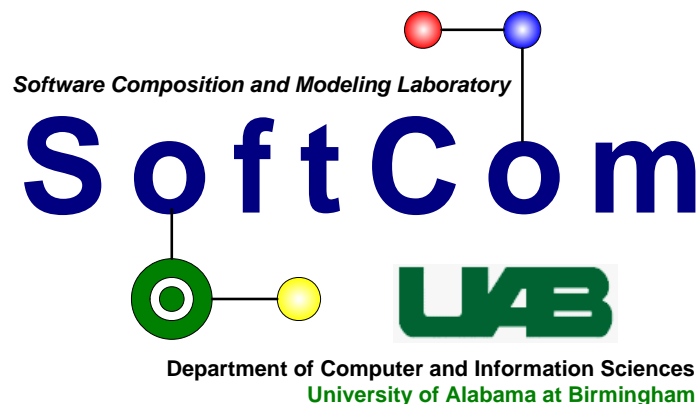


# CoCloRep: A DSL for Code Clones

Robert Tairas

with Shih-Hsi Liu, Frédéric Jouault, and Jeff Gray



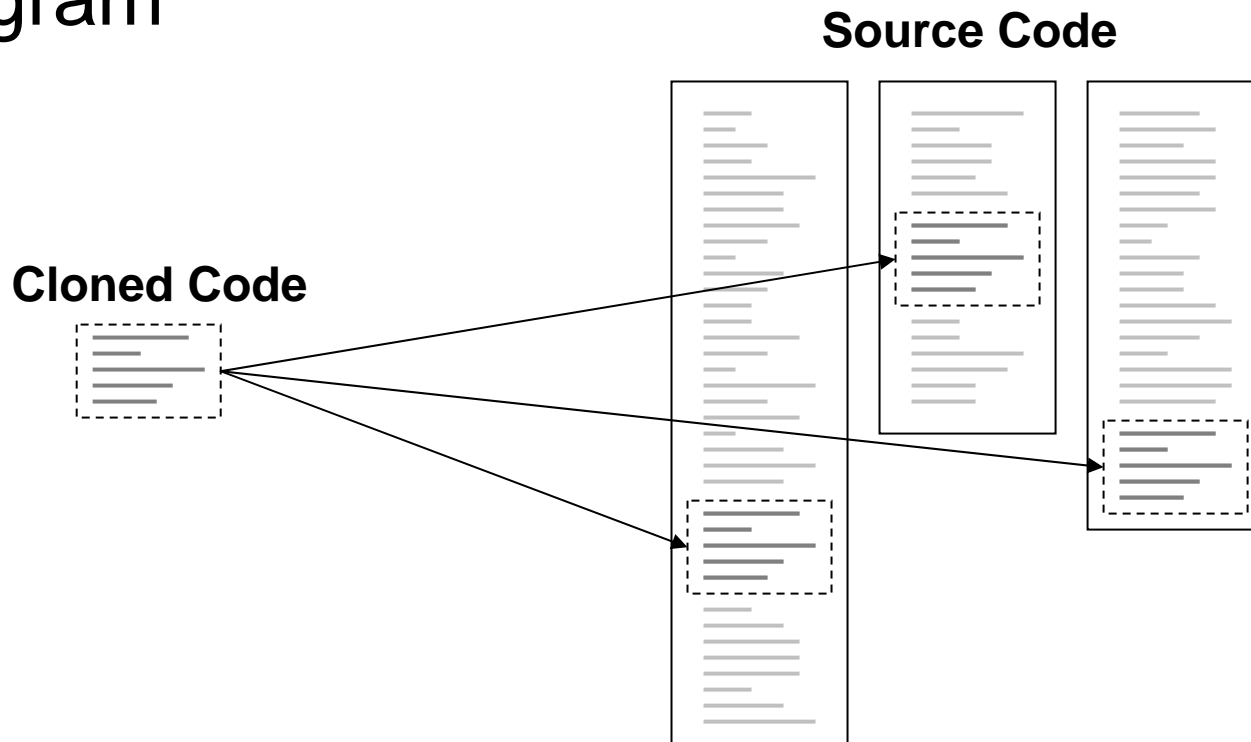
*Workshop on Software Language Engineering  
MoDELS 2007, Nashville, TN*



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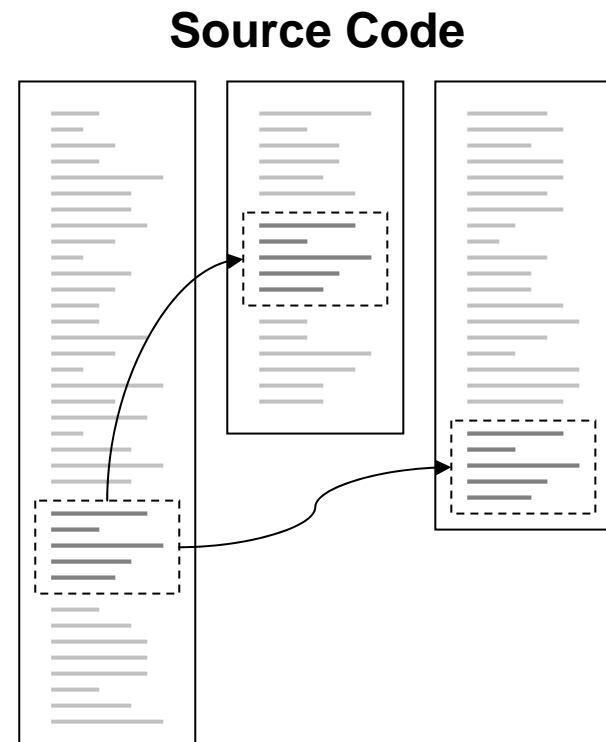
# Code Clones

