Binding Layers Level 0
An abstract multi-purpose component layer

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Summary of the presentation

1. Introduction
   - Previous work: OSA Project (with J. Ribault)
   - Simulation-oriented components: DEVS
2. Problem Statement
   - Level 0: an Abstract Component Model
   - Other Issues addressed in Binding Layers Project
3. Binding Layers Explained
   - Level 0
   - Upper Levels
4. Conclusions & Perspectives

Motivations

"Build from scratch or reuse?"

- There is no perfect simulator BUT
  - All the elements of your perfect simulator probably exist.
  - if not, build only the missing part !

"Can we trust our simulation results ?"

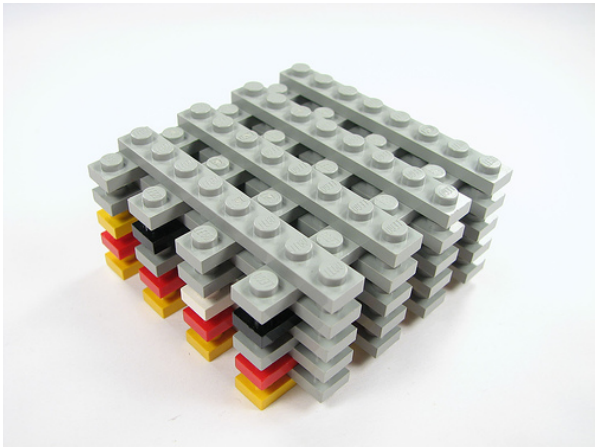
- Trust comes from validation step (cf. VV&A)
- More reusing $\rightarrow$ less validation

"Which credibility in comparing results with others studies ?"

- More sharing $\rightarrow$ more credibility

Objectives

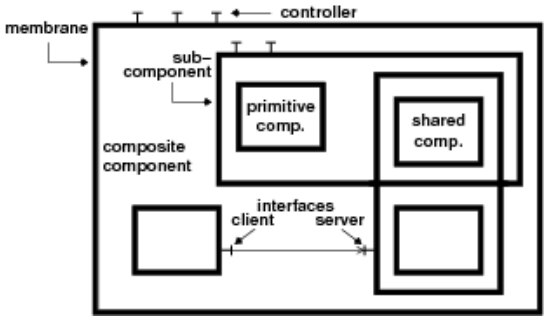
- Separation of modeling concerns
  - → component-based framework
- Separation of simulation concerns
  - → layered approach
- Bridge between concerns
  - → aspect-oriented programming
- Backup and replayability
  - → maven project management

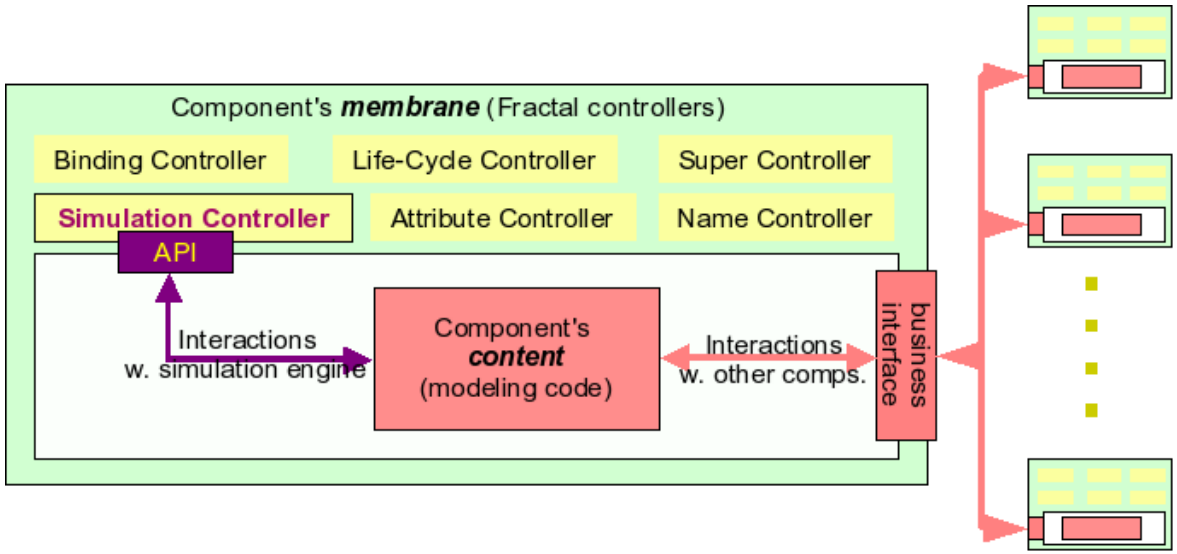


- GOAL
  - build from or reuse existing parts from others simulators and third-party tools

