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Models and Aspect Weaving

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Modeling in Science & Engineering

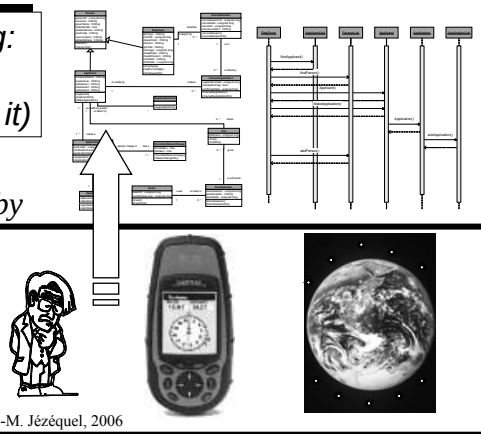
- A Model is a *simplified* representation of an *aspect* of the World for a specific *purpose*

Specificity of Engineering: Model something not yet existing (in order to build it)

M_1 (modeling space)

Is represented by

M_0 (the world)



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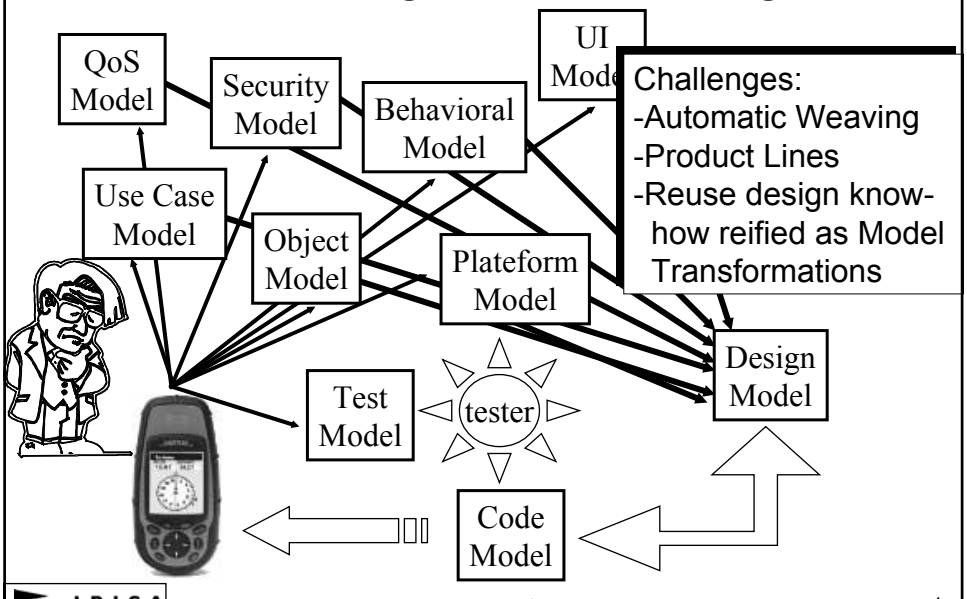
Model and Reality in Software

- Usualy 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 défini un ensemble de *points de jonction* spécifié par une *expression de coupe*
  - la recomposition des aspects est appelée *tissage*
- A pour origine l'AOP popula
  par AspectJ
  - Kizcalez et al., ECOOP 97

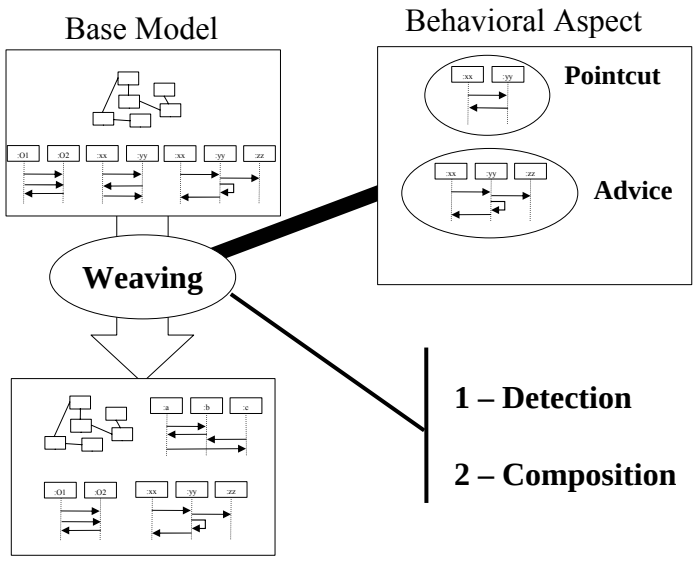
  >> identifié par le MIT comme une des 10 techn

Bénéfices attendus:
→ meilleur modularité,
+ maintenable
+ évolutif
+ réutilisable

Base Models and Aspects

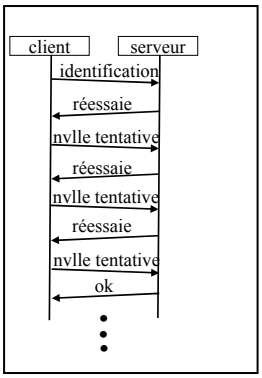
- Ideally, all aspects are equally important
  - Symmetrical AOSD
- In practice, a base model is useful to provide a backbone (canvas) on which aspects are woven
- An aspect is then described as
  - A pointcut
    - » pattern describing relevant points in the execution
  - An advice
    - » New behavior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

Overview

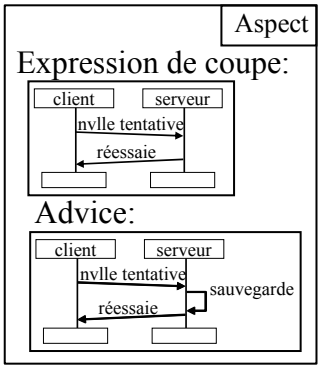


Tissage Statique d'Aspects Comportementaux

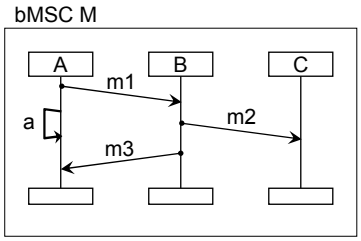
Un scénario de base



Un aspect comportemental

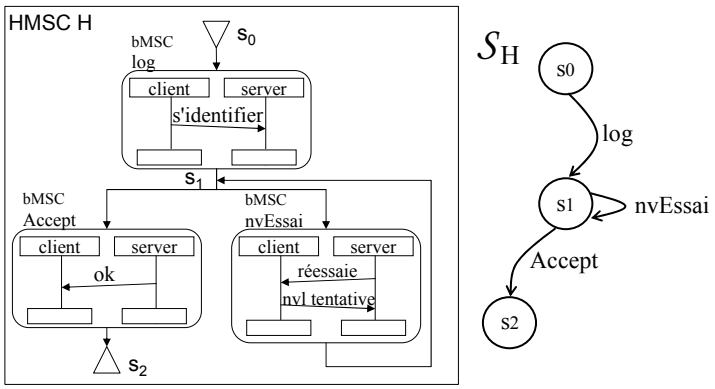


Message Sequence Charts (MSCs) (ou SD) bas niveau: bMSC



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

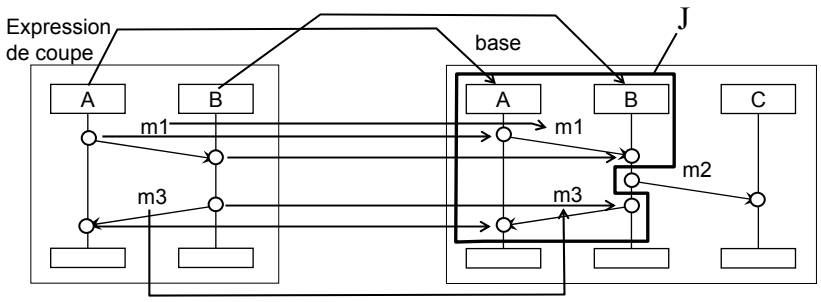
Message Sequence Charts haut niveau: HMSC