- Code clone: a sequence of statements that are duplicated at multiple locations in a program



# Clones in Source Code

- Origin: copy-and-paste parts of code from one location to another
  - The copied code already works correctly
  - No time to be efficient
- Research shows that 6-8% of large-scale application code are clones (Jiang, 2006)



# Background: Clone Detection Tools

- String
  - (Johnson, 1994), (Ducasse, 1999)
- Token
  - Dup (Baker, 1996), CCFinder (Kamiya, 2002), (Basit, 2007)
- Abstract Syntax Tree
  - CloneDR (Baxter, 1998), (Koschke, 2006), (Evans, 2007)
- Program Dependence Graph
  - (Komondoor, 2001), (Krinke, 2001)
- Metrics
  - (Mayrand, 1996), (Kontogiannis, 1997)

# Background: Clone Analysis

- The detection stage can report a lot of clones
- What to do with the clones
  - Keep them as-is
  - Refactor
- Clone analysis in the Grammarware space
  - Metrics based on variable properties and distance (Higo, 2004)
  - Relationships in the class hierarchy (Golomingi, 2001)
  - Method-level clone grouping (Balazinska, 2000)

# Related Work: Clones as Models

- Clone Region Descriptors
  - Representation of clones for future monitoring and modification (Duala-Ekoko, 2007)
- Clone-Pair Model
  - Relationship of each clone pair in the group (Giesecke, 2006)
- Regional Group of Clones
  - Based on software entity locations used for determining structural relationships (Kapsner, 2006)

# Goal

- Representation and analysis of clones using Model-Driven Engineering (MDE)
  - Representation of clones as models via a Domain-Specific Language (DSL)
  - Analysis of these models through model transformations

# Types of Clones

## Original code

```
int main() {  
    int x = 1;  
    int y = x + 5;  
    return y;  
}
```

```
int func1() {  
    int x = 1;  
    int y = x + 5;  
    return y;  
}
```

Exact match

```
int func2() {  
    int p = 1;  
    int q = p + 5;  
    return q;  
}
```

Exact match with  
differing variable names

```
int func3() {  
    int s = 1;  
    int t = s + 5;  
    s++;  
    return t;  
}
```

Near exact match

# Types of Clones

## Original code

```
int main() {  
    int x = 1;  
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    return y;  
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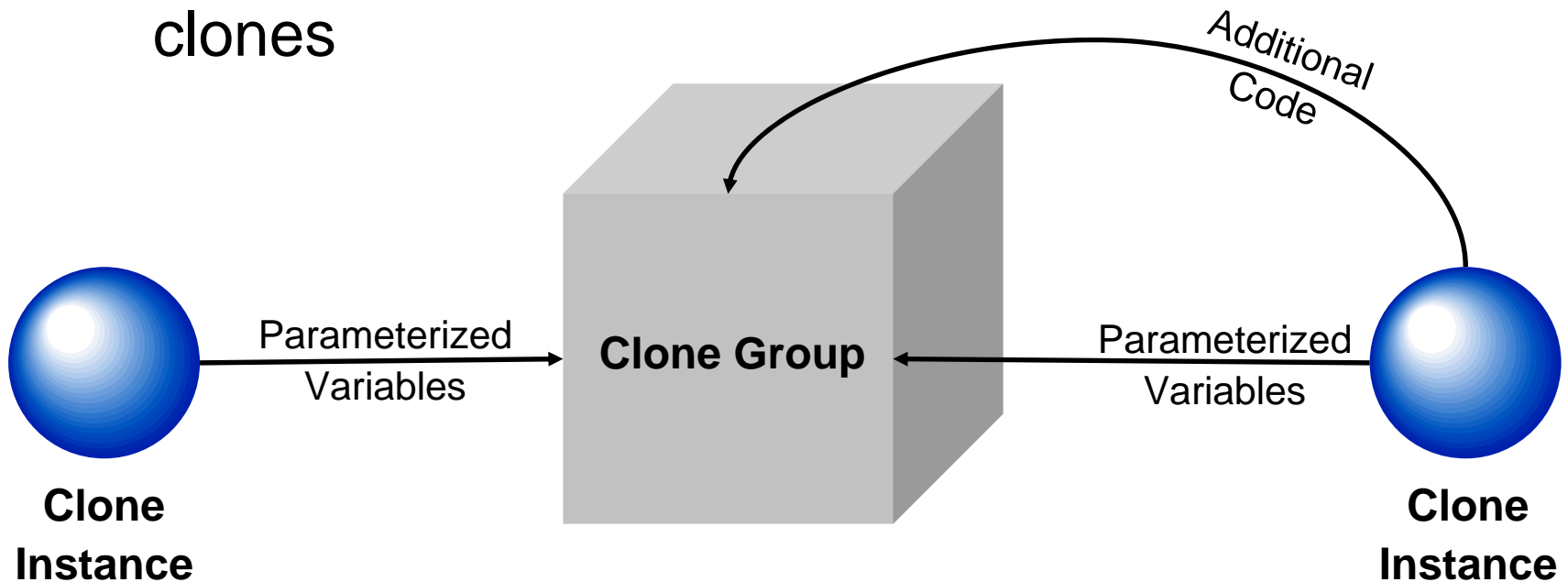
Exact match with  
differing variable names

```
int func3() {  
    int s = 1;  
    int t = s + 5;  
    s++;  
    return t;  
}
```

Near exact match

# Representing Clones

- Clone group: a set of clones representing the same duplication of code
  - A clone group contains the commonalities of the clones



# First DSL: Clones

