Implementing Test Coverage in Epsilon

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Presentation Structure

- Introduction to MDE
- Project Motivation
- Introduction to Software Testing Metrics
- Statement Coverage
- Branch Coverage
- Case Study
- Conclusions
- Further Work

Introduction - Model Driven Engineering

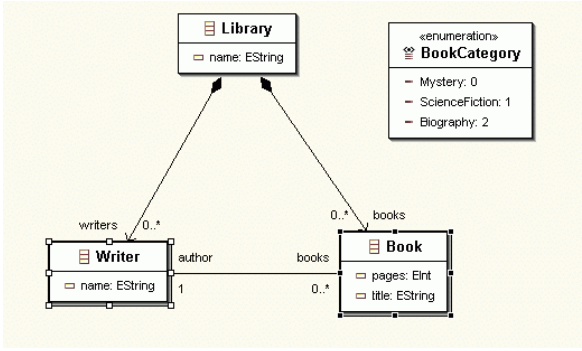


Figure : A sample model [Eclipse, 2014]

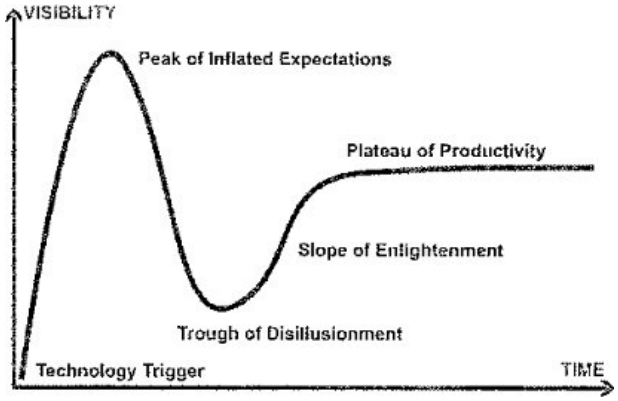


Figure : The technology hype cycle [M. Brambilla, 2012]

Introduction - Model Driven Engineering

- Has a set of languages for MDE purposes
- Languages are interpreted

Motivation

```
if ((err = ReadyHash(&SSLHashSHA1, &hashCtx)) != 0)
    goto fail;
if ((err = SSLHashSHA1.update(&hashCtx, &clientRandom)) != 0)
    goto fail;
if ((err = SSLHashSHA1.update(&hashCtx, &serverRandom)) != 0)
    goto fail;
if ((err = SSLHashSHA1.update(&hashCtx, &signedParams)) != 0)
    goto fail;
    goto fail;
if ((err = SSLHashSHA1.final(&hashCtx, &hashOut)) != 0)
    goto fail;
```

Figure : Apple's SSL Bug [Imperial Violet, 2014]

Motivation

- Epsilon currently lacks any test coverage metrics.
- Useful features will attract more users to MDE, and improve the quality of MDE tools.

Introduction - Software Testing Metrics

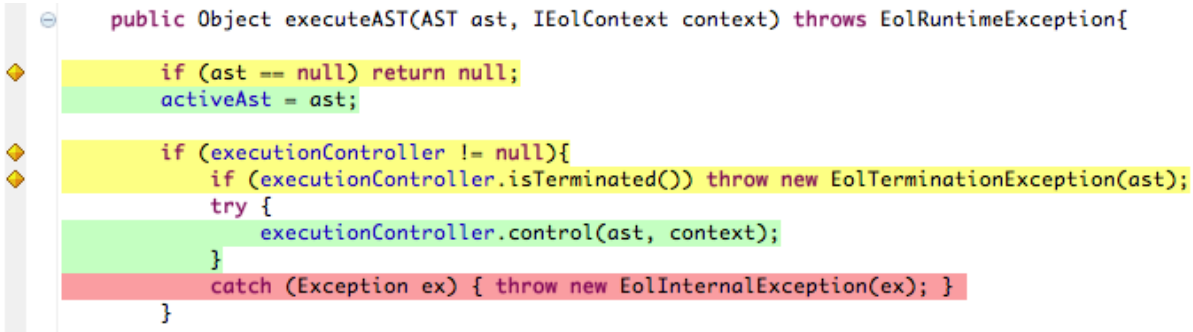


Figure : EclEmma [EclEmma.org, 2014]