Open Simulation Architecture

A component-based framework

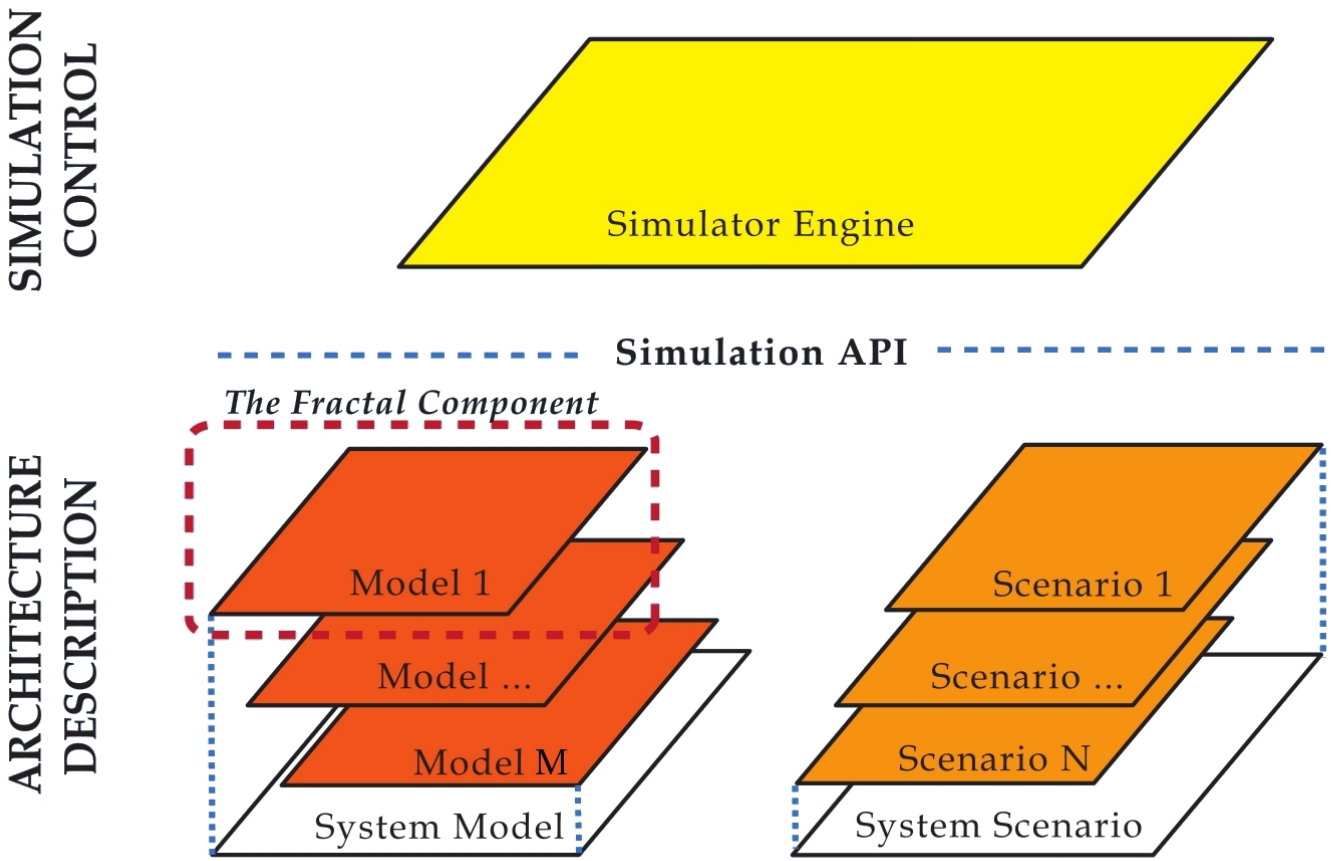




OSA extends Fractal Components

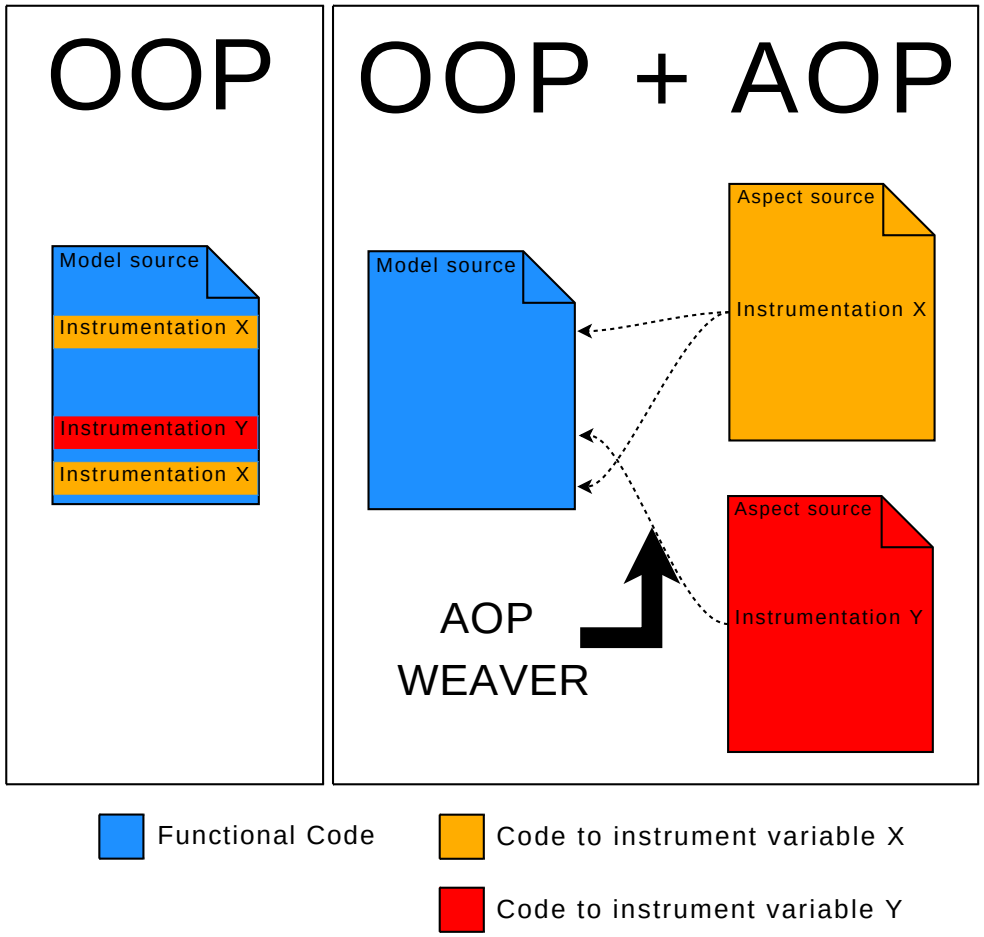
Open Simulation Architecture

A layered approach



Open Simulation Architecture

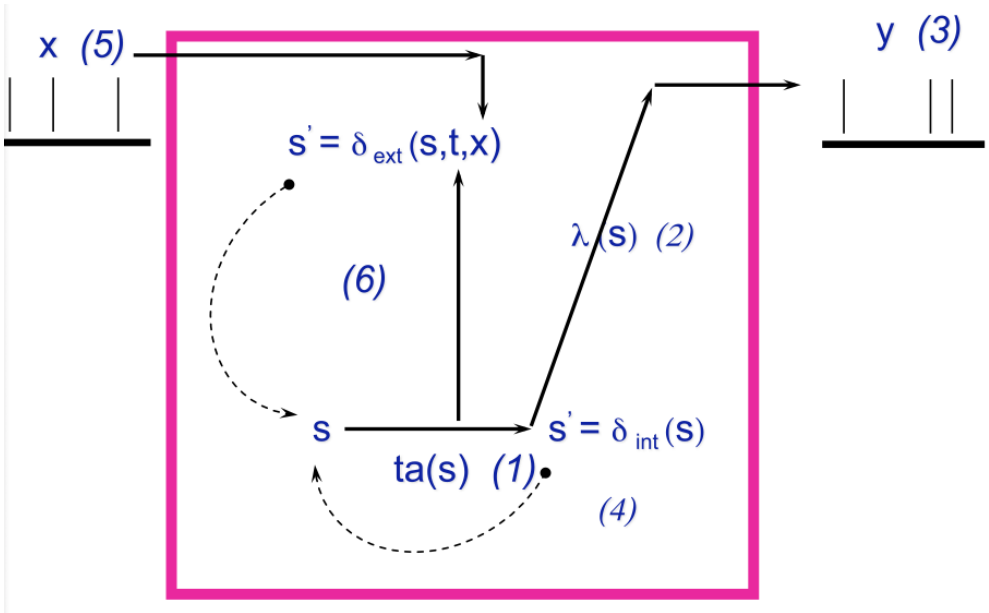
aspect-oriented programming



DEVS formalism

Anatomy of a component

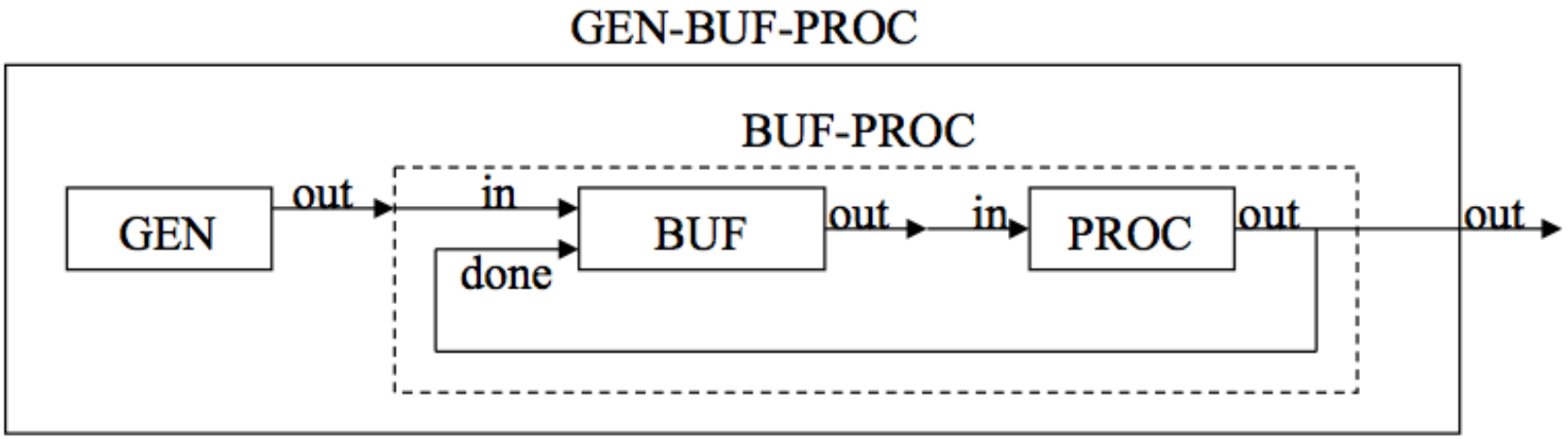
$$< X, Y, S, \delta_{int}, \delta_{ext}, \lambda, ta >$$



(Image: G. Wainer)

- Components are similar to objects
- Ports/Connectors: Data-flow (carry bags of events)
- Strong semantic of operation:
  - X, Y, S : Input events, Output events, States
  - $\delta_{int} : S \rightarrow S$ (Internal transition function)
  - $\delta_{ext} : S \times X \times T \rightarrow S$ (External transition function)
  - $\lambda : S \rightarrow Y$ (Output function)
  - $ta : S \rightarrow T$ (Time advance function)

DEVS formalism
DEVS Assemblies



- Hierarchical: atomic vs. coupled
- Oriented Bindings
- Multi-points Bindings
- Static binding

- Strong Semantics

  $< X, Y, D, \{M_i\}, \{I_i\}, \{Z_{ij}\}, sel >$

  X, Y: Inputs and outputs

  D: Set of names

  $M_i, i \in D$: basic DEVS

  $< X_i, Y_i, S_i, \delta_{inti}, \delta_{exti}, \lambda_i, ta_i >$

Very Large component-based architectures

Large architectures are quite common in simulation...

- Global world-size telecommunications
- Road traffic
- Body cells
- Particles
- ...

