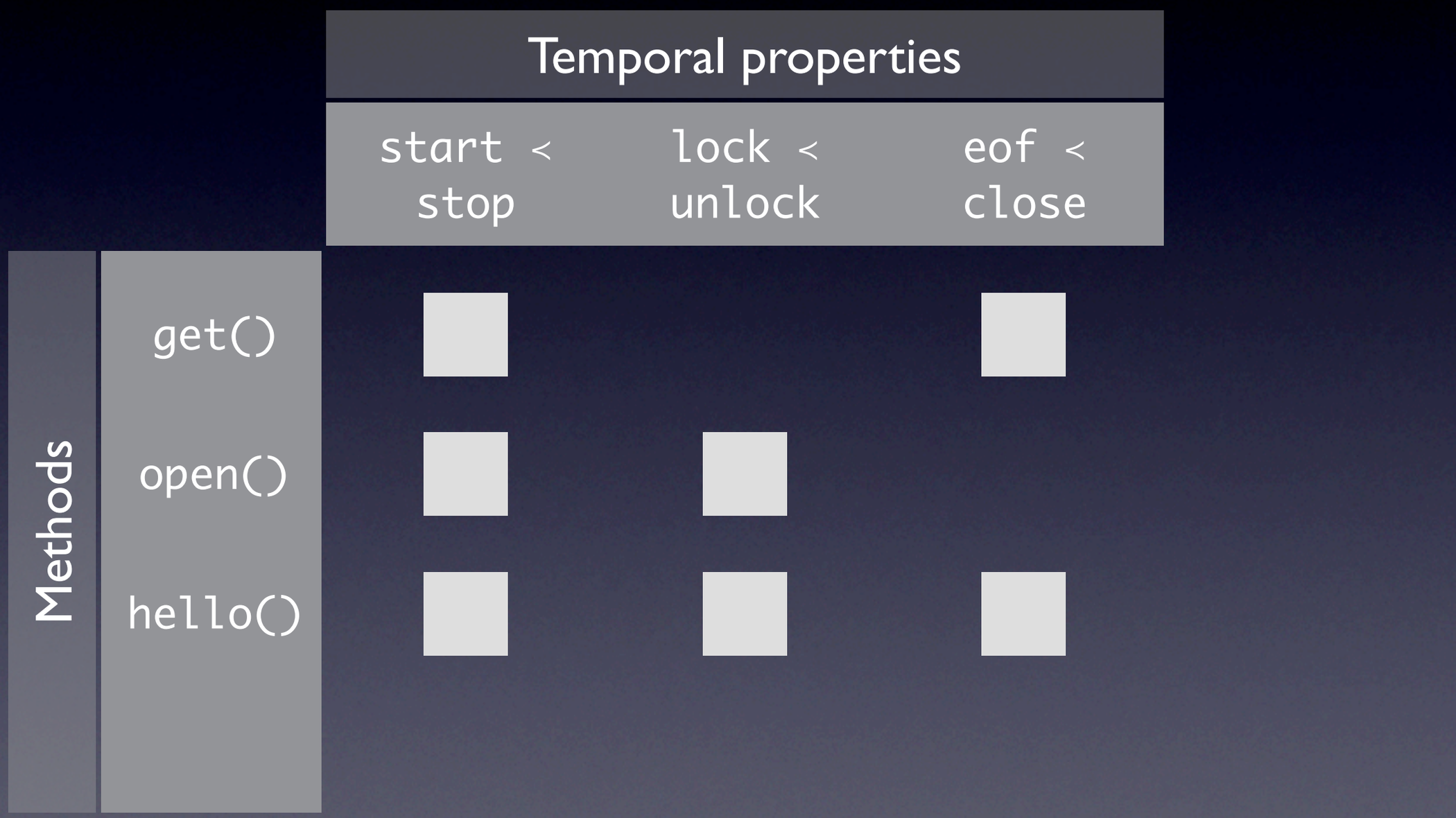

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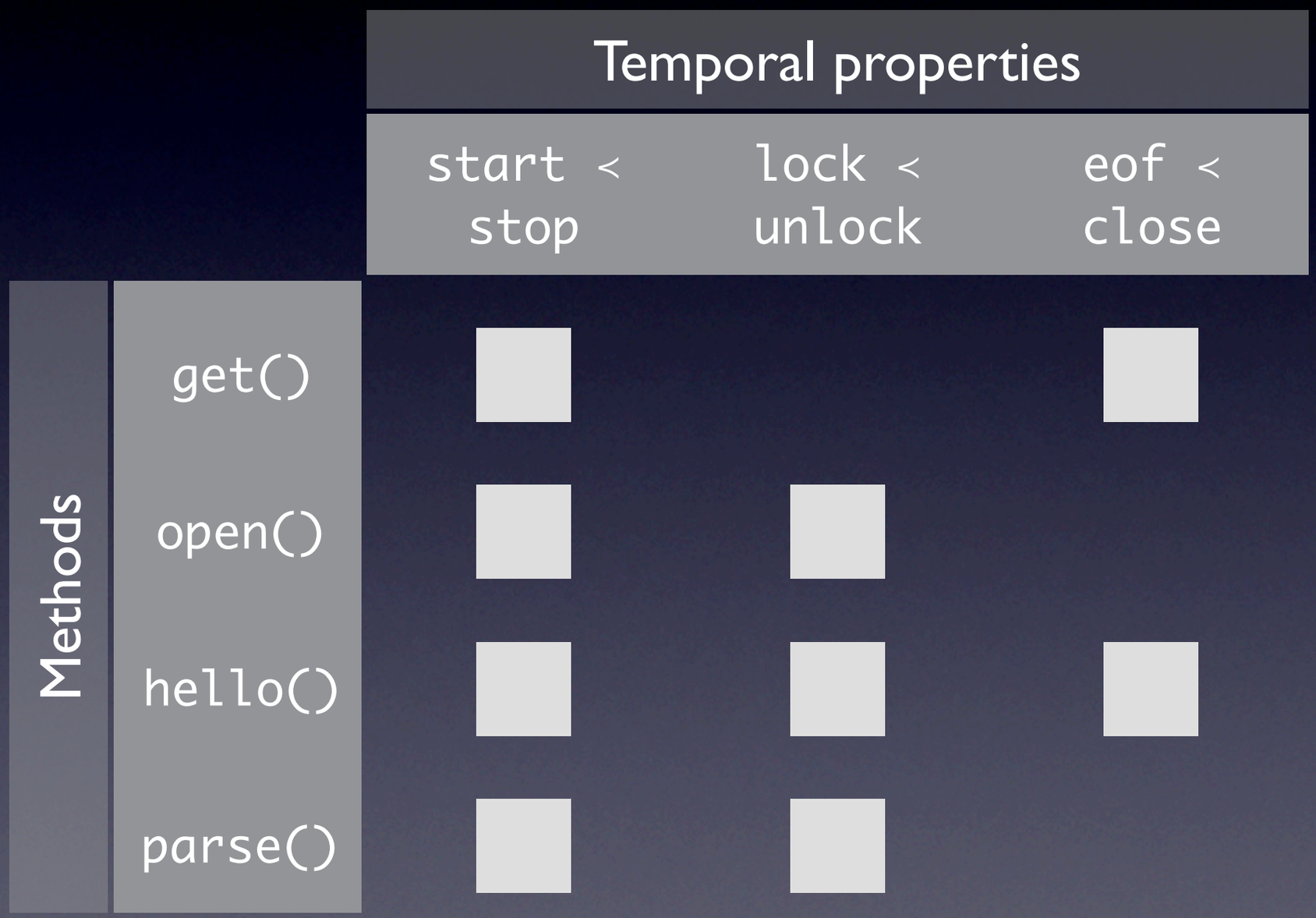