- Statement Coverage
- Branch Coverage
- Path Coverage

Implementing Statement Coverage

```
1  "Hello, World".println();
```

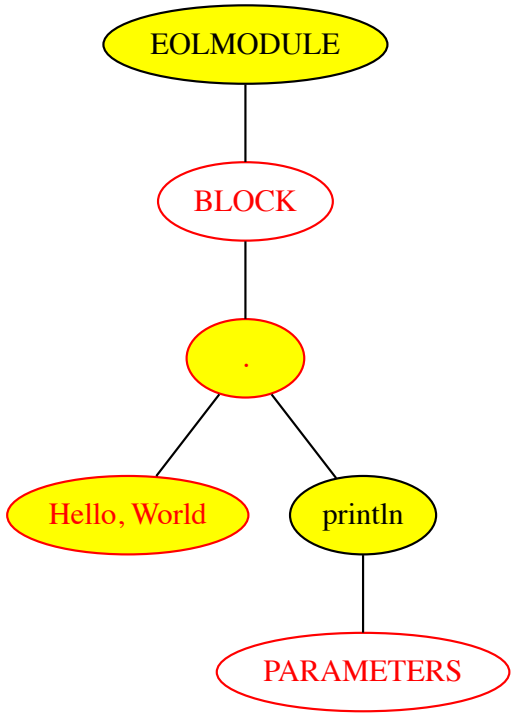


Figure : The executed AST for the 'Hello, World' program

Implementing Statement Coverage

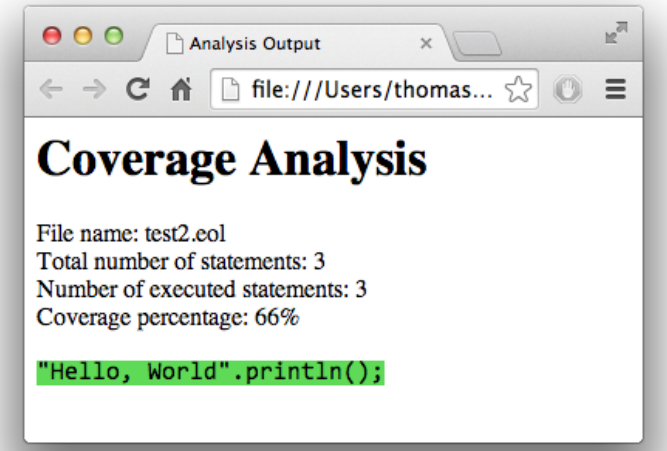


Figure : The HTML output from test ST-01, shown in Google Chrome

Implementing Statement Coverage

```
1  "Hello, World".println();
```

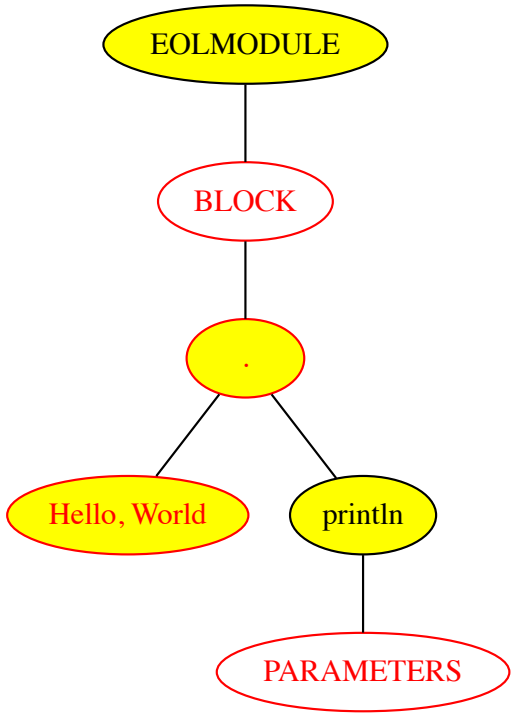


Figure : The executed AST for the 'Hello, World' program

Implementing Statement Coverage

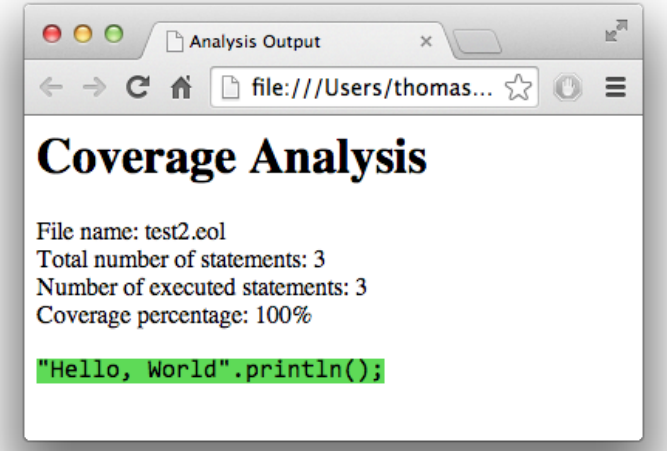
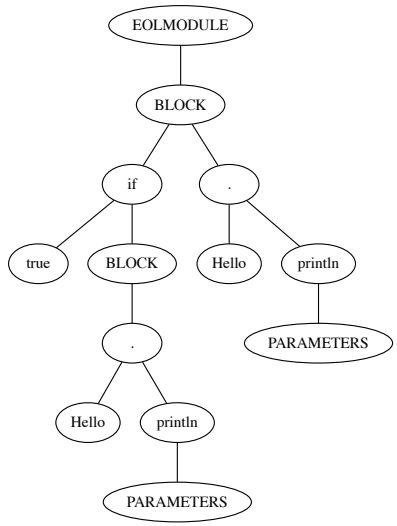


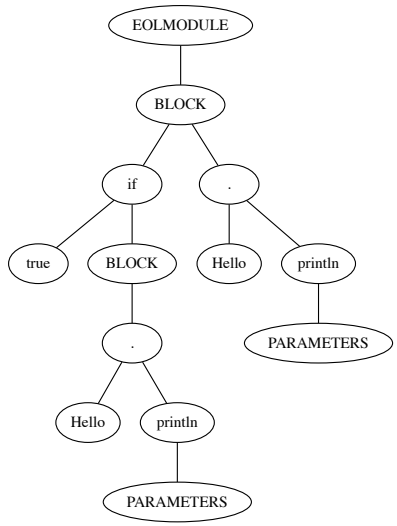
Figure : The fixed HTML output from test ST-01, shown in Google Chrome

Implementing Branch Coverage



- Need to count the number of branches executed