```
-- clone 1
1: int g;
2: int f = g + 3;
3: i = i + 1;
4: c = f + m;

-- clone 2
1: int q;
2: int p = q + 3;
3: c = p + m;
```



```
-- clone instances
1: instance r = cg(f, g) {
2:   t {
3:     i = i + 1;
4:   }
5: };
6:
7: instance s = cg(p, q);

-- clone group
1: clone cg($a, $b) {
2:   int $b;
3:   int $a = $b + 3;
4:   {{ t }}
5:   c = $a + m;
6: }
```

# First DSL: Clones

**-- clone 1**

```
1: int g;  
2: int f = g + 3;  
3: i = i + 1;  
4: c = f + m;
```

**-- clone 2**

```
1: int q;  
2: int p = q + 3;  
3: c = p + m;
```



**-- clone instances**

```
1: instance r = cg(f, g) {  
2:   t {  
3:     i = i + 1;  
4:   }  
5: };  
6:  
7: instance s = cg(p, q);
```

**-- clone group**

```
1: clone cg($a, $b) {  
2:   int $b;  
3:   int $a = $b + 3;  
4:   {{ t }}  
5:   c = $a + m;  
6: }
```

# First DSL: Clones

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-- clone 1
1: int g;
2: int f = g + 3;
3: i = i + 1;
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-- clone instances
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1: clone cg($a, $b) {
2:   int $b;
3:   int $a = $b + 3;
4:   {{ t }}
5:   c = $a + m;
6: }
```

# Second DSL: Commands

## ■ Input:

```
variables cg;
```

## ■ Output:

```
1: Variable information for clone group cg
```

```
2: Declared variables:
```

```
3:   b
```

```
4:   a
```

```
5: Outside assigned variables:
```

```
6:   c
```

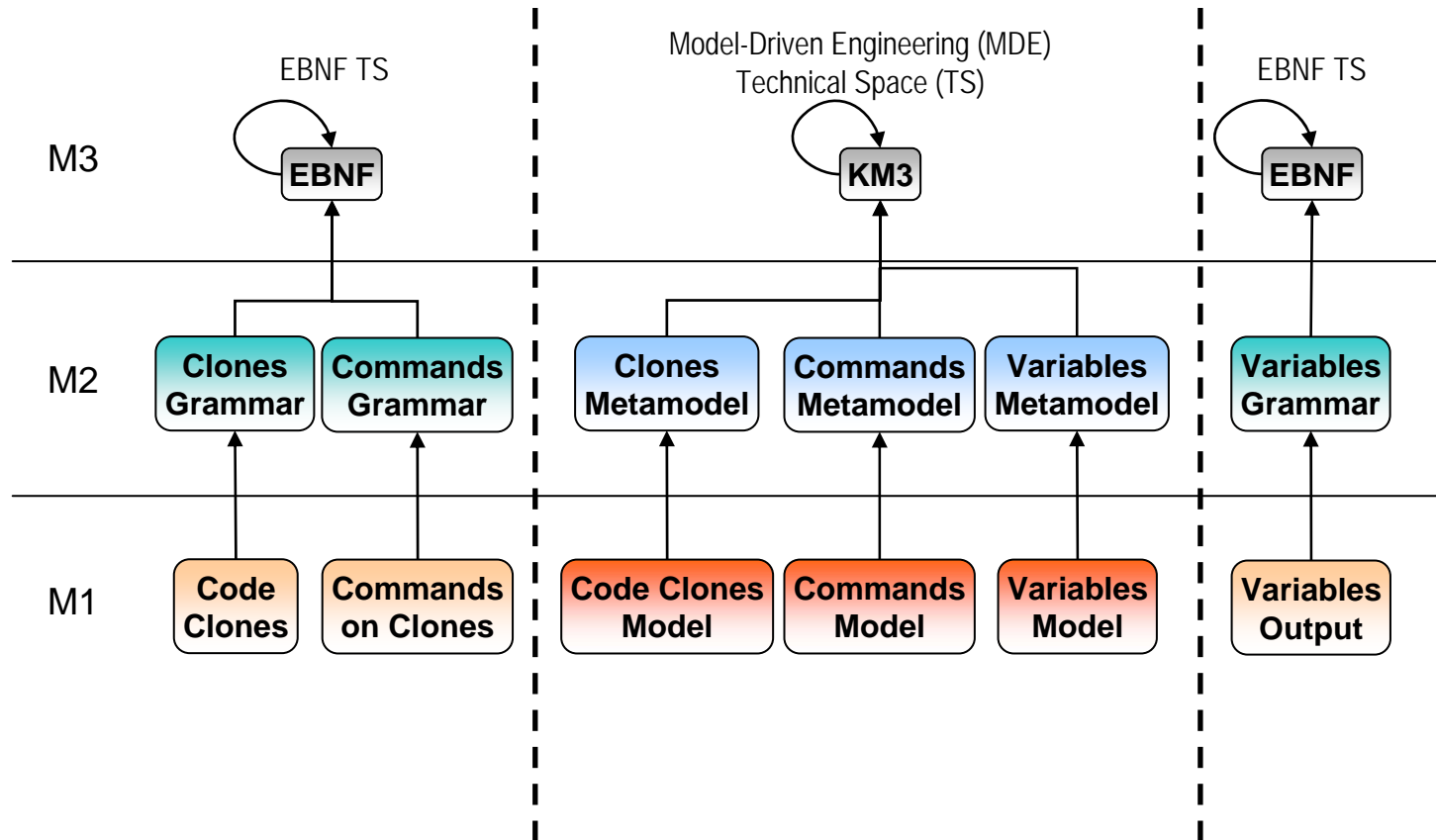
```
7:   i (in instance r)
```

```
8: Outside non-assigned variables:
```

```
9:   m
```