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



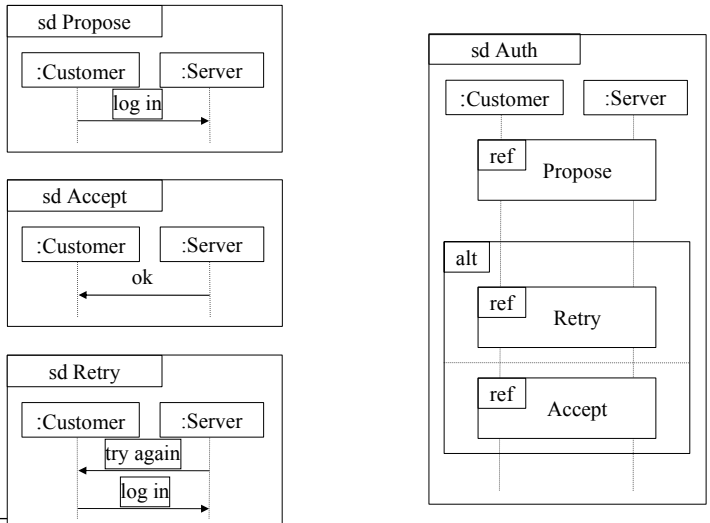
- Une partie J d'un scénario de base est un point de jonction s'il existe un isomorphisme de bMSCs entre l'expression de coupe et J.

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

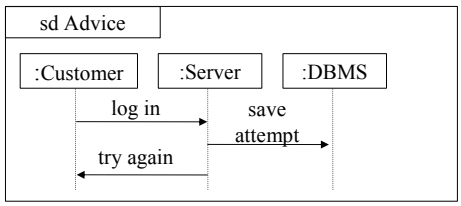
(based on J. Klein & F. Fleurey works)



