Grid programming with components:
an advanced COMPonent platform
for an effective invisible grid

GridCOMP
Effective Components for the Grids

Adaptative Behavior with GCM

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October 31th, 2007
Beijing, China
北京 - 中华人民共和国

Outline

- Motivation
  - why adaptive and autonomic management
  - why skeletons
- Behavioural Skeletons
  - parametric composite component with management
  - functional and non-functional description
  - families of behavioural skeletons
- GCM implementation
  - some hints today, much more tomorrow
    - Nicola Tonellotto and Patrizio Dazzi talk at "ProActive and GCM Tutorial and Hands-On Grid Programming" (Thursday 15,30-16,30)
  - preliminary experiments and performances

CGM model key points

- Hierarchic model
  - Expressiveness
  - Structured composition
- Interactions among components
  - Collective/group
  - Configurable/programmable
  - Not only RPC, but also stream/event
- NF aspects and QoS control
  - Autonomic computing paradigm

Why Autonomic Computing

- // programming & the grid
    - concurrency exploitation, concurrent activities set up, mapping/scheduling, communication/synchronisation handling and data allocation, ...
    - manage resources heterogeneity and unreliability, networks latency and bandwidth unsteadiness, resources topology and availability changes,

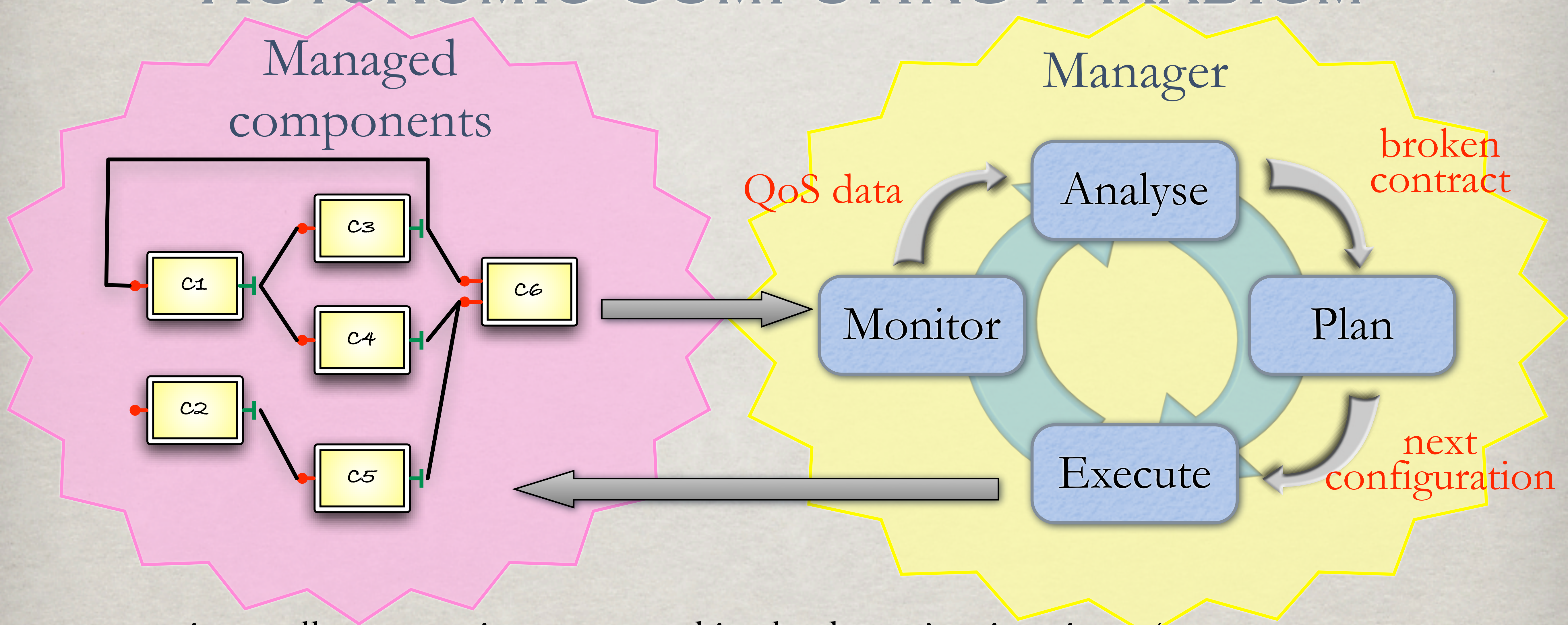
... and a non trivial QoS for **applications**

