

Models and Aspect Weaving

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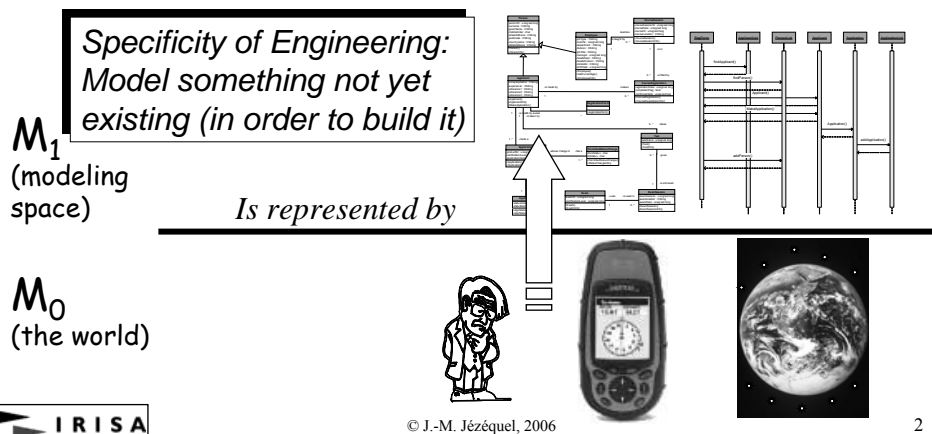
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<http://www.irisa.fr/prive/jezequel>

Modeling in Science & Engineering

- A Model is a *simplified* representation of an *aspect* of the World for a specific *purpose*



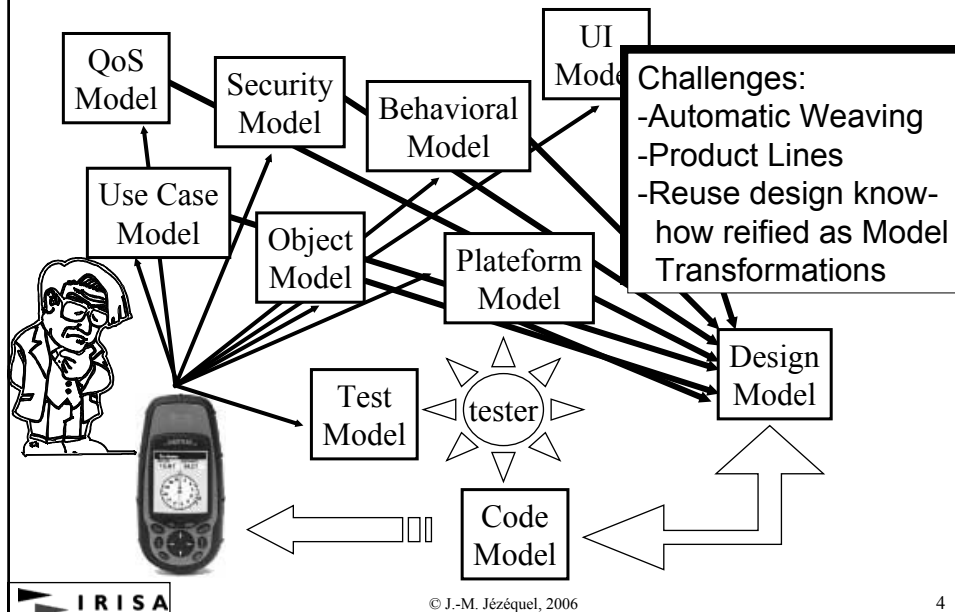
Model and Reality in Software

- Usually in Engineering, Models & Systems have different natures (bridge drawings and concrete bridge)
 - Sun Tse: *Do not take the map for the reality*
 - Magritte



- Whereas a program *is* a model
- Software Models: from contemplative to productive

Modeling and Weaving



Développement Logiciel Par Aspect (AOSD)

- Eviter la "*tyrannie de la décomposition dominante*"[Tar99]
 - qui empêche de modulariser certaines *préoccupations*
- Les concepts de l'AOSD:
 - ces préoccupations sont encapsulées dans des *aspects*
 - un aspect définit un ensemble de *points de jonction* spécifié par une *expression de coupe*
 - la recombinaison des aspects est appelée *tissage*
- A pour origine l'AOP populaire par AspectJ
 - Kizcalez et al., ECOOP 97
 - >> identifié par le MIT comme une des 10 techn

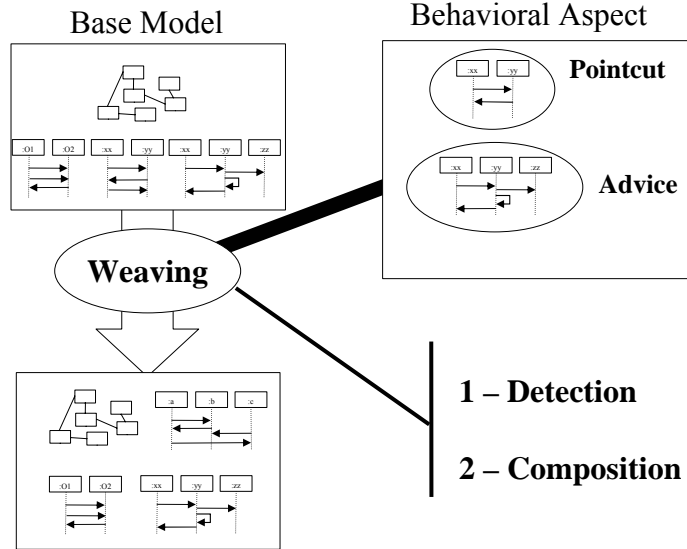
Bénéfices attendus:

- meilleur modularité,
- + maintenable
- + évolutif
- + réutilisable

Base Models and Aspects

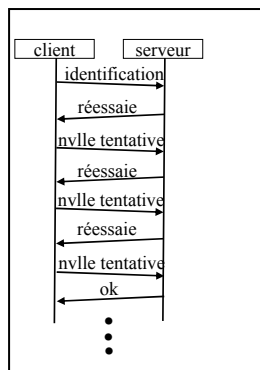
- Ideally, all aspects are equally important
 - Symmetrical AOSD
- In practice, a base model is useful to provide a backbone (canvas) on which aspects are woven
- An aspect is then described as
 - A pointcut
 - » pattern describing relevant points in the execution
 - An advice
 - » New behavior to replace (or complement) the matched ones

Overview

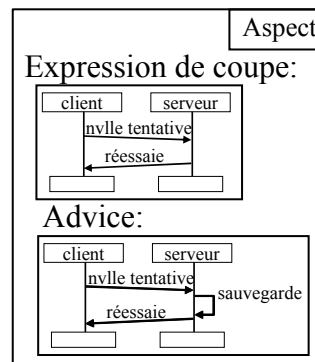


Tissage Statique d'Aspects Comportementaux

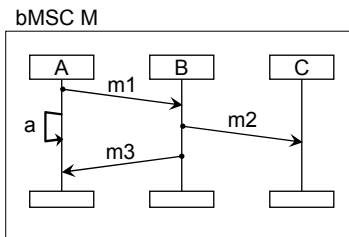
Un scénario de base



Un aspect comportemental

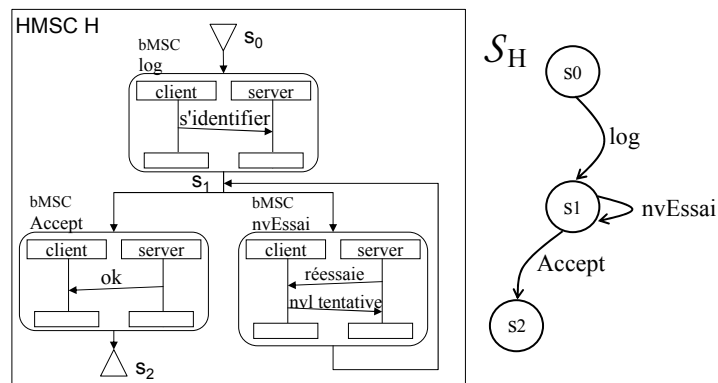


Message Sequence Charts (MSCs) (ou SD) bas niveau: bMSC



- bMSC définit un ensemble d'événements et une relation de
précédence sur ces événements

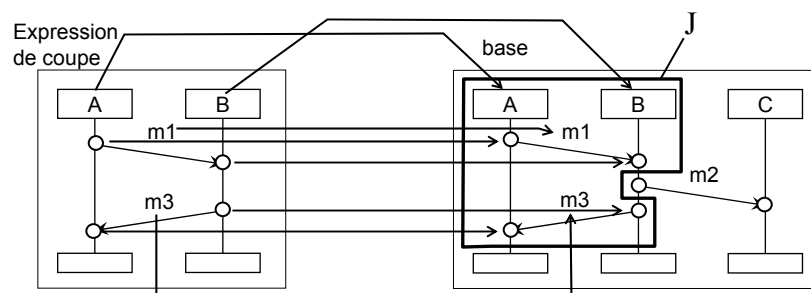
Message Sequence Charts haut niveau: HMSC



Points de jonction et langage d'expression de coupe

- Lié à un langage d'expression de coupe qui permet de spécifier où un aspect doit être composé avec le modèle de base
- Un point de jonction représente une "zone" où un aspect est entremêlé avec une autre préoccupation
- Le langage d'expression de coupe est le mécanisme qui permet de séparer une préoccupation transversale (un aspect) du modèle de base.