- Could consider each child of an AST, but there are some branches that we don't want to count
- Could consider all of the blocks of the AST, but there aren't always blocks (case statement, if statement).
- Need to consider path coverage

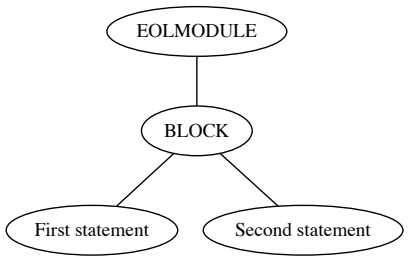
Implementing Branch Coverage - Conversion Algorithm



- Depth First Search
- Special cases for each statement
- Interface to add new statements

Implementing Branch Coverage - Creating a CFG

```
1  "First statement";
2  "Second statement";
```



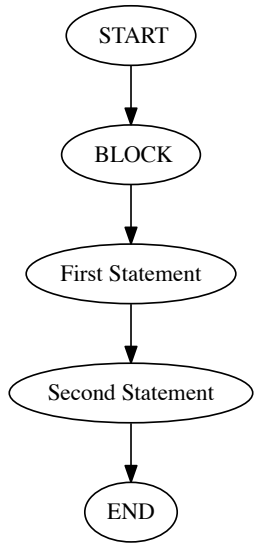
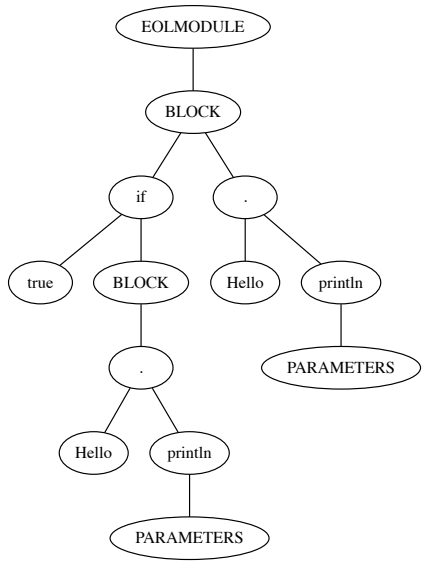


Figure : From left to right: The block's code, AST and desired CFG

Implementing Branch Coverage - Creating a CFG

```
1  if (true) {
2    "Hello".println();
3  }
4
5  "Hello".println();
```