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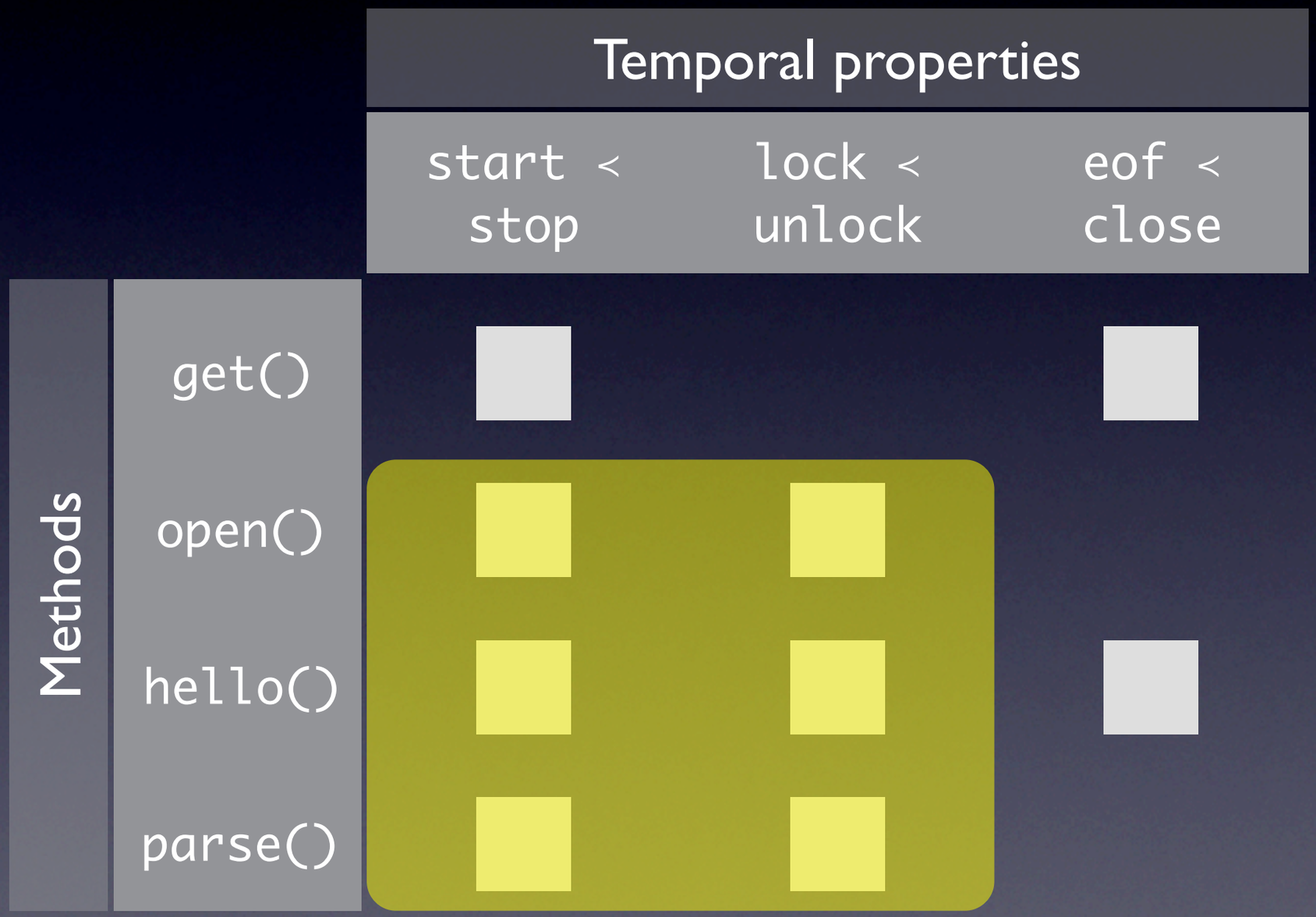

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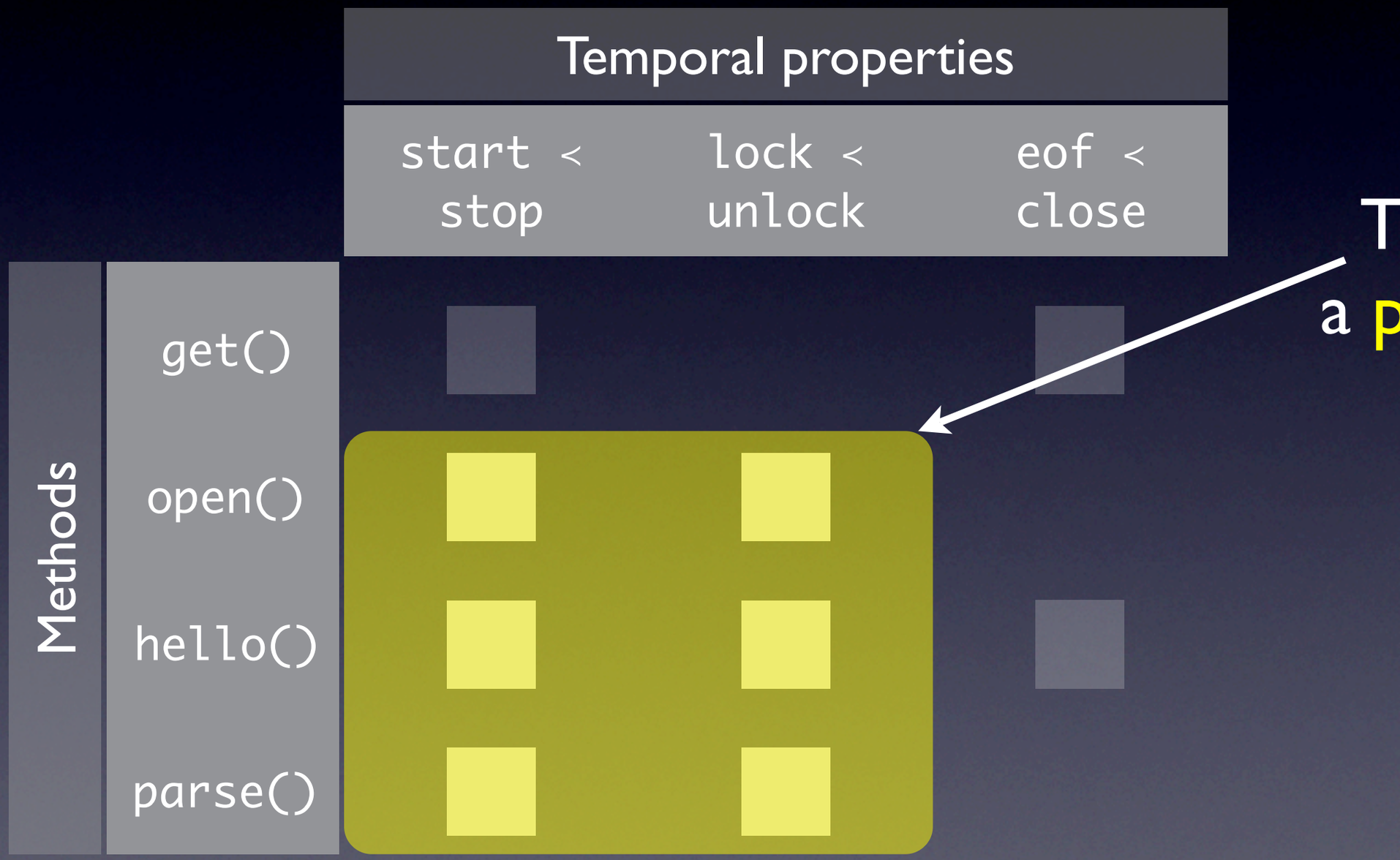