# Model Transformation Process

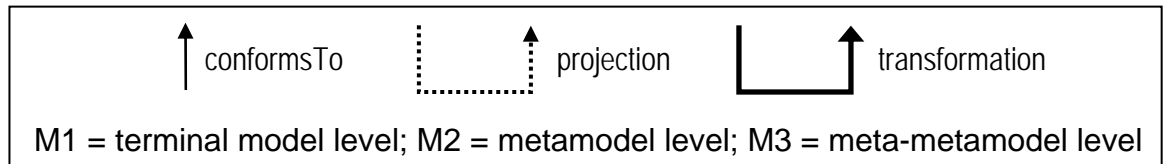
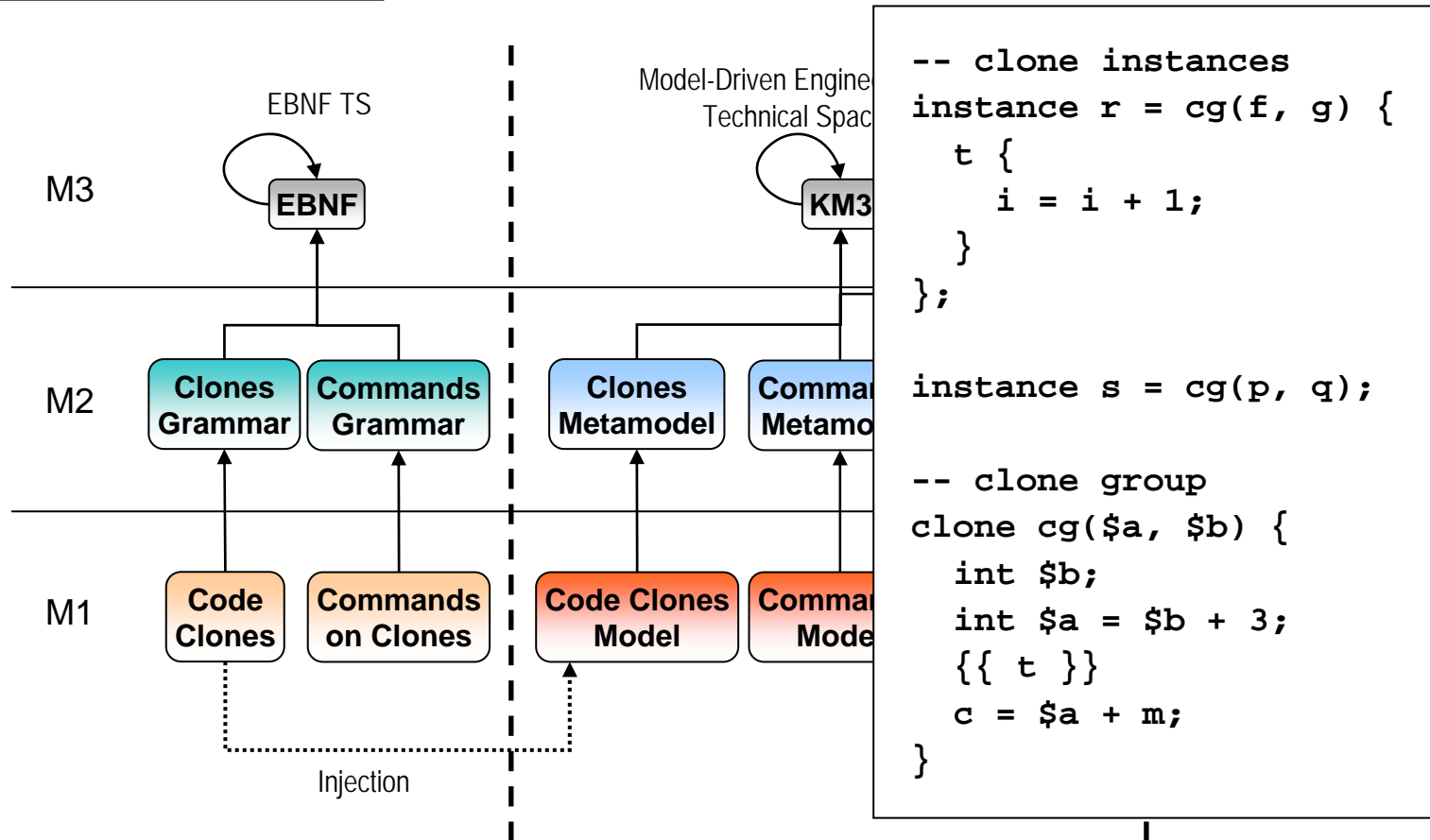
variables command



