VarexJ: A Variability-Aware Java Interpreter

Testing Configurable Systems

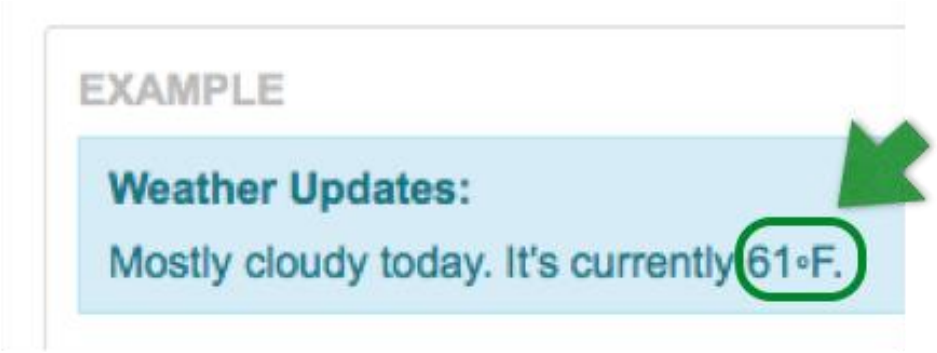
Jens Meinicke, Chu-Pan Wong, Christian Kästner

FOSD Meeting 2015

Feature Interaction

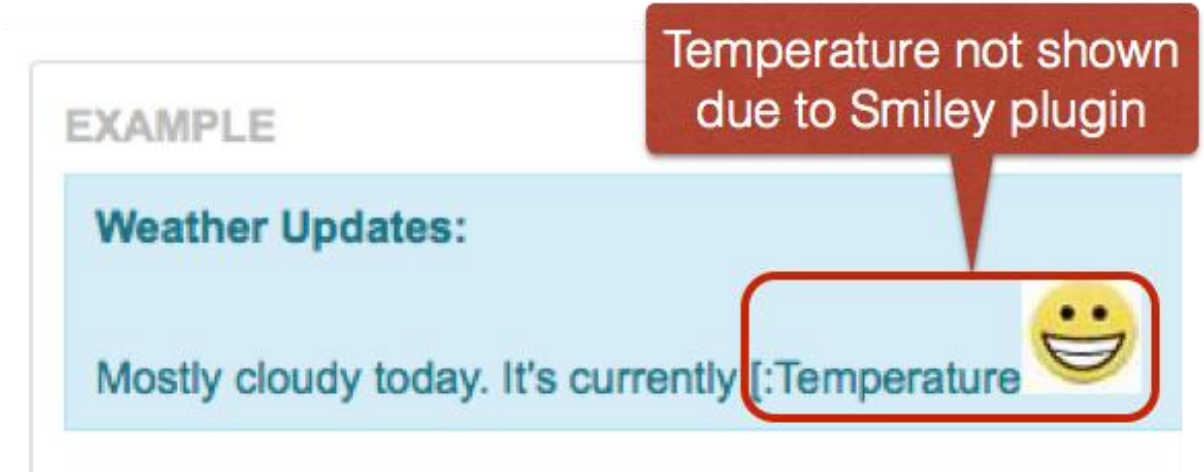
Weather

Smiley

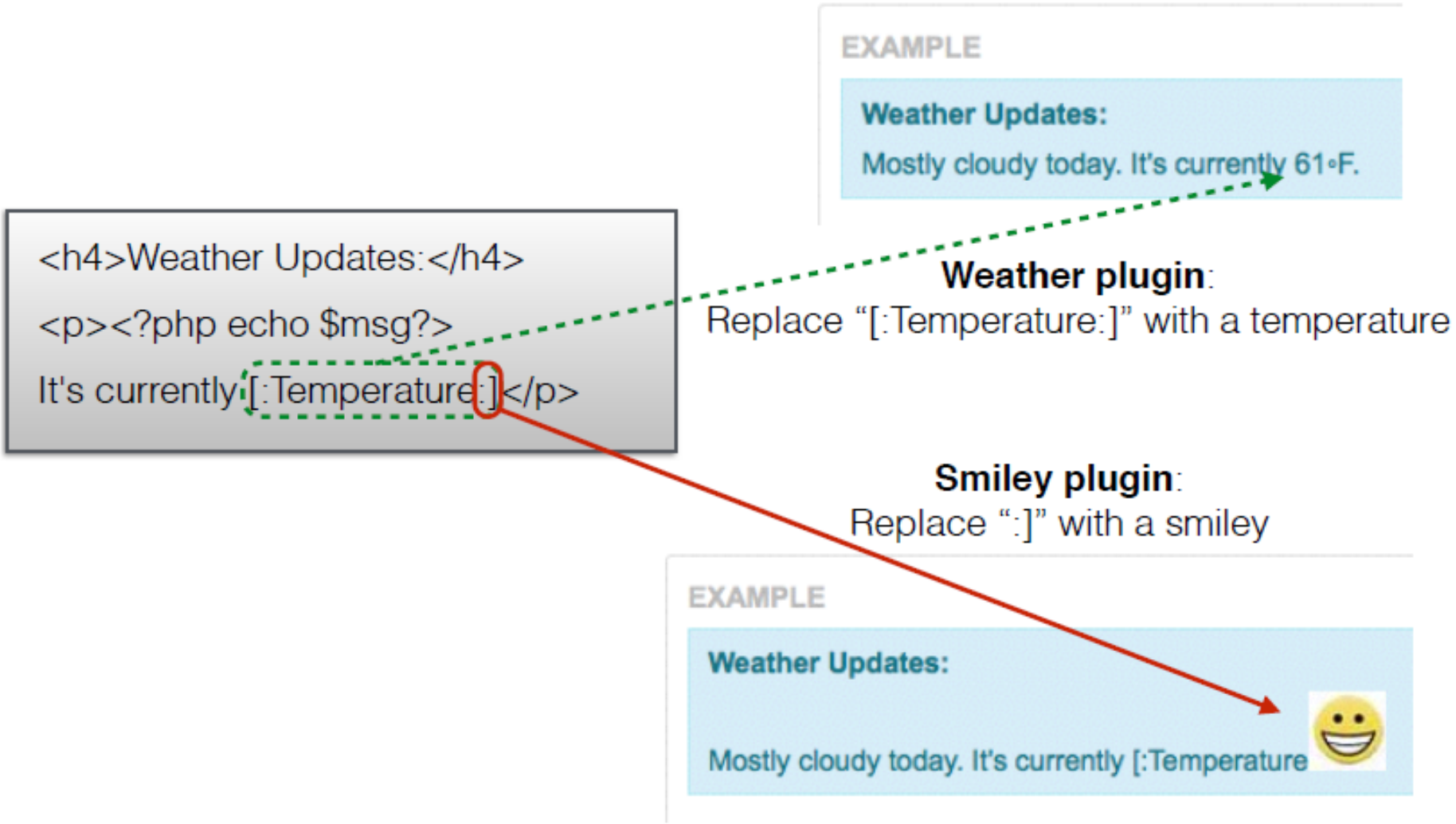


Weather

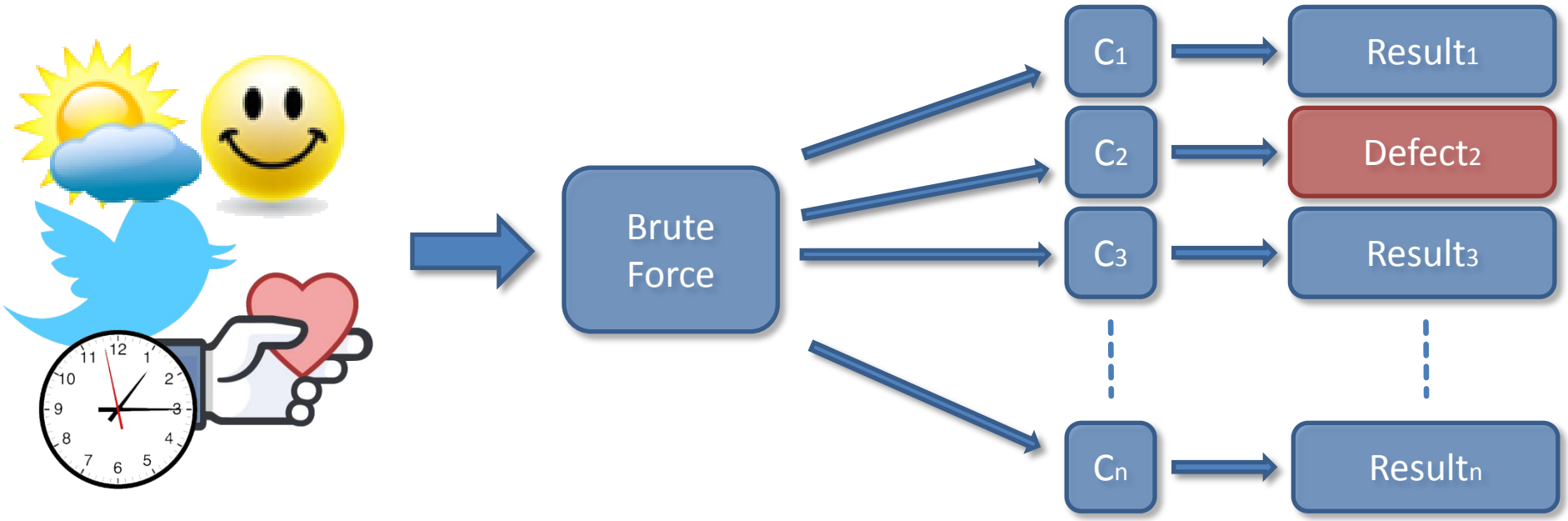
Smiley



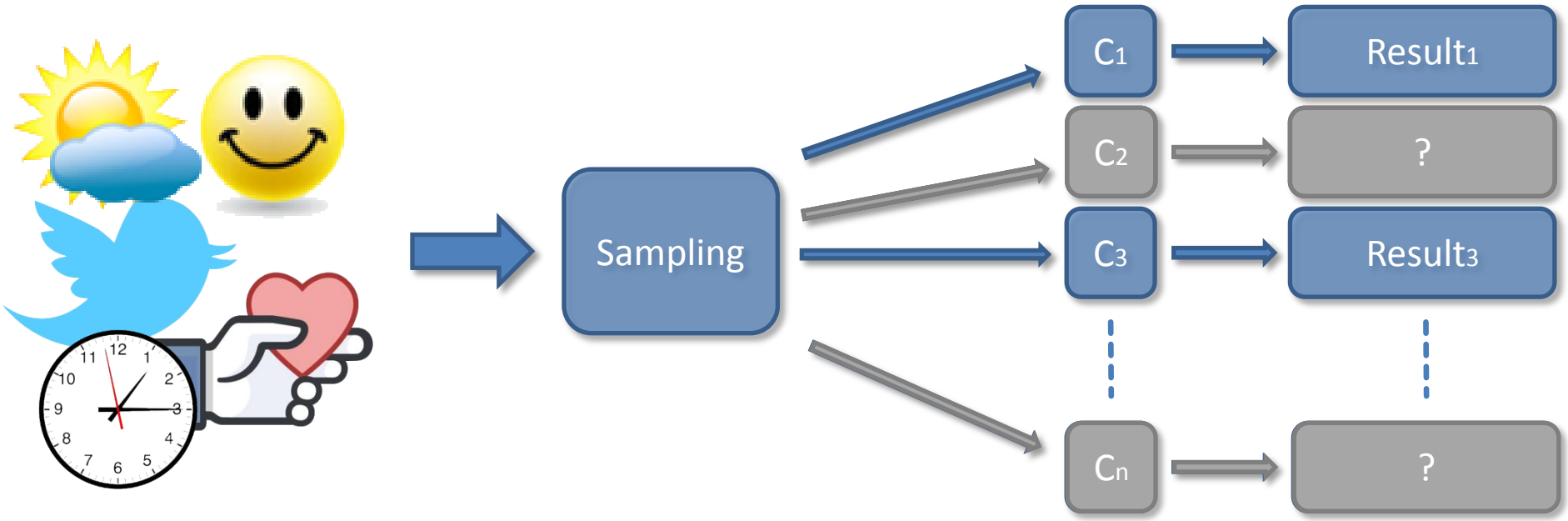
Feature Interaction

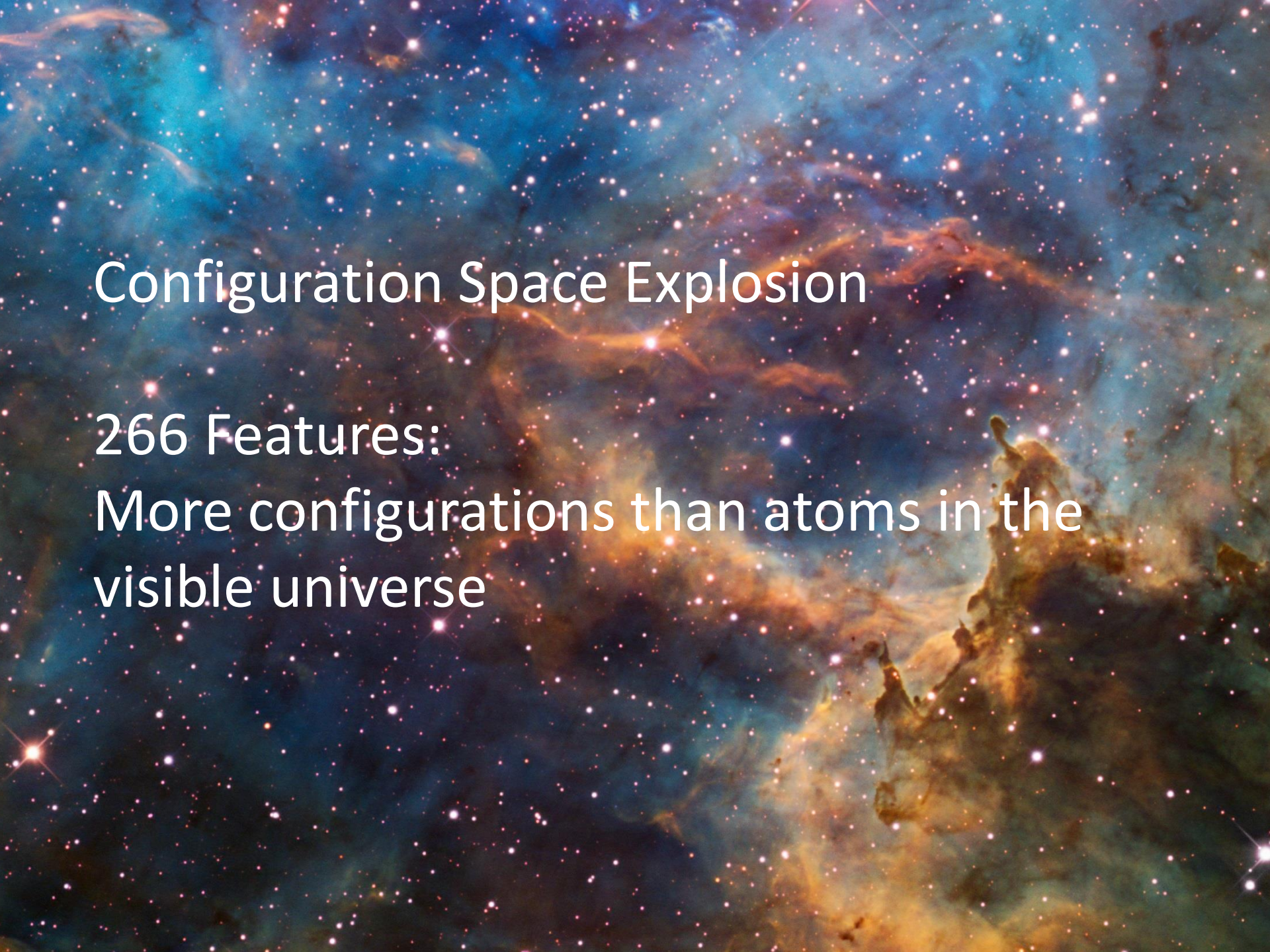