not easy leveraging only on middleware

our approach:

high-level methodologies + tools

Autonomic Computing paradigm



- monitor: collect execution stats: machine load, service time, input/output queues lengths, ...
- analyse: instantiate performance models with monitored data, detect broken contract, in and in the case try to detect the cause of the problem
- plan: select a (predefined or user defined) strategy to re-convey the contract to validity. The strategy is actually a "program" using execute API
- execute: leverage on mechanism to apply the plan

Why skeletons 1/2

- Management is difficult
  - Application change along time (ADL not enough)
  - How "describe" functional, non-functional features and their inter-relations?
  - The low-level programming of component and its management is simply too complex
- Component reuse is already a problem
  - Specialising component yet more with management strategy would just worsen the problem
  - Especially if the component should be reverse engineered to be used (its behaviour may change along the run)

Why skeletons 2/2

- Skeletons represent patterns of parallel computations (expressed in GCM as graphs of components)
- Exploit the inherent skeleton semantics
  - thus, restrict the general case of skeleton assembly
  - graph of any component ➠ parametric networks of components exhibiting a given property
  - enough general to enable reuse
  - enough restricted to predetermine management strategies
- Can be enforced with additional requirements
  - E.g.: Any adaptation does not change the functional semantics

Behavioural Skeletons idea

- Represent an evolution of the algorithmic skeleton concept for component management
    - abstract parametric paradigms of component assembly
    - specialized to solve one or more management goals
        - self-configuration/optimization/healing/protection.
- Are higher-order components
- Are not exclusive
    - can be composed with non-skeletal assemblies via standard components connectors
        - overcome a classic limitation of skeletal systems