Définition de Points de Jonction



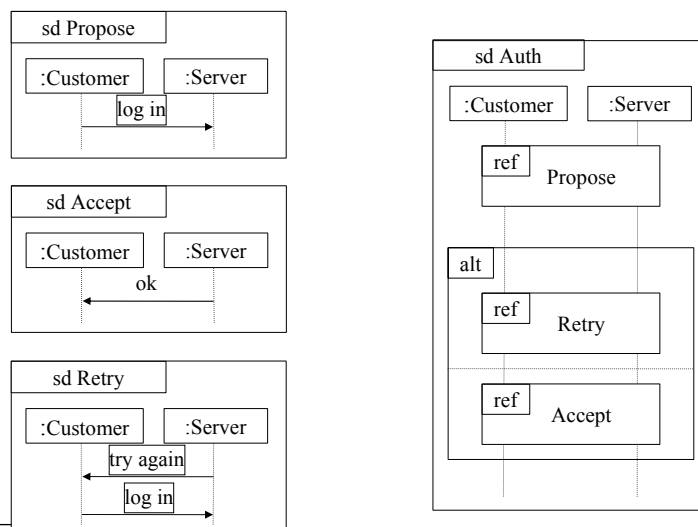
- Une partie J d'un scénario de base est un point de jonction s'il existe un isomorphisme de bMSCs entre l'expression de coupe et J.

Composability & Aspect Weaving

- Unfortunately, traditional aspect weaving (e.g. in AspectJ) has very bad composability properties.
- After weaving aspect A1 into B, maybe A1oB does no longer match A2 pointcut, while B alone did.
 - And conversely...
- Let's explore these issues with scenario languages, as in UML/HMSC etc.
 - And show how it can be automated with Kermeta

Example: Base Model

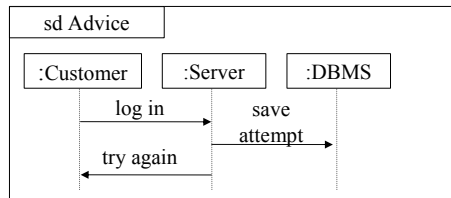
(based on J. Klein & F. Fleurey works)



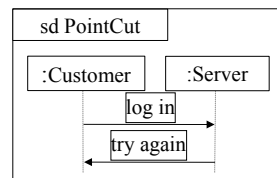
Example: Behavioral Aspect

Behavioral Aspect = Advice + Pointcut + Morphism

Advice



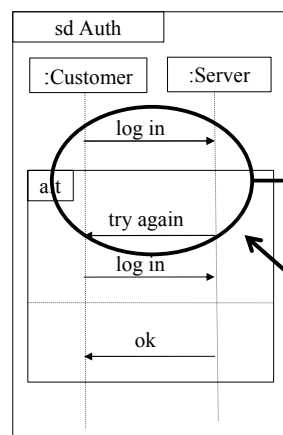
Pointcut



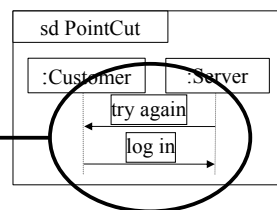
Matching based on sub-SD inclusion

$BaseModel = sd1 \text{ seq } pointcut \text{ seq } sd2$

Base Model



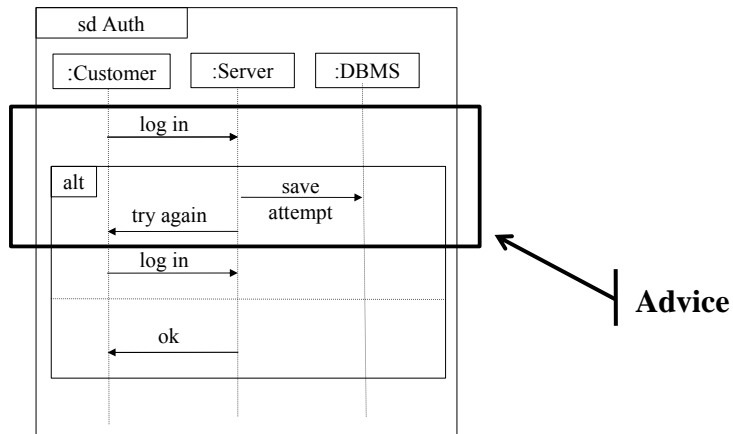
Pointcut



1 Joinpoint

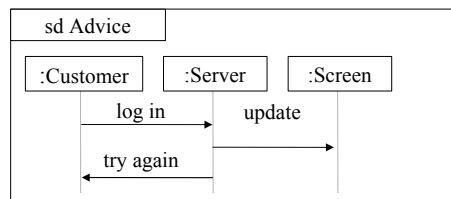
Example: Composition

Result Model

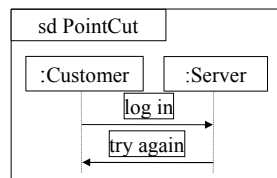


2nd aspect: update screen

Advice



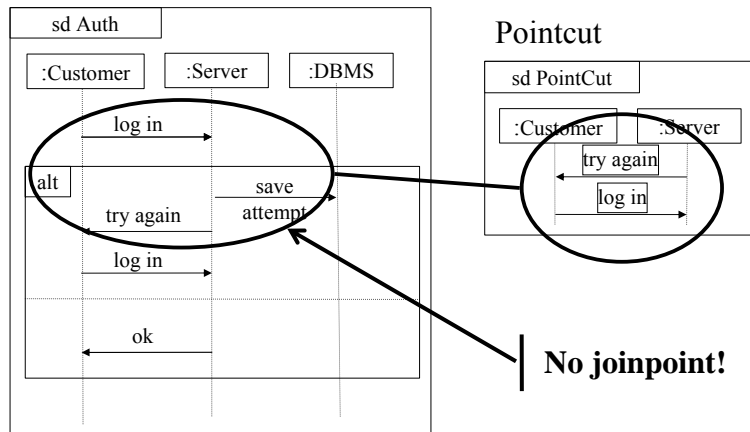
Pointcut



Matches base scenario, but no longer woven one!