Testing Configurable Systems

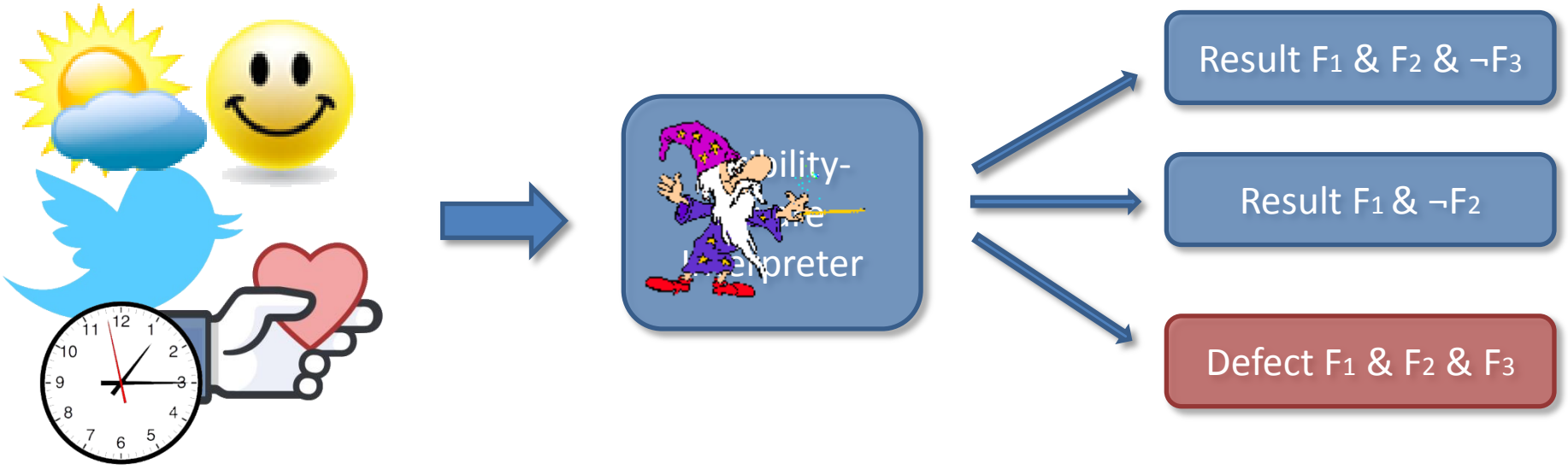


Testing Configurable Systems




Configuration Space Explosion
266 Features:
More configurations than atoms in the visible universe

Testing Configurable Systems



[CRE12, NCN14, M14]

VarexJ

Variability-Aware **ex**ecution for **J**ava

Based on the interpreter of Java Pathfinder

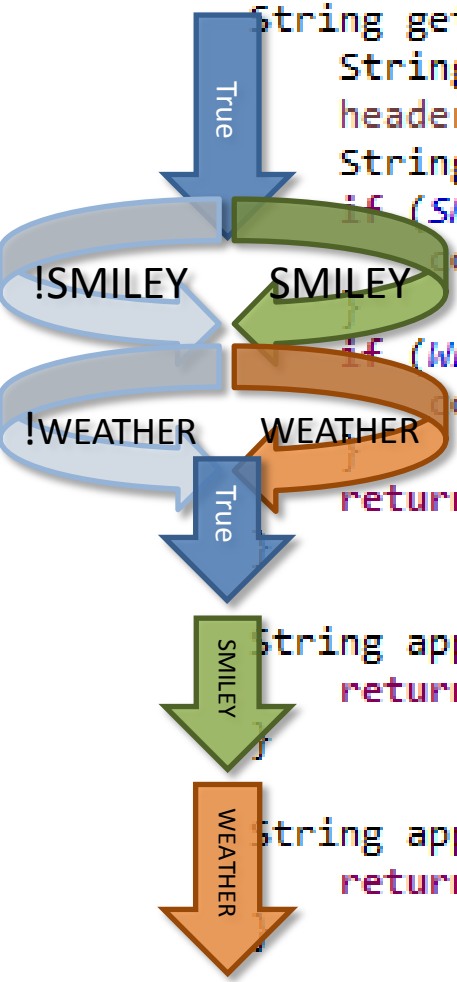
Share as much redundant instructions as possible

