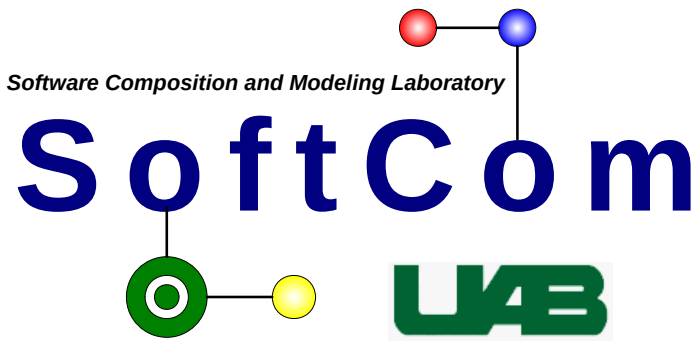
CoCloRep: A DSL for Code Clones

Robert Tairas

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



Department of Computer and Information Sciences
University of Alabama at Birmingham

Workshop on Software Language Engineering
MoDELS 2007, Nashville, TN

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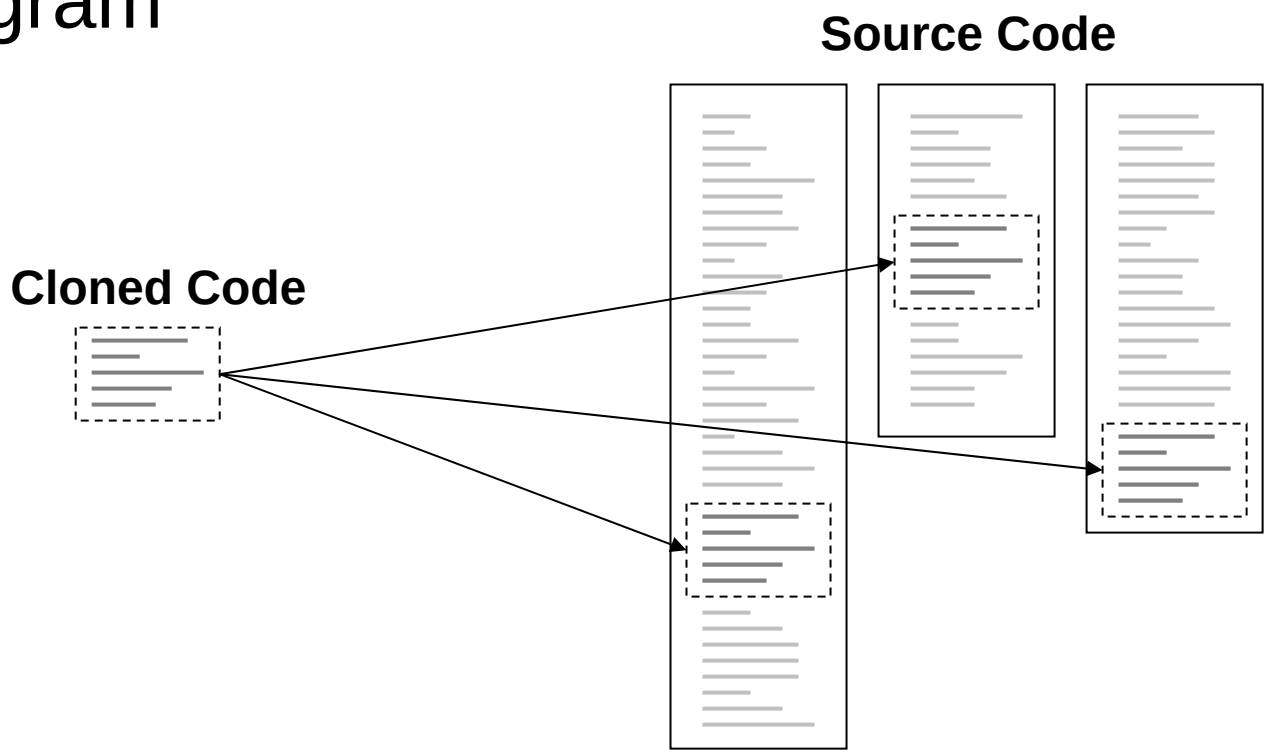
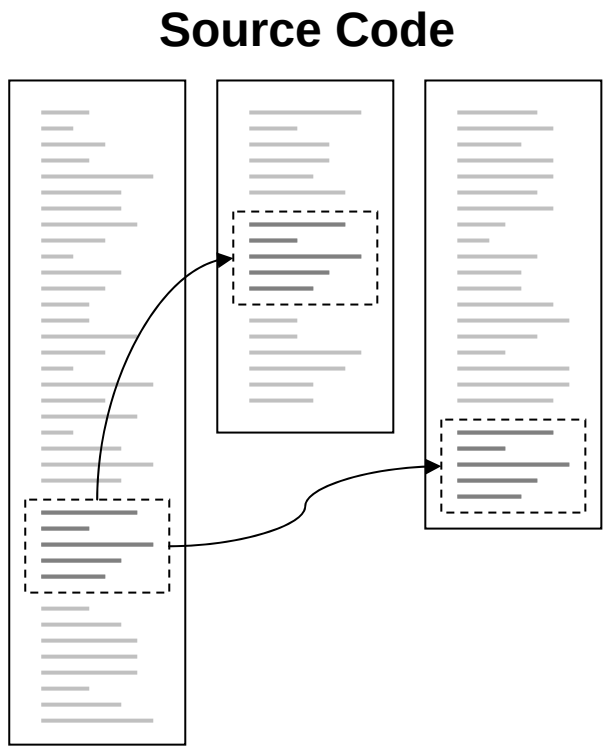
Code Clones

