PL 2008 - Punta Arenas
Aspects, Processes, and Components

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The basic idea

- There is usually no specific support for concurrency in AOP languages.
- Both (regular) stateful aspects and processes can be represented as automata.
- What about modelling both the base program and aspects as automata and combine stateful aspects and concurrency (between base and aspects as well as between aspects).
- May such a model be used to synthesize aspects and facilitate reuse?

Stateful Aspects [DFS02, DFS04]

- Standard aspects are stateless, they deal with a unique atomic action (a *join point*):

  `if` *pointcut*`(`*join point*`)` `eval(`*advice*`);`

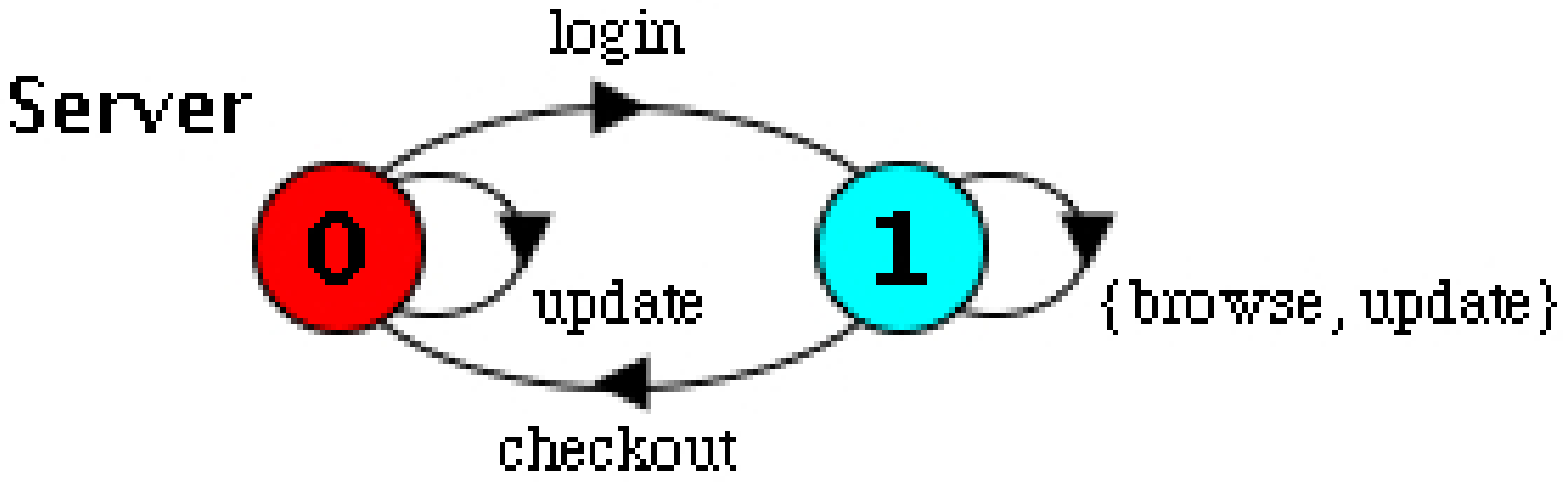
- Stateful aspects may affect the execution of the base program, depending on the *state* of the program, ie depending on the previous execution.

  `if` *pointcut*1`(`*join point*`)` `eval(`*advice*1`);`
  `if` *pointcut*2`(`*join point*`)` `eval(`*advice*2`);`

Base Model

```
Server =
  ( login -> Session
  | update -> Server
  ),
```

```
Session =
  ( checkout -> Server
  | update -> Session
  | browse -> Session
  ).
```