Share redundant data

https://github.com/meinicke/VarexJ

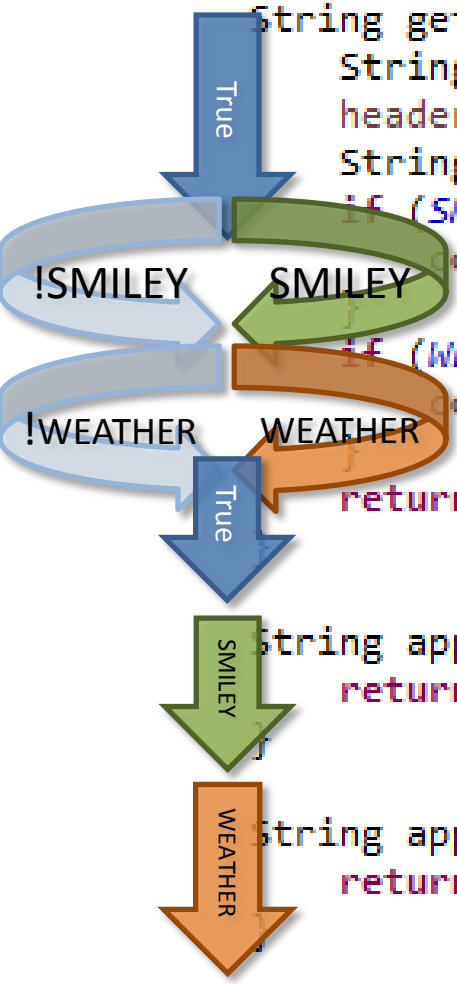
```
content = Choice(SMILEY,
  “<p>…[:Temperature<img=“smiley.jpg”></p>”,
  Choice(WEATHER,
    “<p>…10°C>”,
    “<p>…[:Temperature:]>”))
```

```
@Conditional
static boolean SMILEY = true;
@Conditional
static boolean WEATHER = true;

String getHTML() {
    String header = "<h4>Weather Updates:</h4>";
    header = header + '\n';
    String content = "<p>It's currently [:Temperature:].</p>";
    if (SMILEY) {
        content = applySmiley(content);
    }
    if (WEATHER) {
        content = applyWeather(content);
    }
    return header + content;
}

String applySmiley(String content) {
    return content.replaceAll("\\:\\]", "<img src=\"smiley.jpg\">");
}

String applyWeather(String content) {
    return content.replaceAll("\\[:Temperature\\:\\]", "10°C");
}
```



```
content = Choice(SMILEY,
  “<p>…[:Temperature<img=“smiley.jpg”></p>”,
  Choice(WEATHER,
    “<p>…10°C>”,
    “<p>…[:Temperature:]>”))
```

```
@Conditional
static boolean SMILEY = true;
@Conditional
static boolean WEATHER = true;

String getHTML() {
    String header = "<h4>Weather Updates:</h4>";
    header = header + '\n';
    String content = "<p>It's currently [:Temperature:].</p>";
    if (SMILEY) {
        content = applySmiley(content);
    }
    if (WEATHER) {
        content = applyWeather(content);
    }
    return
```

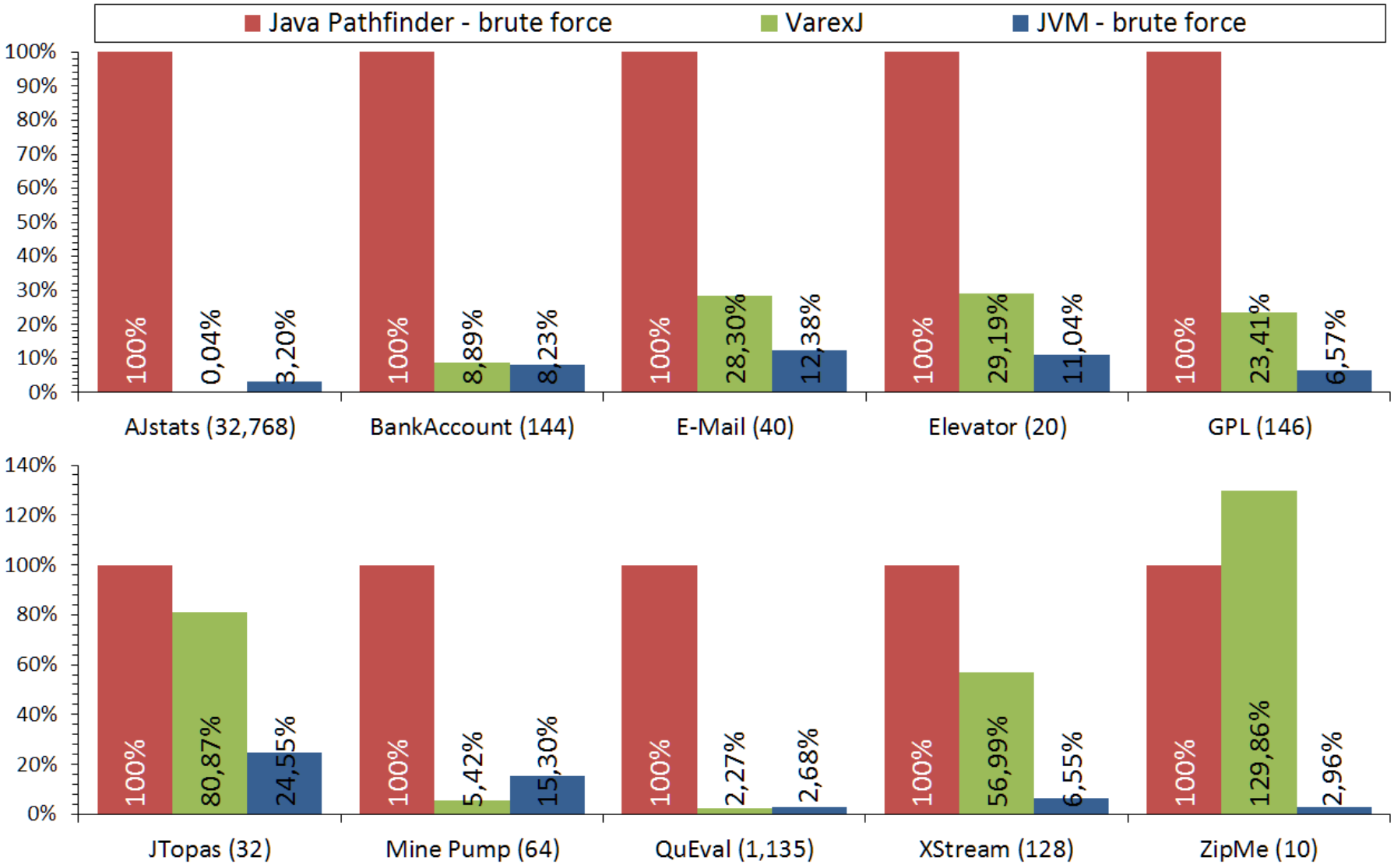



```
{<h4>Weather Updates:</h4>
<p>It's currently [:Temperature<img src="smiley.jpg">.</p>} : SMILEY
{<h4>Weather Updates:</h4>
<p>It's currently [:Temperature:].</p>} : !SMILEY & !WEATHER
{<h4>Weather Updates:</h4>
<p>It's currently 10°C.</p>} : !SMILEY & WEATHER
```

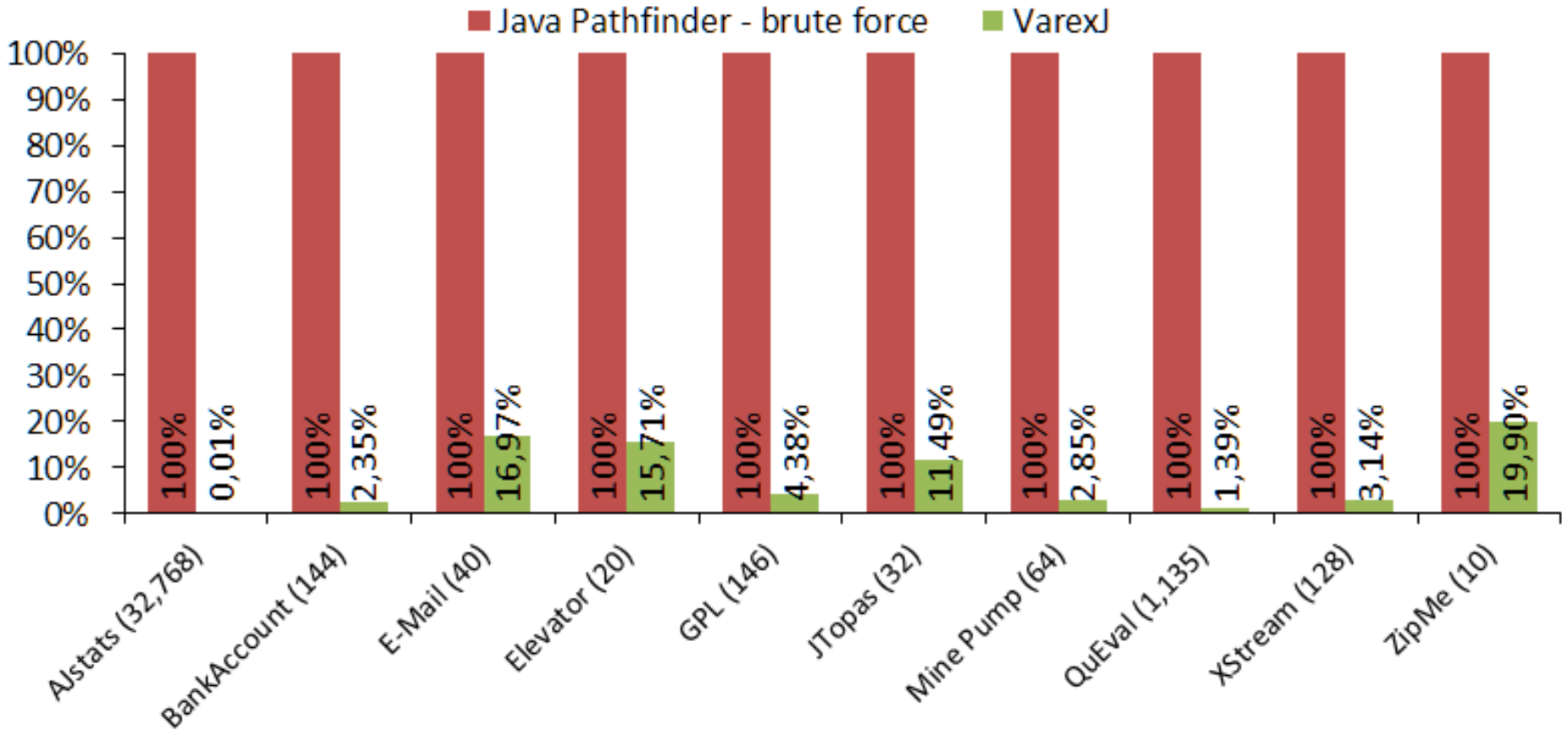
```
String app
    return
}

String applyWeather(String content) {
    return content.replaceAll("\\[:Temperature\\:\\]", "10°C");
}
```