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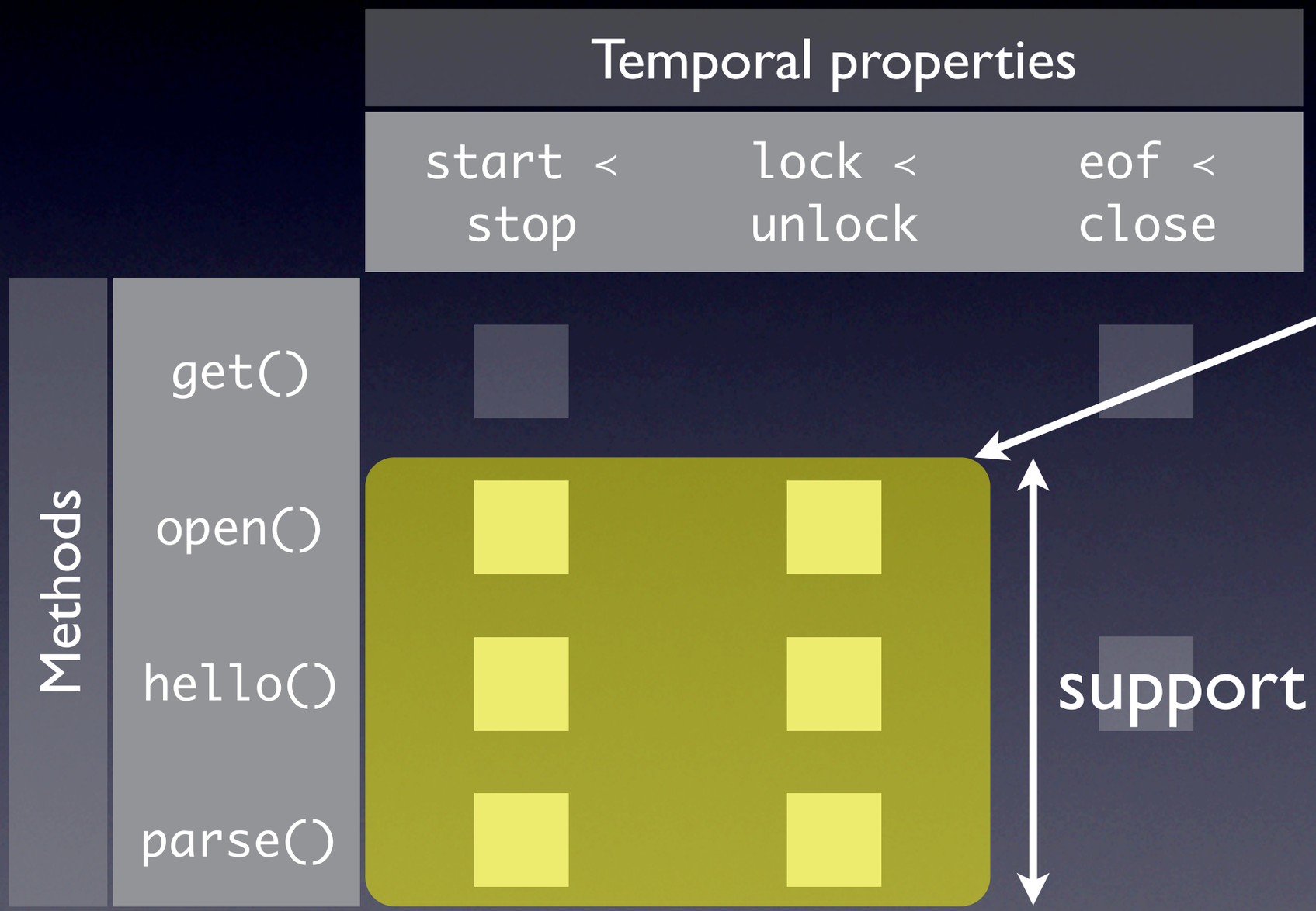
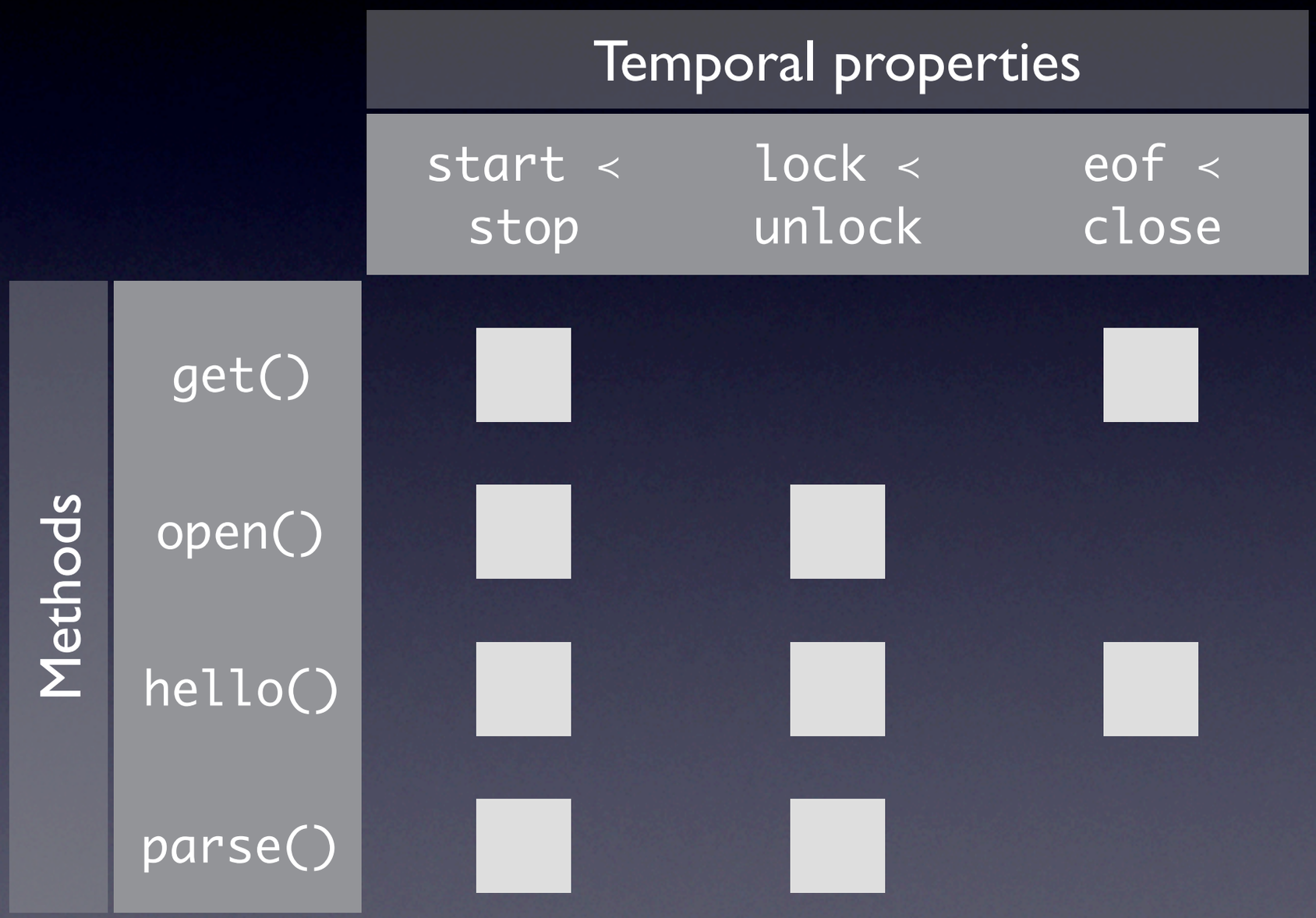