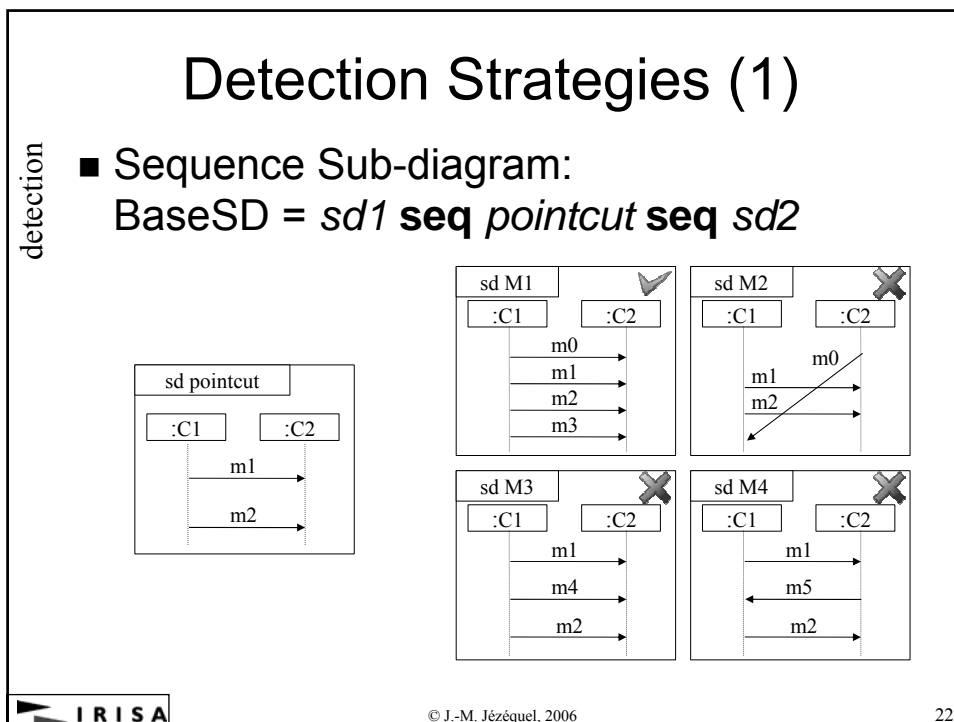
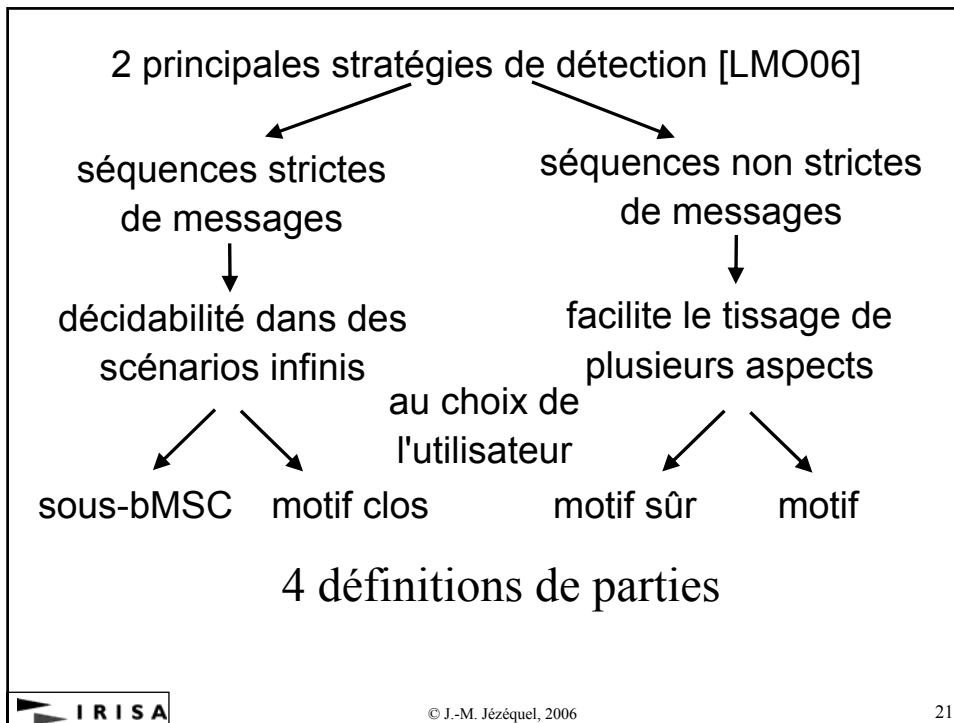
Impossible Composition

Result Model



More advanced detection needed

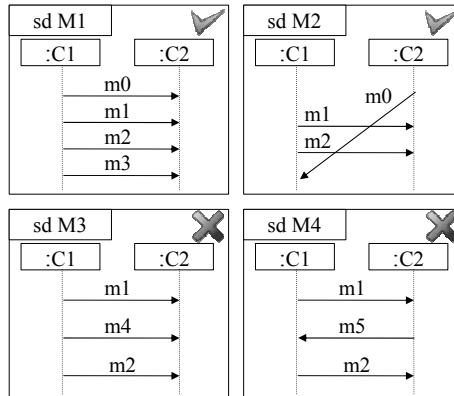
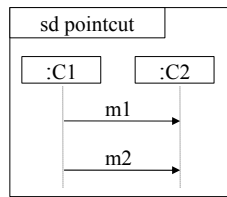
- Two possible strategies beyond sub-sequence diagram
 - Closed part
 - Pattern
- Static Analysis to find Joinpoints over HMSCs (loop unrolling!).



Detection Strategies (2)

detection

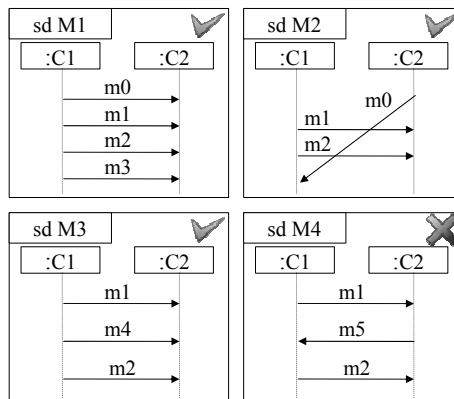
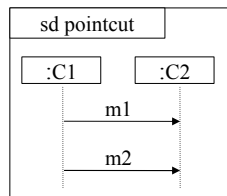
■ Closed Part



Detection Strategies (3)

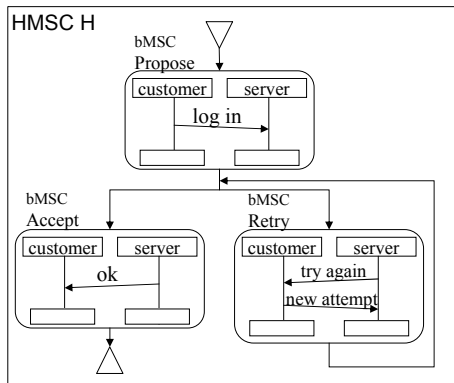
detection

■ Pattern

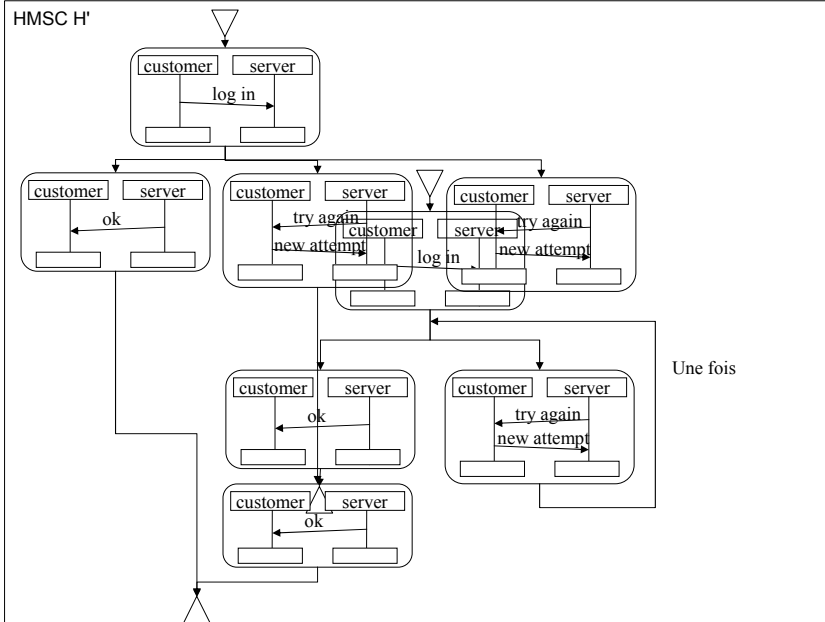
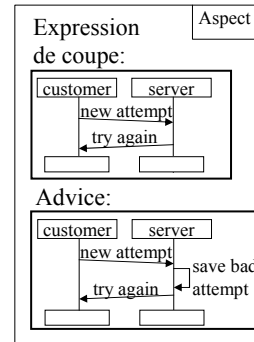