...New web-based services reach unprecedent scale

- Today: Twitter, Google, FB, ...
- Tomorrow??

How to build very large component-based architectures?

North face approach...

- Choose a component model
- Read docs...

  ...scratch your head for long hours...
- ...Build hello world example

  (without following tutorial!)
- Design the big architecture...

  ...Using proprietary tools/language

  ...and pray.

What if result it is not satisfactory?

RESTART from scracth?

- Component content (code) might be reusable...
- ...but the architecture?

Separation of Concerns

Architecture vs. Behavior

- Architecture = assemblies
- Behavior = code

Simulation concerns

- Model subject of study
- Build scenario(s)
- Instrument, Observe
- Collect and process data
- Distribute execution
- ...

Software (engineering) concerns

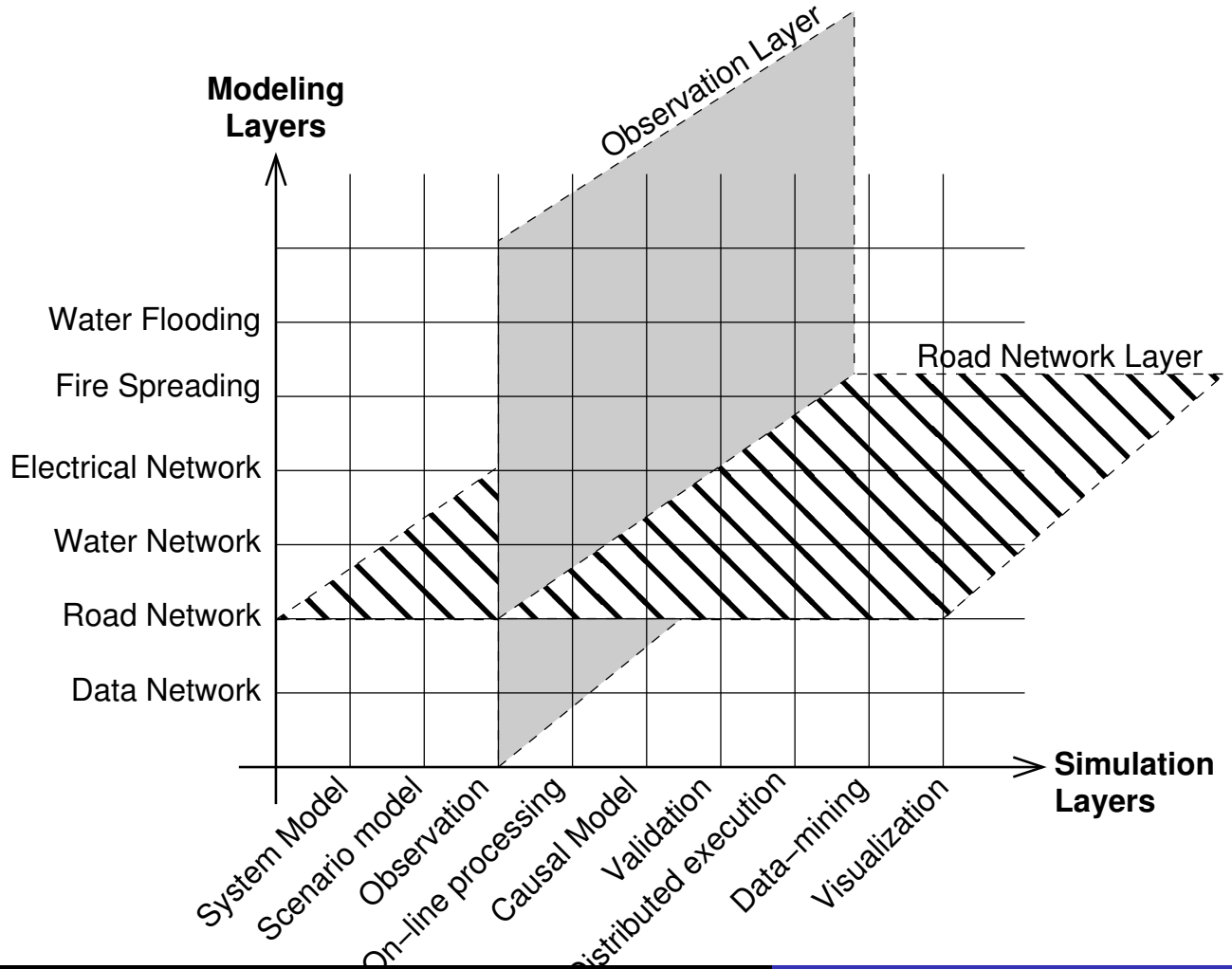
- Security, confidentiality
- Persistence
- Reconfiguration/life cycle
- Fault detection/recovery
- Real time
- Debugging
- ...

How to Separate Concerns?

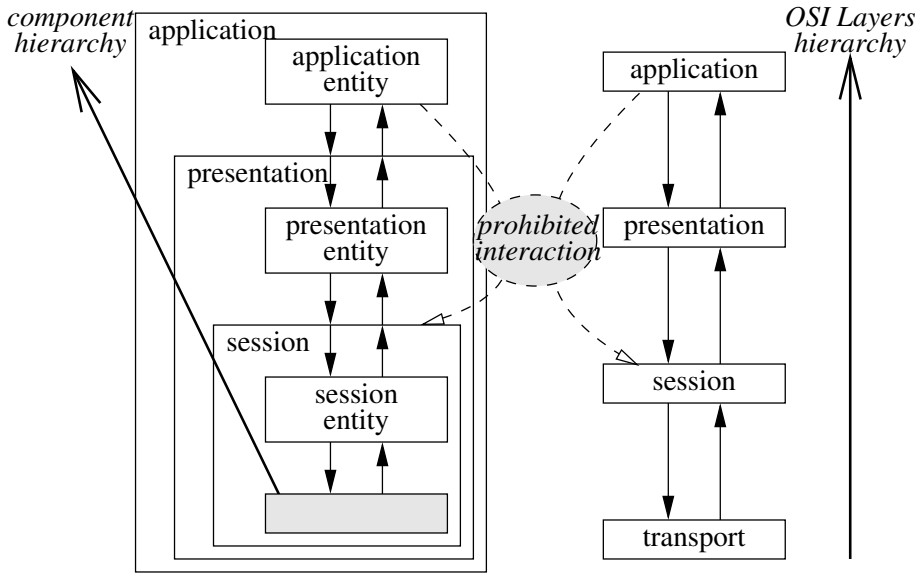
And REUSE them!