Does it Scale?

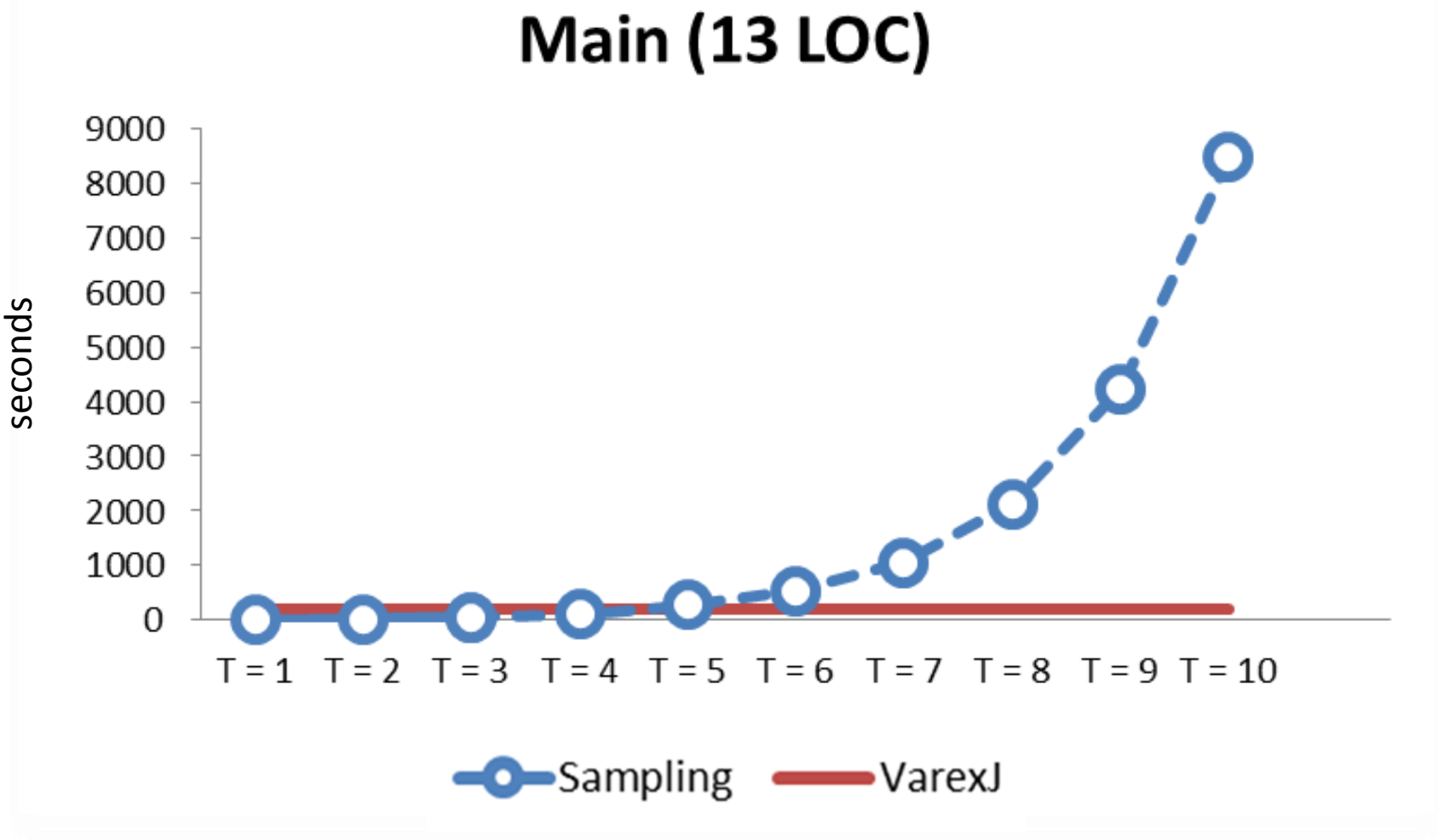
Execution Time



Sharing of Instructions

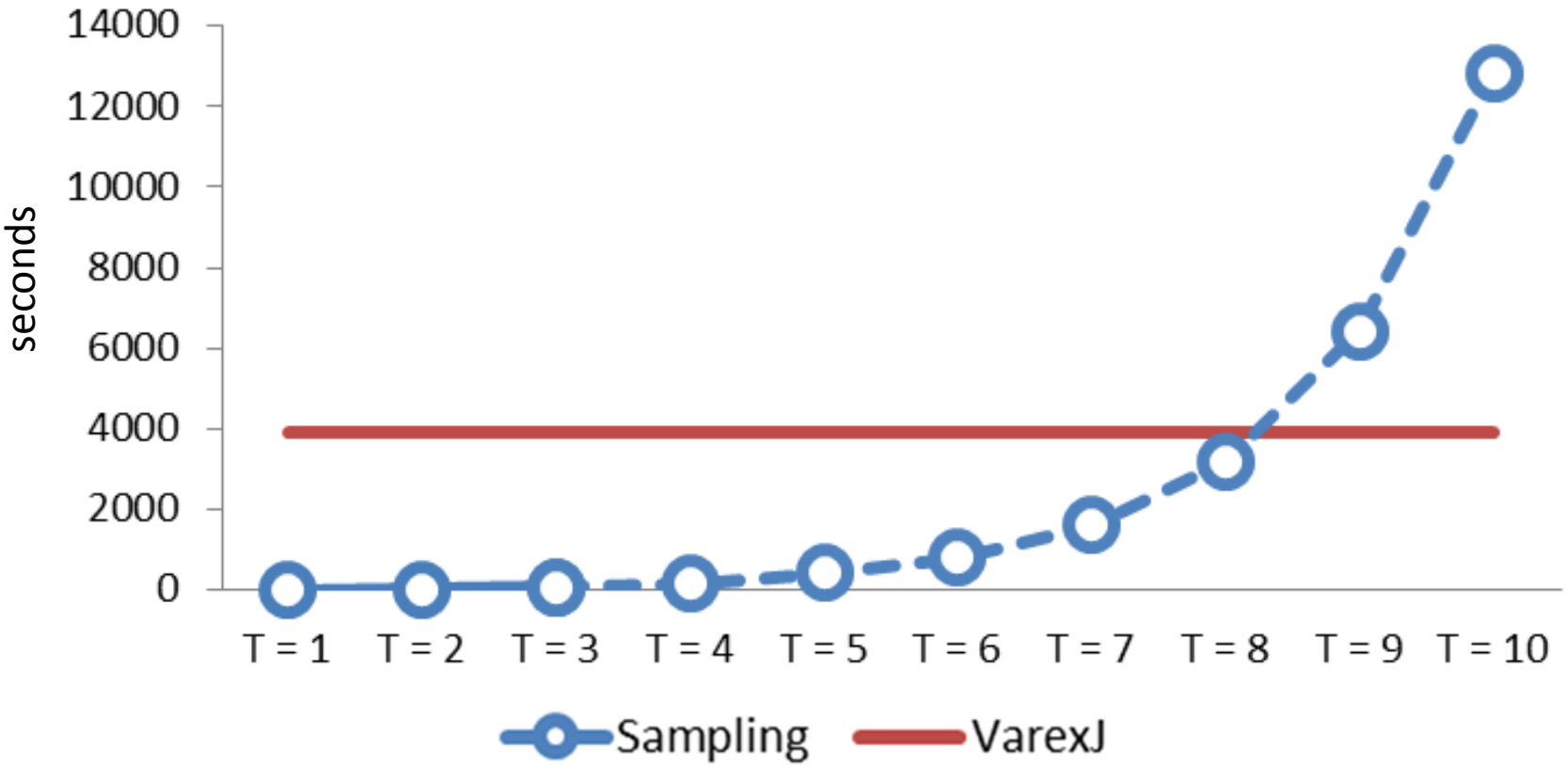


checkstyle


Main (13 LOC)
seconds
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
T = 1
T = 2
T = 3
T = 4
T = 5
T = 6
T = 7
T = 8
T = 9
T = 10
Sampling
VarexJ