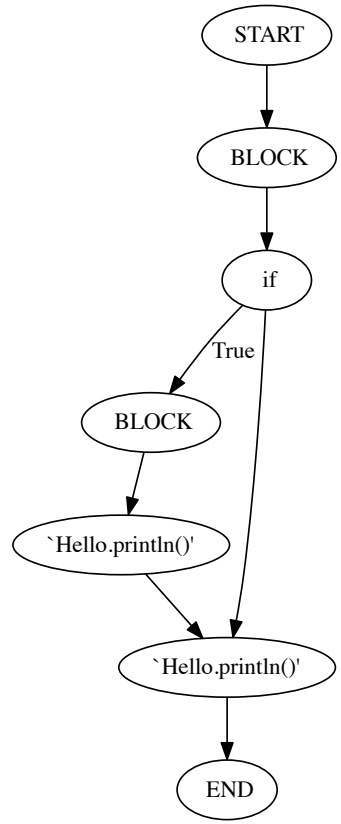
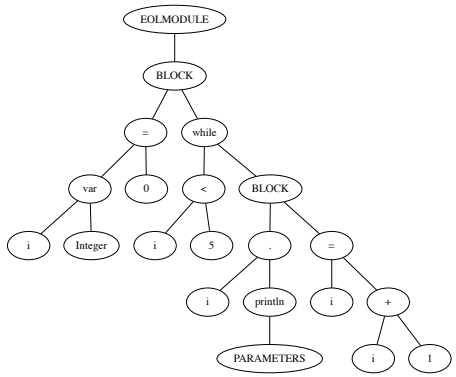


Figure : From left to right: Code for an if statement, its AST and desired CFG

Implementing Branch Coverage - Creating a CFG

```
1  var i : Integer = 0;
2
3   while (i < 5) {
4    i.println();
5    i = i+1;
6  }
```



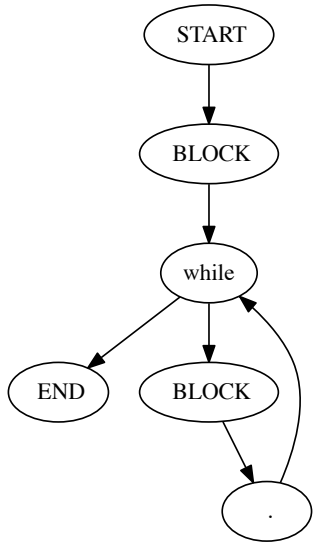


Figure : From left to right: The while loop code (taken from the Epsilon Book), AST and desired CFG

Implementing Branch Coverage - Creating a CFG

```
1  var i : Integer = 0;
2
3  switch (i) {
4    case 0 : "Zero".println();
5    case 1 : "One".println();
6    case 2 : "Two".println();
7    default : "Unknown".
         println();
8  }
```

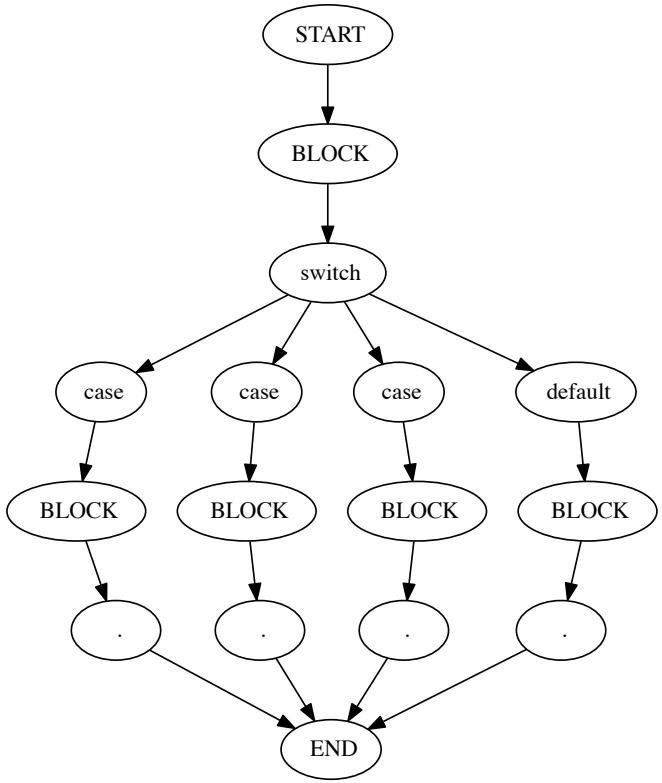


Figure : A switch statement and its CFG.