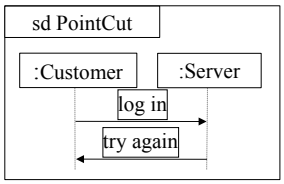
Example: Behavioral Aspect

Behavioral Aspect = Advice + Pointcut + Morphism

Advice



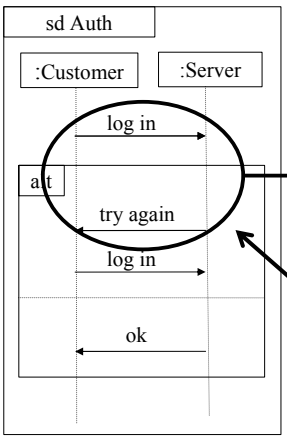
Pointcut



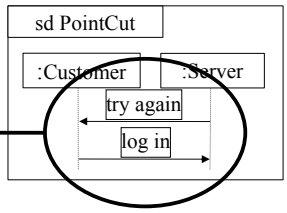
Matching based on sub-SD inclusion

BaseModel = sd1 **seq** *pointcut* **seq** *sd2*

Base Model



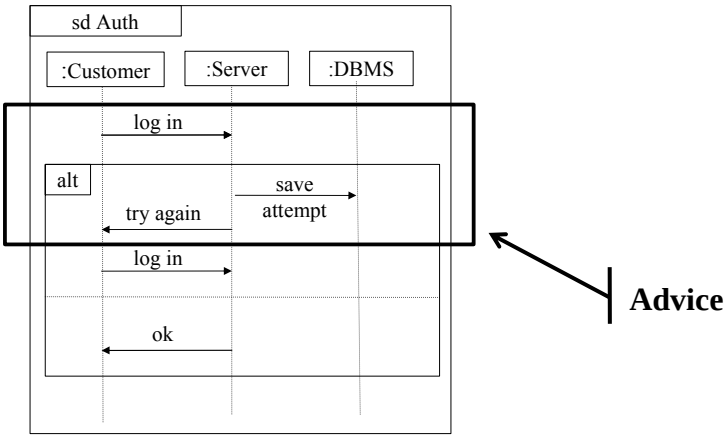
Pointcut



1 Joinpoint

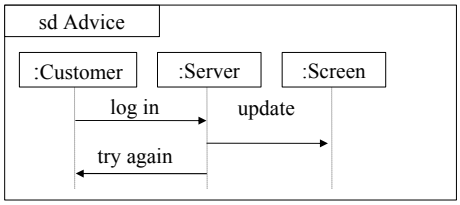
Example: Composition

Result Model

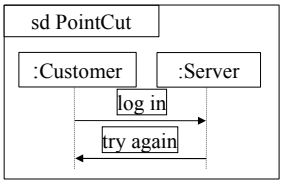


2nd aspect: update screen

Advice

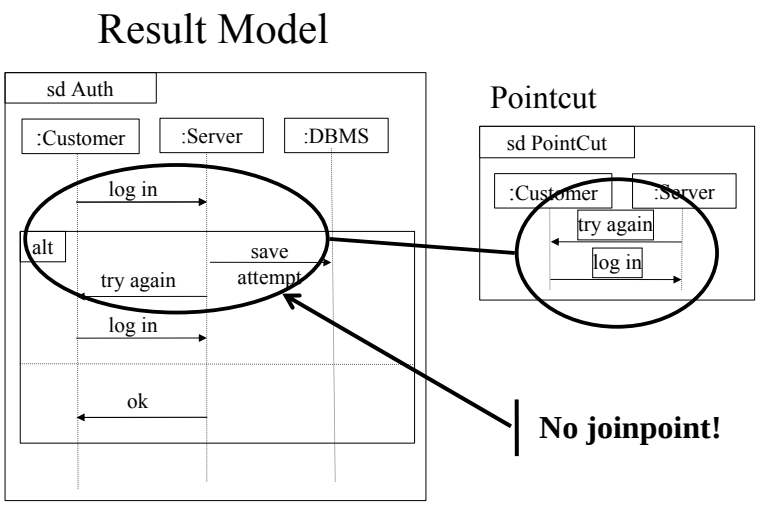


Pointcut



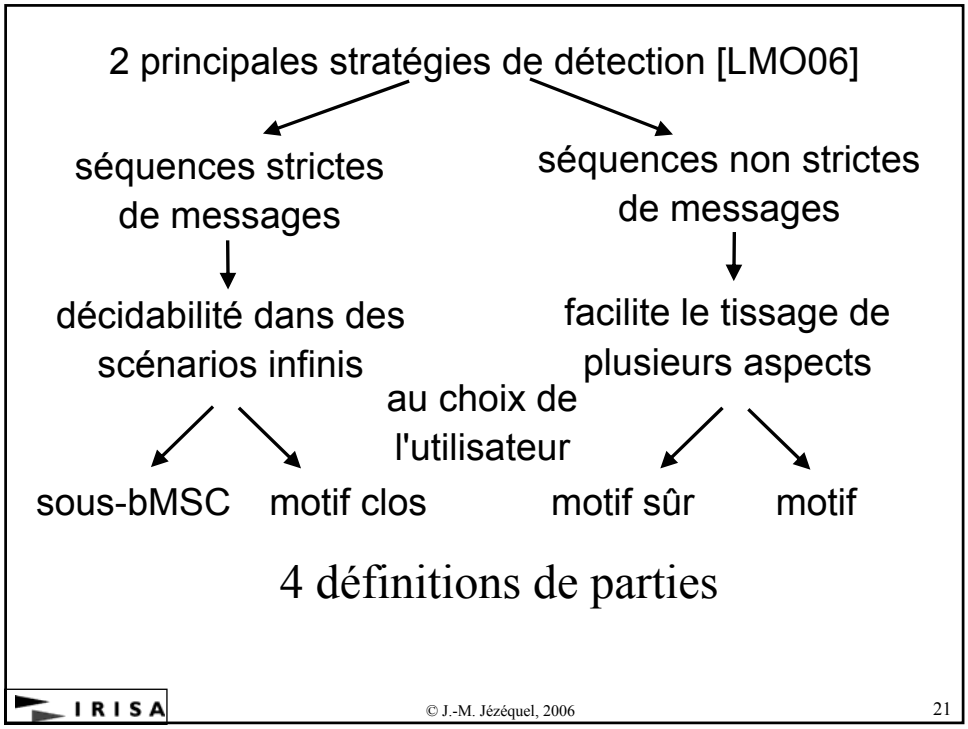
Matches base scenario, but no longer woven one!

Impossible Composition



More advanced detection needed

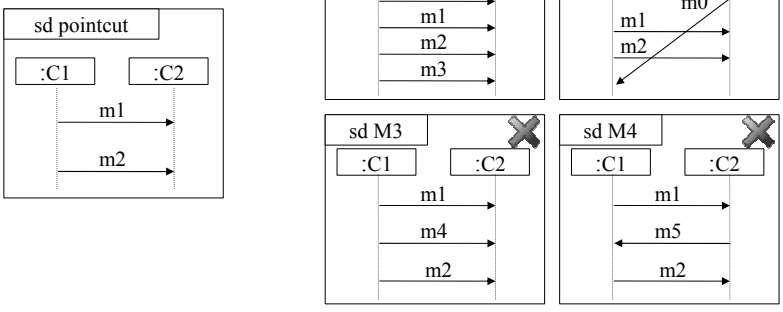
- Two possible strategies beyond sub-sequence diagram
  - Closed part
  - Pattern
- Static Analysis to find Joinpoints over HMSCs (loop unrolling!).



Detection Strategies (1)

detection

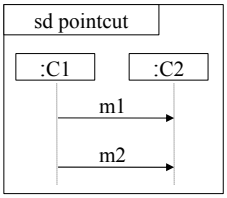
- Sequence Sub-diagram:
  BaseSD = *sd1* **seq** *pointcut* **seq** *sd2*

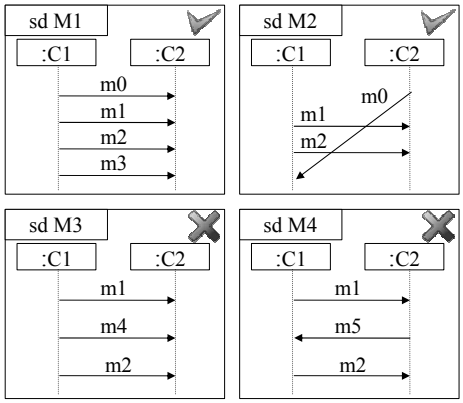


Detection Strategies (2)

detection

- Closed Part

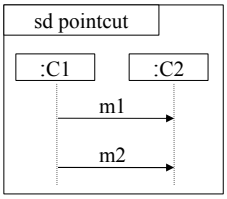


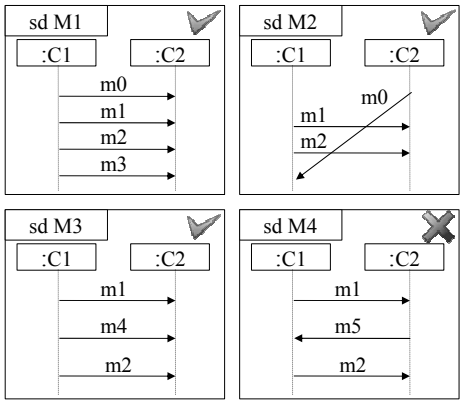


Detection Strategies (3)