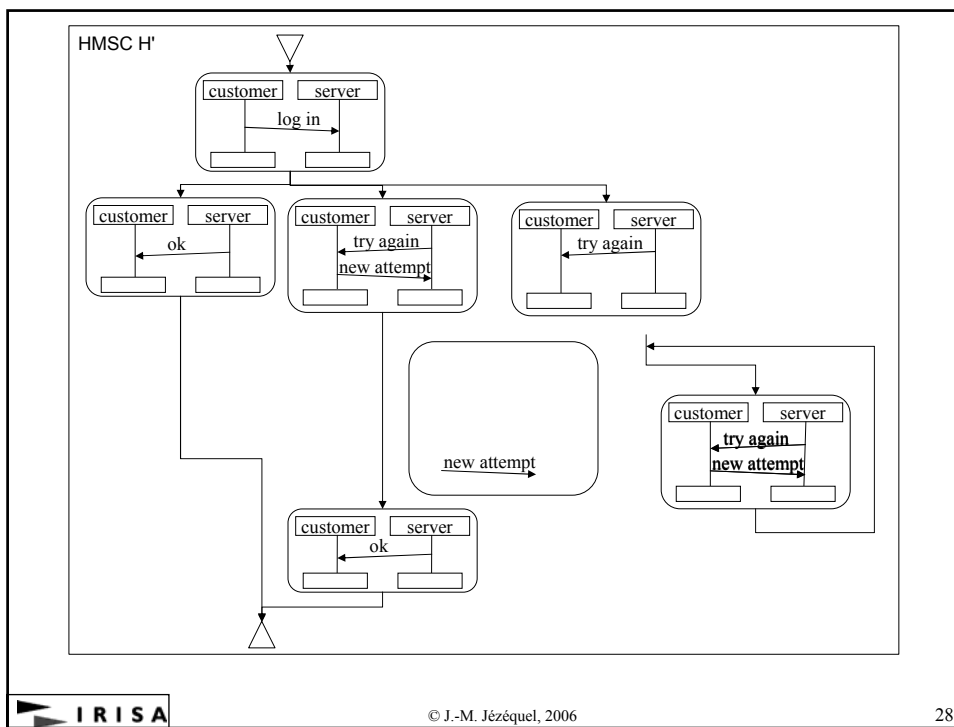
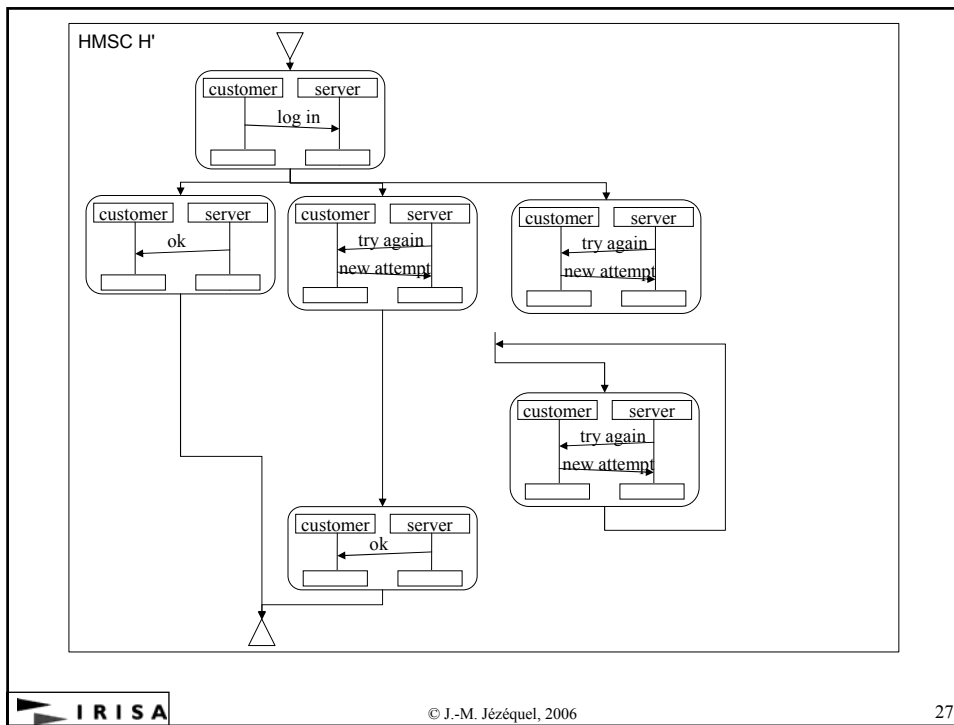
Detection in infinite scenarios

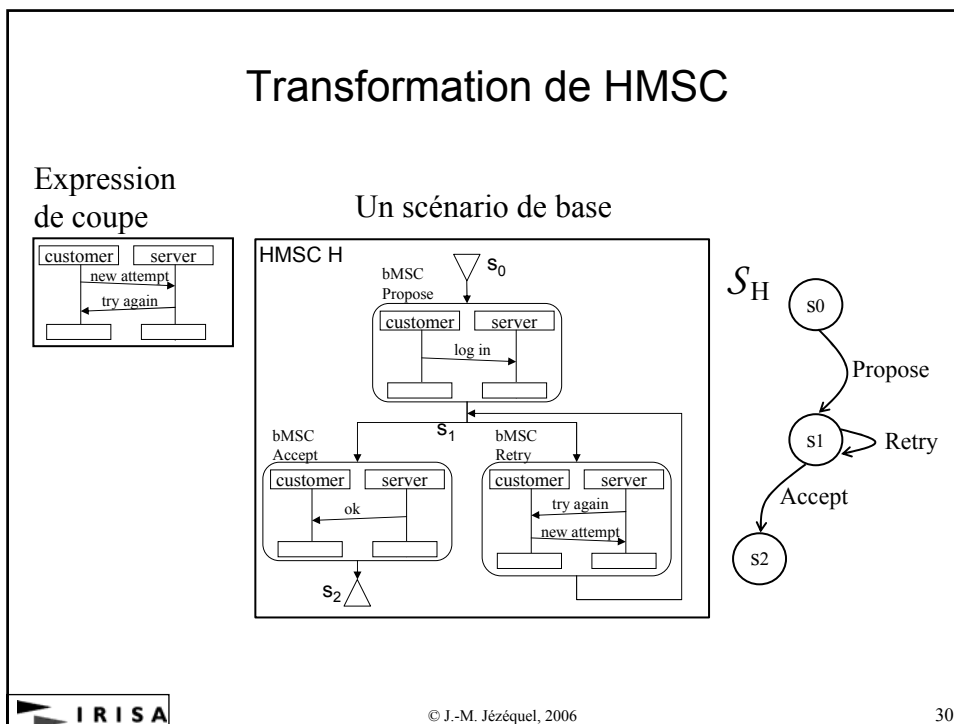
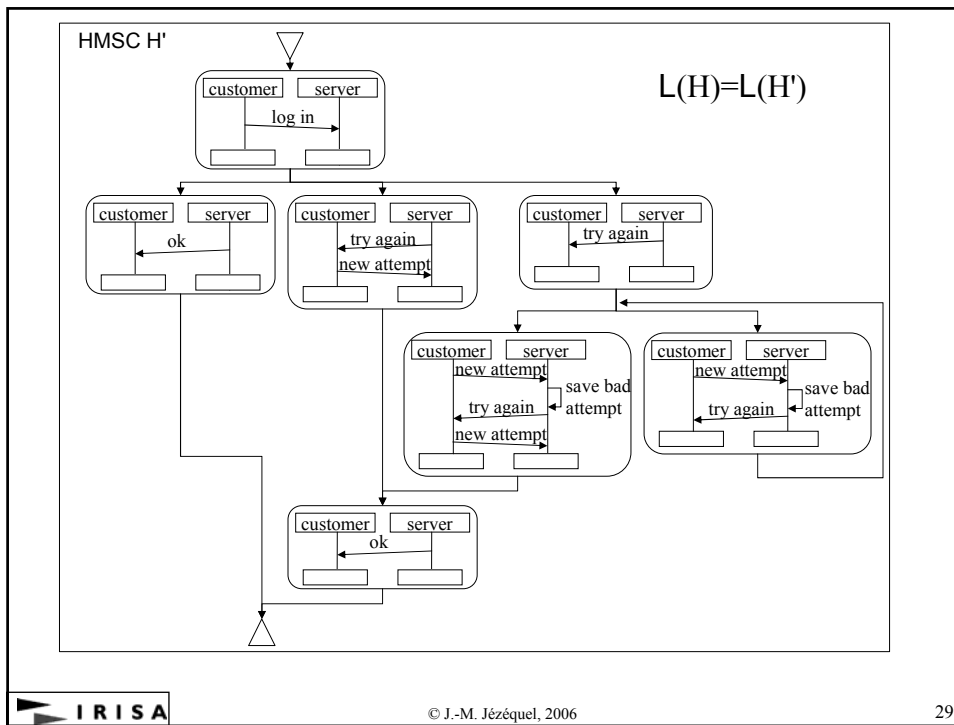
Base scenario