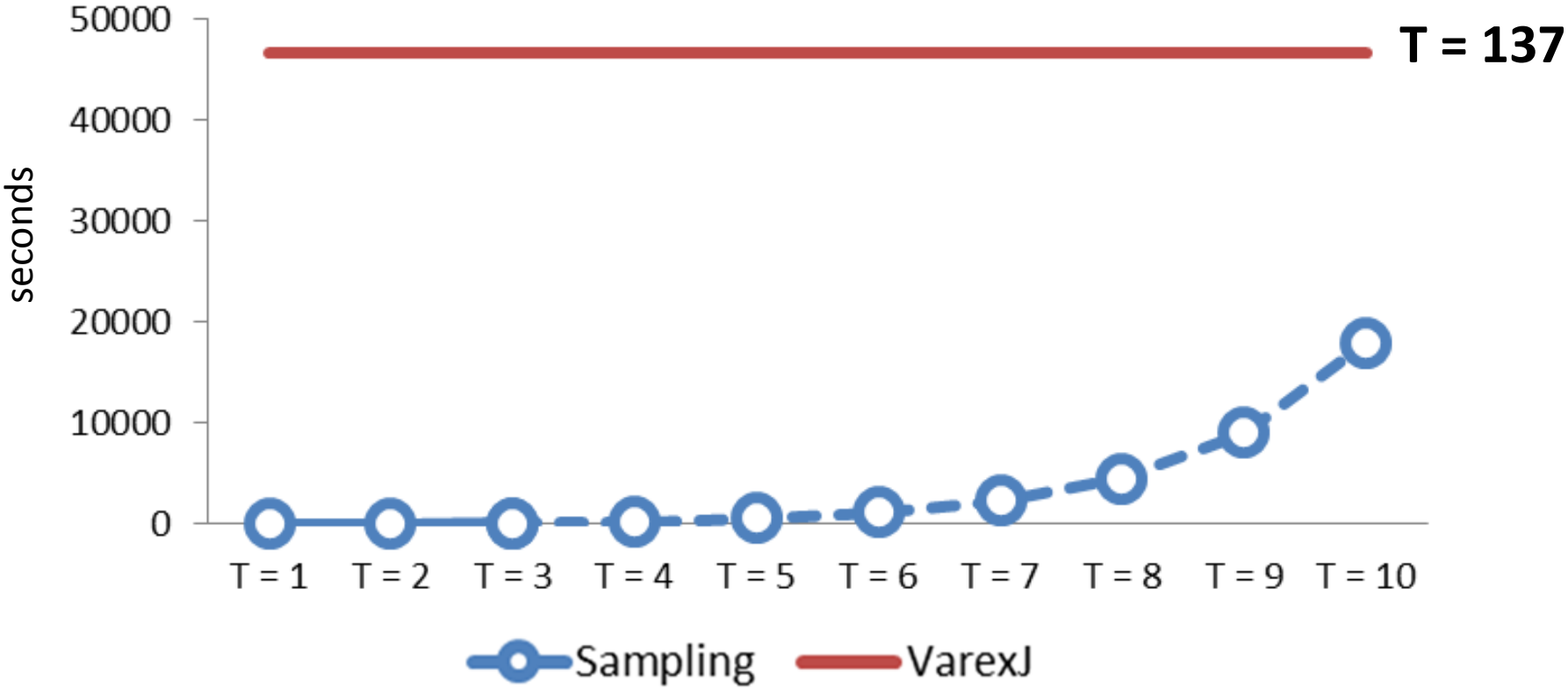
checkstyle

RandomSearch (153 LOC)



checkstyle

Checker (641 LOC)



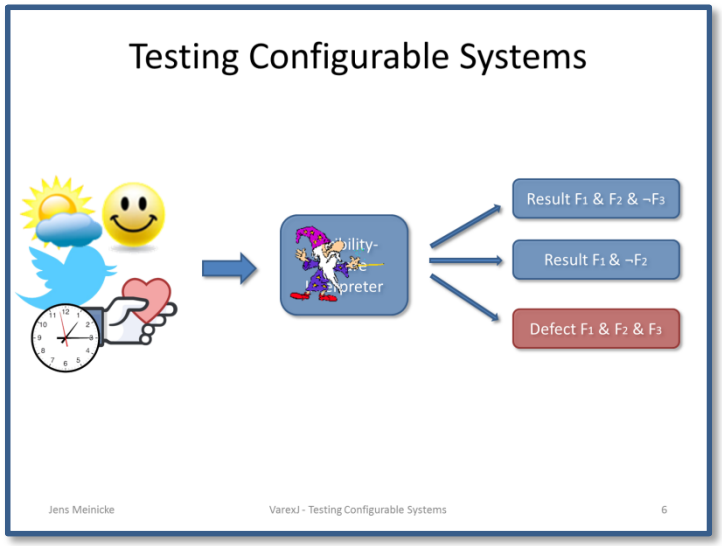
References

Jens Meinicke. **VarexJ: A Variability-Aware Interpreter for Java Applications**. Master's thesis, University of Magdeburg, Germany, December 2014.

Hung Viet Nguyen, Christian Kästner, and Tien N. Nguyen. **Exploring Variability-Aware Execution for Testing Plugin-Based Web Applications**. In Proceedings of the International Conference on Software Engineering (ICSE), pages 907–918. ACM, 2014.

Christian Kästner, Alexander von Rhein, Sebastian Erdweg, Jonas Pusch, Sven Apel, Tillmann Rendel, and Klaus Ostermann. **Toward Variability-Aware Testing**. In Proceedings of the International SPLC Workshop Feature-Oriented Software Development (FOSD), pages 1–8. ACM, 2012b.

So far…


Testing Configurable Systems
Result F1 & F2 & ¬F3
Result F1 & ¬F2
Defect F1 & F2 & F3
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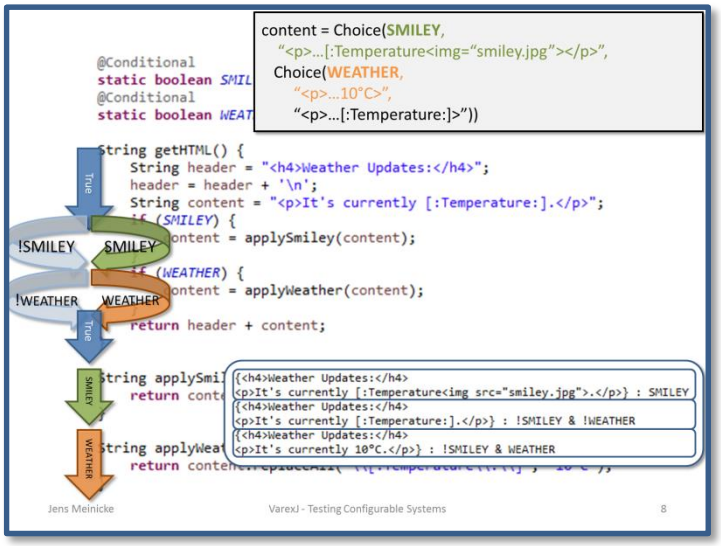
content = Choice(SMILEY,
" ...[:Temperature<img="smiley.jpg"> ",
Choice(WEATHER,
" ...10°C>",
" ...[:Temperature:]>"))
@Conditional
static boolean SMIL
@Conditional
static boolean WEAT
String getHTML() {
String header = "<h4>Weather Updates:</h4>";
header = header + '\n';
String content = " It's currently [:Temperature:]. ";
if (SMILEY) {
ontent = applySmiley(content);
if (WEATHER) {
ontent = applyWeather(content);
return header + content;
True
!SMILEY
SMILEY
!WEATHER
WEATHER
True
{<h4>Weather Updates:</h4>
It's currently [:Temperature<img src="smiley.jpg">. } : SMILEY
{<h4>Weather Updates:</h4>
It's currently [:Temperature:]. } : !SMILEY & !WEATHER
{<h4>Weather Updates:</h4>
It's currently 10°C. } : !SMILEY & WEATHER
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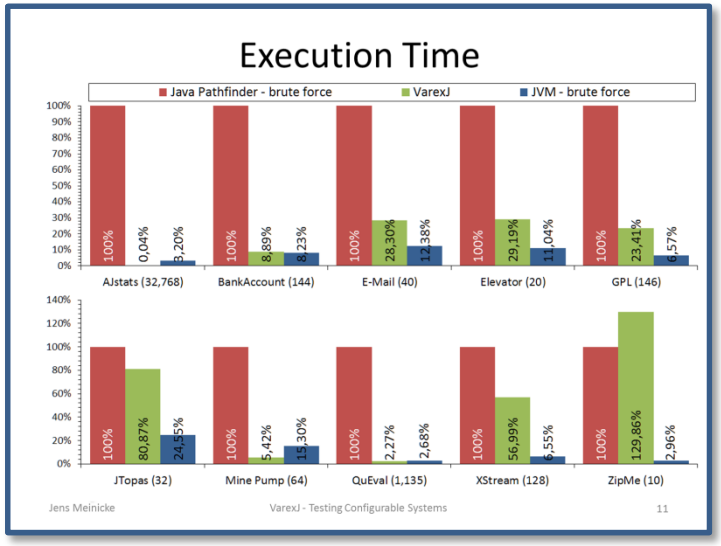
Execution Time
Java Pathfinder - brute force
VarexJ
JVM - brute force
AJstats (32,768)
BankAccount (144)
E-Mail (40)
Elevator (20)
GPL (146)
JTopas (32)
Mine Pump (64)
QuEval (1,135)
XStream (128)
ZipMe (10)
Jens Meinicke
VarexJ - Testing Configurable Systems
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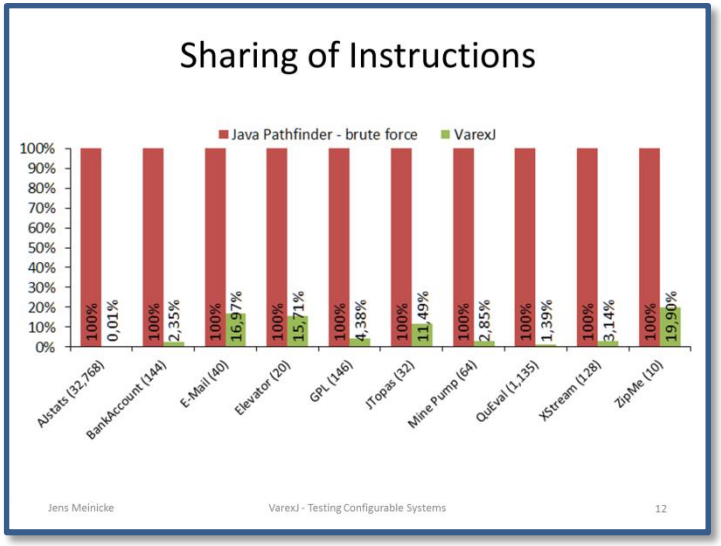
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VarexJ: A Variability-Aware Java Interpreter