Detecting anomalies



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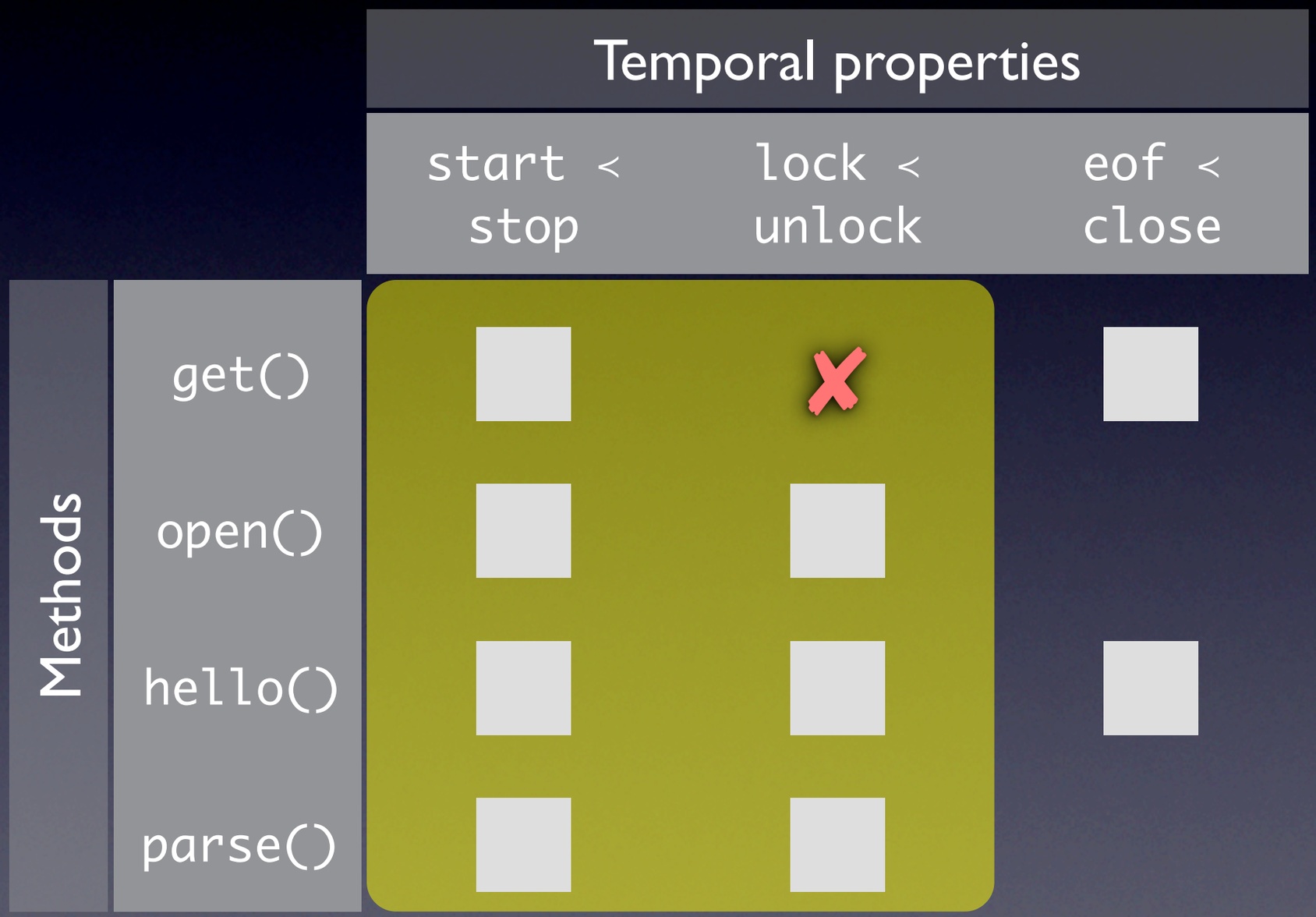