M1 = terminal model level; M2 = metamodel level; M3 = meta-metamodel level

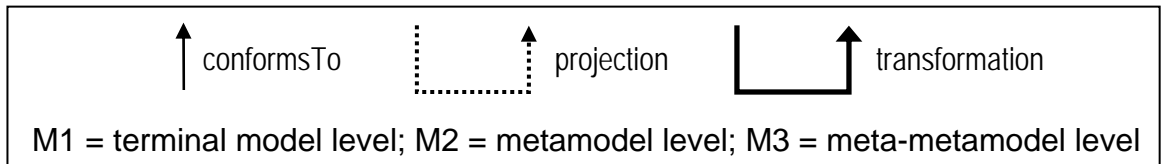
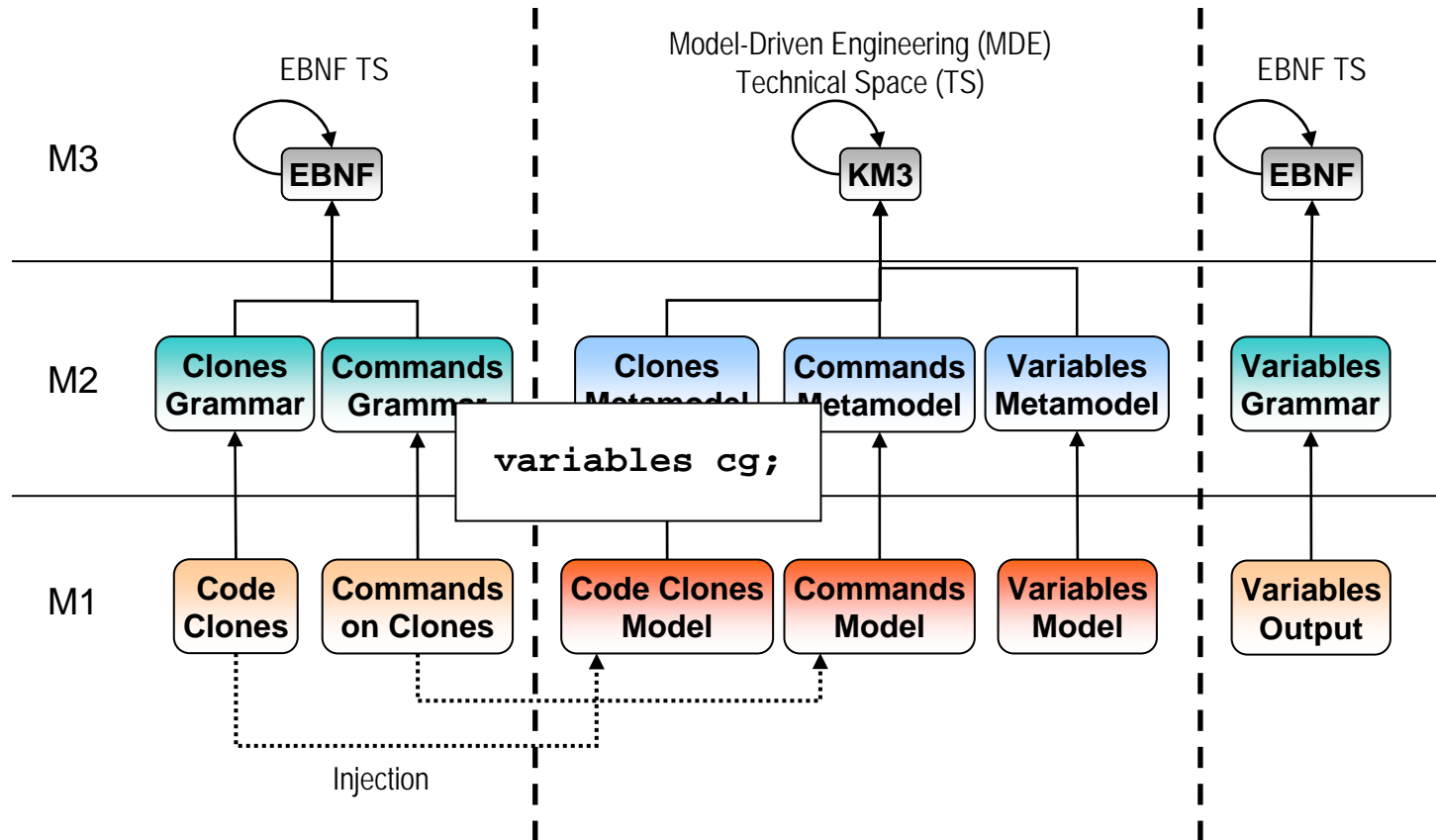
# Model Transformation Process