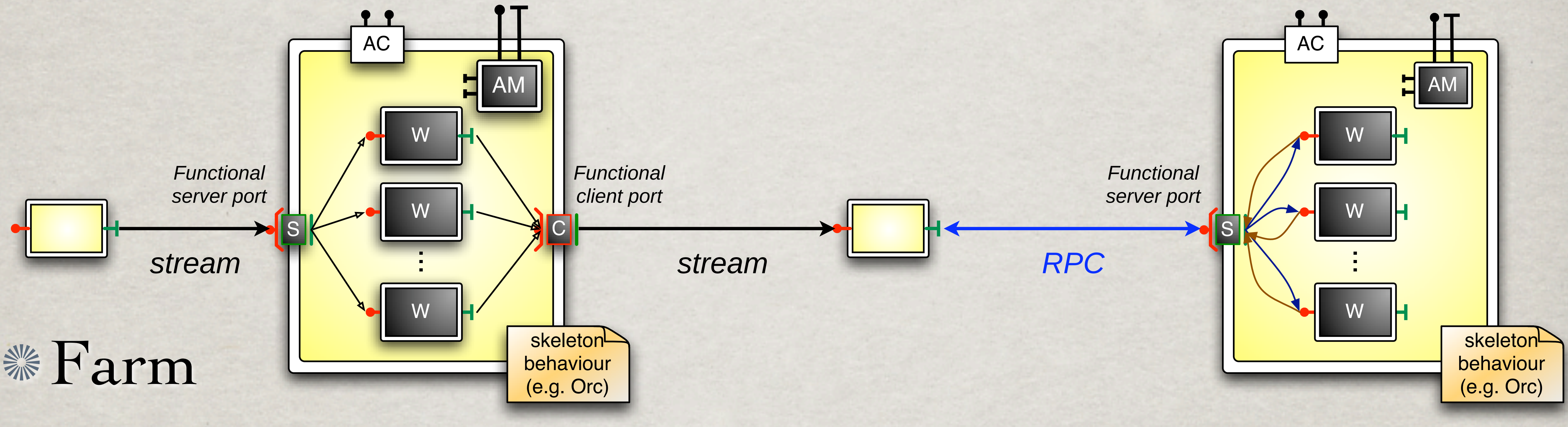
Behavioural Skeletons proprieties

- Expose a description of its functional behaviour
- Establish a parametric orchestration schema of inner components
- May carry constraints that inner components are required to comply with
- May carry a number of pre-defined plans aiming to cope with a given self-management goal
- Carry an implementation (they are factories)

Be-Skeletons families

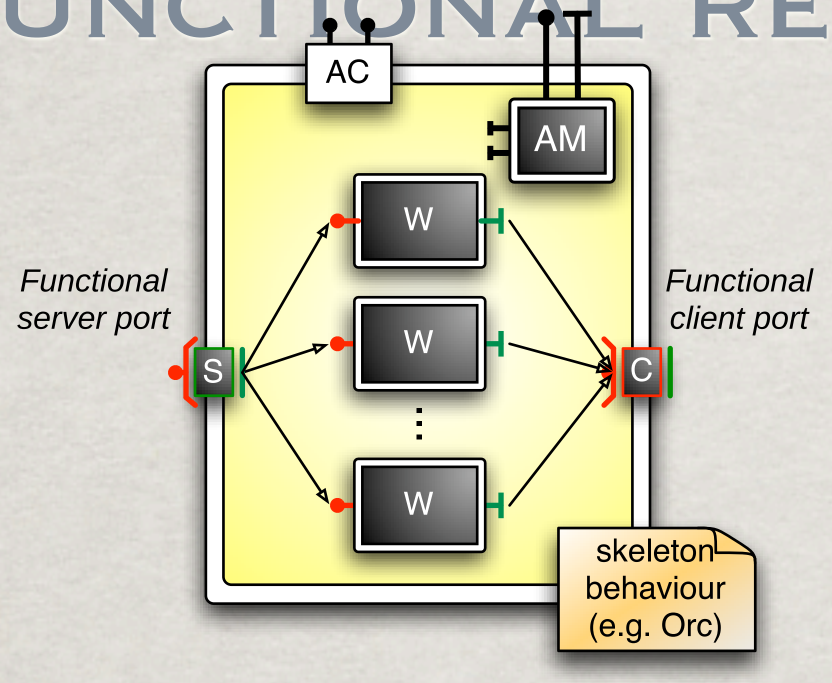
- Functional Replication
  - Farm/parameter sweep (self-optimization)
  - Simple Data-Parallel (self-configuring map-reduce)
  - Active/Passive Replication (self-healing)
- Proxy
  - Pipeline (coupled self-protecting proxies)
- Wrappers
  - Facade (self-protection)
- Many others can be borrowed from Design Patterns

Functional replication



- Farm
  - S = unicast, C = from_any, W = stateless inner component
- Data Parallel
  - S = scatter, C = gather, W = stateless inner component
- Fault-tolerant Active Replication
  - S = broadcast, C = get_one_in_a_set, W= stateless inner ...
- ...