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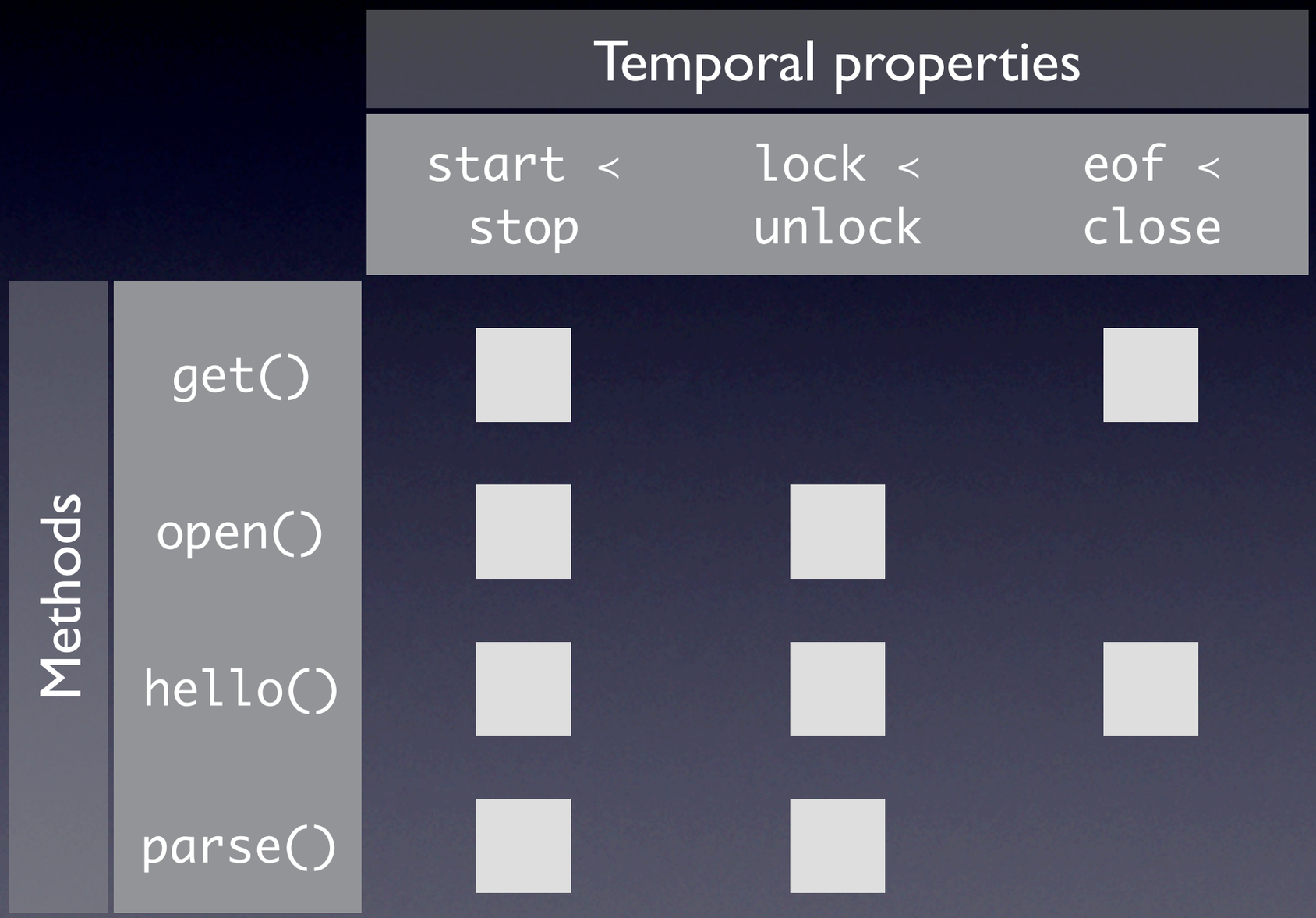

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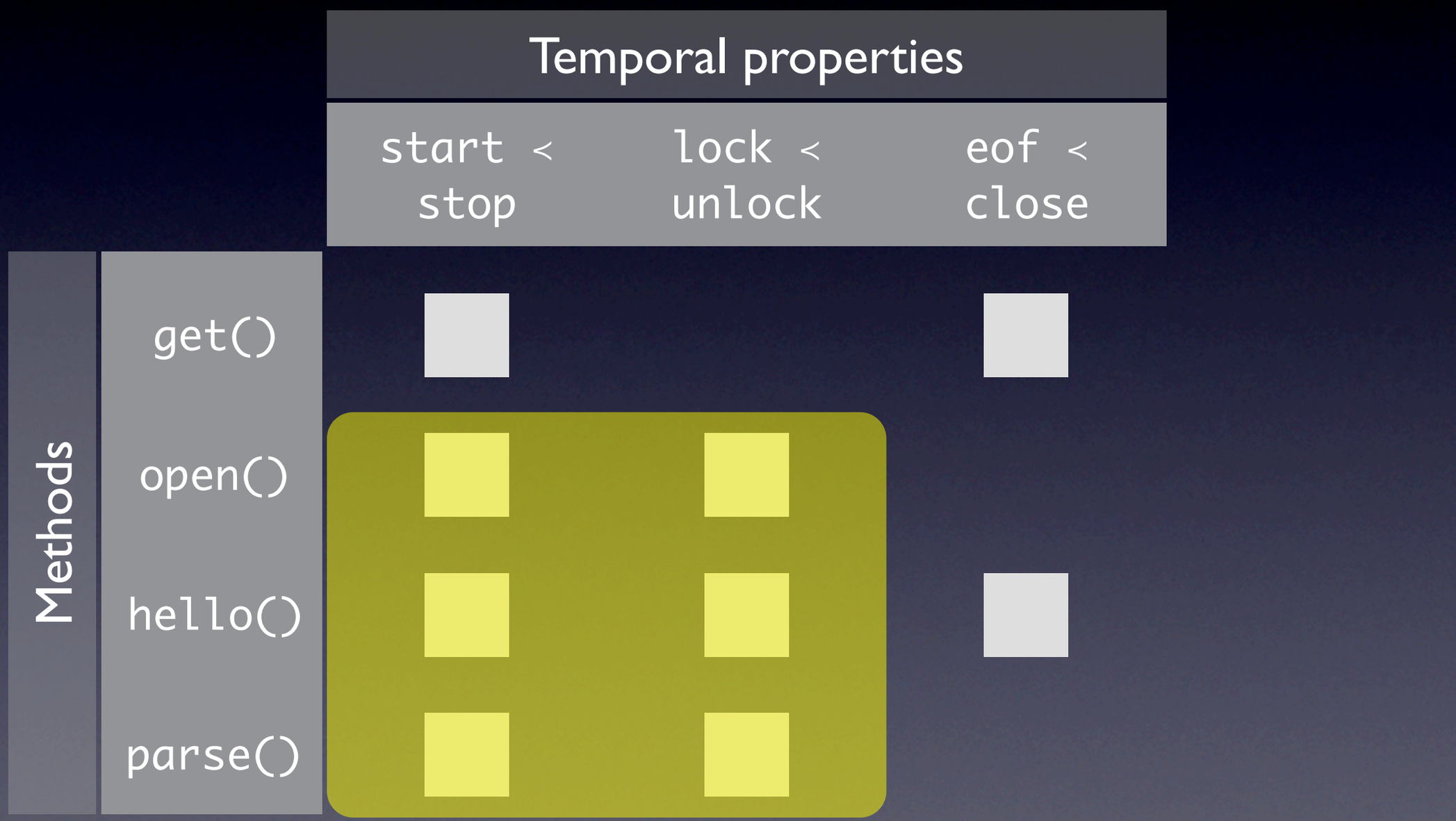