- 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 (Kapser, 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

Bellon, Koschke, Antoniol, Krinke, and Merlo. Comparison and Evaluation of Clone Detection Tools, *Transactions on Software Engineering* (2007)

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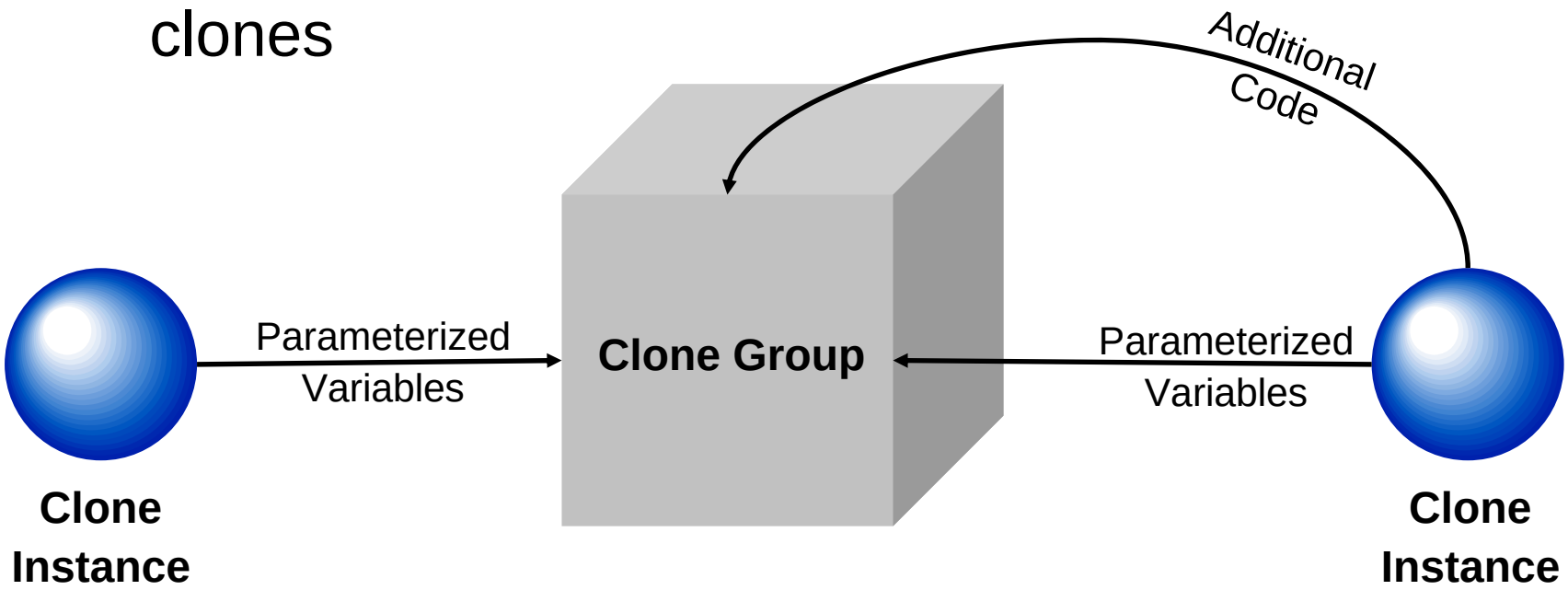
Representing Clones

- 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) {
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3:   int $a = $b + 3;
4:   {{ t }}
5:   c = $a + m;
6: }
```

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6: }
```

Second DSL: Commands

- Input:

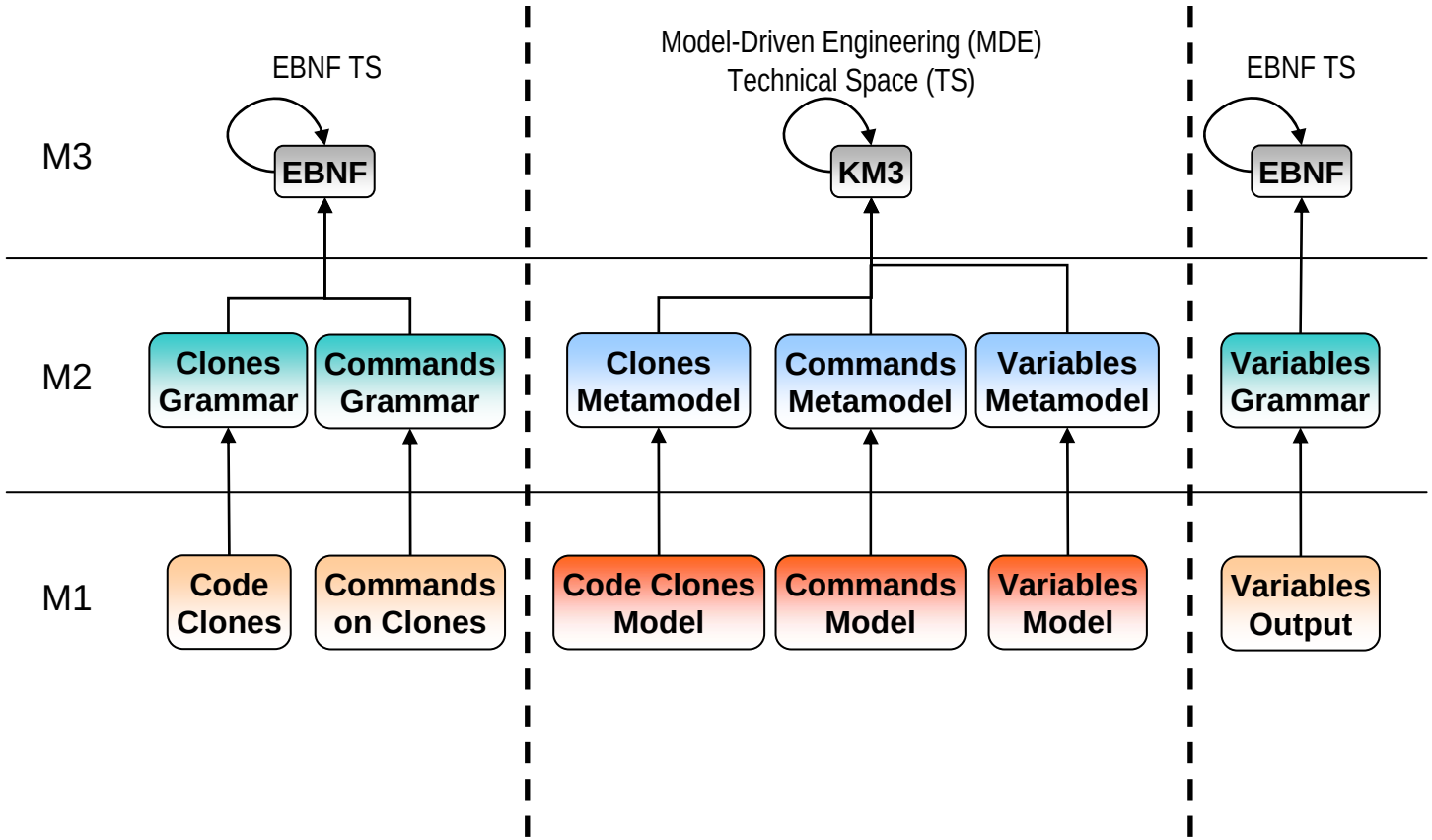
```
variables cg;
```

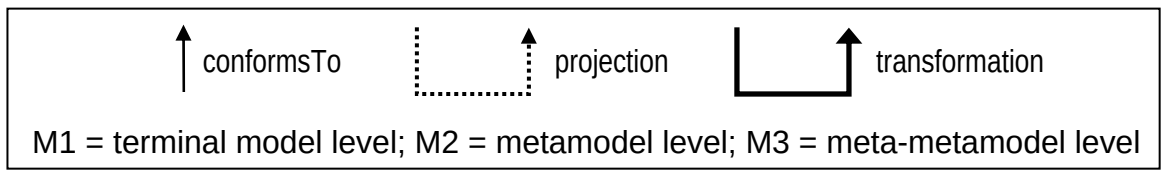
- Output:

```
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





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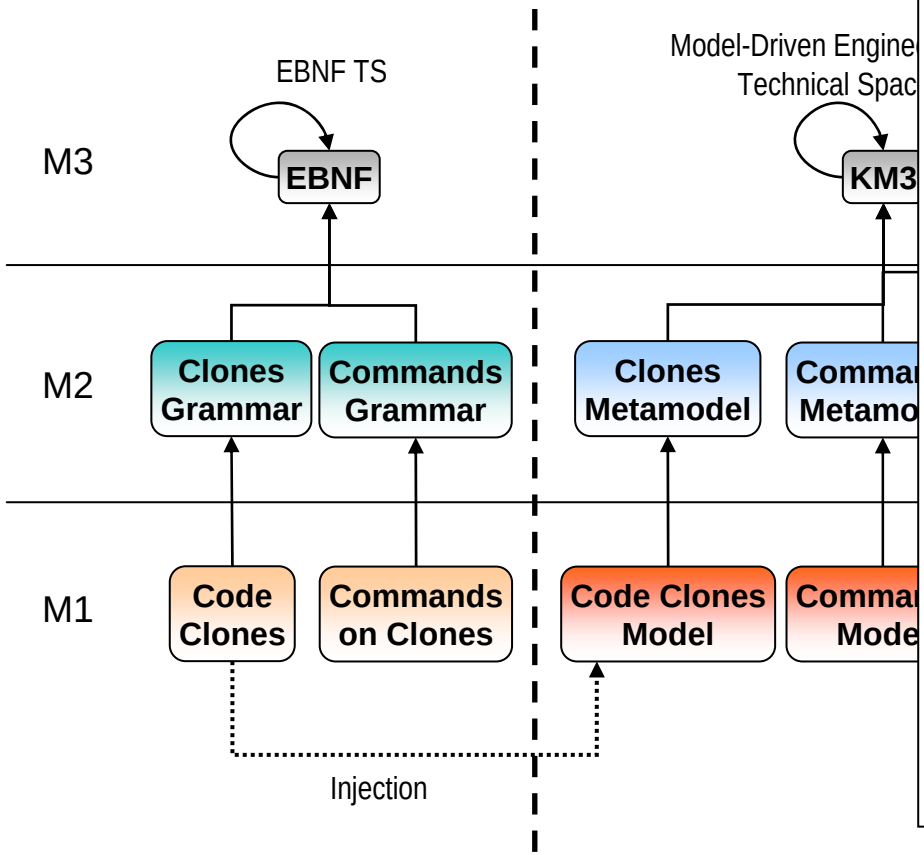


```
-- clone instances
instance r = cg(f, g) {
  t {
    i = i + 1;
  }
};

instance s = cg(p, q);

-- clone group
clone cg($a, $b) {
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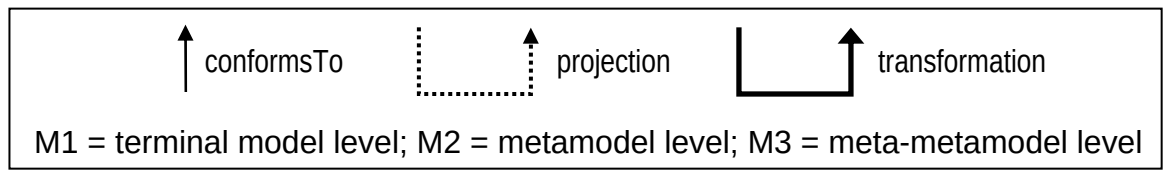