Example of a many concerns simulation

Simulation of a "Digital City" project



The problem with hierarchy



A choice has to be made

What is ouside ?
(implies what is inside)

How to focus only on the "inside" level?

- Deeply burried
- Scattered . . .

Unified *Architecture* API

My Dream Component API

1. model=InitModel(“AModel.cfg” , “path/to/app.cfg”)
2. hello=model.CreateInstance(“Hello”)
3. world=model.CreateInstance(“World”)
4. model.Connect(hello,world)
5. model.Go!()

Challenge

Make it work with (m)any component model!

Core Principles of API

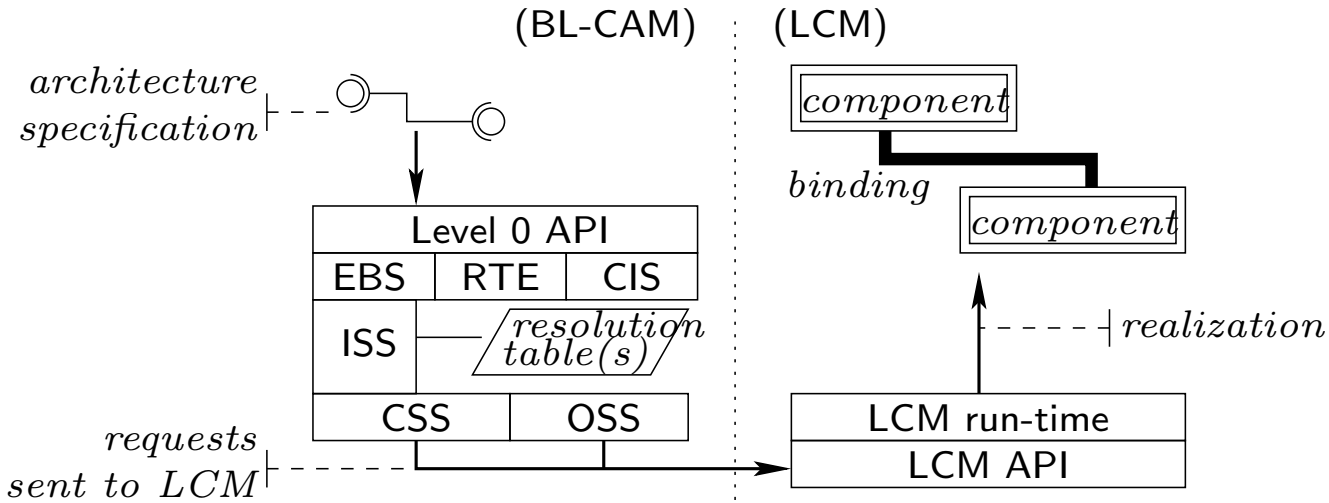
Main Assumptions/Constraints

- Components have object semantics
- Bindings can be multi-points
- Bindings are oriented
- Hide any specific details
- Construction support mandatory
- Destruction support optional

Specific Issues to be Address

- Sequence of operations
- Attachment details
- Details of instance creation
- Unsupported operations

Binding Layers Level 0 Specification



Demo!

(previous version. . .)

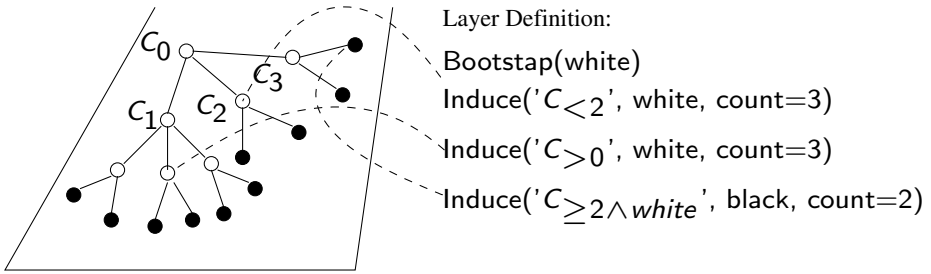
Level 1
Dynamicity support

Add support for programming layers

- Built on top of Level 0 API
- Provide a simple scripting language
- Support for automatic configuration

Instructions

- Boostrap(type, count)
- Induce(predicate, type, count)
- Bind(Predicate,Predicate)