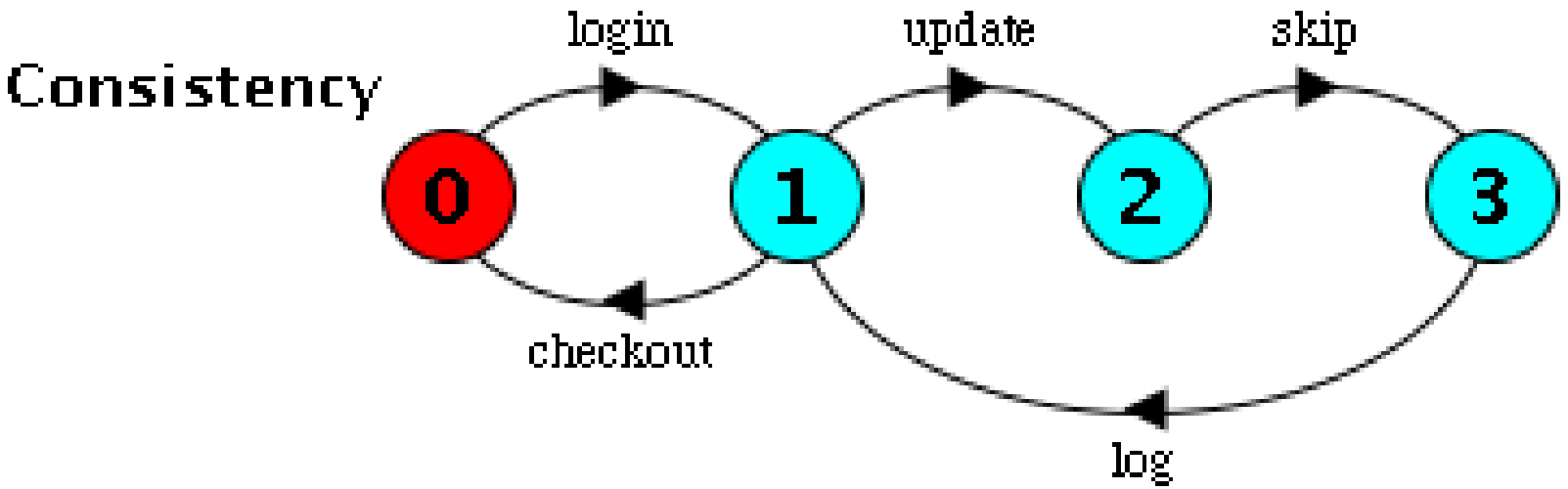
Aspect

Event-Based AOP (EAOP) [DFS02].

$$\mu a.\,(\text{login};\, \mu a'.\,((\underline{\text{update} \triangleright \text{skip};\, \text{log}};\, a') \,\square\, (\text{checkout};\, a)))$$

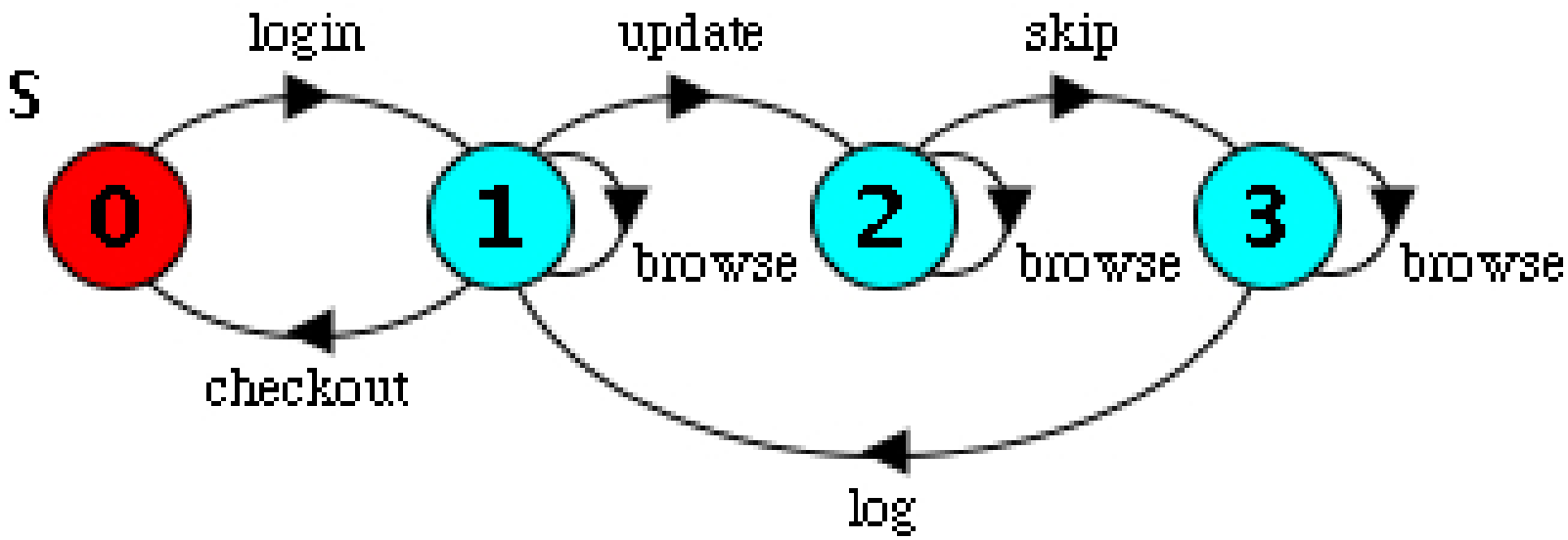
```
Consistency =
  ( login -> Session
  ),
```

```
Session =
  ( update -> skip -> log -> Session
  | checkout -> Consistency
  ).
```



Woven Model

```
||S = (Server || Consistency).
```



Problems:

- We want to execute `update` out of a session
- We don't want to `update` within a session

Instrumentation of Base

- We are interested in the event "an update is about to take place" in order to execute a *before* advice.
- When "an update is about to take place" an aspect interested in updates should be able to decide whether the action should take place or not.