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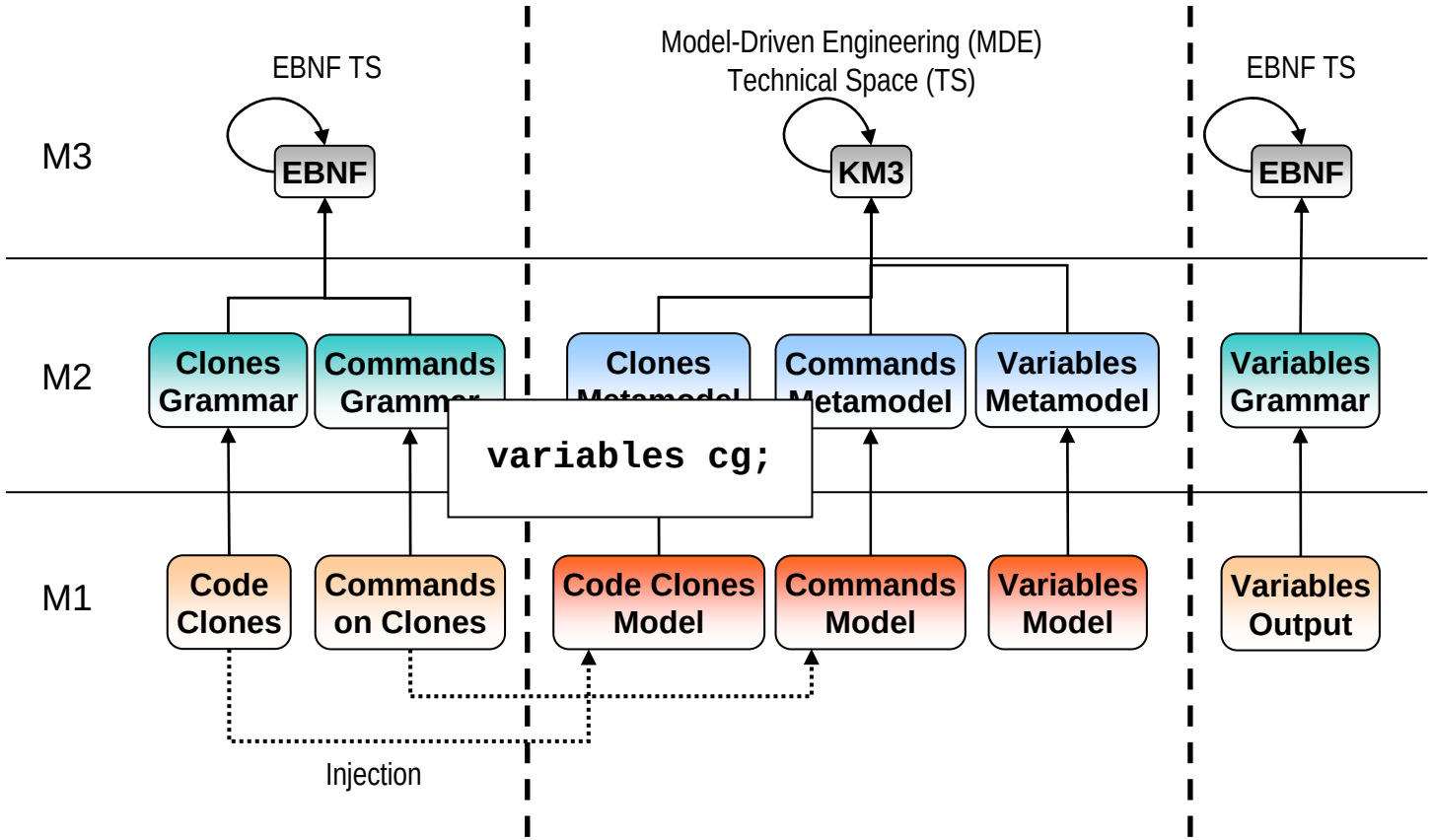