detection

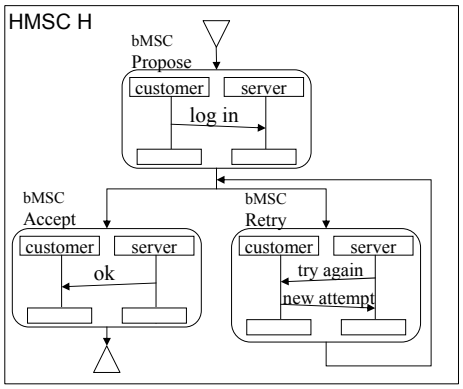
- Pattern



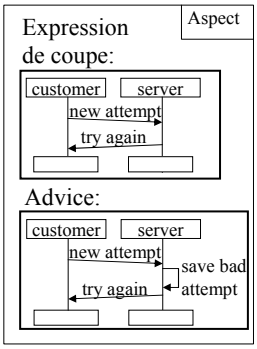


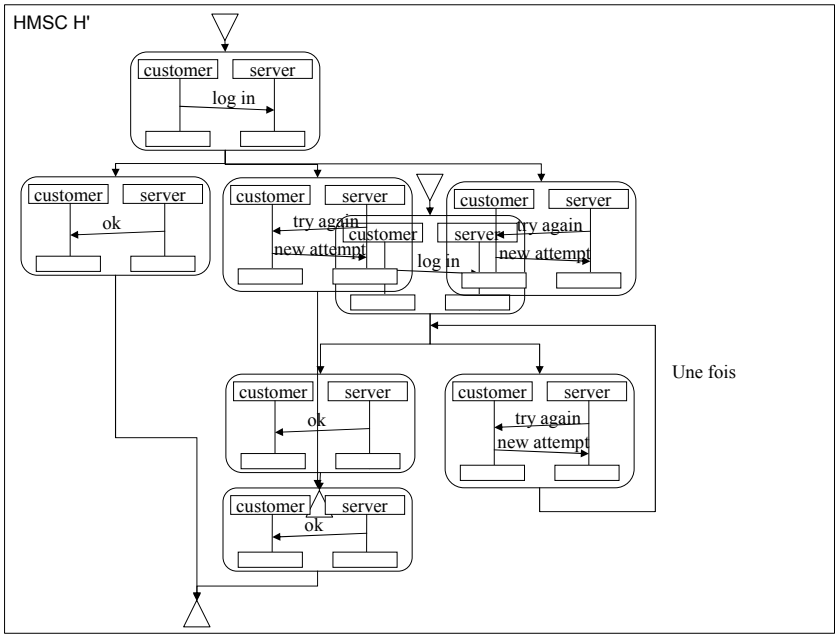
Detection in infinite scenarios

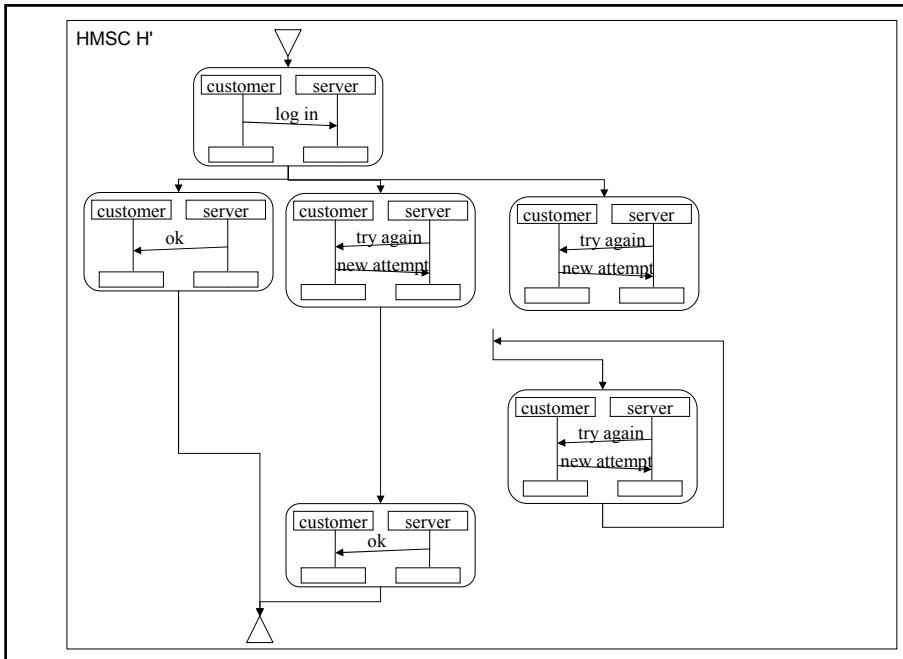
Base scenario



Behavioral aspect






HMSC H'
customer
server
log in
customer
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new attempt
customer
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try again
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try again
new attempt
customer
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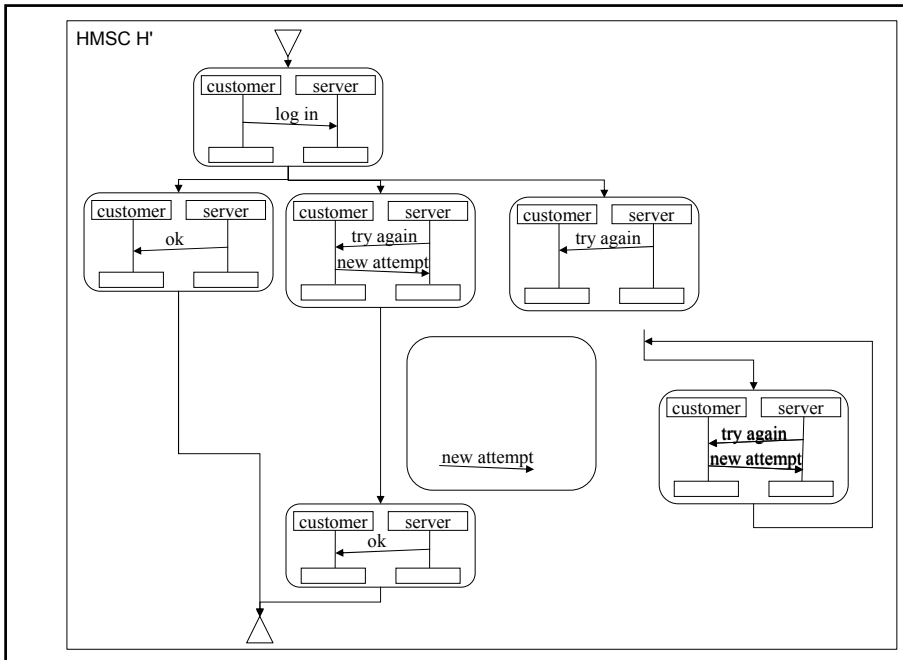
ok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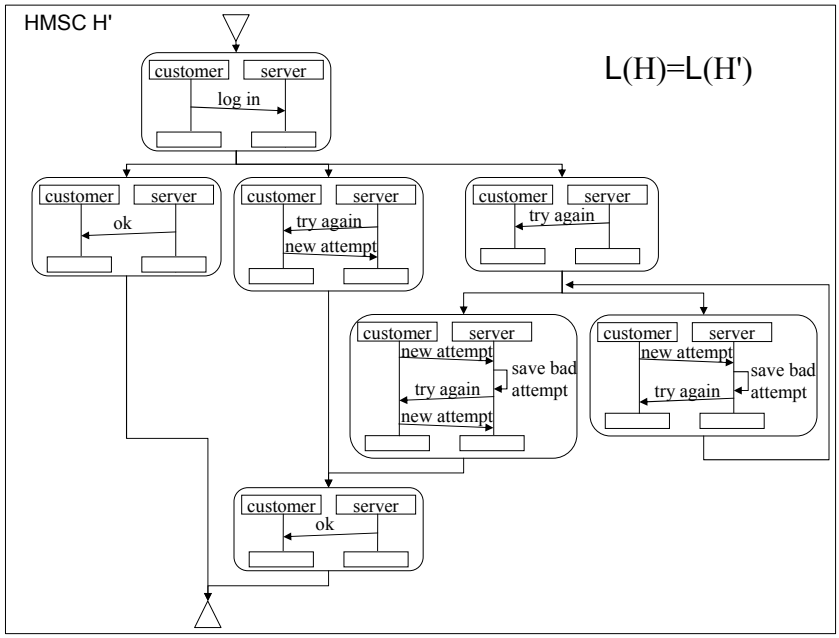
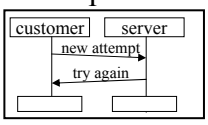
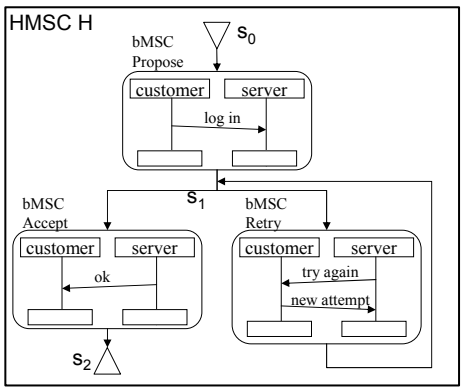