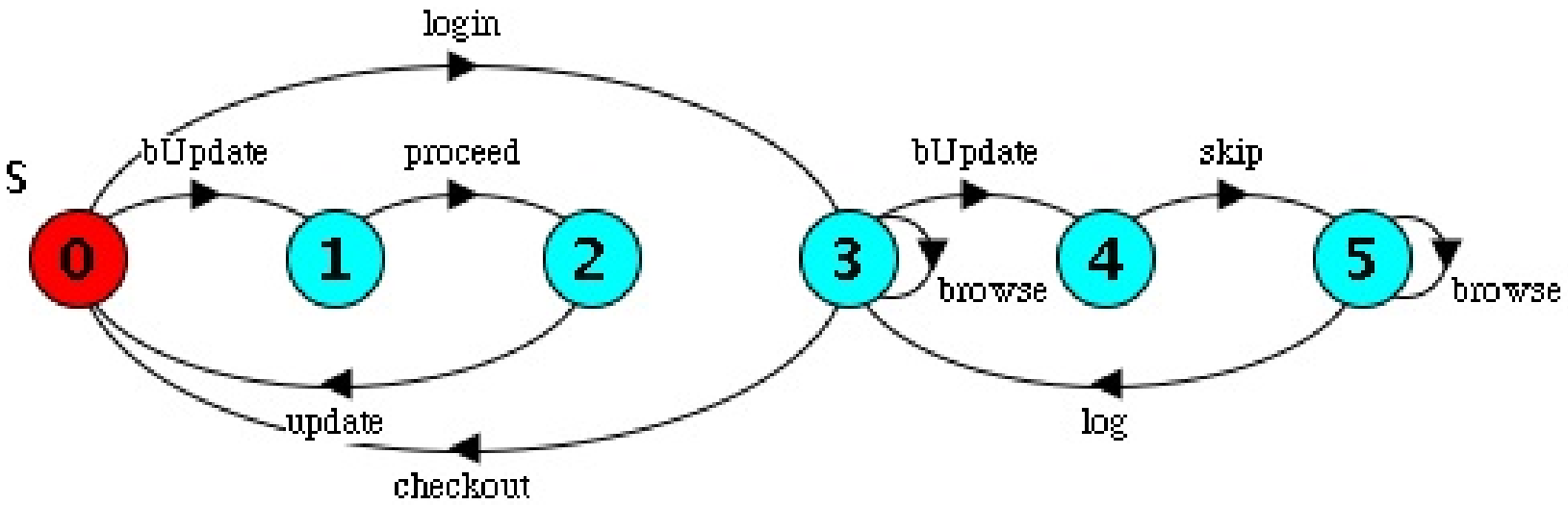
```
Server =
  ( login -> Session
  |  bUpdate -> ( skip -> Server
                | proceed -> update -> Server
                )
  ),
Session =
  ( checkout -> Server
  |  bUpdate -> ( skip -> Session
                | proceed -> update -> Session
                )
```

Adding Waiting Loops to Aspects

- All the actions shared between the base and the aspect: $\{\texttt{login}, \texttt{bUpdate}, \texttt{checkout}\}$ must be dealt with in each aspect state. Some actions are skippable (the aspect may decide not to execute them), others are not skippable.

```
Consistency =
  ( login -> Session
  | bUpdate -> proceed -> Consistency
  | checkout -> Consistency
  ),
Session =
  ( bUpdate -> skip -> log -> Session
  | checkout -> Consistency
  | login -> Session
  ).
```

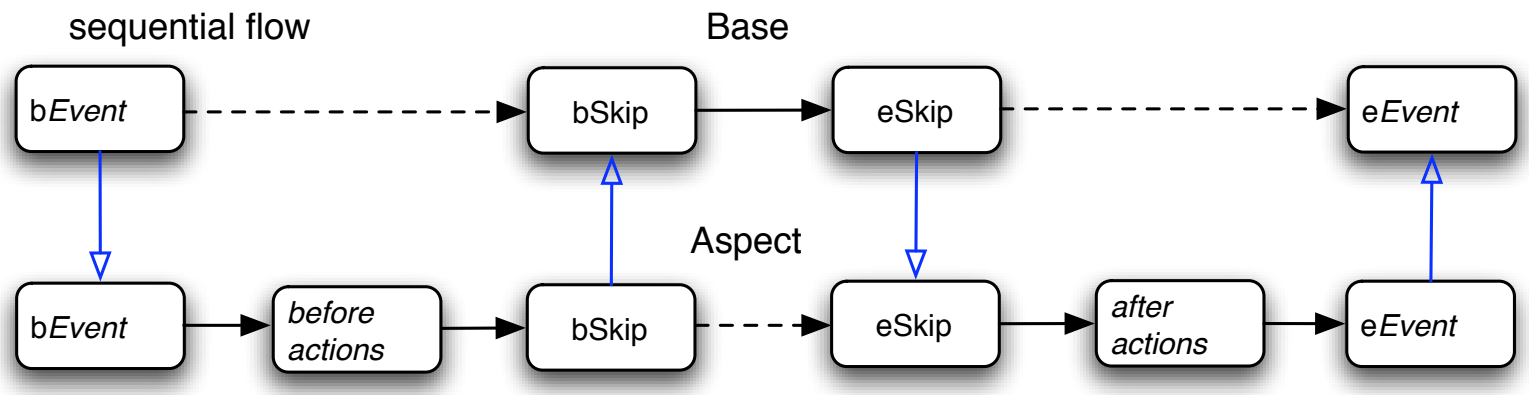
Woven Model


login
bUpdate
proceed
bUpdate
skip
S
0
1
2
3
4
5
browse
browse
update
log
checkout