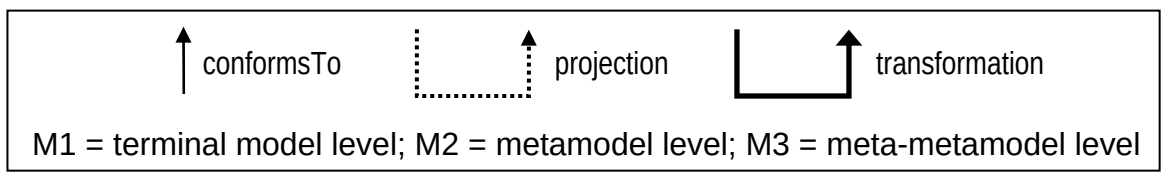

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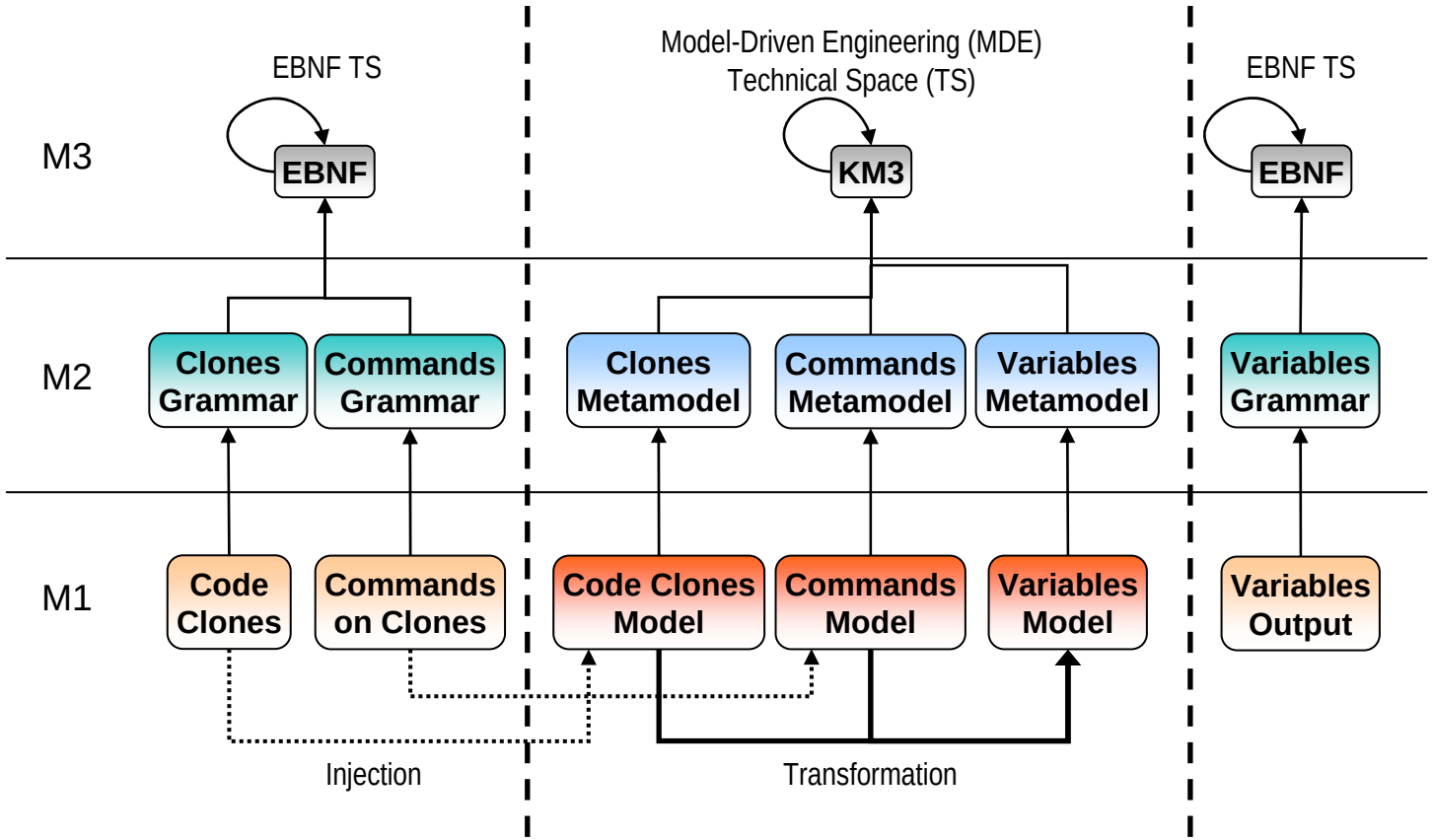