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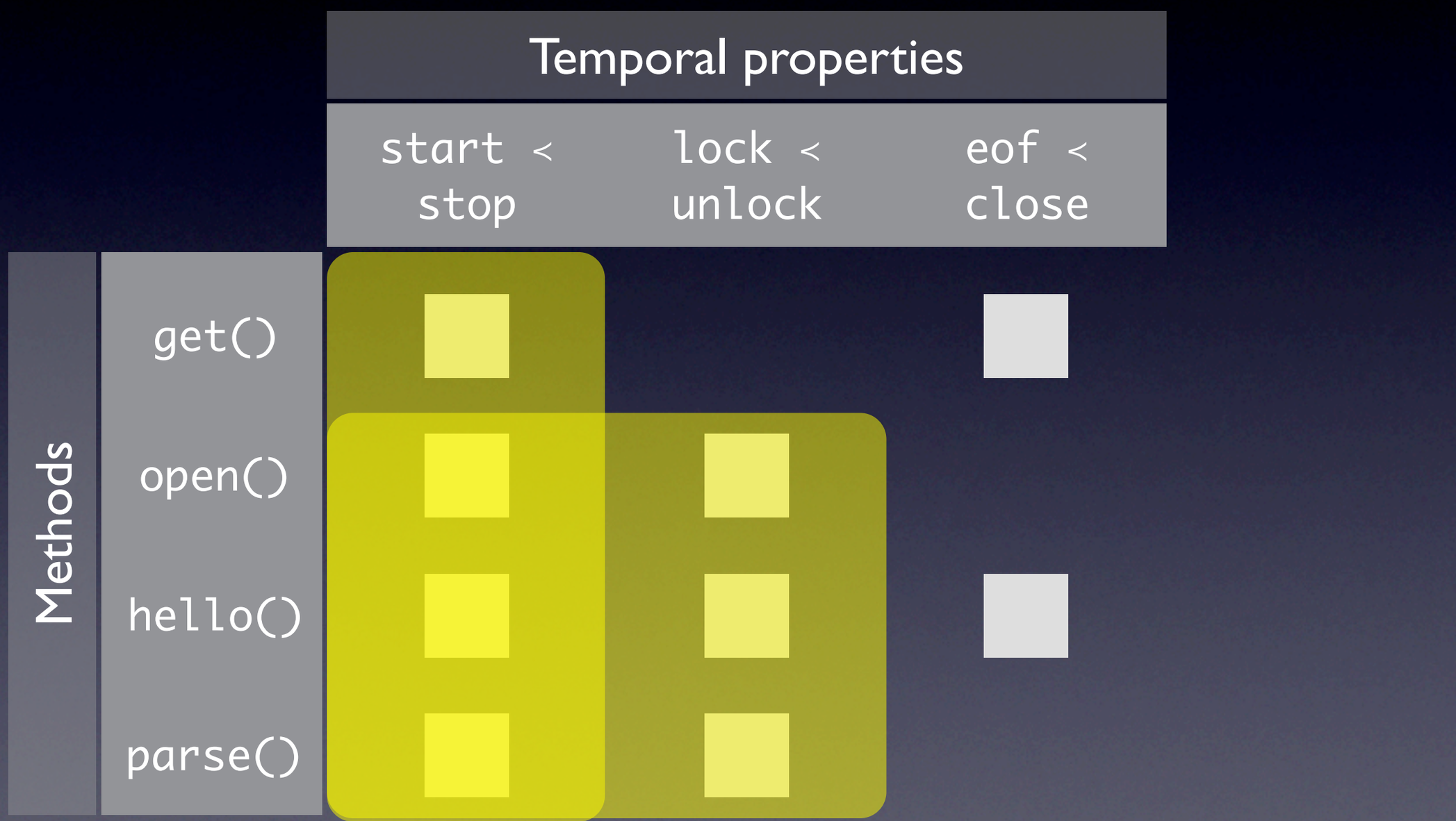

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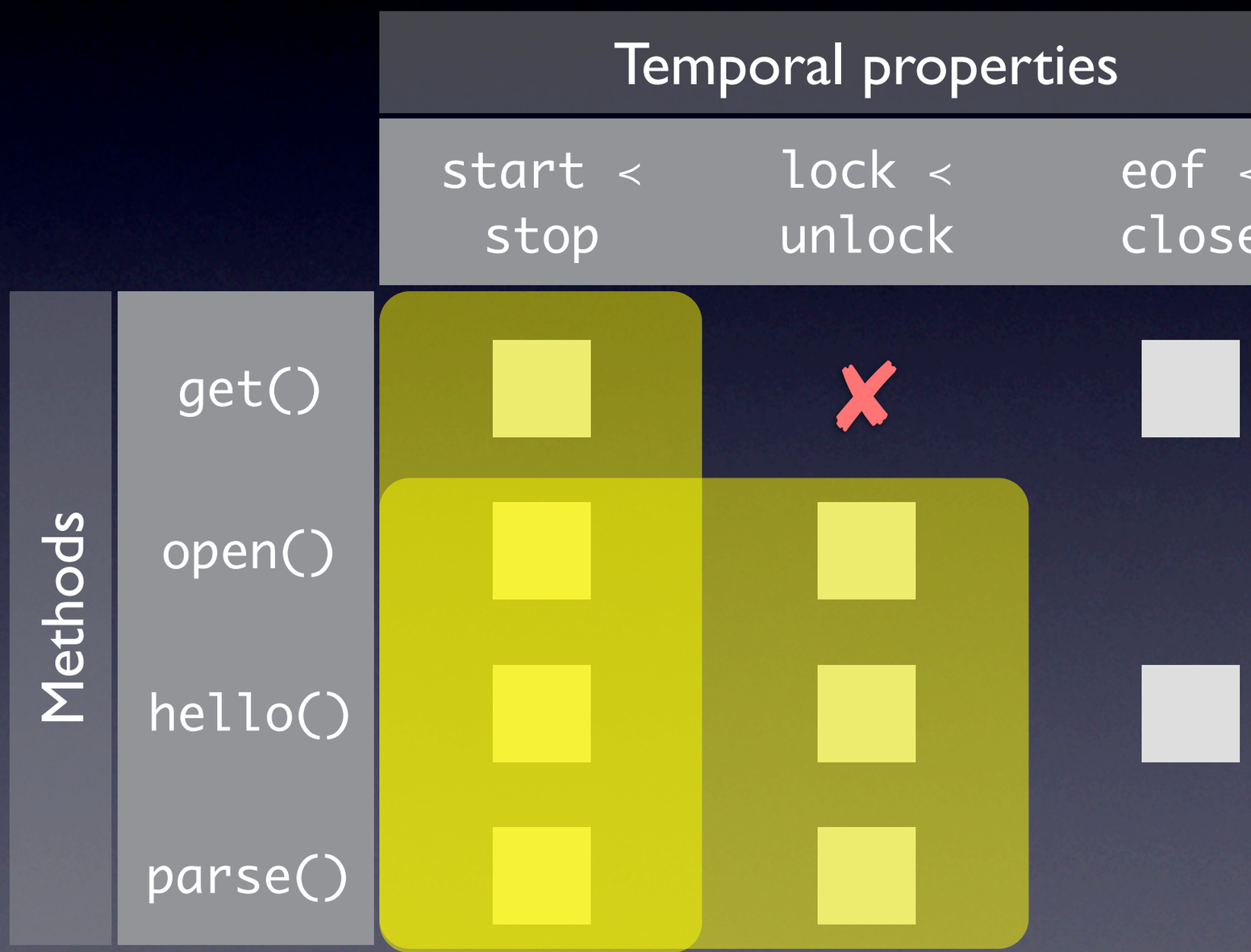

Case study: AspectJ

- Compiler for the AspectJ language
- 36,045 methods in 2,957 classes
- JADET analysis results:
  - 253,084 object usage models created
    Time: 13:19
  - 666 patterns with 276 anomalies found
    Time: 3:47

Ranking anomalies

Top-ranked
(potential defects)

Bottom-ranked
(potential false positives)

Ranking anomalies

Top-ranked
(potential defects)

High support

Bottom-ranked
(potential false positives)

Ranking anomalies

Top-ranked
(potential defects)

High support
High confidence

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(potential false positives)