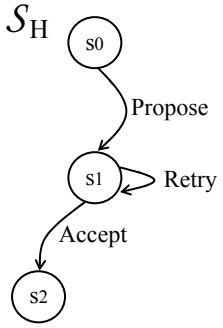
Transformation de HMSC

Expression de coupe



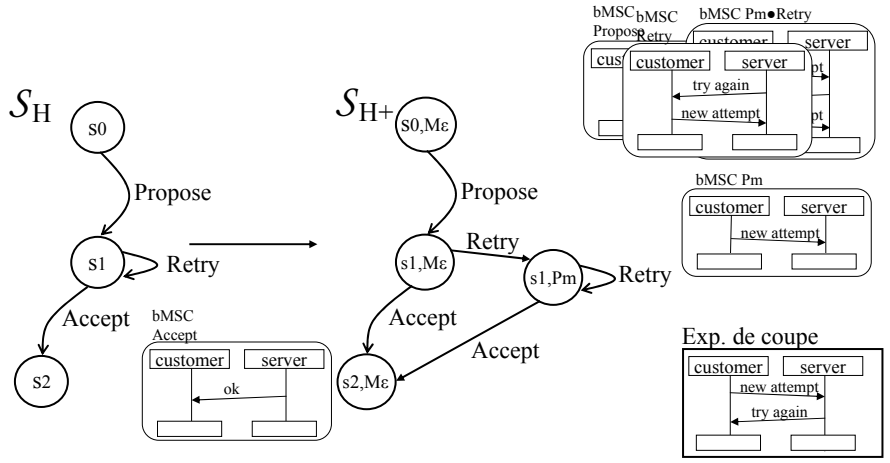
Un scénario de base





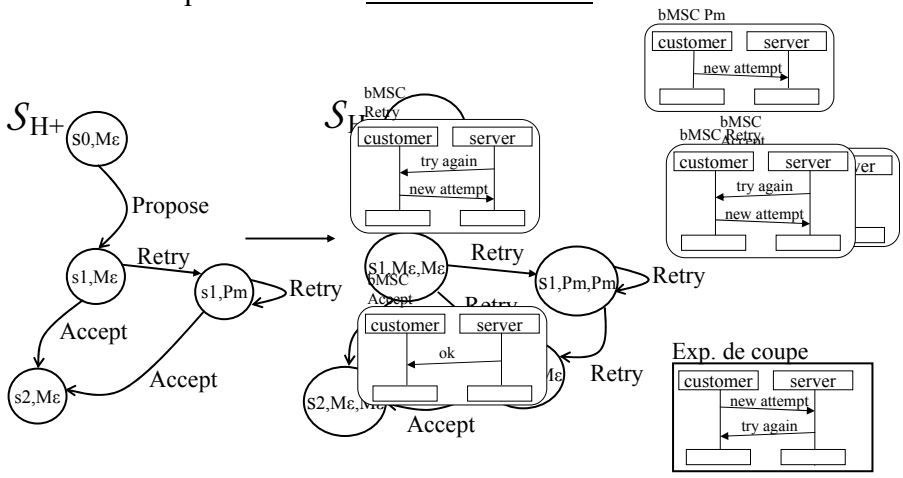
Transformation de HMSC

- Première étape: calcul des <u>détections potentielles</u>



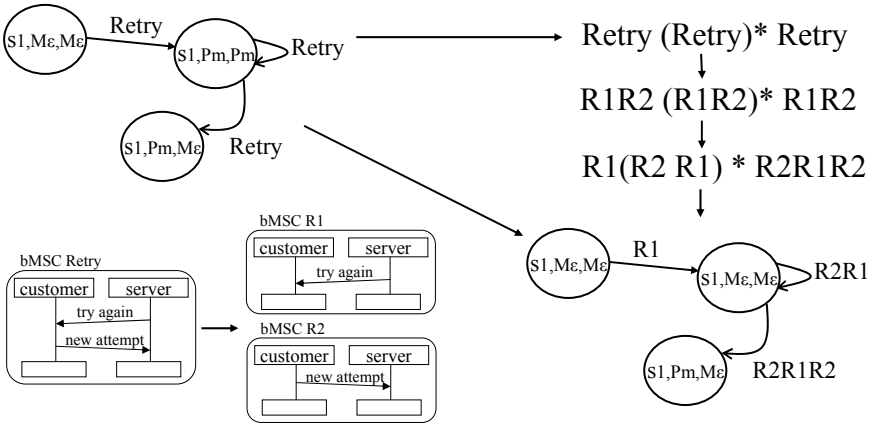
Transformation de HMSC

- Deuxième étape: calcul des <u>détections futures</u>



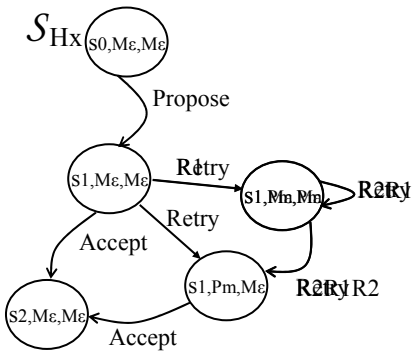
Transformation de HMSC

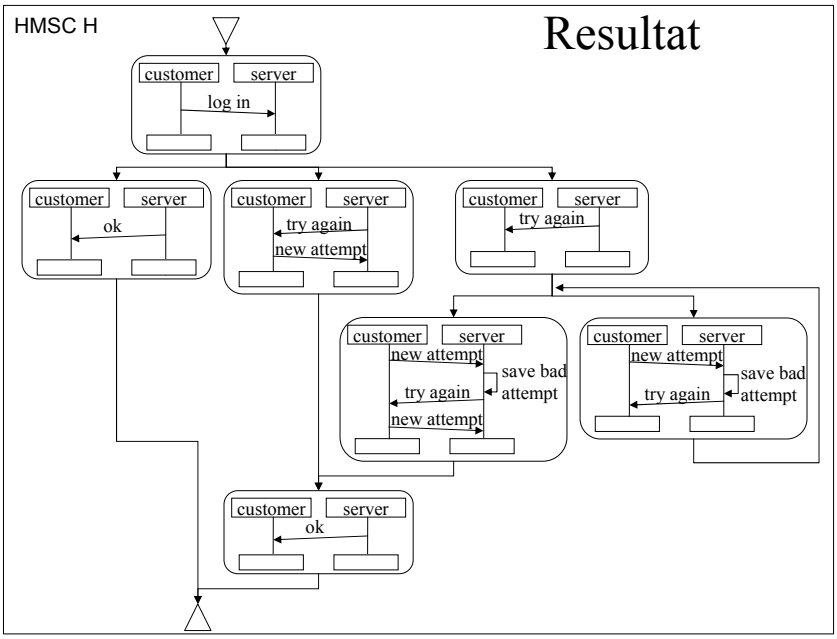
- Troisième étape: utilisation d'expressions régulières, découpe de bMSCs en atomes et permute ces atomes



Transformation de HMSC

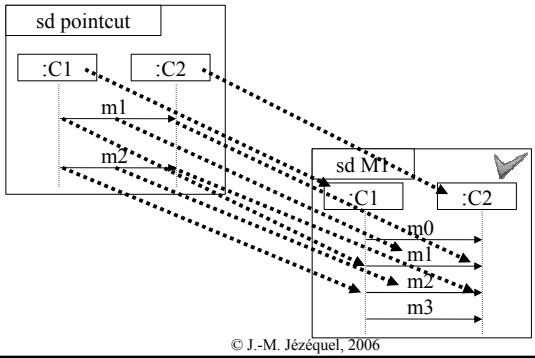
Resultat





Result of the Detection Step

- Create a morphism for each Joinpoint
  - Morphism of instances
  - Morphism of events
  - Morphism of messages (implied)



Composition

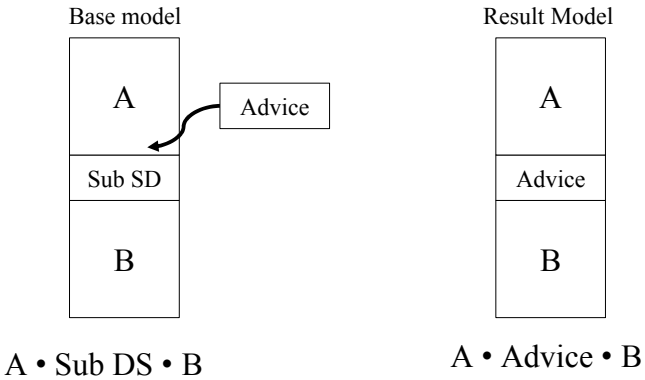
- Compose the advice into the base model
- Depend on the detection strategy