Behavioral aspect

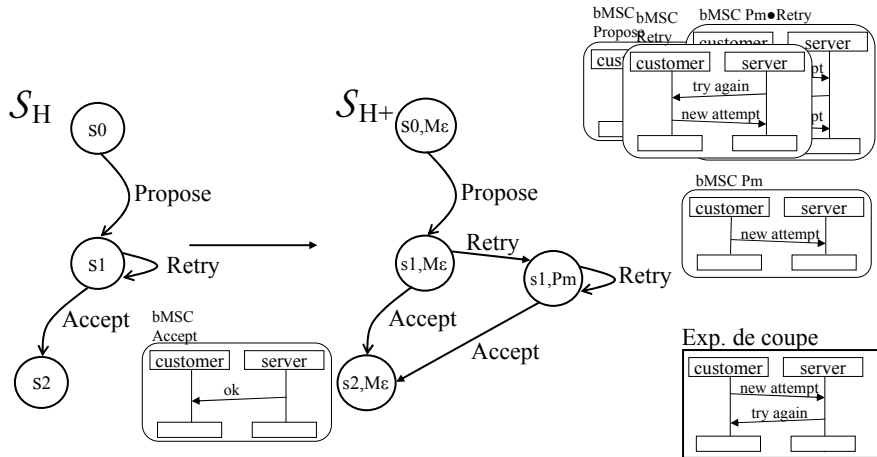






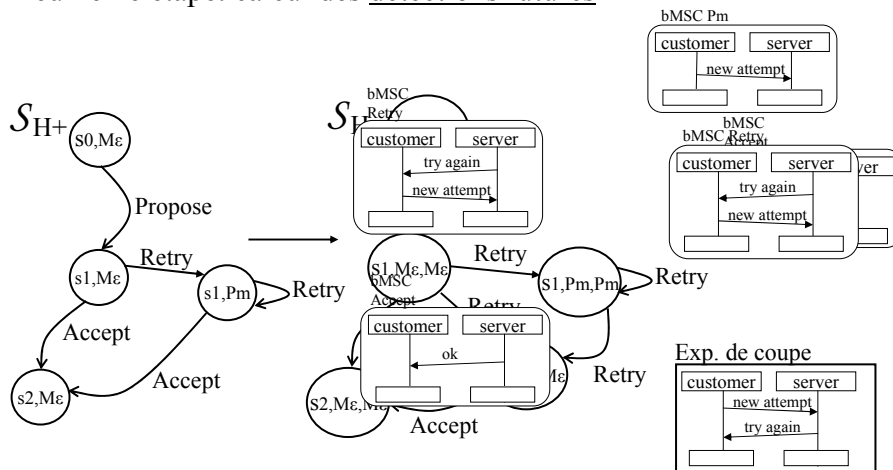
Transformation de HMSC

- Première étape: calcul des détections potentielles



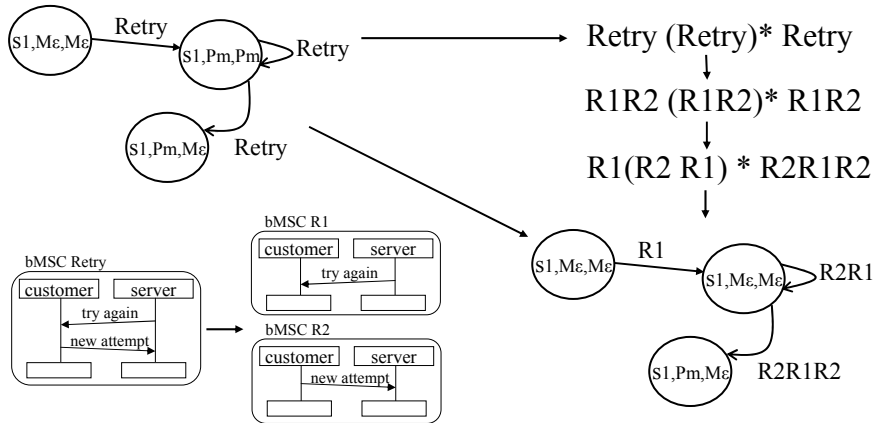
Transformation de HMSC

- Deuxième étape: calcul des détections futures



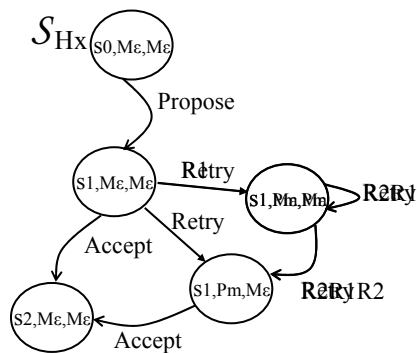
Transformation de HMSC

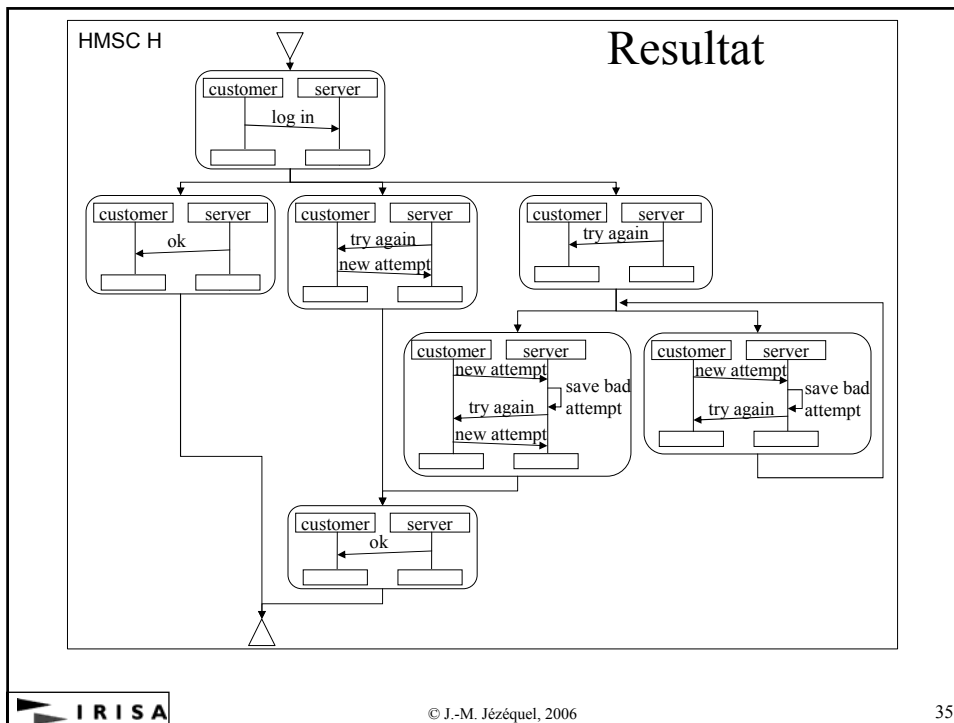
- Troisième étape: utilisation d'expressions régulières, découpe de bMSCs en atomes et permute ces atomes



Transformation de HMSC

Resultat



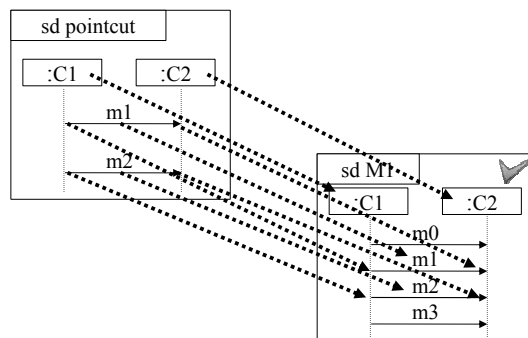


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Result of the Detection Step

■ Create a morphism for each Joinpoint

- Morphism of instances
- Morphism of events
- Morphism of messages (implied)



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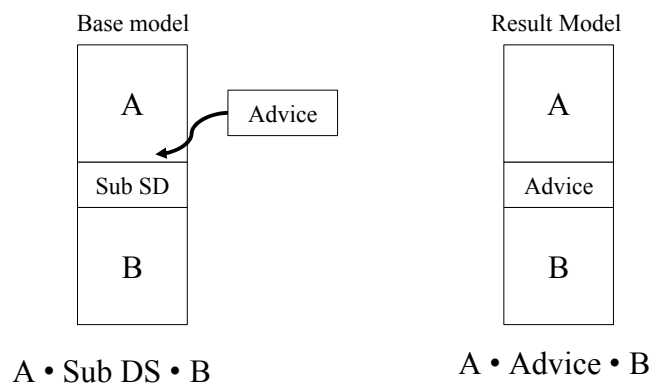
Composition