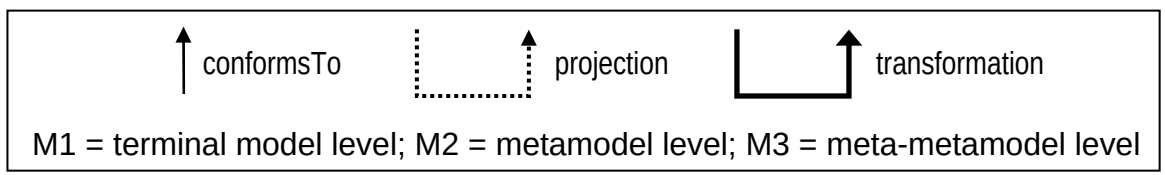

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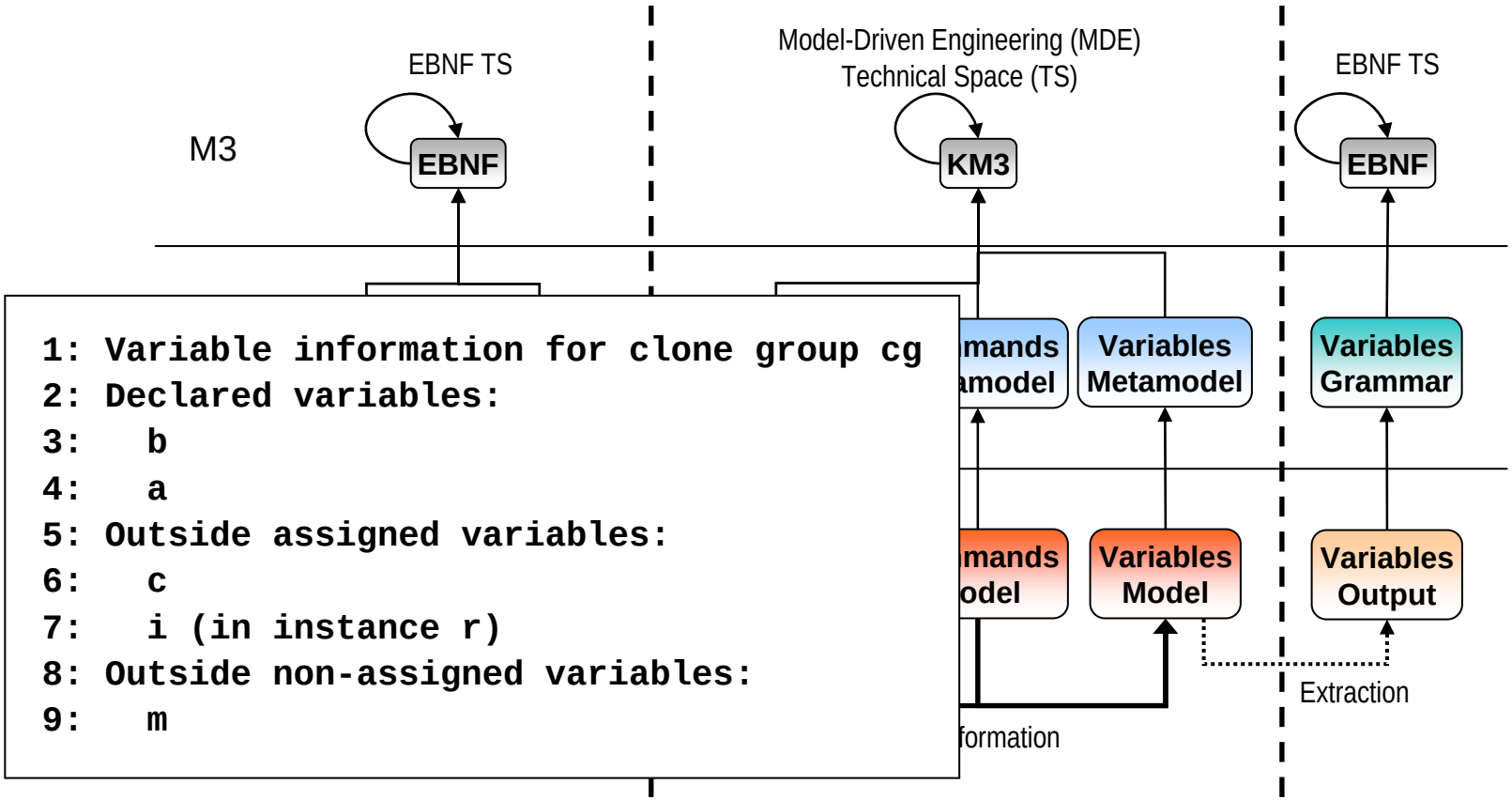


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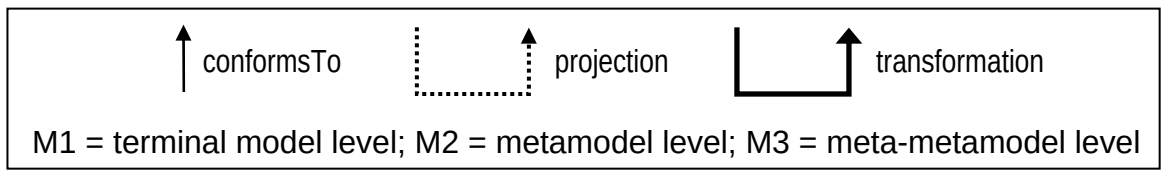