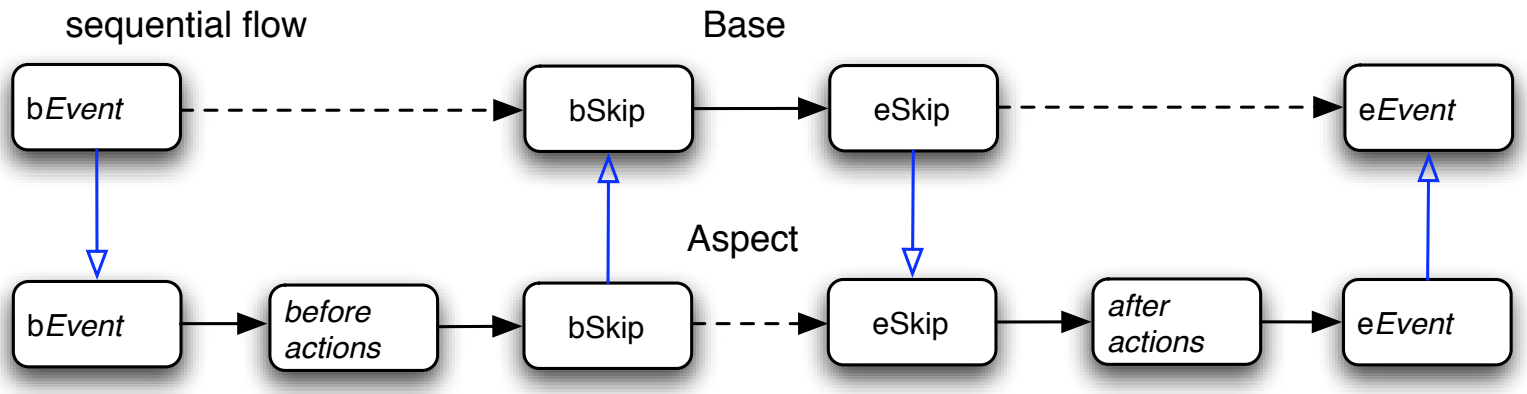
Controlling Concurrency Between Base and Aspect

We introduce pairs of instrumentation events (begin*Event*, end*Event*):

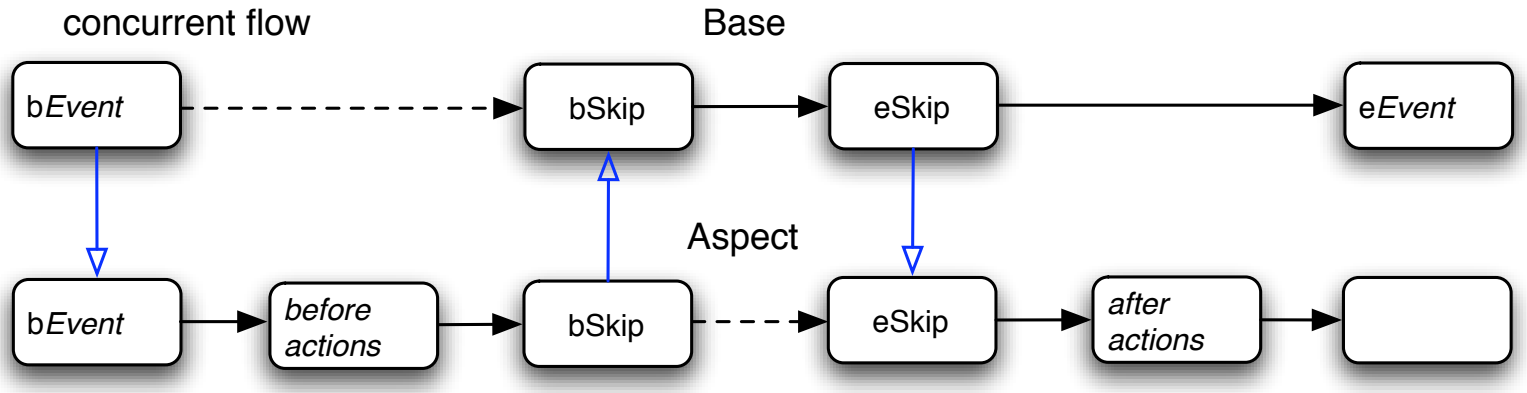
```
bUpdate ->
  ( bSkip -> eSkip -> eUpdate -> Server
  | bProceed -> update -> eProceed -> eUpdate -> Server
  )
```



Controlling Concurrency Between Base and Aspect (2)




```
||ConcurrentConsistency = (Consistency)\{eUpdate}.
```



Summary

- Input:
  - a base program modelled as an FSP `B`
  - a stateful aspect `A` expressed in an extended version of FSP:

```
Consistency =
  ( login -> Session
  ),
```

```
Session =
  ( update > skip , log -> Session
  | checkout -> Consistency
  ).
```

- Output (the *weaving* of `A` into `B`):
  `BaseTransf(B) || hiding(AspectTransf(A))`
- The transformations are independent from the composition.
- Hiding controls concurrency between the base and the aspect.