Composition

Composition

- Sequence sub-diagram

⇨ Weak Sequential Composition



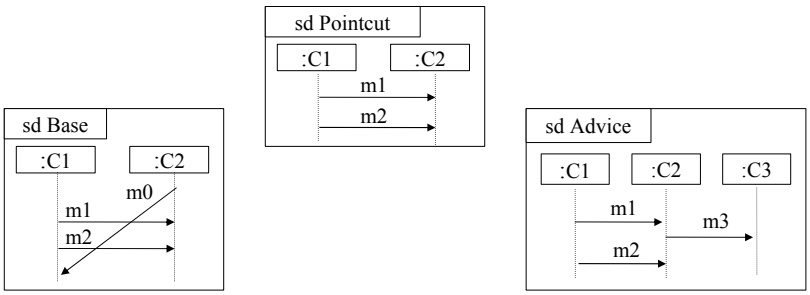
A • Sub DS • B

A • Advice • B

Amalgamed Sum

- For matching on Closed Part & Patterns

  ⇨ Simple composition not possible



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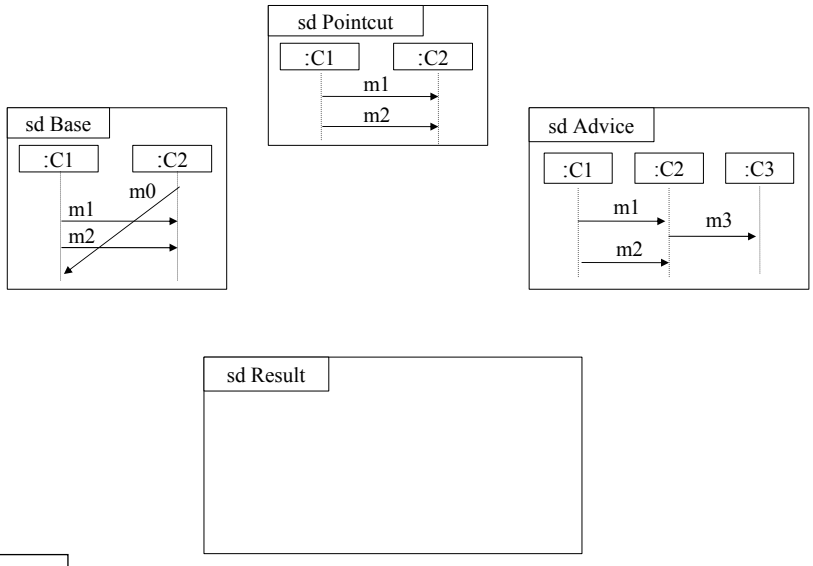

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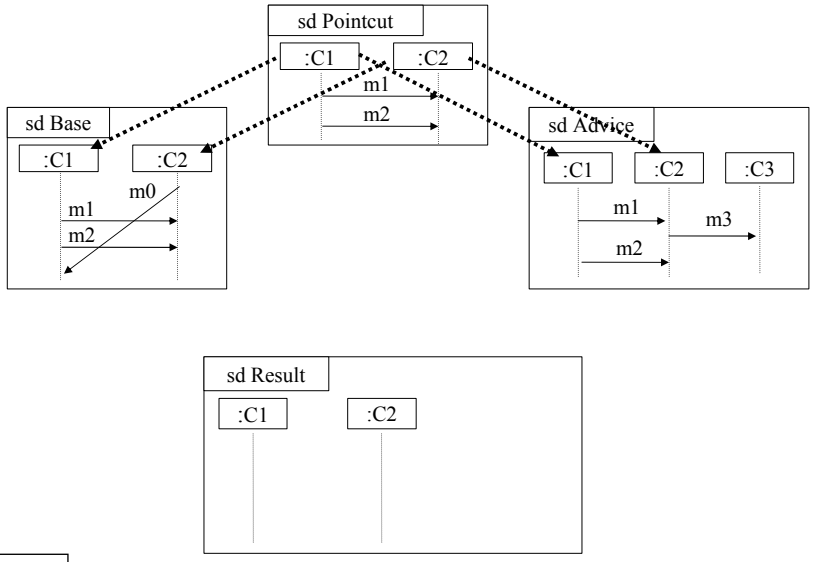

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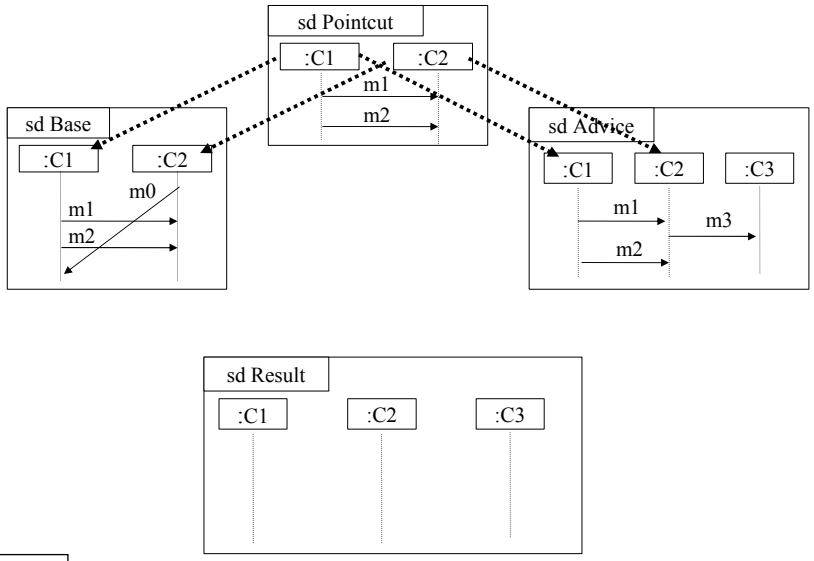

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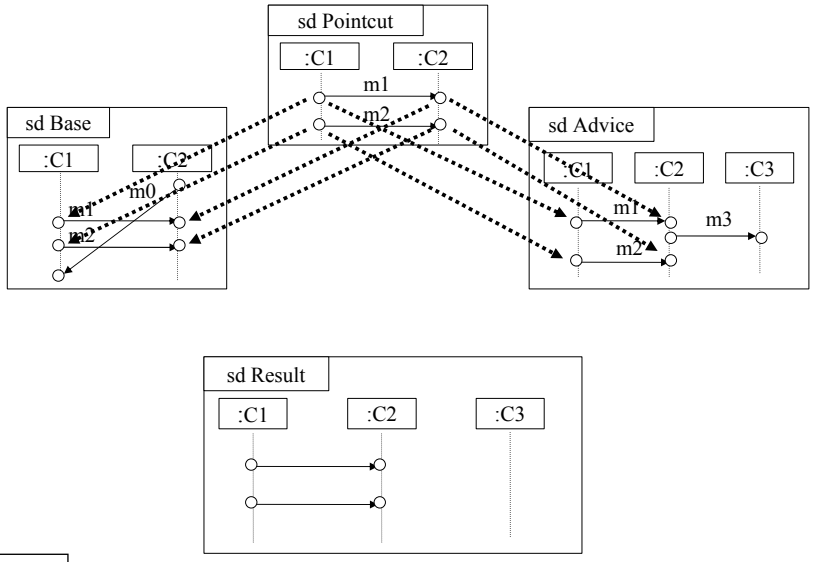