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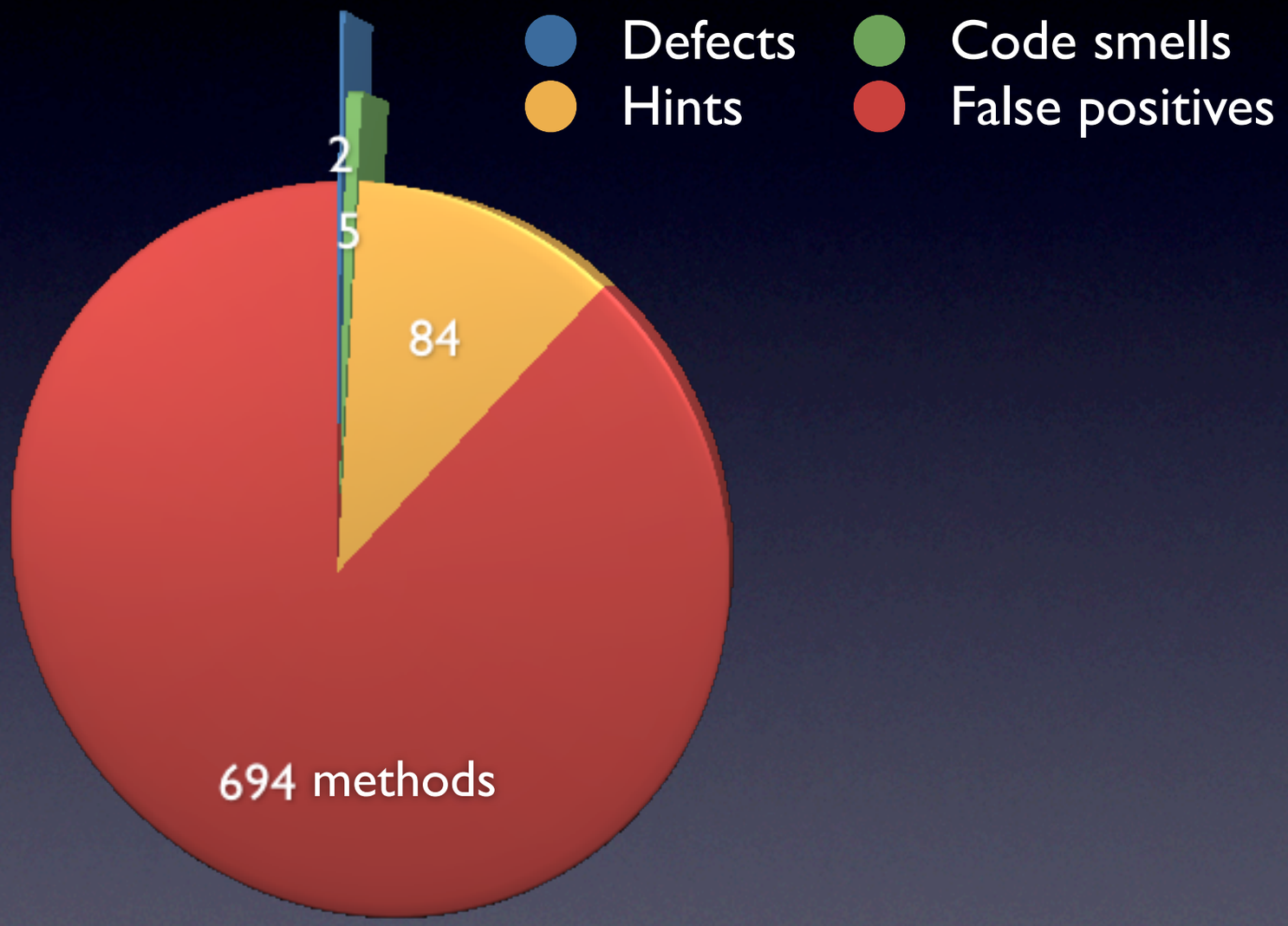
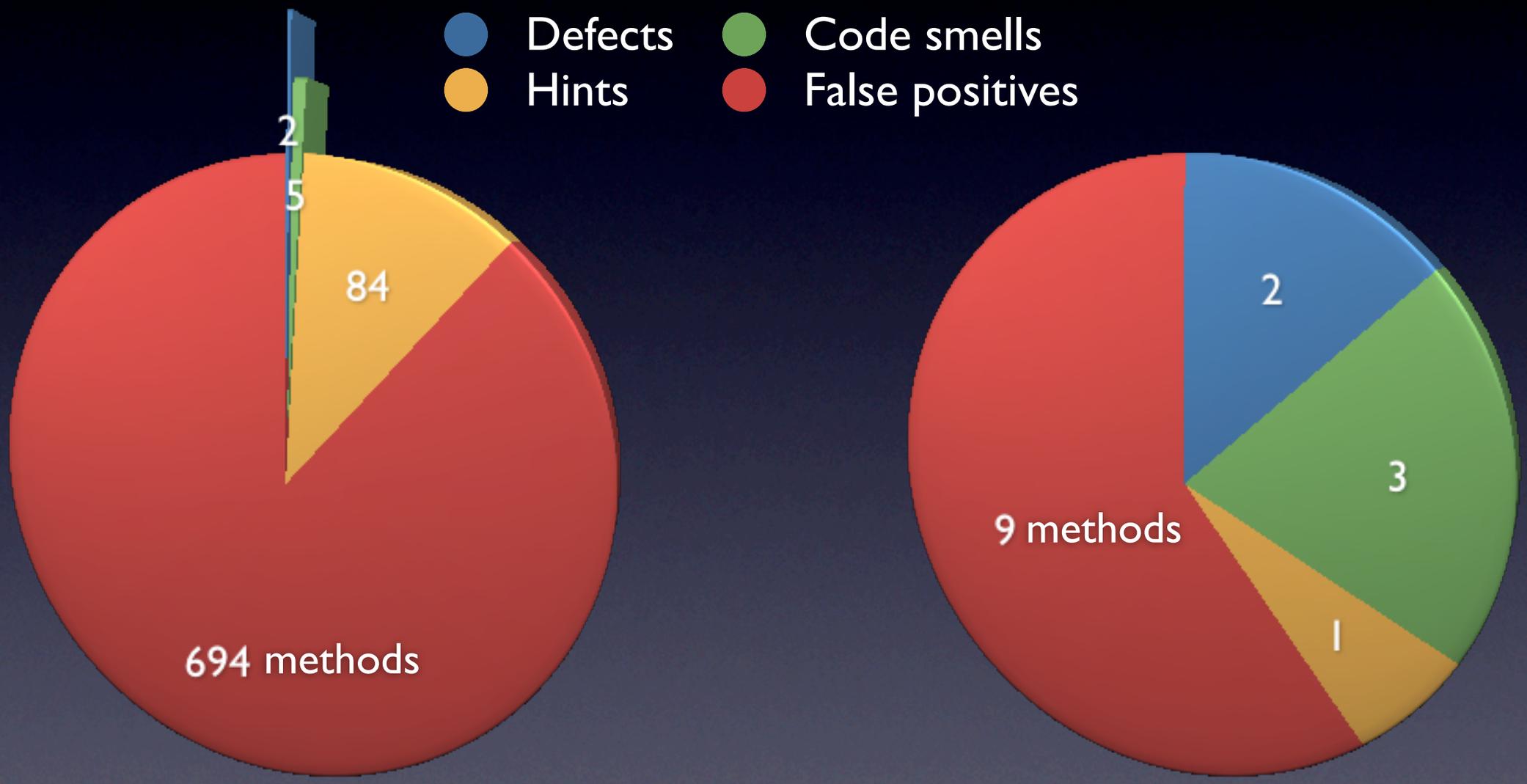
Many similar violations