Composing Aspects - Basic Idea

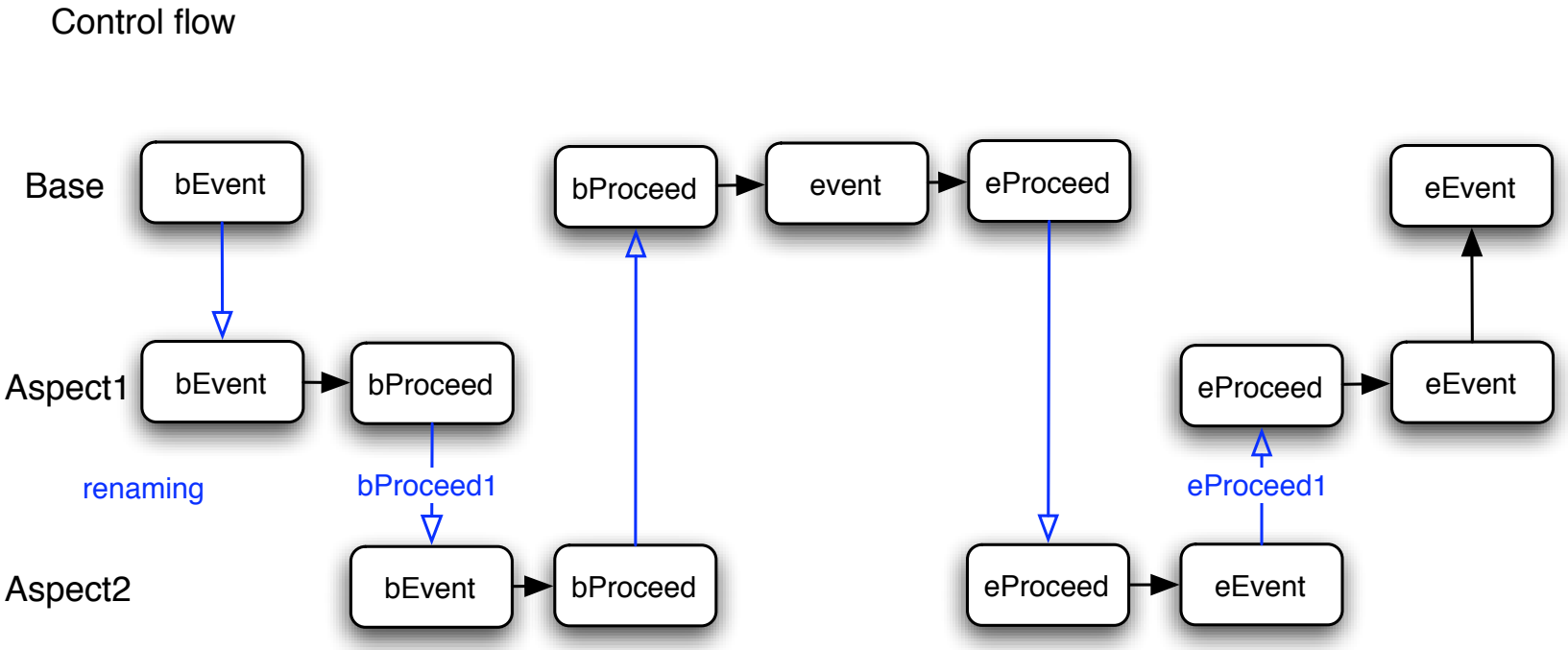
- Abstract point of view: the aspects are composed via operators
- Example: `Fun(Consistency, Safety)` with

$$\text{Safety} \triangleq \mu a''.(\text{update} \triangleright \text{rehash proceed backup}; a'')$$

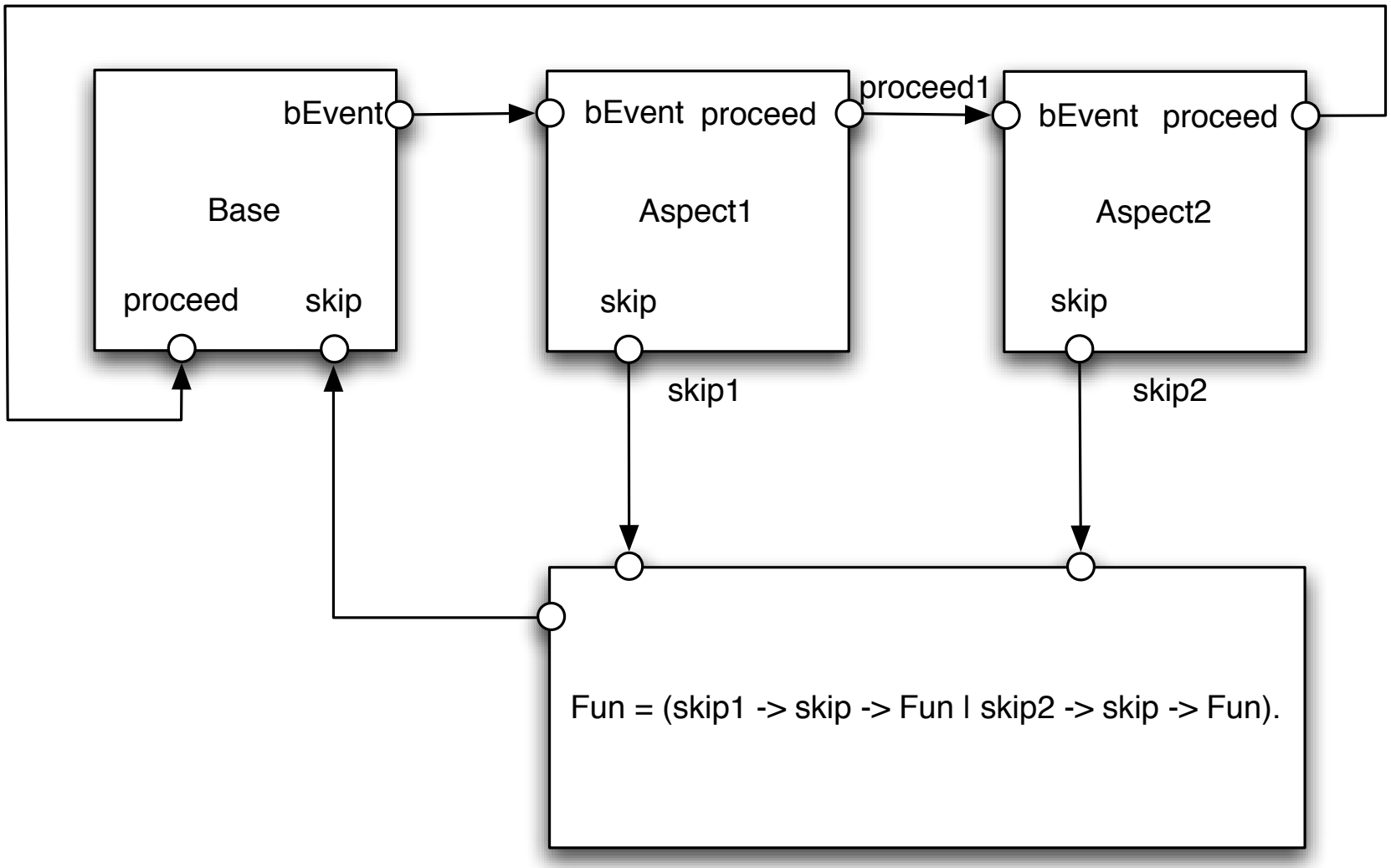
- An operator is modelled as the composition of a specific FSP with a proper renaming.