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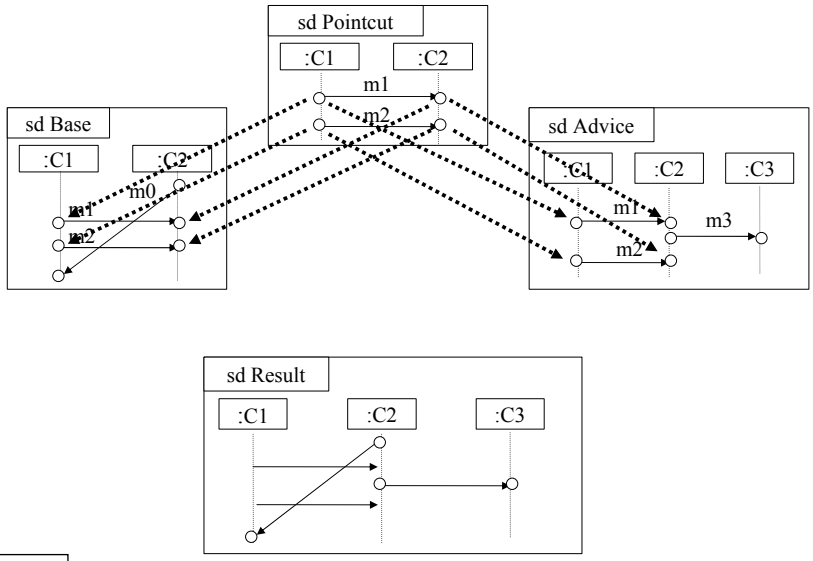

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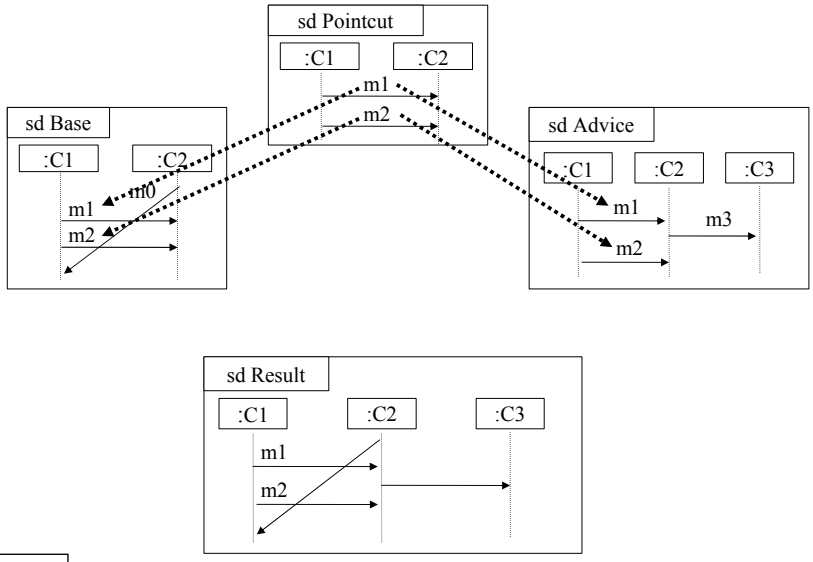

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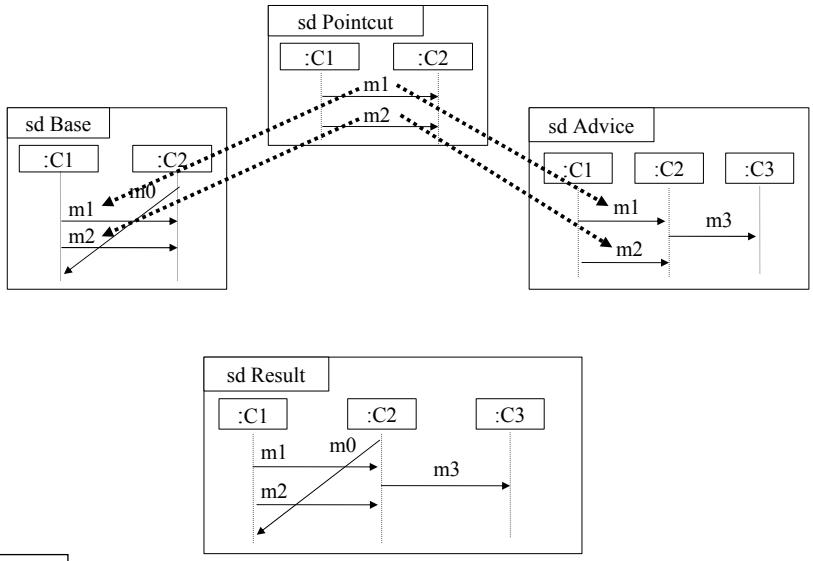

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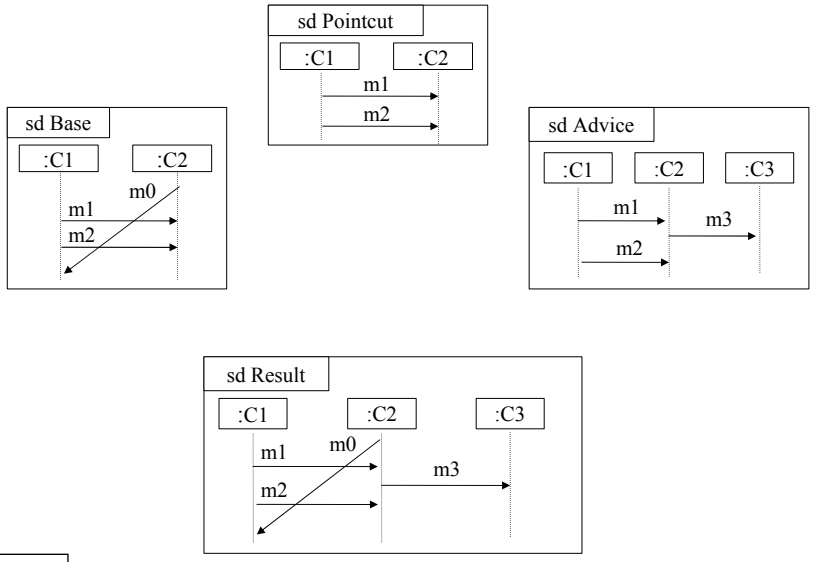
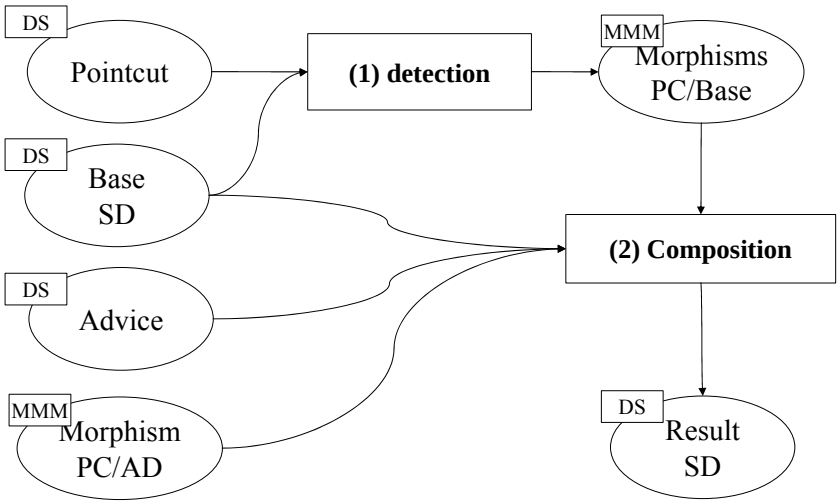