variables command



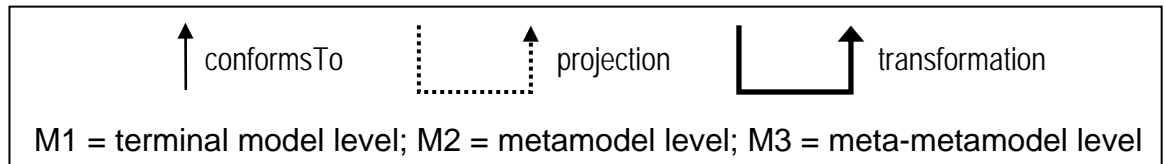
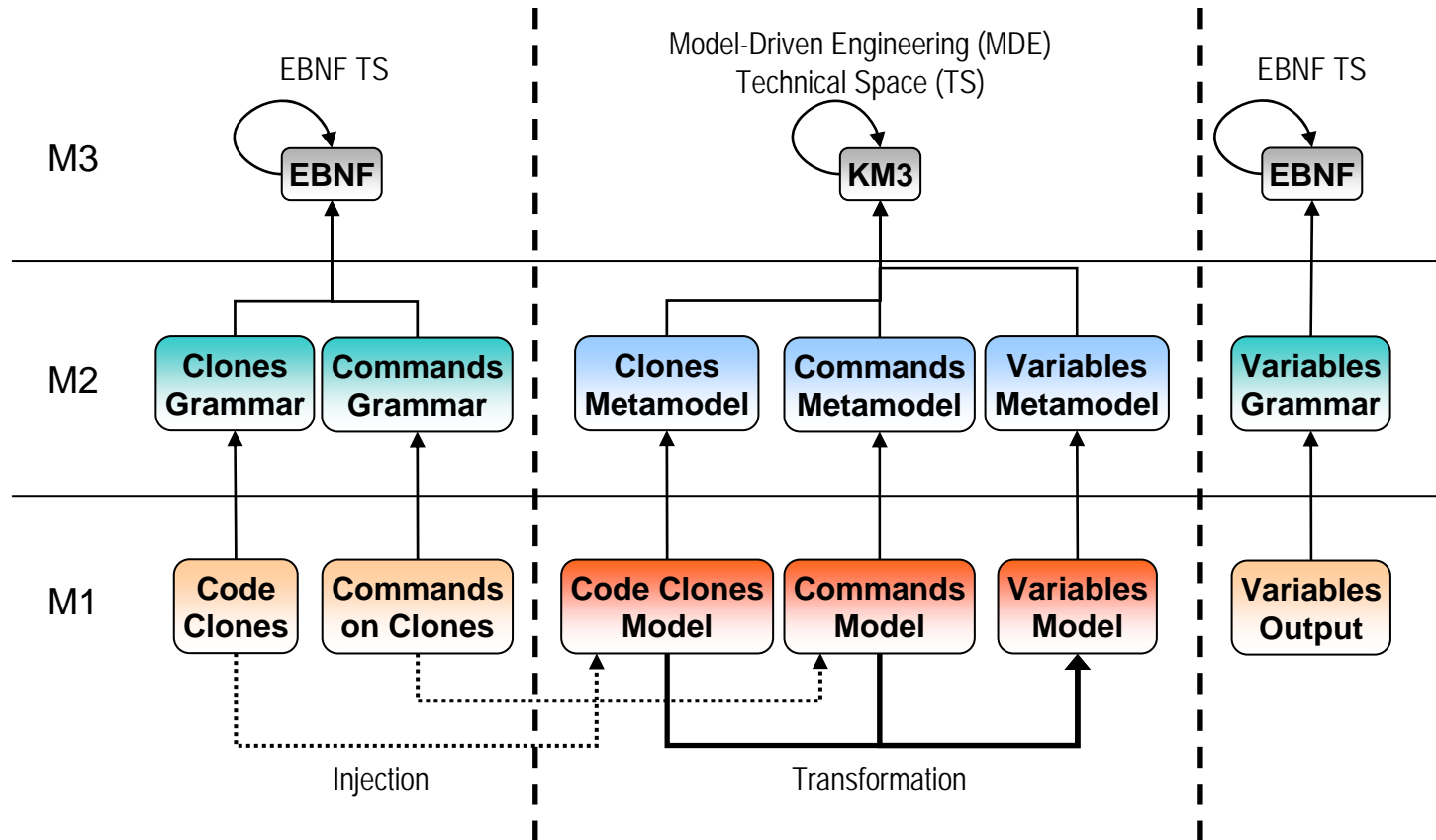
# Model Transformation Process