The Fun Operator

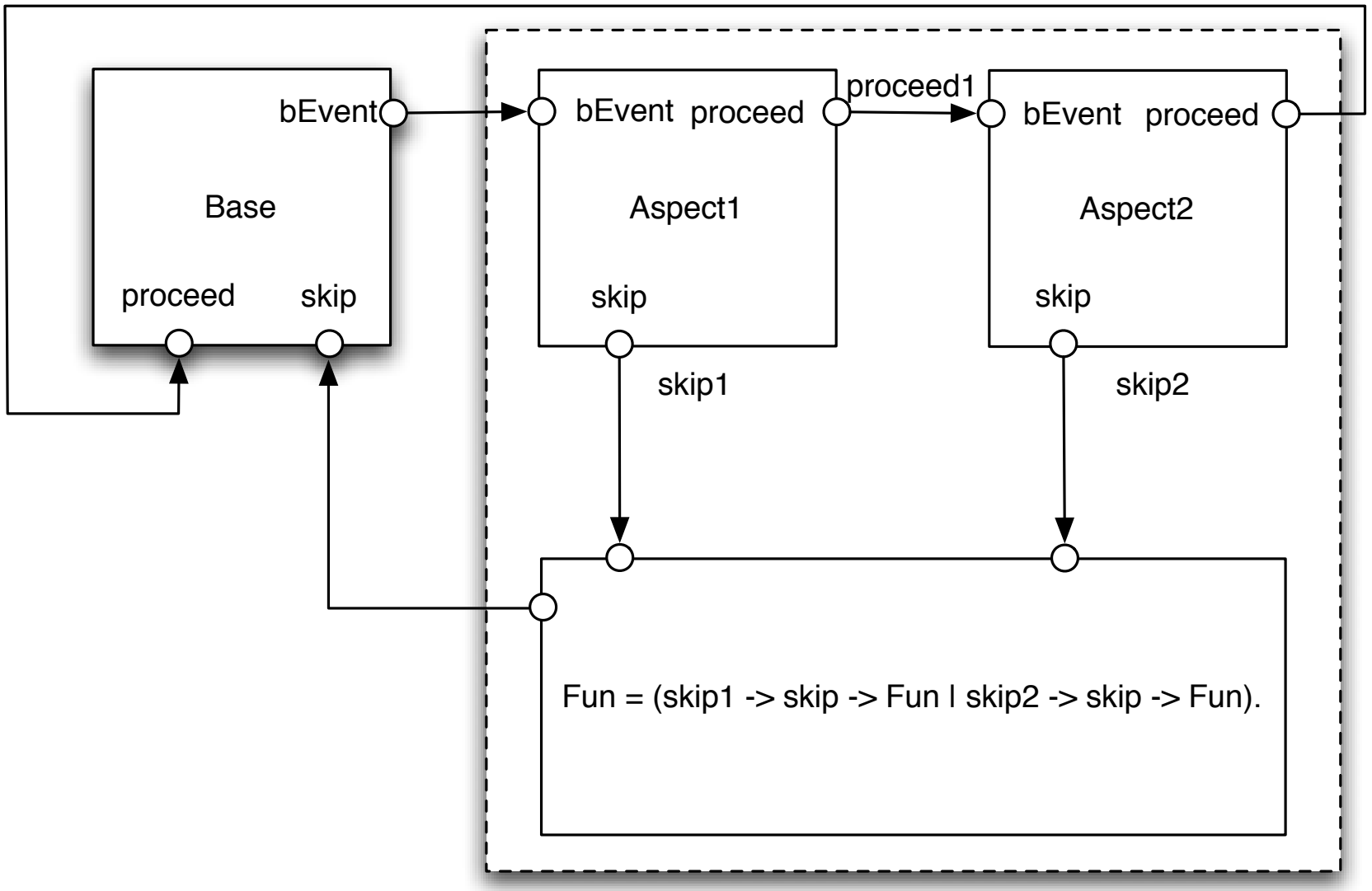
`Fun(Aspect1, Aspect2)` is the "functional" sequential composition (used in AspectJ) of `Aspect1` and `Aspect2`.