EuGENia Case Study

- EuGENia creates a GMF editor from an Ecore metamodel
- It is written in EOL
- It has an EUnit test suite

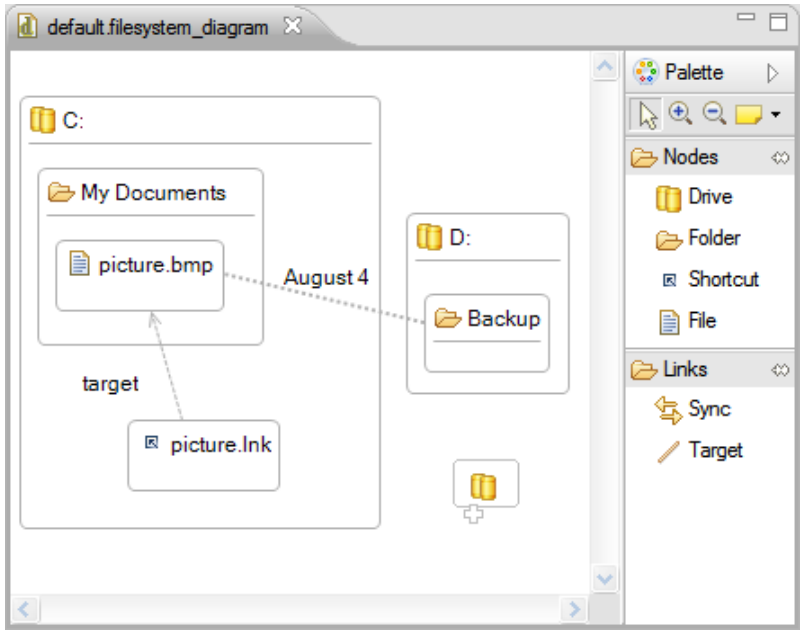


Figure : A sample gmf editor generated by EuGENia

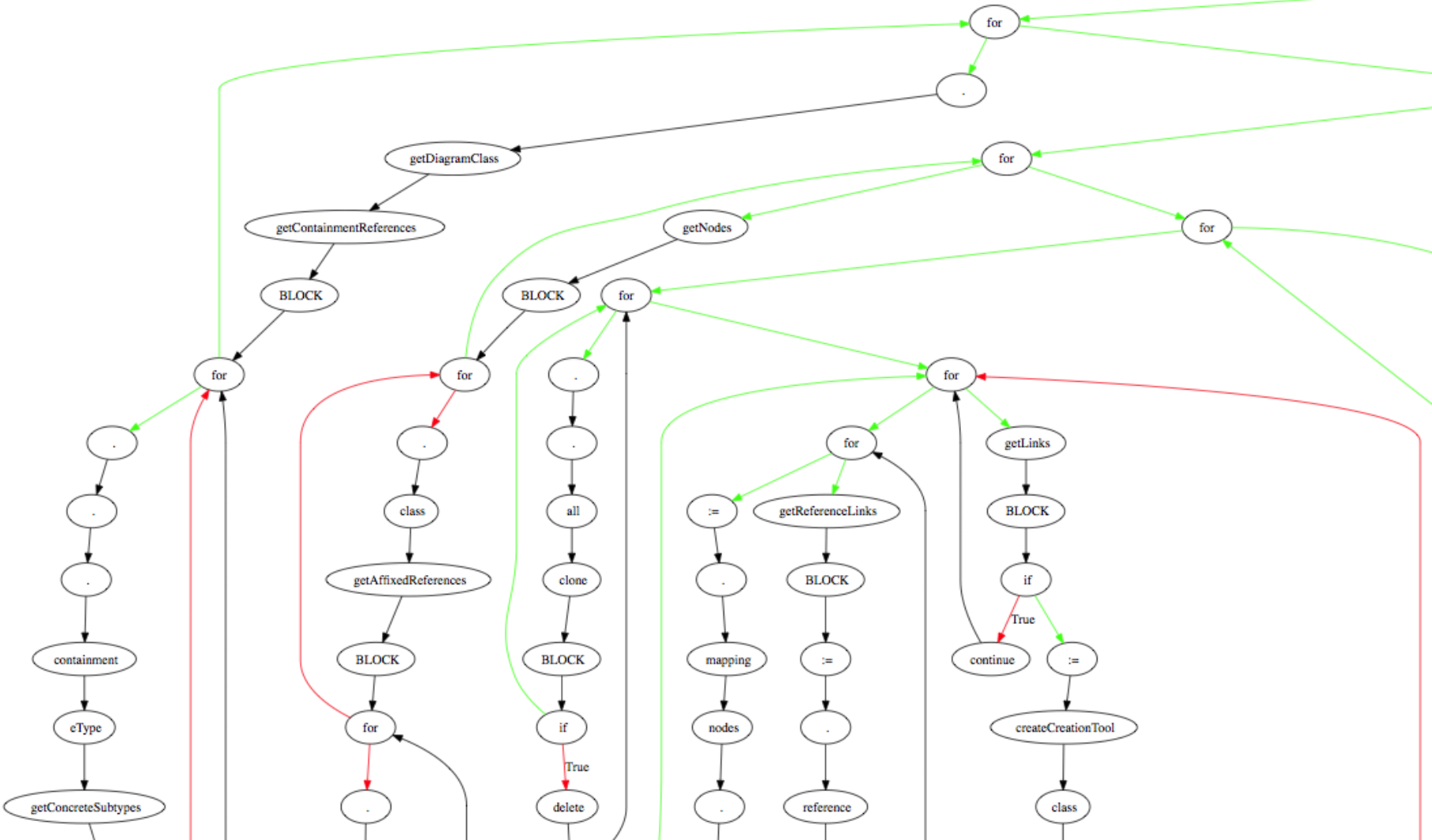
EuGENia Case Study - Statement Coverage

- 49% Statement Coverage

```
@cached
operation getLabelledAttributesFor(class : ECore!EClass) {
    return class.eAllAttributes.select(a|a.isLabelled());
}

@cached
operation getReferenceLinks() {
    var diagramClass := getDiagramClass();
    if (diagramClass.getAnnotationValue('gmf.diagram', 'refsarelinks') = 'true') {
        return ECore!EReference.all.select(r|r.containment = false);
    }
    else {
        return ECore!EReference.all.select(r|r.isLink());
    }
}

@cached
operation ECore!EClass getAllConcreteSubTypes() {
    return ECore!EClass.all.select(c|not c.abstract and c.eAllSuperTypes.includes(self));
}

operation getDiagramClass() : ECore!EClass {
    return ECore!EClass.all.selectOne(c|c.isAnnotatedAs('gmf.diagram'));
}

operation getDiagramContainmentReference(class : ECore!EClass) {
    for (ref in getDiagramClass().getContainmentReferences()){
        if (class.eAllSuperTypes.includes(ref.eType) or class = ref.eType) return ref;
    }
}

operation getOneSuitableContainmentReference(class : ECore!EClass) {
    for (ref in ECore!EReference.all.select(sf|sf.containment)){
        if (class.eAllSuperTypes.includes(ref.eType) or class = ref.eType) return ref;
    }
}

@cached
operation getAllSuitableContainmentReferences(class : ECore!EClass) {