- Compose the advice into the base model
- Depend on the detection strategy

Composition

■ Sequence sub-diagram

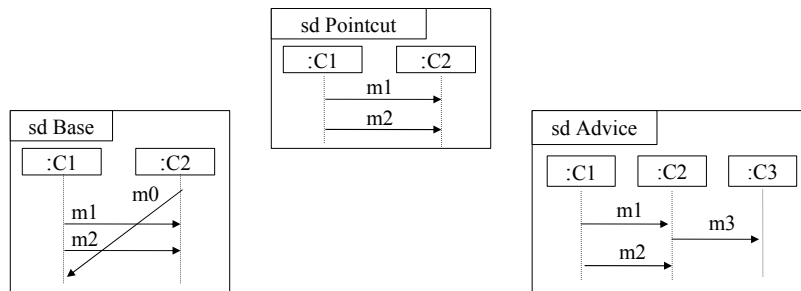
⇒ Weak Sequential Composition



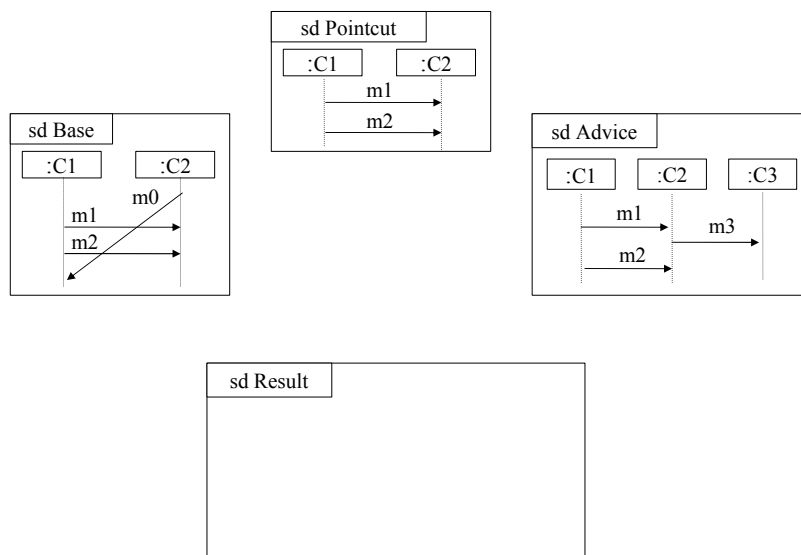
Amalgamed Sum

- ◆ For matching on Closed Part & Patterns

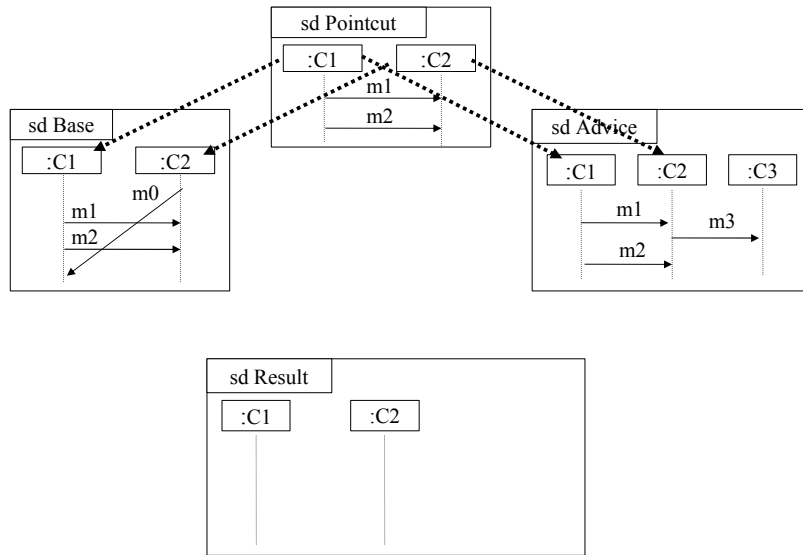
⇒ Simple composition not possible



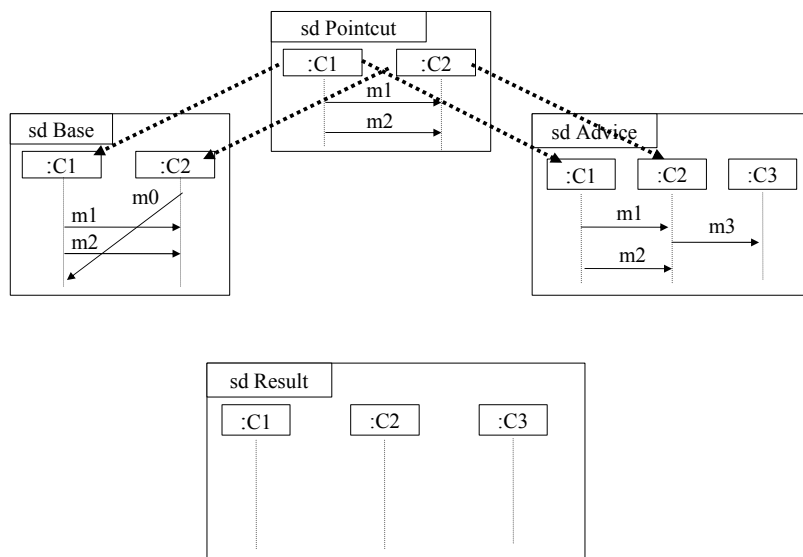
Amalgamed Sum



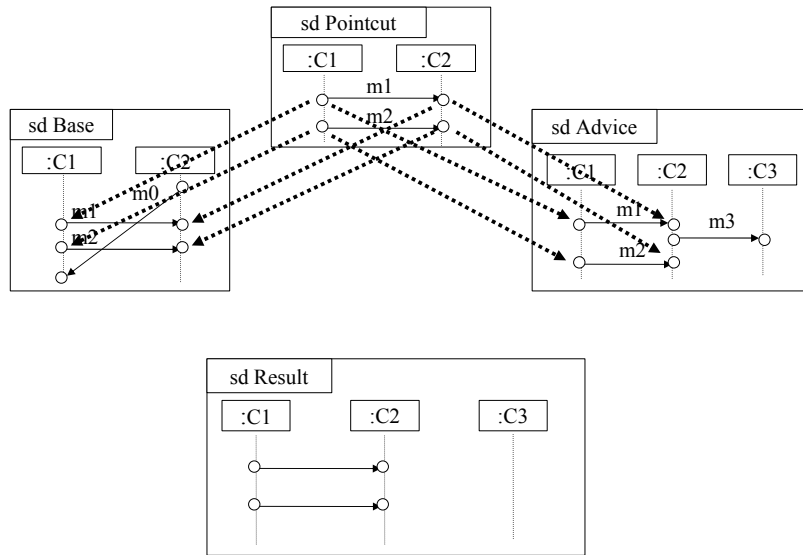
Amalgamated Sum



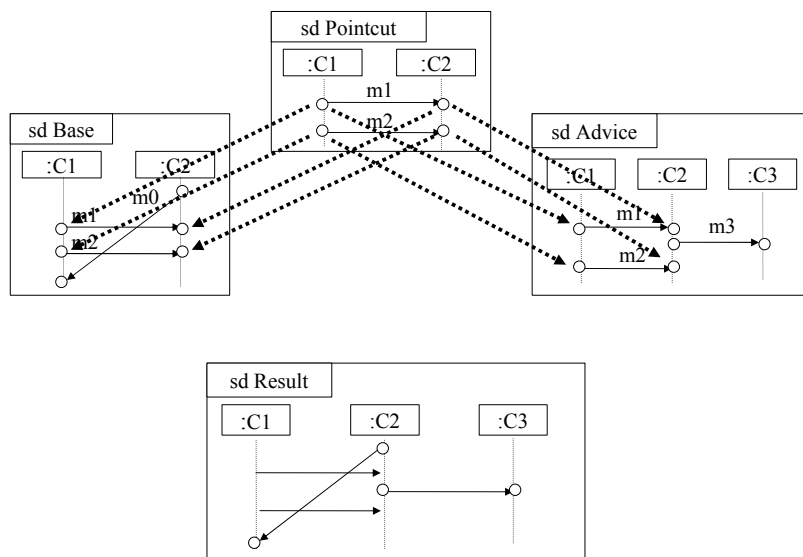
Amalgamated Sum



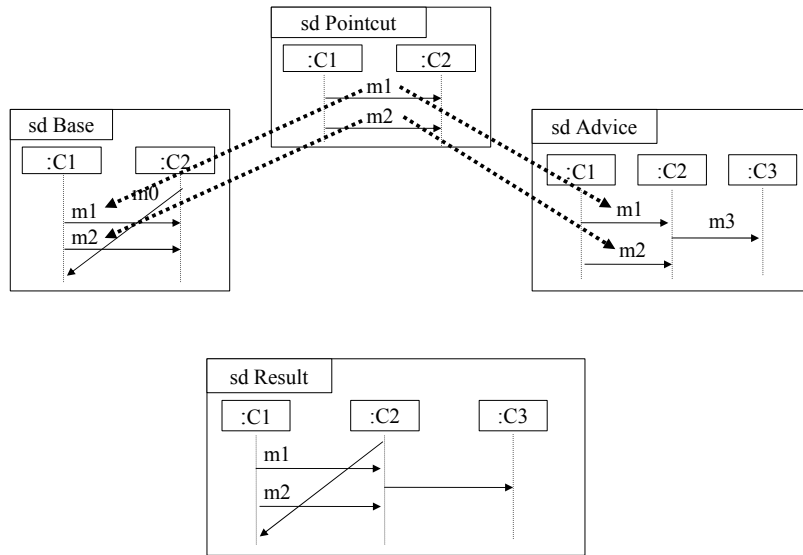
Amalgamed Sum



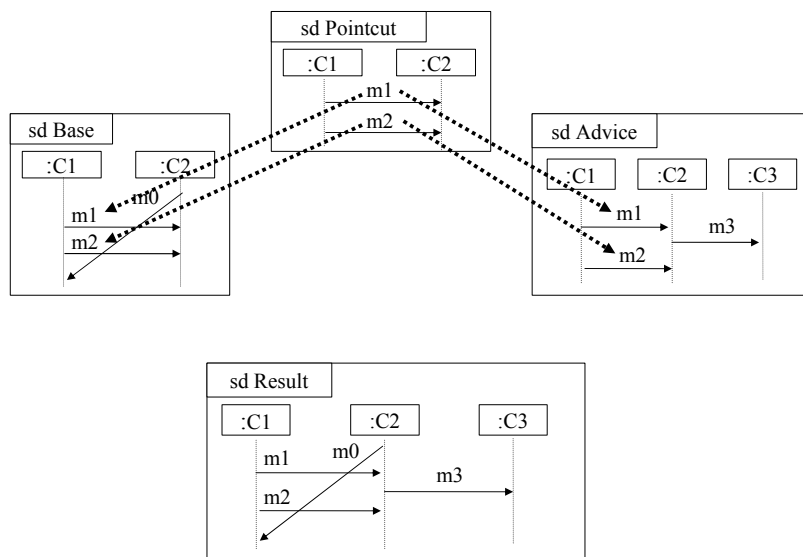
Amalgamed Sum



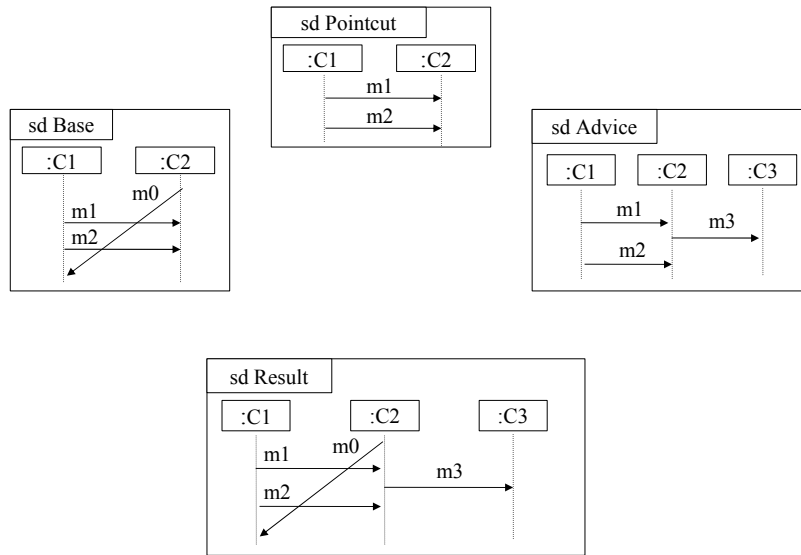
Amalgamed Sum



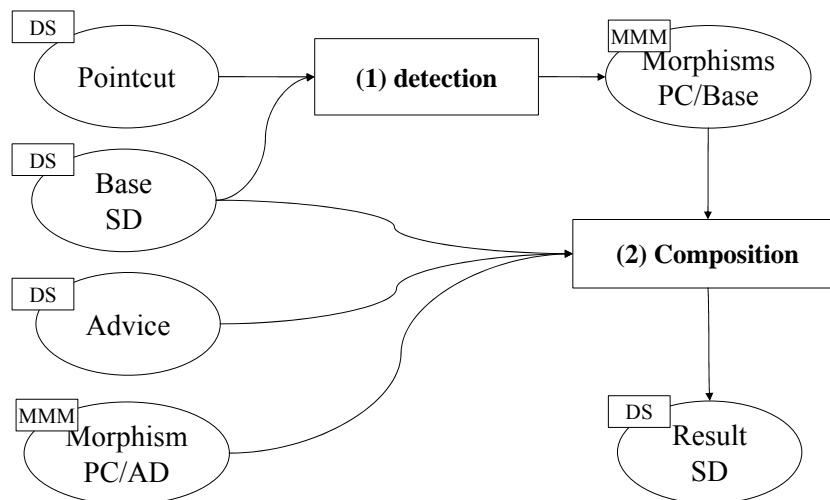
Amalgamed Sum



Amalgamed Sum



Implementation