Implementation



KerMeta in a NutShell

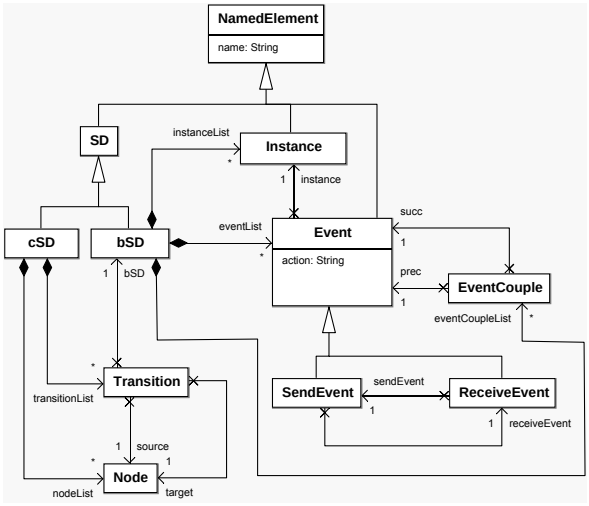
- EMOF superset
  - Any EMOF MetaModel is a valid KerMeta program, and conversely
- Object-Oriented
  - Multiple inheritance / behavior selection
  - Operation overiding / late binding
  - Full reflection (read-only at this time)
- Statically Typed
  - Generics
  - Function types to allow OCL's *forall/exist/iterate*

"Programming style" Issues

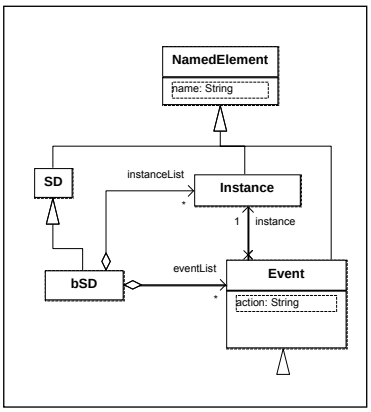
- The transformation is simply the model of an object-oriented program that manipulates model elements
  - Navigation through model is first class though (like in OCL)
- OO techniques
  - Customizability through inheritance/dyn. binding
  - Pervasive use of GoF like Design Patterns

Defining the metamodels

input and output metamodels are the same

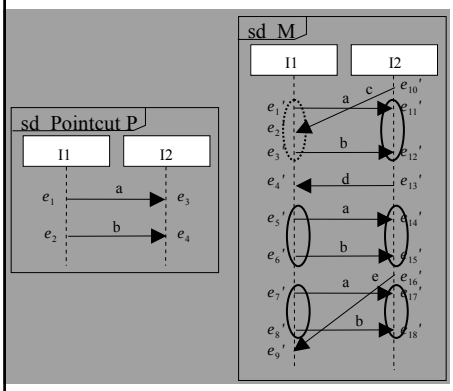


Visual/Textual



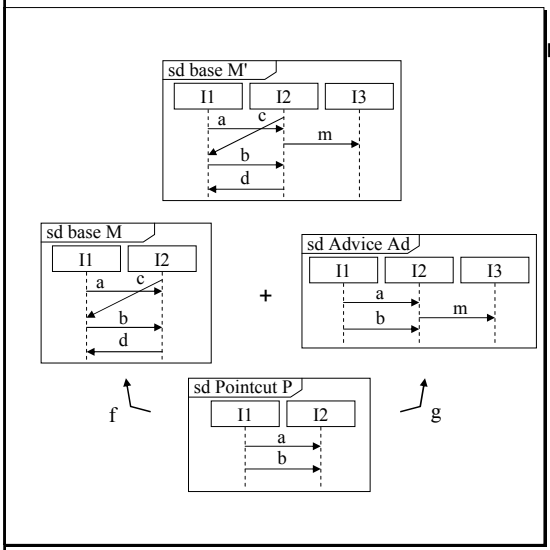

```
package bigSd;
using kermeta::standard
using kermeta::persistence
abstract class NamedElement
{
    attribute name : String[1..1]
}
abstract class SD inherits NamedElement
{}
class BSD inherits SD
{
    attribute events : Event[0..*]
    attribute couples : EventCouple[0..*]
    reference instances : 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 Jm, which satisfies the properties related to the join point policy
  - build isomorphism μ from P to Jm
  - repeat on M-Jm while Jm is not empty

Sequence Diagrams Weaving

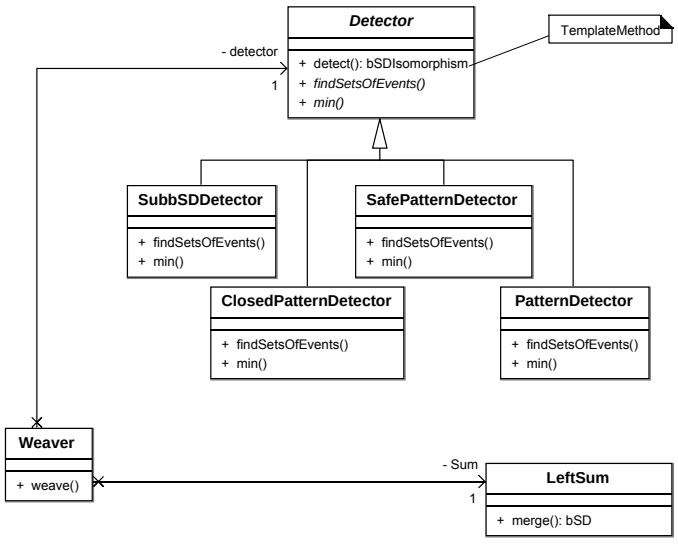


- Composition step: amalgamated sum
  - use P and two morphisms f and g (f being computed by the detection step)
  - keep the common parts between M and Ad
  - add new object I3
  - add the events of M by respecting the order specified on M
  - add the events of Ad by respecting the order specified on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

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

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


Writing the transformation: Detection

```
      require kermeta     require "../models/bigSd.kmt"
      using kermeta::standard     using bigSd
      abstract class Detector{                                                abstract method
        operation findSetOfEvent(evtsOfP: Set<Event>, evts: Set<Event>): Set<Set<Event>>is abstract
        operation min(setOfEvent: Set<Set<Event>>) : 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
```

Writing the transformation: amalgamated Sum

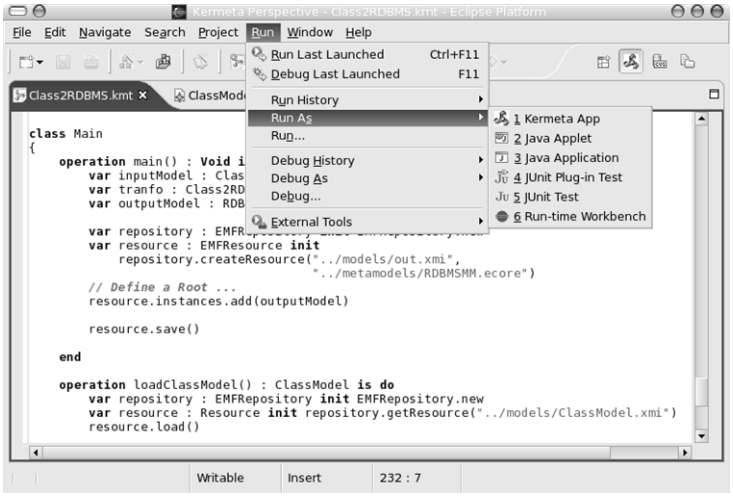
```
require kermeta   require "../models/bigSd.kmt"
using kermeta::standard    using bigSd
class LeftSum {
 operation merge(base : BSD, pointcut : BSD, advice : BSD, f : BSDMorphism, g : BSDMorphism) : BSD is do
        result := BSD.new
        var map: MyHashtable init MyHashtable.new

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

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

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


Executing the transformation



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- Home page
  - http://www.kermeta.org
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