Understanding Feature Interactions

Jens Meinicke, Chu-Pan Wong, Christian Kästner

FOSD Meeting 2015

Analyzing Variability

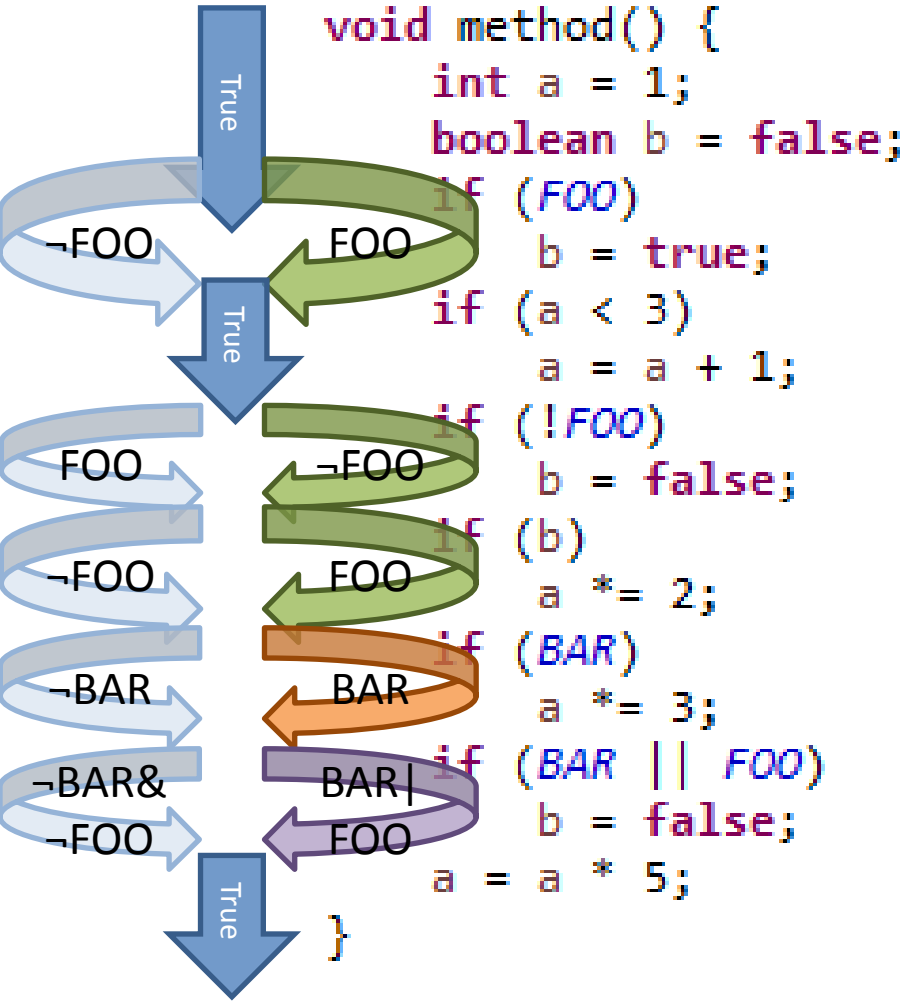
Where do features interact?

Why do features interact?

Are they supposed to interact?

Is the interaction accidental?

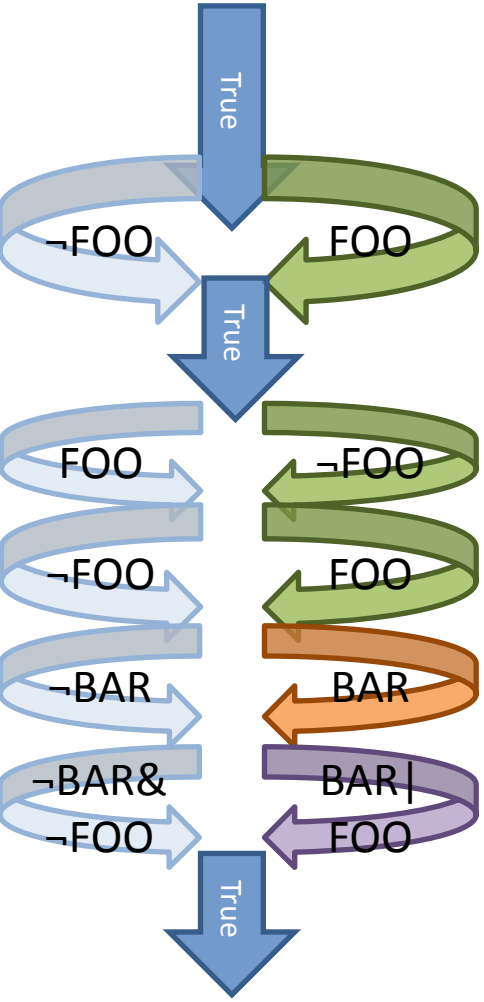
Variability-Aware Execution




```
void method() {
    int a = 1;
    boolean b = false;
    if (FOO)
        b = true;
    if (a < 3)
        a = a + 1;
    if (!FOO)
        b = false;
    if (b)
        a *= 2;
    if (BAR)
        a *= 3;
    if (BAR || FOO)
        b = false;
    a = a * 5;
}
```

a = 1 b = false
a = 1 b = Chc(**FOO**, **true**, false)
a = **2** b = Chc(FOO, true, false)
a = 2 b = Chc(FOO, true, false)
a = Chc(FOO, **4**, 2) b = Chc(FOO, true, false)
a = Chc(FOO, Chc(**BAR, 12**, 4), Chc(**BAR, 6**, 2)) b = Chc(FOO, true, false)
a = Chc(FOO, Chc(BAR,2, 4), Chc(BAR, 6, 2)) b = **false**
a = Chc(FOO,Chc(BAR,**60**,**20**),Chc(BAR,**30**, **10**)) b = false

Variability in Executions




```
void method() {
    int a = 1;
    boolean b = false;
    if (FOO)
        b = true;
    if (a < 3)
        a = a + 1;
    if (!FOO)
        b = false;
    if (b)
        a *= 2;
    if (BAR)
        a *= 3;
    if (BAR || FOO)
        b = false;
    a = a * 5;
}
```

Max features: 2
!FOO & BAR | FOO

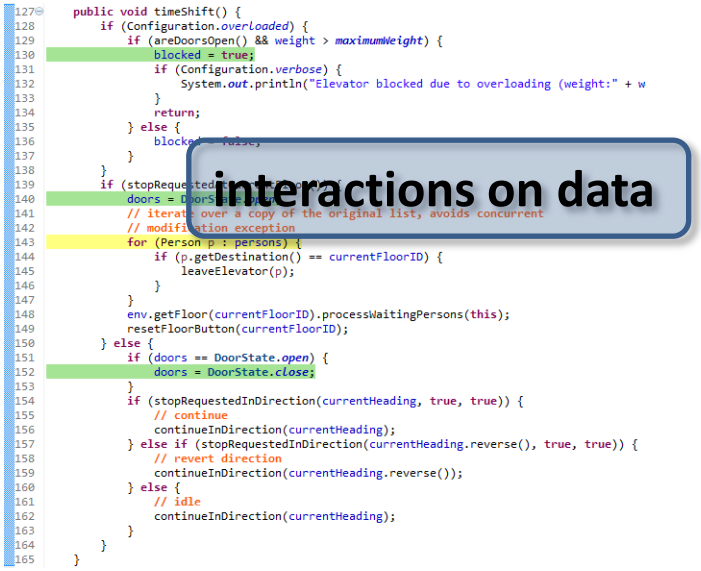
Variability in Data

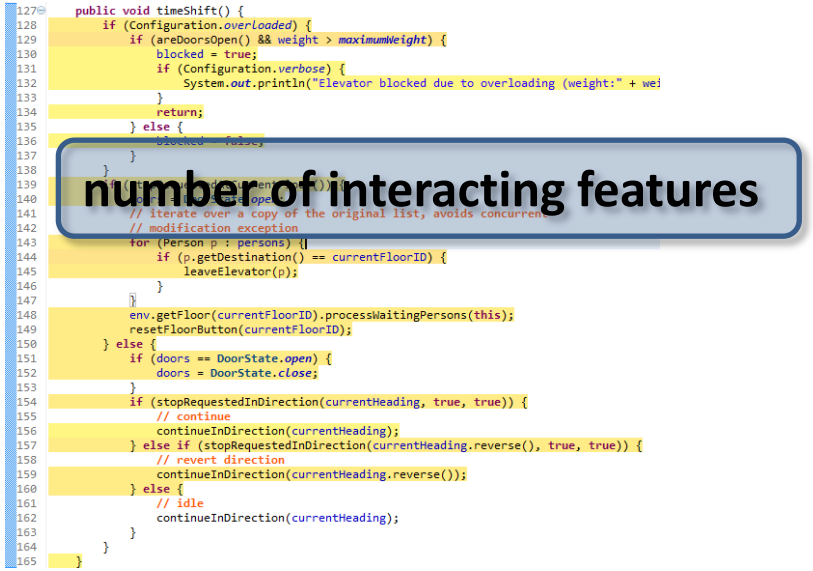
```
void method() {
    int a = 1;
    boolean b = false;
    if (FOO)
        b = true;
    if (a < 3)
        a = a + 1;
    if (!FOO)
        b = false;
    if (b)
        a *= 2;
    if (BAR)
        a *= 3;
    if (BAR || FOO)
        b = false;
    a = a * 5;
}
```