    var suitableReferences : Sequence;
    for (ref in ECore!EReference.all.select(sf|sf.containment)){
```

EuGENia Case Study - Branch Coverage

- 61% Branch Coverage



EuGENia Case Study - Performance

Coverage Type	Time 1 (s)	Time 2 (s)	Time 3 (s)	Average Time (s)	Standard Deviation (s)
None	56.9	52.4	53.6	54.3	2.3
Statement	62.9	63.2	62.3	62.8	0.5
Branch	68.4	65.9	65.7	66.7	1.5

Table : Run times of the EuGENia test suite

- Statement Coverage +15%
- Branch Coverage +23%

Conlusions

Two main contributions:

- Added test coverage to Epsilon
- Documented algorithm for AST to CFG conversion

Case study is of use to EuGENia developers:

- Showed that a lot of code is not covered by test cases
- Showed that a lot of branches are never executed by test cases

Further Work

- HTML output for Branch Coverage
- Path Coverage
  - Calculating number of paths through CFG
- IDE integration

Bibliography

[Eclipse, 2014] : Eclipse. [Online]. Available: http://www.eclipse.org/modeling/gmp/ [M. Brambilla, 2012] : M. Brambilla, J. Cabot, and M. Wimmer, Model-Driven Software Engineering in Practice, ser. Synthesis Lectures on Software Engineering. Morgan & Claypool Publishers, 2012. [Online]. Available: http://dx.doi.org/10.2200/S00441ED1V01Y201208SWE001
[Imperial Violet, 2014] : I. Violet, Apple's ssl/tls bug. [Online]. Available: https://www.imperialviolet.org/2014/02/22/applebug.html
[EclEmma.org, 2014] : M. R. Hoffmann. Jacoco - java code coverage. [Online]. Available: http://www.eclemma.org/jacoco/trunk/index.html