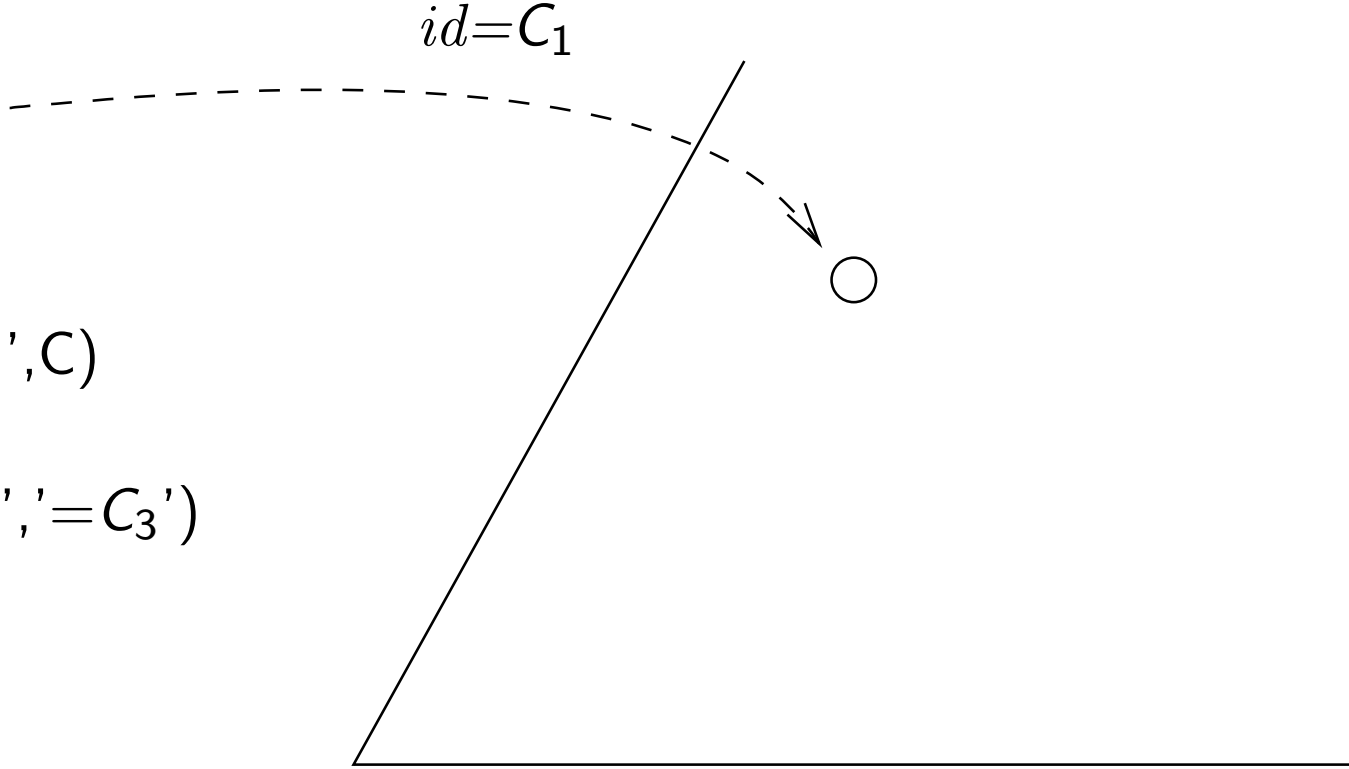
Level 1
Example

Layer Instructions:

Bootstrap(C)
Bootstrap(C)

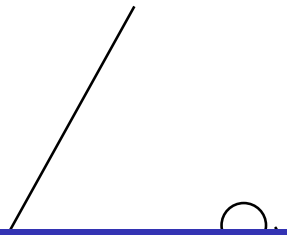
Induction('$=C_1$',C)

Binding('$=C_{1,2}$','$=C_3$')



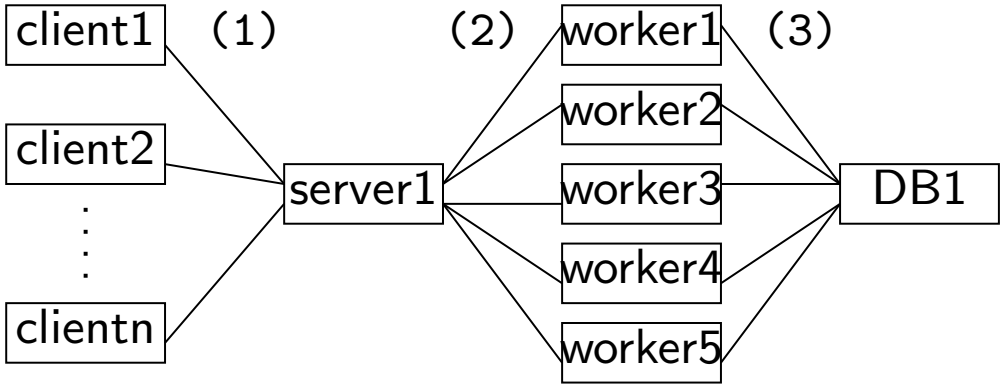
Layer Instructions:

Bootstrap(C)
Bootstrap(C)



On-demand instance creation

Induce_or_connect




```
(1) induce_or_connect('client.*','server','client:server')
(2) induce('server.*','worker','server:worker',count=5)
(3) induce_or_connect('worker.*','DB','worker:db')
```