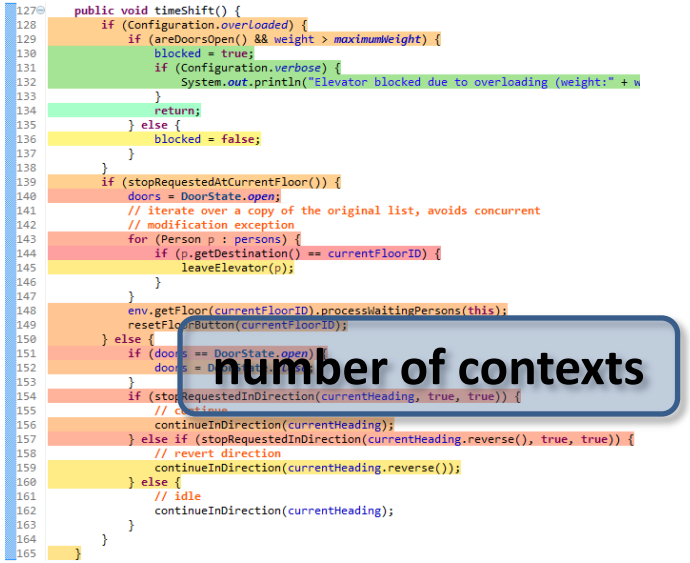
a = 1 b = false
a = 1 b = Chc(**FOO**, **true**, false)
a = **2** b = Chc(FOO, true, false)
a = 2 b = Chc(FOO, true, false)
a = Chc(FOO, **4**, 2) b = Chc(FOO, true, false)
a = Chc(FOO, Chc(**BAR, 12**, 4), Chc(**BAR, 6**, 2))
R, 6, 2))
R,**30**, **10**))

Interaction: 2
a (BAR):
2 : {!FOO: [2] ; FOO: [4] }
->
4 : {!FOO & !BAR: [2] ; FOO & !BAR: [4] ;
!FOO & BAR: [6] ; FOO & BAR: [12] }

Some Views on Elevator







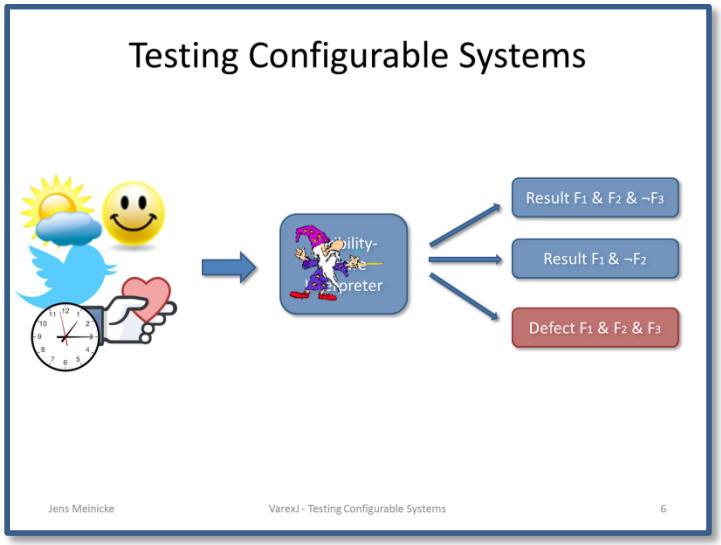
Big Questions

How do features interact in real world systems?

What pattern cause (high) feature interactions?

How do dangerous and unpredictable feature interactions appear?

Summary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Result F1 & ¬F2
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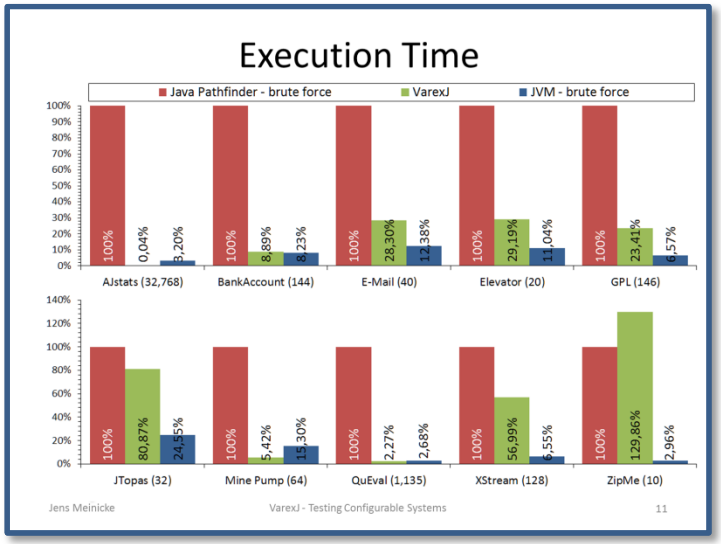
VarexJ - Testing Configurable Systems
6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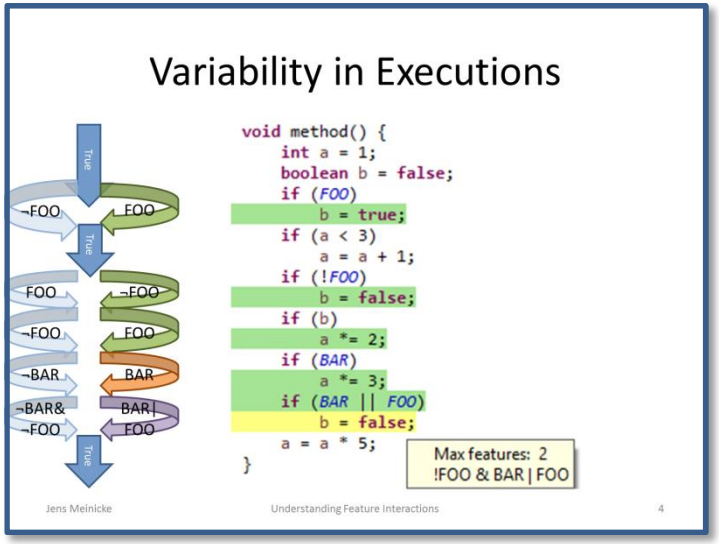
Variability in Executions
void method() {
int a = 1;
boolean b = false;
if (FOO)
b = true;
if (a < 3)
a = a + 1;
if (!FOO)
b = false;
if (b)
a *= 2;
if (BAR)
a *= 3;
if (BAR || FOO)
b = false;
a = a * 5;
}
Max features: 2
!FOO & BAR | FOO
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Understanding Feature Interactions
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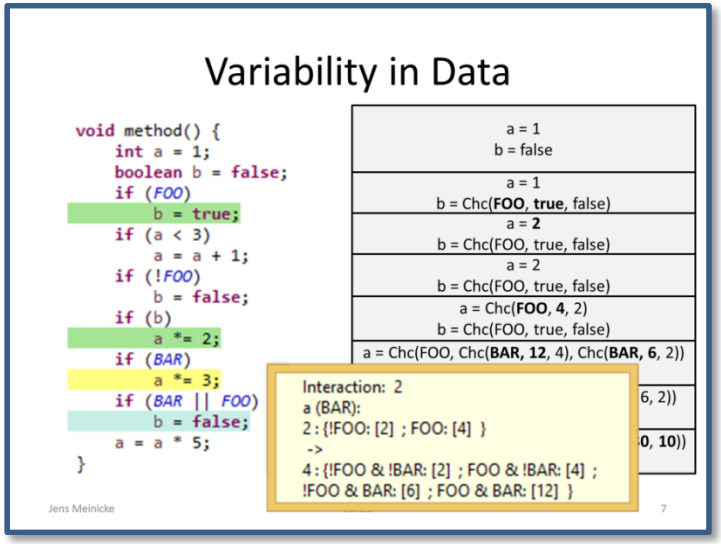
Variability in Data
void method() {
int a = 1;
boolean b = false;
if (FOO)
b = true;
if (a < 3)
a = a + 1;
if (!FOO)
b = false;
if (b)
a *= 2;
if (BAR)
a *= 3;
if (BAR || FOO)
b = false;
a = a * 5;
}
a = 1
b = false
a = 1
b = Chc(FOO, true, false)
a = 2
b = Chc(FOO, true, false)
a = 2
b = Chc(FOO, true, false)
a = Chc(FOO, 4, 2)
b = Chc(FOO, true, false)
a = Chc(FOO, Chc(BAR, 12, 4), Chc(BAR, 6, 2))
Interaction: 2
a (BAR):
2 : {!FOO: [2] ; FOO: [4] }
->
4 : {!FOO & !BAR: [2] ; FOO & !BAR: [4] ;
!FOO & BAR: [6] ; FOO & BAR: [12] }
Jens Meinicke
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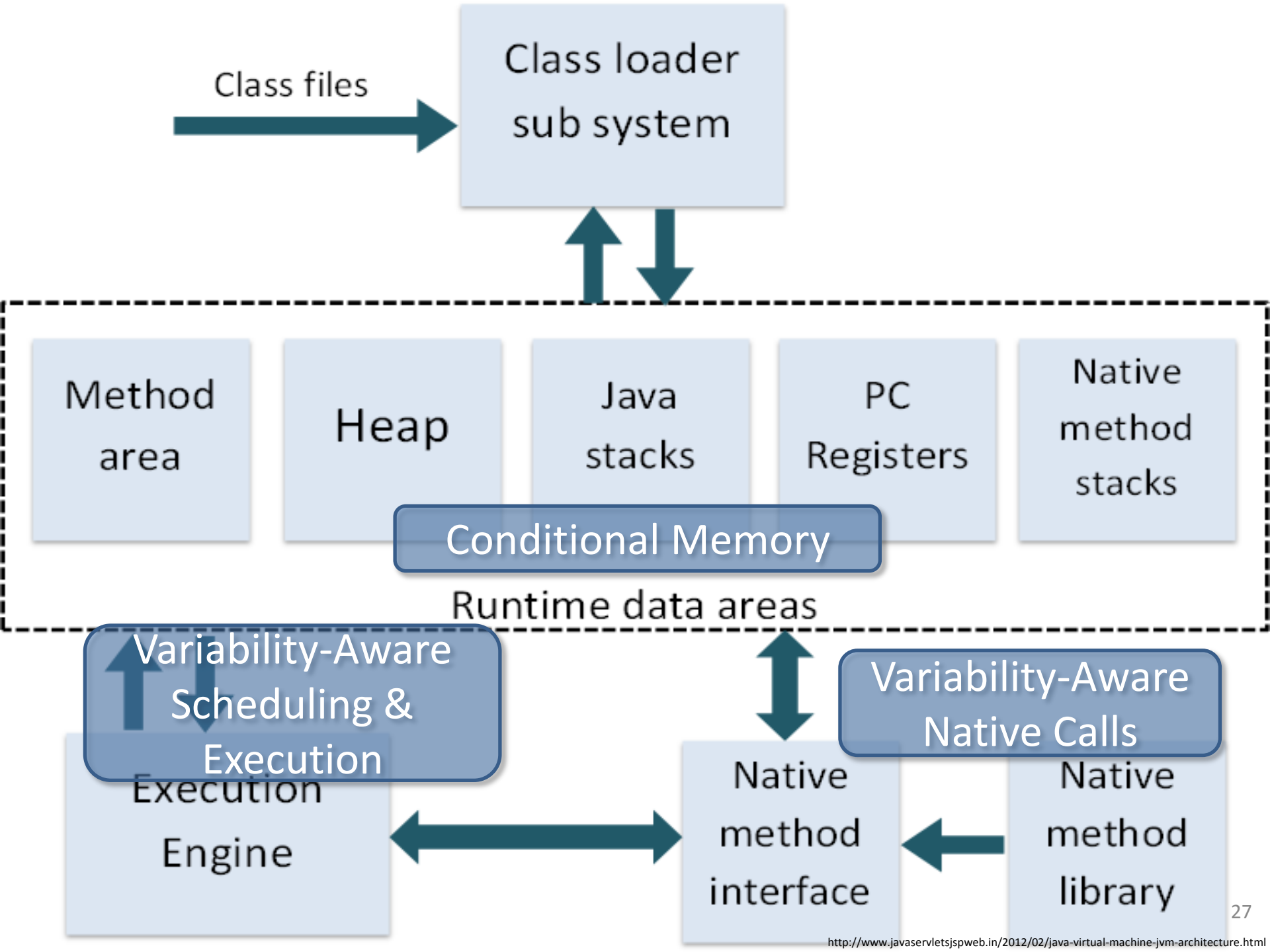
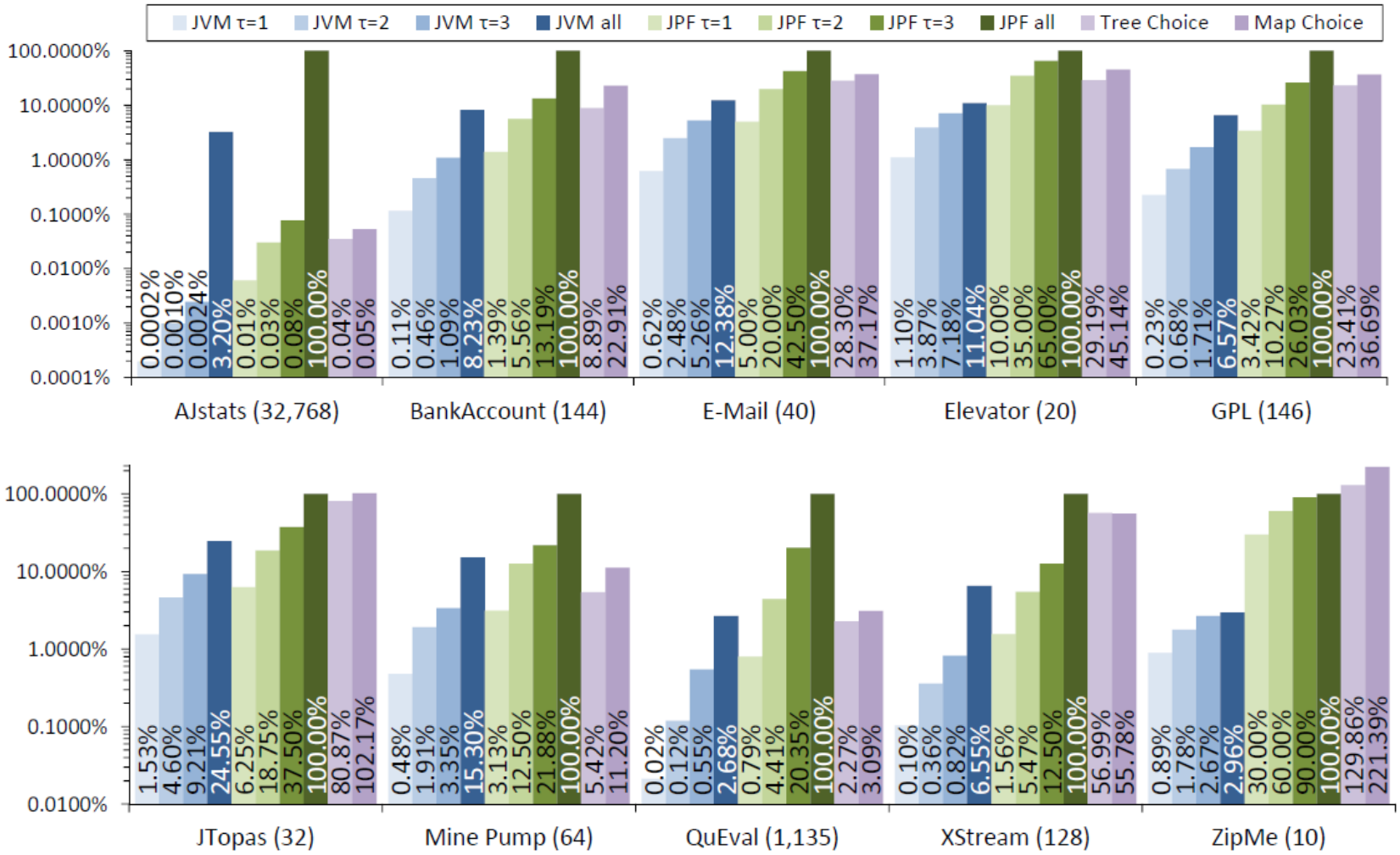