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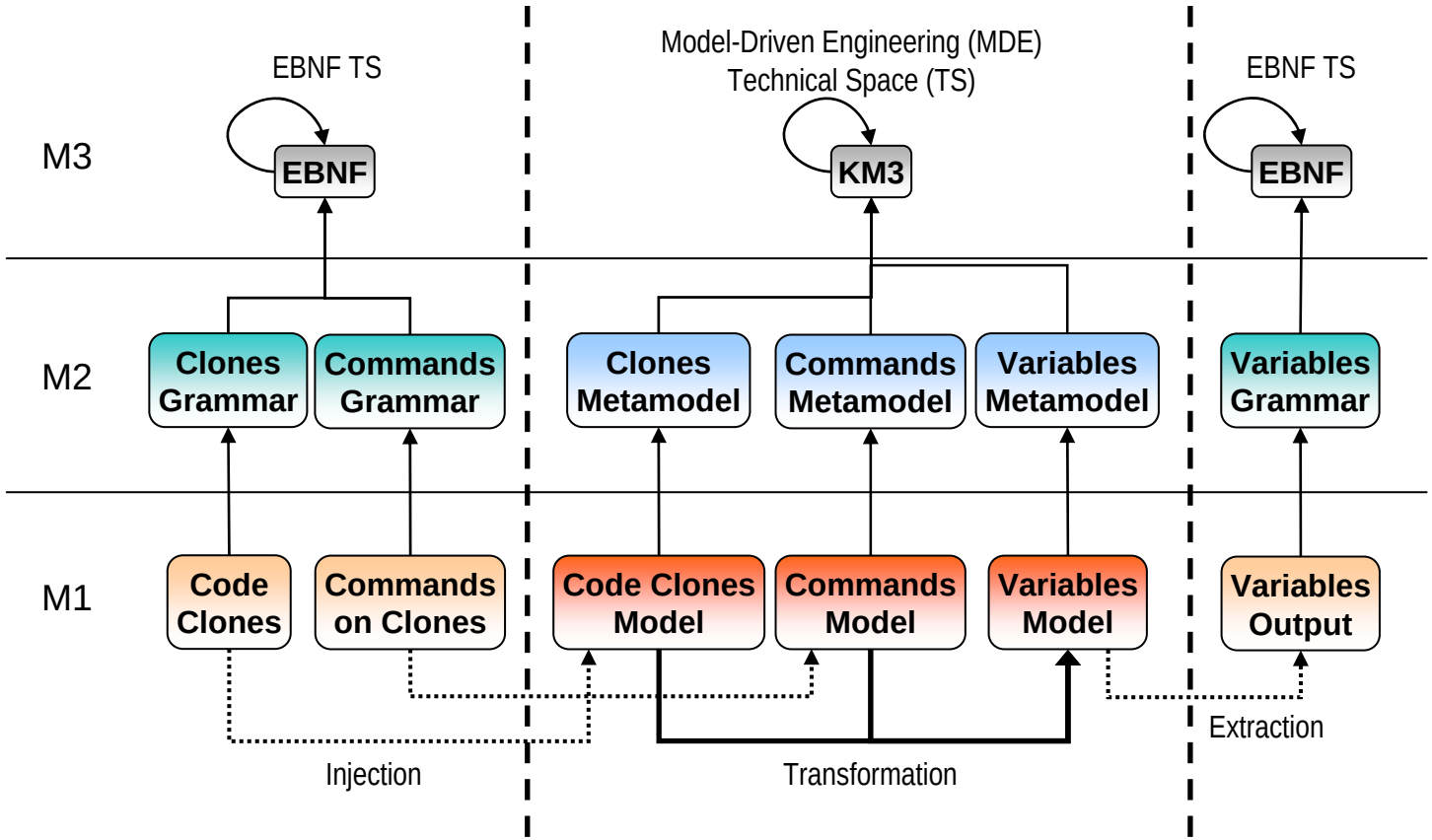

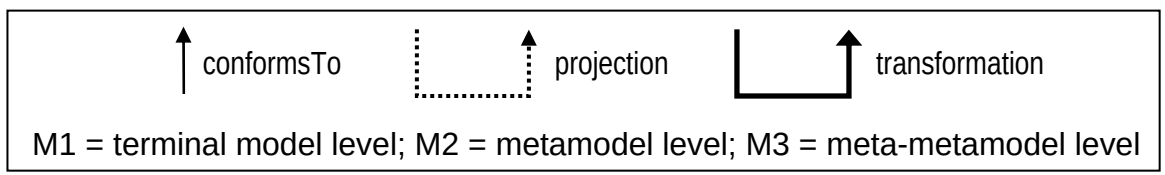

AMMA Platform (ATLAS Model Management Architecture)

- 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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```

```
-- 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:    ;
```

Tranformation 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;
}
```

Tranformation 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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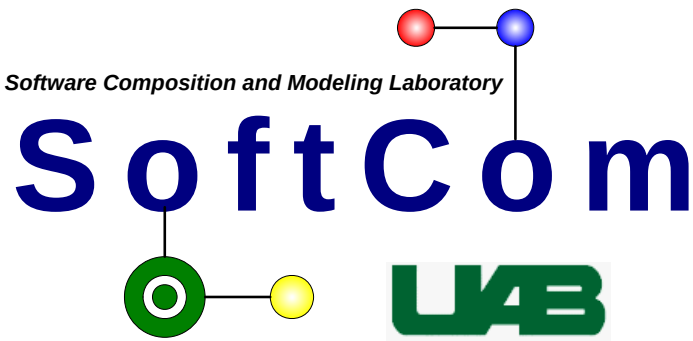

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