variables command



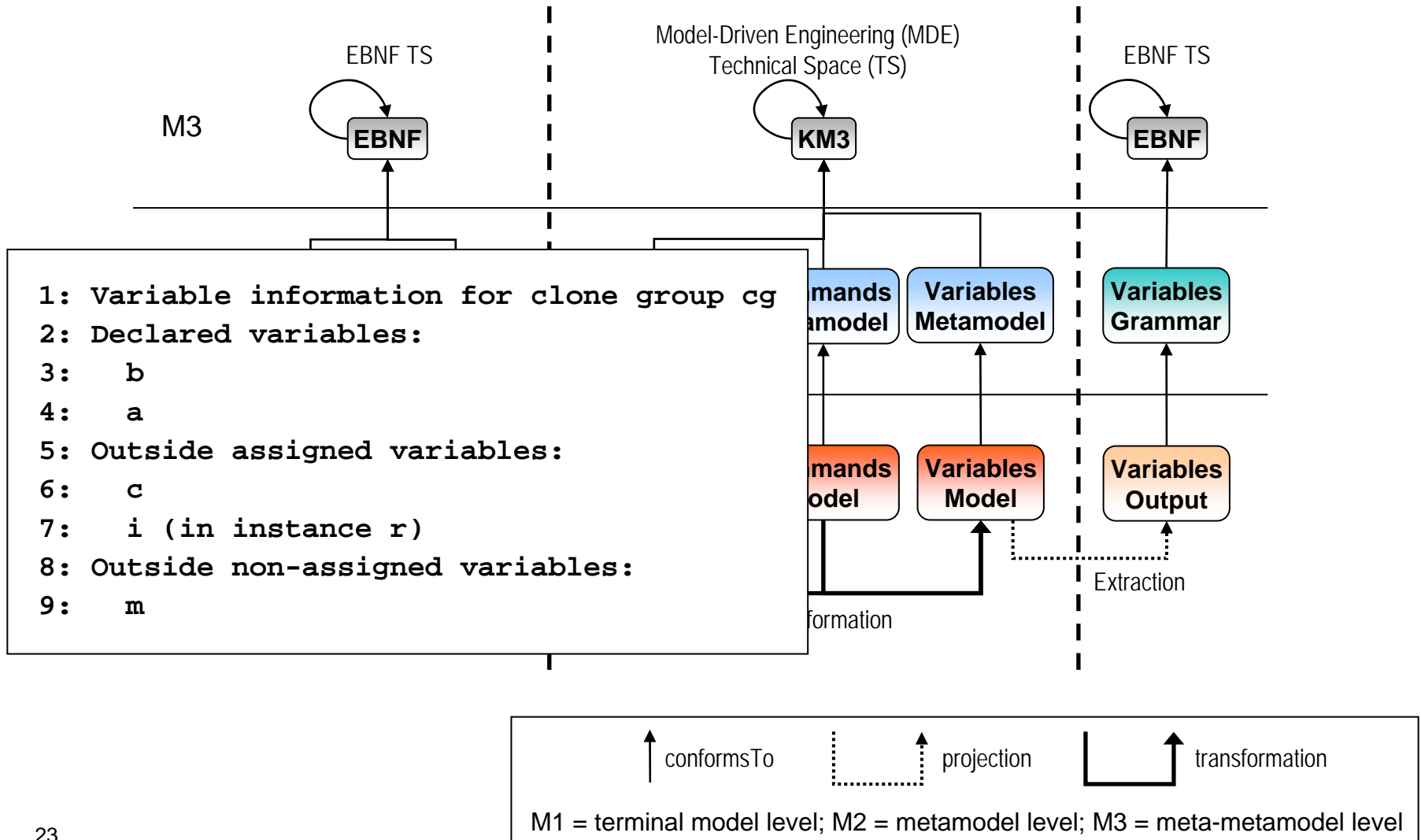
# Model Transformation Process

variables command



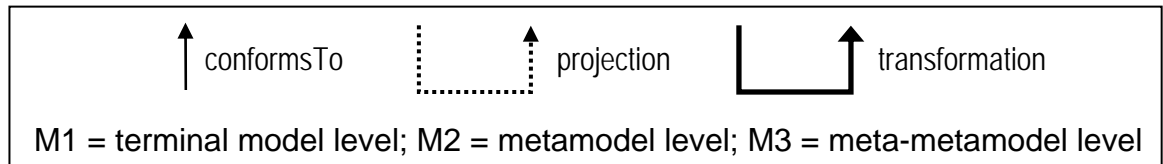
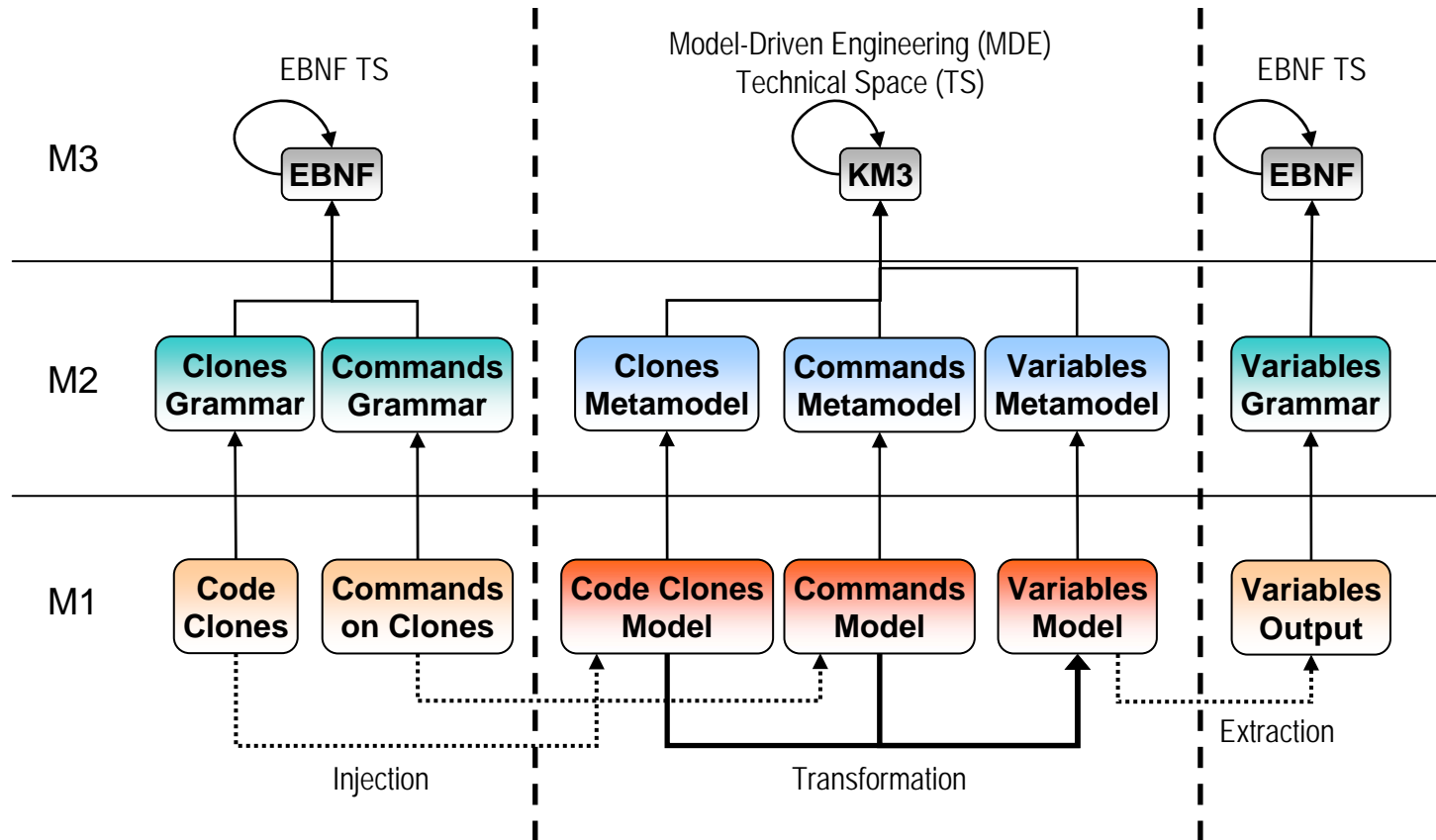
# Model Transformation Process

```
variables command
```