http://www.javaservletsjspweb.in/2012/02/java-virtual-machine-jvm-architecture.html

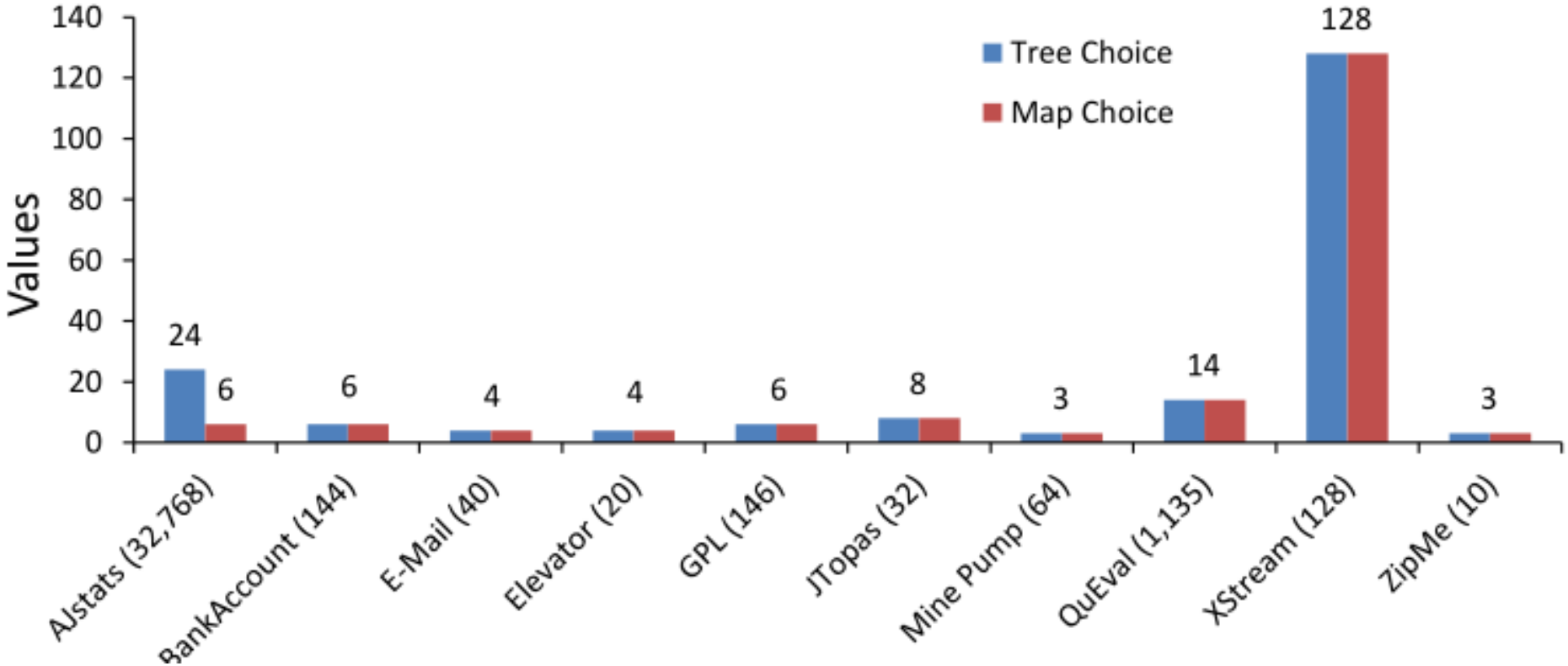
Example Programs

System	Instructions	Features	Products
AJstats	35235	20	32768
BankAccount	4217	10	144
E-Mail	2075	9	40
Elevator	4816	6	20
GPL	2971	22	146
JTopas	14528	5	32
Mine Pump	1687	7	64
QuEval	18294	30	1135
XStream	38234	7	128
ZipMe	12901	8	10

Time for Sampling



Interactions



Sharing of Instrucions