KerMeta in a NutShell

- EMOF superset
 - Any EMOF MetaModel is a valid KerMeta program, and conversely
- Object-Oriented
 - Multiple inheritance / behavior selection
 - Operation overriding / late binding
 - Full reflection (read-only at this time)
- Statically Typed
 - Generics
 - Function types to allow OCL's *forall/exist/iterate*

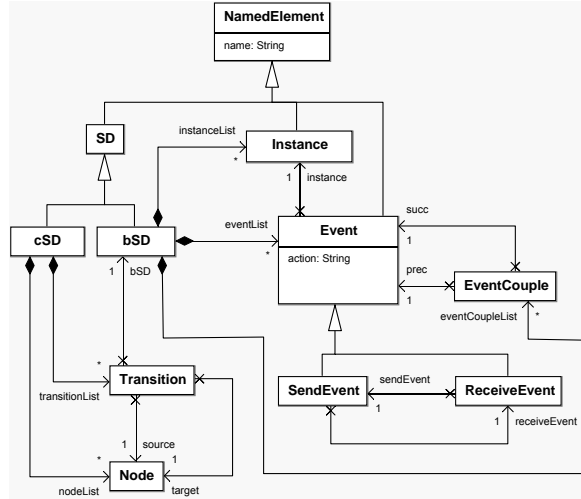


“Programming style” Issues

- The transformation is simply the model of an object-oriented program that manipulates model elements
 - Navigation through model is first class though (like in OCL)
- OO techniques
 - Customizability through inheritance/dyn. binding
 - Pervasive use of GoF like Design Patterns

Defining the metamodels

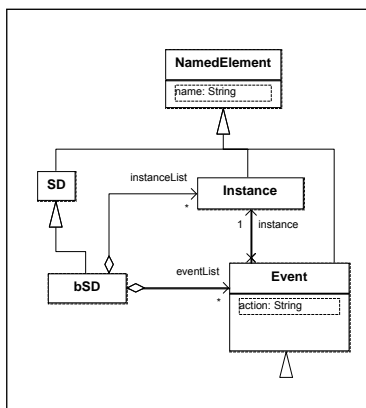
input and output metamodels are the same