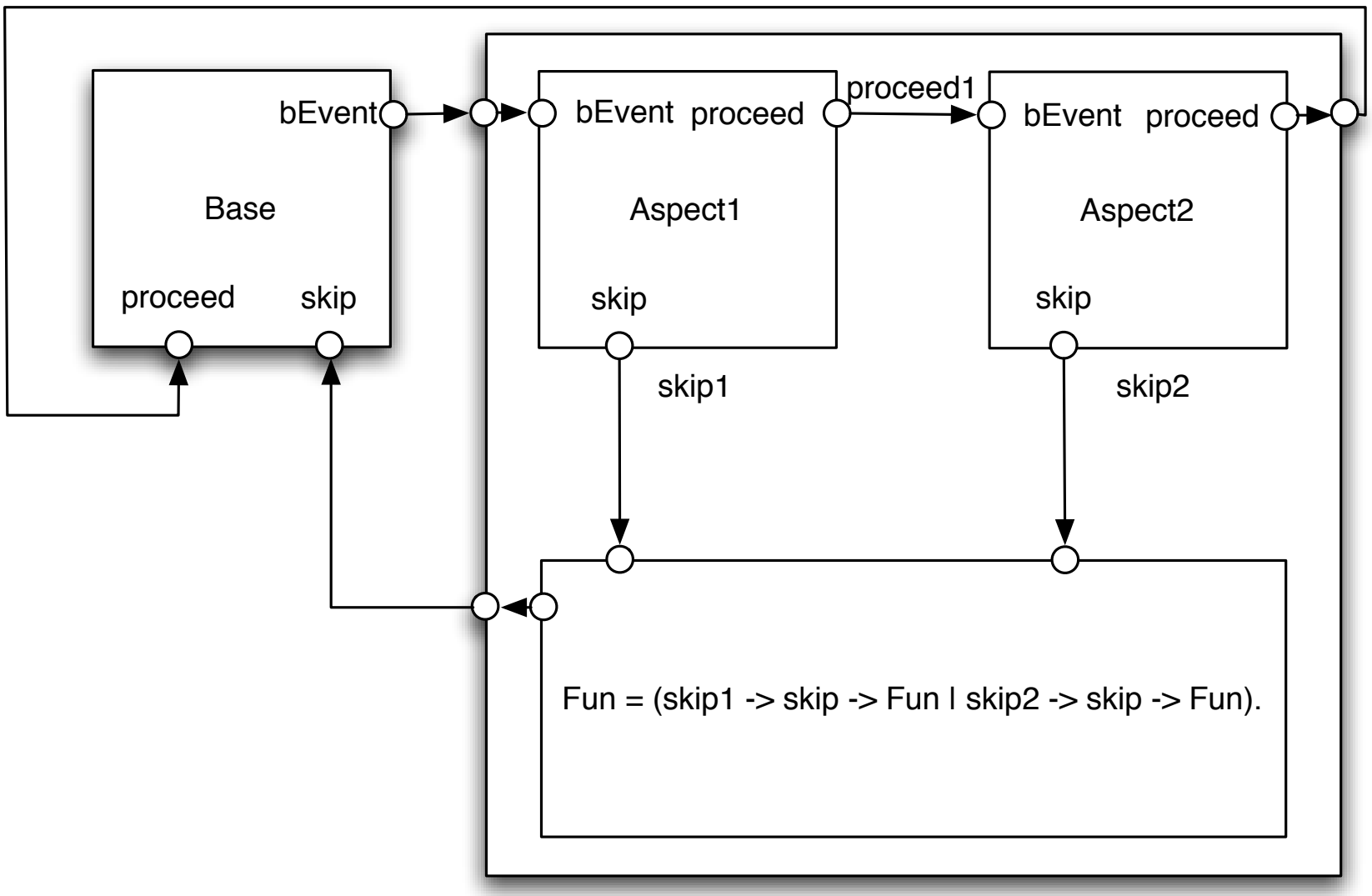
The Fun Operator - Simplified Structural View