# Model Transformation Process

variables command



# AMMA Platform

## (ATLAS Model Management Architecture)

- Platform for defining and transforming models through the following DSL's:
  - KM3: Abstract syntax
  - TCS: Concrete syntax
  - ATL: Transformations

Related Tutorial at MoDELS 2007:

“Putting MDA to Work on Eclipse with the AMMA Tool Suite”  
Tuesday afternoon (October 2)

# Abstract Syntax in KM3 (snippet)

```
1:  -- Root
2:  class Root extends LocatedElement {
3:    reference cloneGroup[*] ordered container : CloneGroup;
4:    reference cloneInstance[*] ordered container : CloneInstance;
5:  }
6:
7:  -- Clone Group
8:  class CloneGroup extends LocatedElement {
9:    attribute cloneName : String;
10:   reference parameters[*] ordered container : Variable;
11:   reference statements[*] ordered container : Statement;
12:  }
13:
14:  -- Clone Instance
15:  class CloneInstance extends LocatedElement {
16:    attribute instanceName : String;
17:    reference cloneName : CloneGroup;
18:    reference arguments[*] ordered container : Variable;
19:    reference boxes[*] ordered container : Box;
20:  }
```

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20:  }
```

```
-- clone group
clone cg($a, $b) {
  int $b;
  int $a = $b + 3;
  {{ t }}
  c = $a + m;
}
```

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12:  }
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14:  -- Clone Instance
15:  class CloneInstance extends LocatedElement {
16:    attribute instanceName : String;
17:    reference cloneName : CloneGroup;
18:    reference arguments[*] ordered container : Variable;
19:    reference boxes[*] ordered container : Box;
20:  }
```

```
-- clone instances
instance r = cg(f, g) {
  t {
    i = i + 1;
  }
};

instance s = cg(p, q);
```

# Concrete Syntax in TCS (snippet)

```
1:  -- Root
2:  template Root main
3:    :  cloneGroup cloneInstance
4:    ;
5:
6:  -- Clone Group
7:  template CloneGroup context addToContext
8:    :  "clone" cloneName "(" parameters{separator = ","} ")"
9:    " {" statements " }"
10:   ;
11:
12:  -- Clone Instance
13:  template CloneInstance context addToContext
14:    :  "instance" instanceName "=" cloneName{refersto = cloneName}
15:    "(" arguments{separator = ","} ")"
16:    (isDefined (boxes) ? " {" boxes{separator = ","} " }" ) ";"
17:   ;
```

# Transformation in ATL (snippet)

```
1: lazy rule DeclaredVar {
2:   from s : Clones!CloneGroup
3:   to t   : Variables!DeclaredVar (
4:     variables <- Sequence {
5:       s.statements->collect(e |
6:         if e.oclIsKindOf(Clones!DeclarationStat) then
7:           e.variable.varName
8:         else
9:           Sequence{}
10:        endif
11:       ) ,
12:     thisModule.processBox1(s.cloneName)
13:   }
14: )
15: }
```

```
-- clone group
clone cg($a, $b) {
  int $b;
  int $a = $b + 3;
  {{ t }}
  c = $a + m;
}
```

# Transformation in ATL (snippet)

```
1:  helper def: processBox1(t: String): Sequence(OclAny) =
2:    Clones!CloneInstance.allInstancesFrom('IN1')
3:    ->select(e | e.cloneName.cloneName = t)
4:    ->iterate(f;
5:      test : Sequence(OclAny) = Sequence{} | test->including(
6:        if f.boxes->size() = 0 then
7:          Sequence{}
8:        else
9:          f.boxes->collect(g | g.statements)->flatten()
10:         ->collect(h |
11:           if h.oclIsKindOf(Clones!DeclarationStat) then
12:             h.variable.varName + ' (in ' + f.instanceName + ')'
13:           else
14:             Sequence{}
15:           endif
16:         )
17:       endif
18:     )
19:   );
```

```
-- clone instances
instance r = cg(f, g) {
  t {
    i = i + 1;
  }
};

instance s = cg(p, q);
```

# Summary

Initial effort of representation and analysis of clones using MDE:

- Representation of clones (as models)
  - Commonalities stored in clone groups
  - Uniqueness stored in clone instances
- Analysis of clones (via model transformations)
  - Transformations with both declarative and imperative constructs

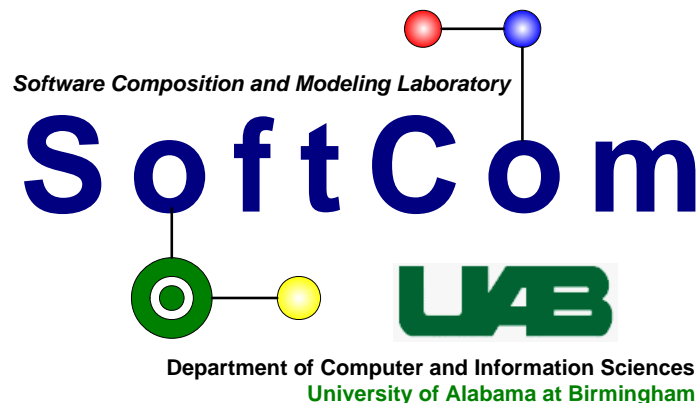
# Future Work

- Reunited
  - Instead of a separate metamodel for clone representation, consider “extending” metamodel of source program
- Comparison
  - More detailed comparisons with existing approaches

# Thank you. Questions?

- CoCloRep Project: <http://www.cis.uab.edu/tairasr/coclorep>
- Clone Detection Literature: <http://www.cis.uab.edu/tairasr/clones/literature>
- SoftCom Laboratory: <http://www.cis.uab.edu/softcom>

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