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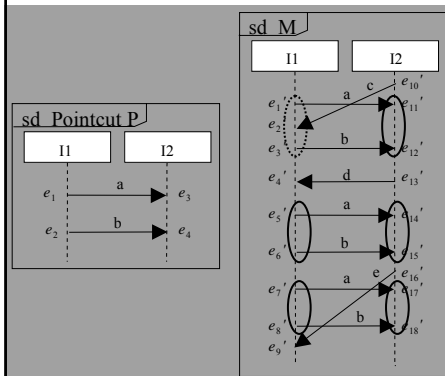
Visual/Textual



```

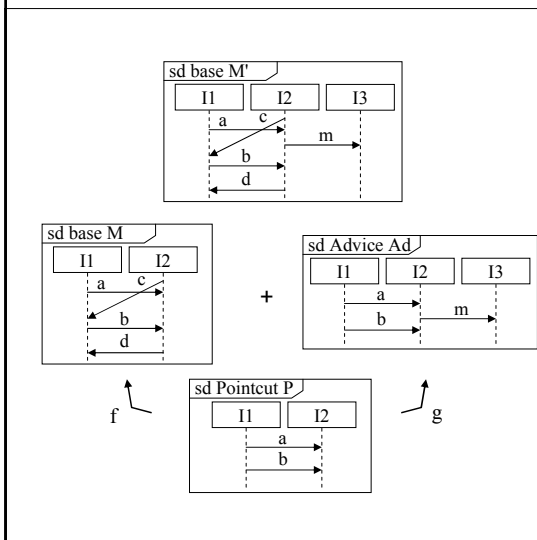
package bigSd;
using kermeta::standard
using kermeta::persistence
abstract class NamedElement
{
    attribute name : String[1..1]
}
abstract class SD inherits NamedElement
{}
class BSD inherits SD
{
    attribute events : Event[0..*]
    attribute couples : EventCouple[0..*]
    reference instances : Instance[0..*]
    ...
}
abstract class Event inherits NamedElement
{
    attribute action : String[1..1]
    reference onInstance : Instance[1..1]
    ...
}
    
```

Sequence Diagrams Weaving



- Choice of the join point policy
- Detection step:
 - for each object, we compute the sets of (successive or not) events which have the same label as the events of P
 - compute the minimum set of events, called J_m , which satisfies the properties related to the join point policy
 - build isomorphism μ from P to J_m
 - repeat on $M - J_m$ while J_m is not empty

Sequence Diagrams Weaving

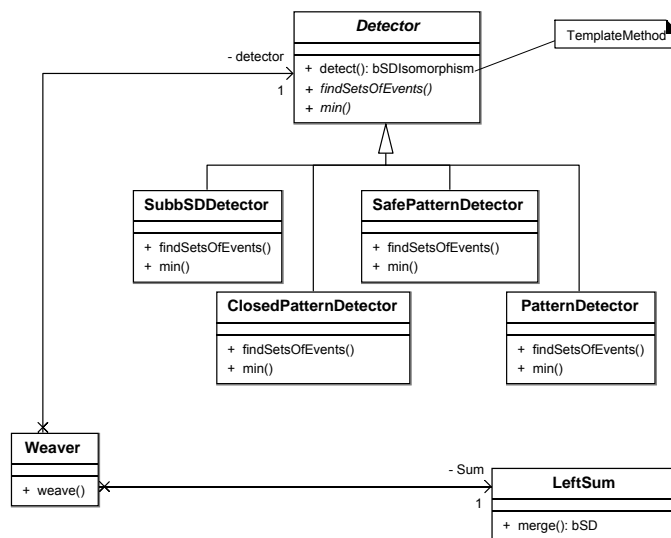


- Composition step: amalgamated sum
 - use P and two morphisms f and g (f being computed by the detection step)
 - keep the common parts between M and Ad
 - add new object I3
 - add the events of M by respecting the order specified on M
 - add the events of Ad by respecting the order specified on the advice

Object-orientation

- Classes and relations, multiple inheritance, late binding, static typing, class genericity, exception, typed function objects
- OO techniques such as patterns, may be applied to model transformations
 - Template method to encapsulate basic *detect* algorithm
 - » Substeps redefined in subclasses

SD Weaver Architecture



Writing the transformation: Weaver

```
require kermeta require "../models/bigSd.kmt" require "../detectionAlgorithm/Detection.kmt"
require "../amalgamatedSum/LeftSum.kmt"
using kermeta::standard using bigSd
```

```
class Weaver {
  operation weave(base : BSD, pointcut : BSD, advice : BSD, g : BSDMorphism) : BSD is do
```

```
    result := BSD.new
    //Choice of join point policy
    var detection: Detection init ClosedPatternDetection.new
    var sum: LeftSum init LeftSum.new
    var f: BSDMorphism init BSDMorphism.new
    var setOfMorphism : Set< BSDMorphism > init Set< BSDMorphism >.new
```

Initialization

```
    //Detection Step
    f:= detection.detect(pointcut, base)
    while (f != null)
      setOfMorphism.add(f)
      f:= detection.detect(pointcut, minus(base,f))
    end
```

Detection Step

```
    //Composition Step
    setOfMorphism.each{f | result := sum.merge(result, pointcut, advice, f, g)
```

Composition Step

```
  end
```



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Writing the transformation: Detection

```
require kermeta require "../models/bigSd.kmt"
using kermeta::standard using bigSd
```

abstract method

```
abstract class Detector{
  operation findSetOfEvent(evtsOfP: Set<Event>, evts: Set<Event>): Set<Set<Event>> is abstract
  operation min(setOfEvent: Set<Set<Event>>) : Set<Set<Event>> is abstract
```

```
  operation detect (pointcut : BSD, base : BSD) : BSDMorphisms is do
    result := BSDMorphisms.new
```

initialization

```
  var evts : Set<Event> init Set<Event>.new var evtsOfP : Set<Event> init Set<Event>.new
  var V : Set<Set<Event>> init Set<Set<Event>>.new
  var setOfEvent: Set<Set<Set<Event>>> init Set<Set<Set<Event>>>.new
```

```
  pointcut.instances.each{ instance |
    //projection on an instance
    evts := base.events.select{e|e.onInstance== instance}
    evtsOfP := pointcut.events.select{e|e.onInstance== instance}
    //sets of events which have the same action name as the events of P on instance
    //findSetsOfEvent depends of the join point definition
    V := findSetsOfEvent(evtsOfP, evts)
    setOfEvent.add(V)
  }
```

```
  // take the first set of events satisfying the properties // min depends of the join point definition
  Epart=min(setOfEvent)
```

```
  // build the isomorphism from pointcut to Epart
  result := buildIsomorphism(pointcut, Epart)
```

```
end
```



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Writing the transformation: amalgamated Sum

```

require kermeta require "../models/bigSd.kmt"
using kermeta::standard using bigSd
class LeftSum {
  operation merge(base : BSD, pointcut : BSD, advice : BSD, f : BSDMorphism, g : BSDMorphism) : BSD is do
    result := BSD.new
    var map: MyHashtable init MyHashtable.new

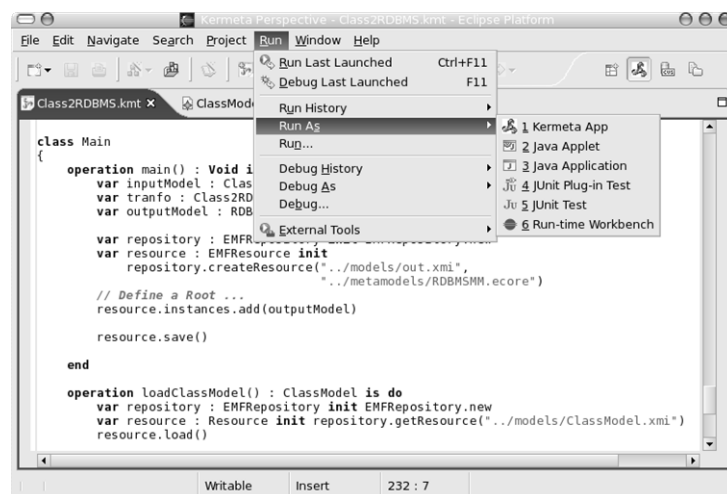
    result.name := "woven-" + base.name
    result.copyInstances(base.instances)
    result.copyInstances(self.complementaryUnion(advice.instances, g.rinstancesMappings))

    result.copyEvents2(self.complementaryUnion(base.events, f.reventsMappings), void, void)
    result.copyEvents2(self.complementaryUnion(advice.events, g.reventsMappings), g.rinstancesMapping,
      f.instancesMappings)
    result.copyEvents2(self.twoTimesMapped(base.events, f.reventsMappings, g.eventsMappings), void, void)

    result.events.each{ event |
      if SendEvent.isInstance(event) then
        var e: SendEvent
        e? = event
        result.addCouple(e, e.receiveEvent)
      end
    }
  end
}

```

Executing the transformation



Smoothly interoperates
with Eclipse/EMF
Open Source
► Download it *now!*



**A statically typed object-oriented
executable meta-language**

- Home page
 - <http://www.kermeta.org>
- Development page
 - <http://kermeta.gforge.inria.fr/>