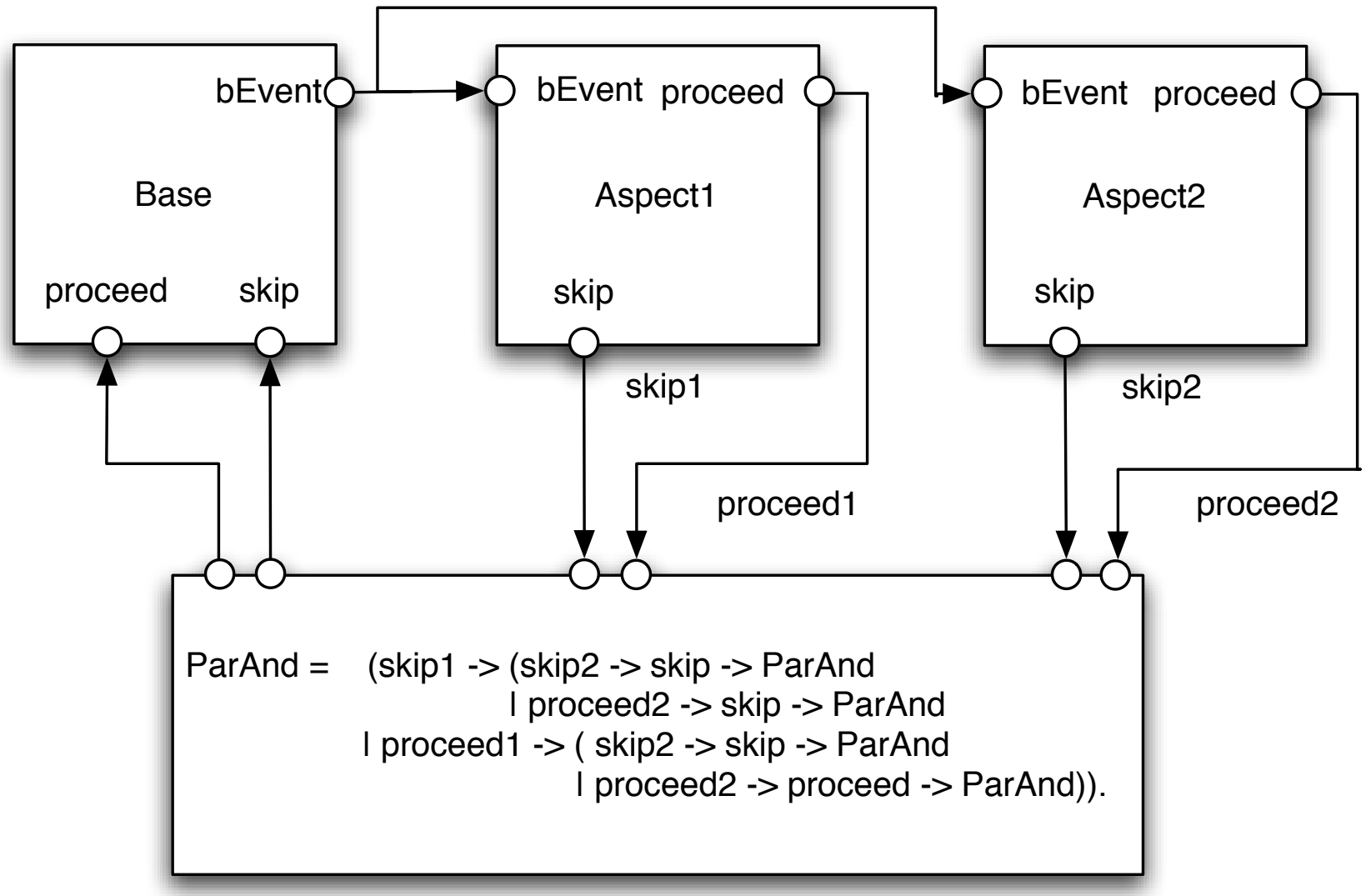
The Fun Operator - Simplified Structural View



The Fun Operator - Simplified Structural View



The ParAnd Operator - Simplified Structural View



Prototype: Baton [NN07a]

- The base program is instrumented with AspectJ-like pointcuts describing the actions of interest (using Reflex [TTPN08]).
- The previous transformations are used to generate the aspects (as active objects) from a concrete syntax close to FSP (using Metaborg/SDF).
- Calls to a global monitor are used to synchronize the shared actions:
  - two synchronization barriers per transition!
  - naive but guarantees correction wrt the model

Aspect

```
aspect Consistency {
  public void log(Client client, Admin admin) {
    System.out.println(admin + " skipped:"
                               + client + " is connected.");
  }
  behaviour {
    Server  = ( login(Client client) -> InSession(client) ),
    InSession(client) =
      ( update(Admin admin) > skip, log(client,admin)
          -> InSession(client)
      | checkout(client) -> Server ).
  }
}
```

Connector

```
connector ClientConnector{
  connect login(Client c) :
    execution(* Client.login(..)) && this(c);
  connect checkout(Client c) :
    execution(* Client.checkout(..)) && this(c);
}
```

Main Program

```
main Ecommerce{
  Aspect aspect = new ParAnd(new Consistency(), new Safety());
  Client client = new Client();
  Admin admin = new Admin();
  Connector clientCon = new ClientConnector();
  Connector adminCon = new AdminConnector();
  Baton.connect(aspect,clientCon,client);
  Baton.connect(aspect,adminCon,admin);
  Baton.start();
}
```

Prototype Components/Aspects [NN07b]

- The base program is structured as components with interfaces specifying the provided and required services, as well as the published events (these are kinds of *open modules* [Ald05]).
- Published events look very much like required services, but their connection is optional.
- The aspect protocols are also associated to interfaces specifying the expected events (and their property `skippable` or not) as well as the required services.
- An application composed of components and aspects is transformed/compiled into a component-based application.

Concurrent Event-Based AOP (CEAOP)

- A formal model of concurrent stateful aspects [DLBNS06].
  - Transformation semantics (translation into pure FSP).
  - The base as well as the aspects can be concurrent.
  - Composition operators are used to coordinate the aspects and the base program.
- Prototype implementations (extensions of Java).
- The aspects can be reused in various compositions.
- Clarifies the relationship between stateful aspects and process calculi.

Current work

These ideas are currently integrated into a new version of CaesarJ [AGMO06]:

- Extended advice language
- Processes are class members and can be redefined or extended in superclasses, and composed using mixin composition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