Level 2
Support for extension and sharing

Add support for multiple layers

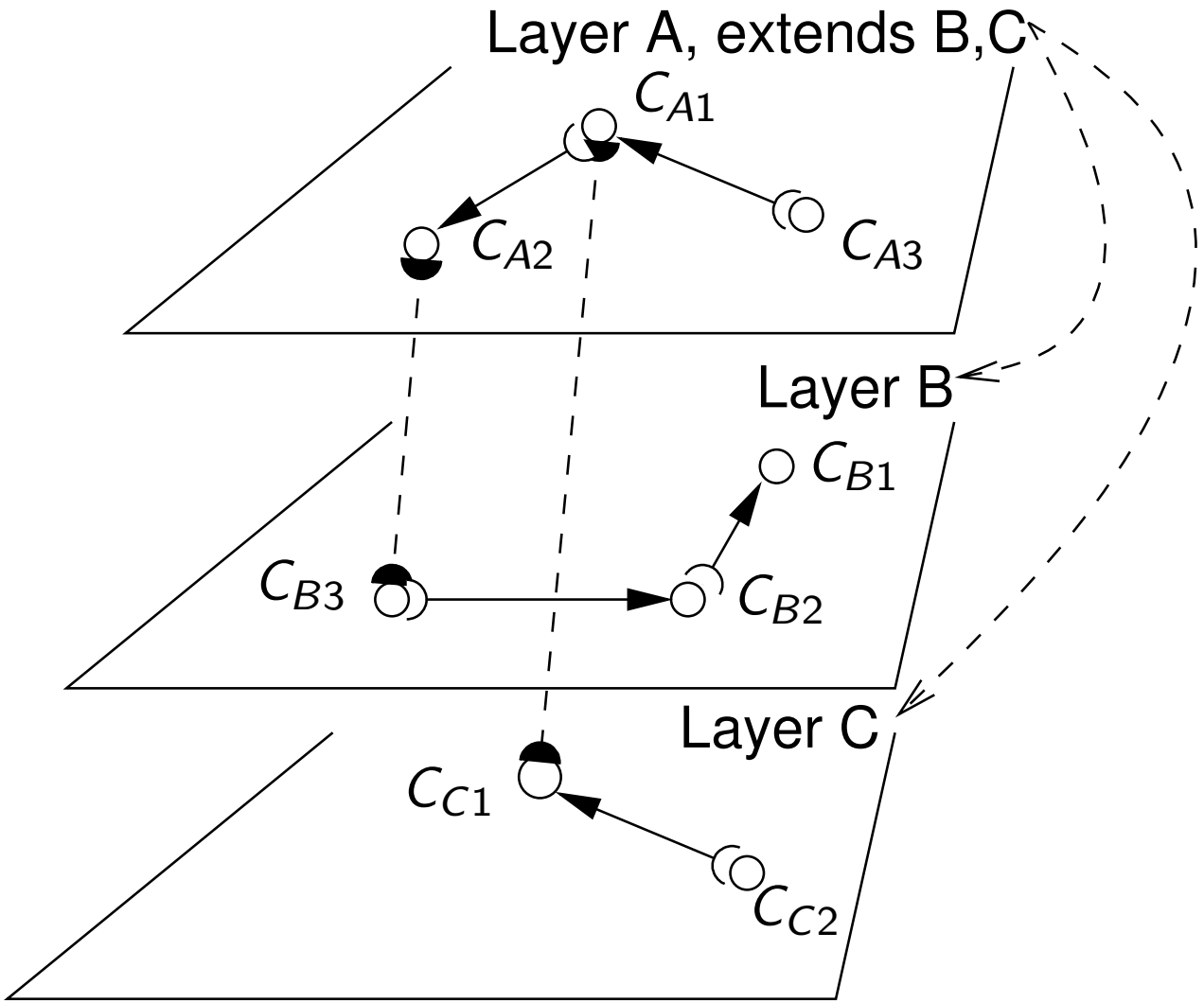
- A layer can extend another
- Extender can replace/remove extendee's instructions
- Extender can share with extendee

Special feature

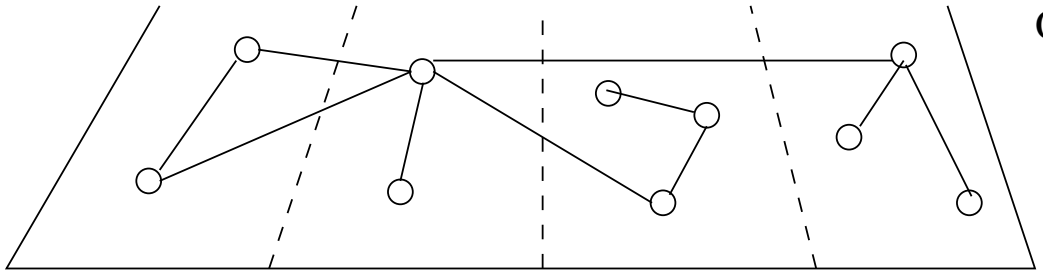
NO CLOSURE: a layer is NOT a component $\rightarrow$ NO Hierarchy
CLAIM: Hierarchy is believed to be hindering Separation of Concern.
SUBSTITUTE: Component Sharing

Level2

Example of sharing & extension



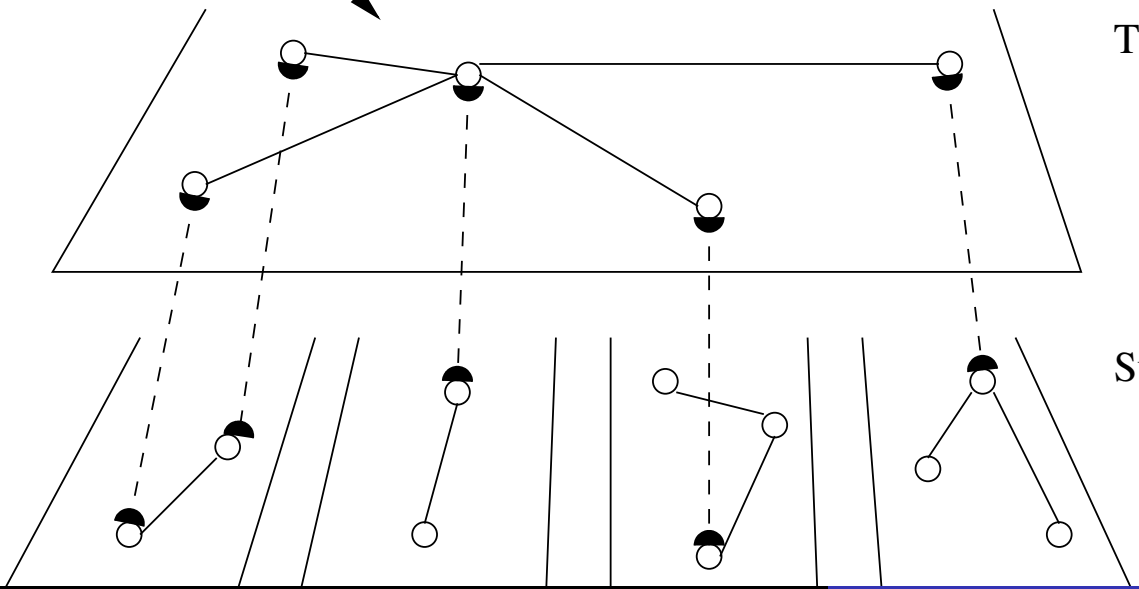
Level 3
Layer Algebra



Origin layer definition:

Layer "Foo", dispatch=fc(C), count=4
Bootstrap(...)
Induce(...)
Bind(...)

Partition Transformation



Top Layer definition:

Layer "Foo−top", extends "Foo−{1−4}"
Bootstrap(...)
Induce(...)
Bind(...)

Sub−Layer definitions:

Layer "Foo−1": Layer "Foo−2": .
Bootstrap(...)
Induce(...)
Bind(...)

Conclusions

Benefits of Level0 Abstract API

- Allows switching model
- Testing/debugging
- Simple programming
- Self-contained
- Base for bigger things

Project Status
Level 0

Almost there !

- Specification complete (Draft soon available)
- Some early implementation (Java)
  - Fractal
  - Dummy
- More validation to come
  - DEVS
  - Process-and-pipe

Project Status
Upper levels

Work in progress. . .

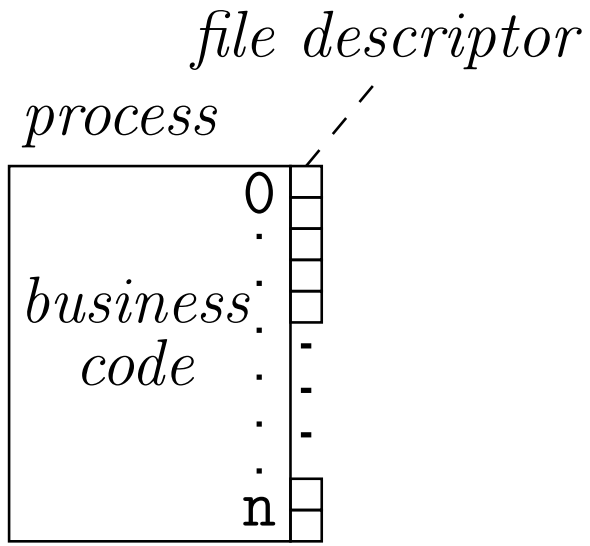
- Level 1: working on specs and proto
- Level 2: seems to work on paper
- Level 3: some ideas need further thinking
- Level 4: maybe an aspect language for weaving layers?

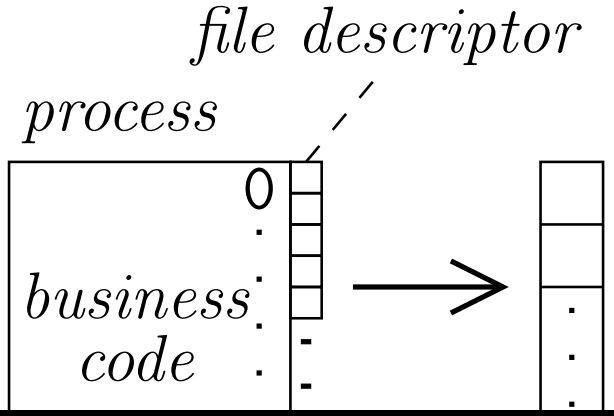
Thank you!

Questions and comment are welcome!

POSIX Process-and-pipes

Anatomy of a component

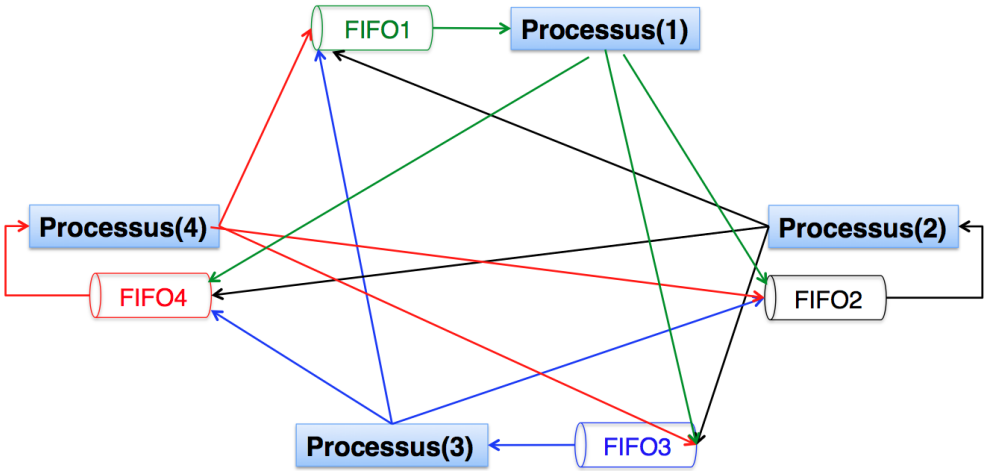




- Components are POSIX process
- Component have a (system) context
- Ports/Connectors: file descriptors
- Content: “business” code
- API: System calls

POSIX Process-and-pipes

Component assemblies



- Flat structure
- Oriented Bindings
- Multi-points Bindings

- Dynamic Bindings
- (re-)configuration tricky
  - opening sequence
  - deadlocks...