AspectJ violations



All anomalies
785 methods

AspectJ violations



All anomalies
785 methods

Top 10 anomalies
15 methods

Violation ranked #1

```
private boolean verifyNIAP (…) {
    …
    Iterator iter = …;
    while (iter.hasNext()) {
        … = iter.next();
        …
        return verifyNIAP (…);
    }
    return true;
}
```

Violation ranked #1

```
private boolean verifyNIAP (…) {
    …
    Iterator iter = …;
    while (iter.hasNext()) {
        … = iter.next();
        …
        return verifyNIAP (…);
    }
    return true;
}
```

Never loops!

Violation ranked #2

```
public String getRetentionPolicy () {
    …
    for (Iterator it = …; it.hasNext();) {
        … = it.next();
        …
        return retentionPolicy;
    }
    …
}
```

Violation ranked #2

```
public String getRetentionPolicy () {
    …
    for (Iterator it = …; it.hasNext();) {
        … = it.next();
        …
        return retentionPolicy;
    }
    …
}
```

Never loops!

Violation ranked #2

```
public String getRetentionPolicy () {
    …
    for (Iterator it = …; it.hasNext();) {
        … = it.next();
        …
        return retentionPolicy;
    }
    …
}
```

Never loops!

Fortunately, there can be at most one retention policy!

Violation ranked #7

```
public void visitCALOAD (CALOAD o) {
    Type arrayref = stack().peek(1);
    Type index = stack().peek(0);
    indexOfInt(o, index);
    arrayrefOfArrayType(o, arrayref);
}
```

Violation ranked #7

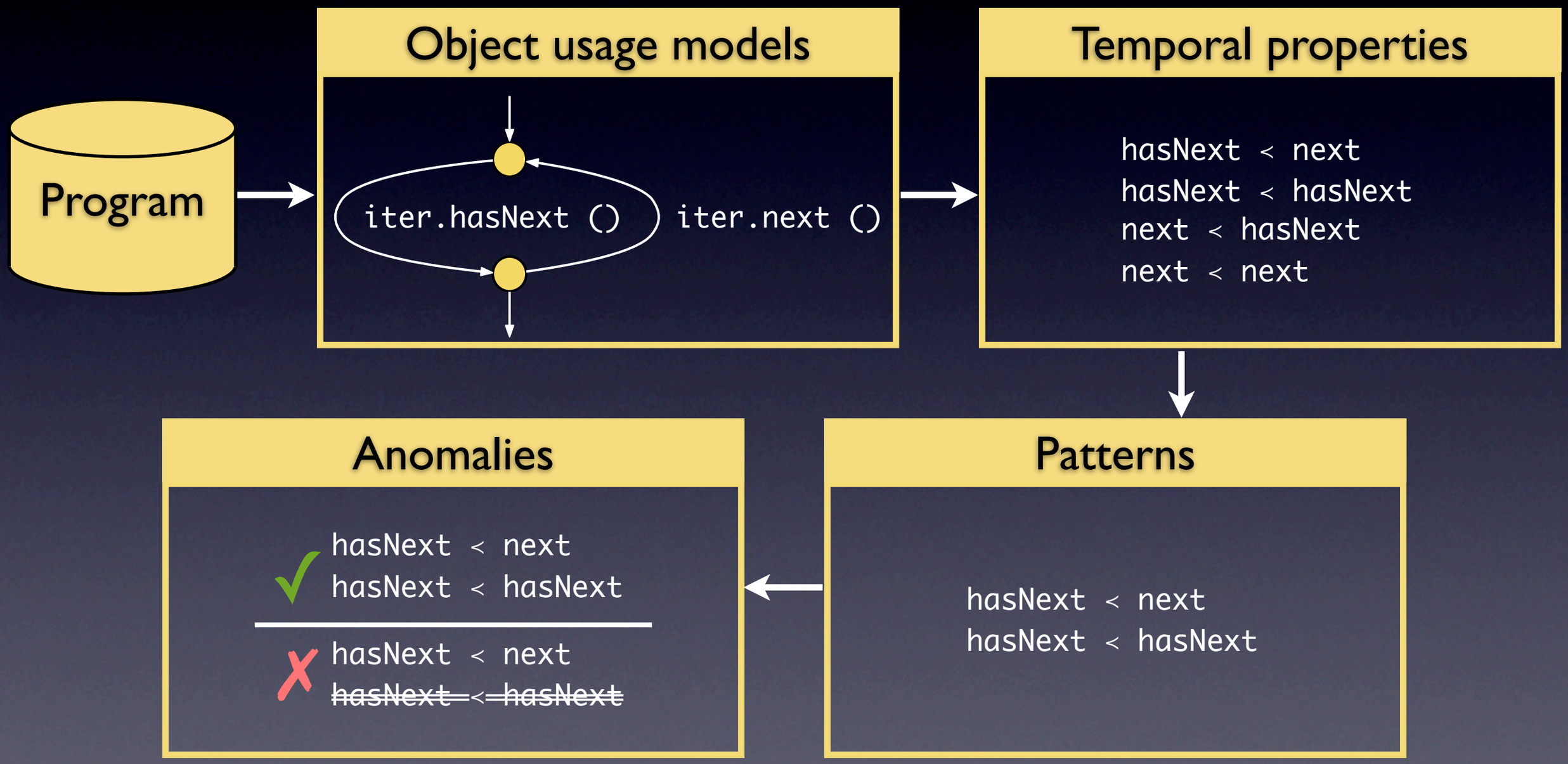
```
public void visitCALOAD (CALOAD o) {
    Type arrayref = stack().peek(1);
    Type index = stack().peek(0);
    indexOfInt(o, index);
    arrayrefOfArrayType(o, arrayref);
}
```

Doesn’t check if arrayref holds chars!

Related work

- FindBugs by Hovemeyer and Pugh (SIGPLAN Notices Dec. 2004)
- PR-Miner by Li and Zhou (ESEC/FSE 2005)
- DynaMine by Livshits and Zimmermann (ESEC/FSE 2005)
- Perracotta by Yang and Evans (ICSE 2006)
- Chronicler by Ramanathan et al. (ICSE 2007)

JADET


Program
Object usage models
iter.hasNext ()
iter.next ()
Temporal properties
hasNext ≺ next
hasNext ≺ hasNext
next ≺ hasNext
next ≺ next
Patterns
hasNext ≺ next
hasNext ≺ hasNext
Anomalies
hasNext ≺ next
hasNext ≺ hasNext
hasNext ≺ next
hasNext ≺ hasNext

JADET

- creates models that accurately reflect structure of the code
- detects anomalies in sequences of method calls
- scales to industrial code
- found two new defects in AspectJ
- http://www.st.cs.uni-sb.de/models/