Functional replication

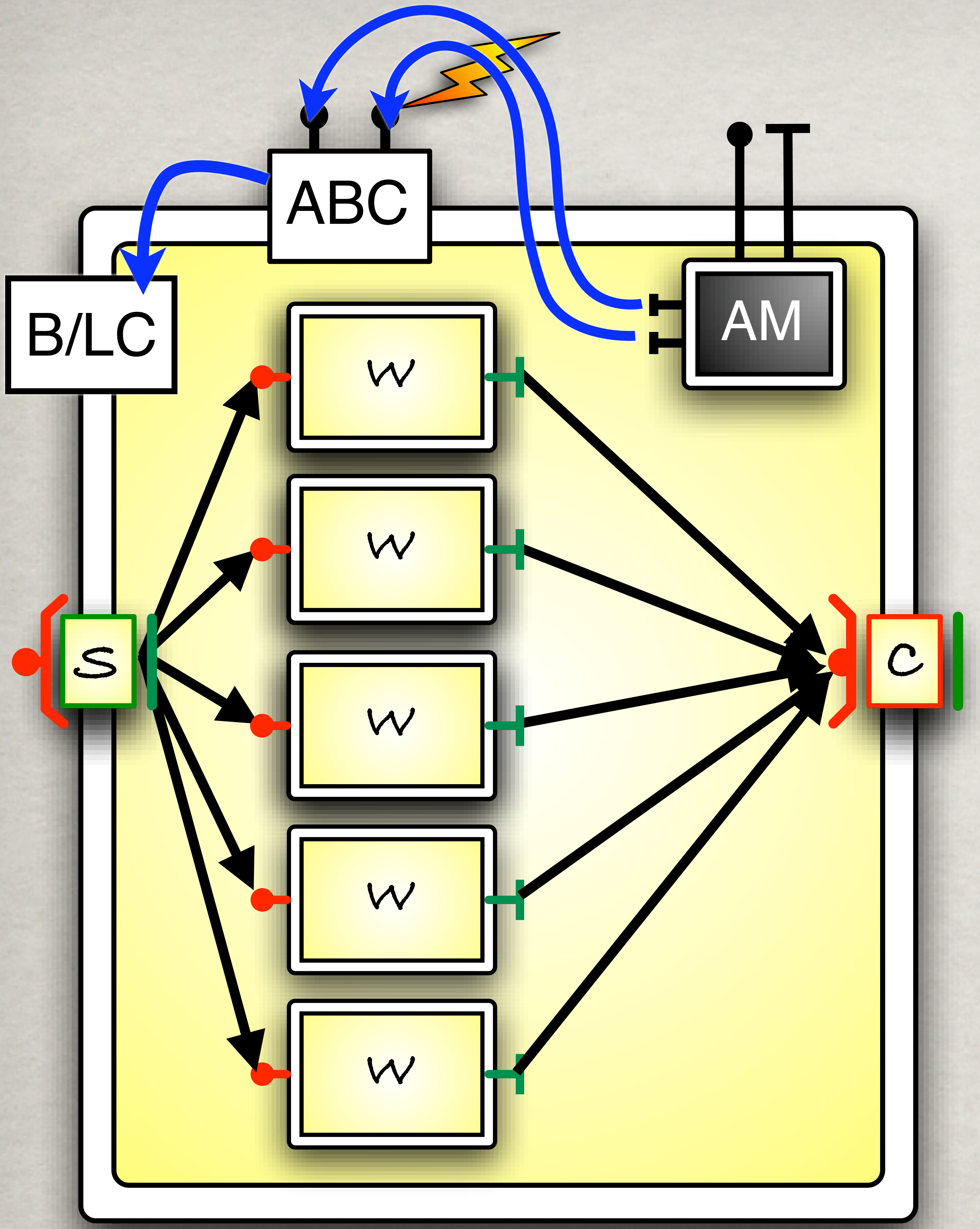


Functional behaviour description (orchestration)

$$system(data, S, G, W, in, out, N) \triangleq$$
$$S(data, in) \mid (\mid i : 1 \leq i \leq N : W_i(in_i, out_i)) \mid C(out)$$
$$W_i(in_i, out_i) \triangleq$$
$$in_i.get > tk > process(tk) > r > (out_i.put(r) \mid W_i(in_i, out_i))$$

- Meant to parametrically expose all allowed adaptation
  - Any AM policy that does not change this semantics is *correct*
  - As an example changing ***i*** in this schema is correct
  - Functional semantics is invariant from ***i***, non-functional one is not (and changing ***i*** means changing the number of Ws for self-* purposes

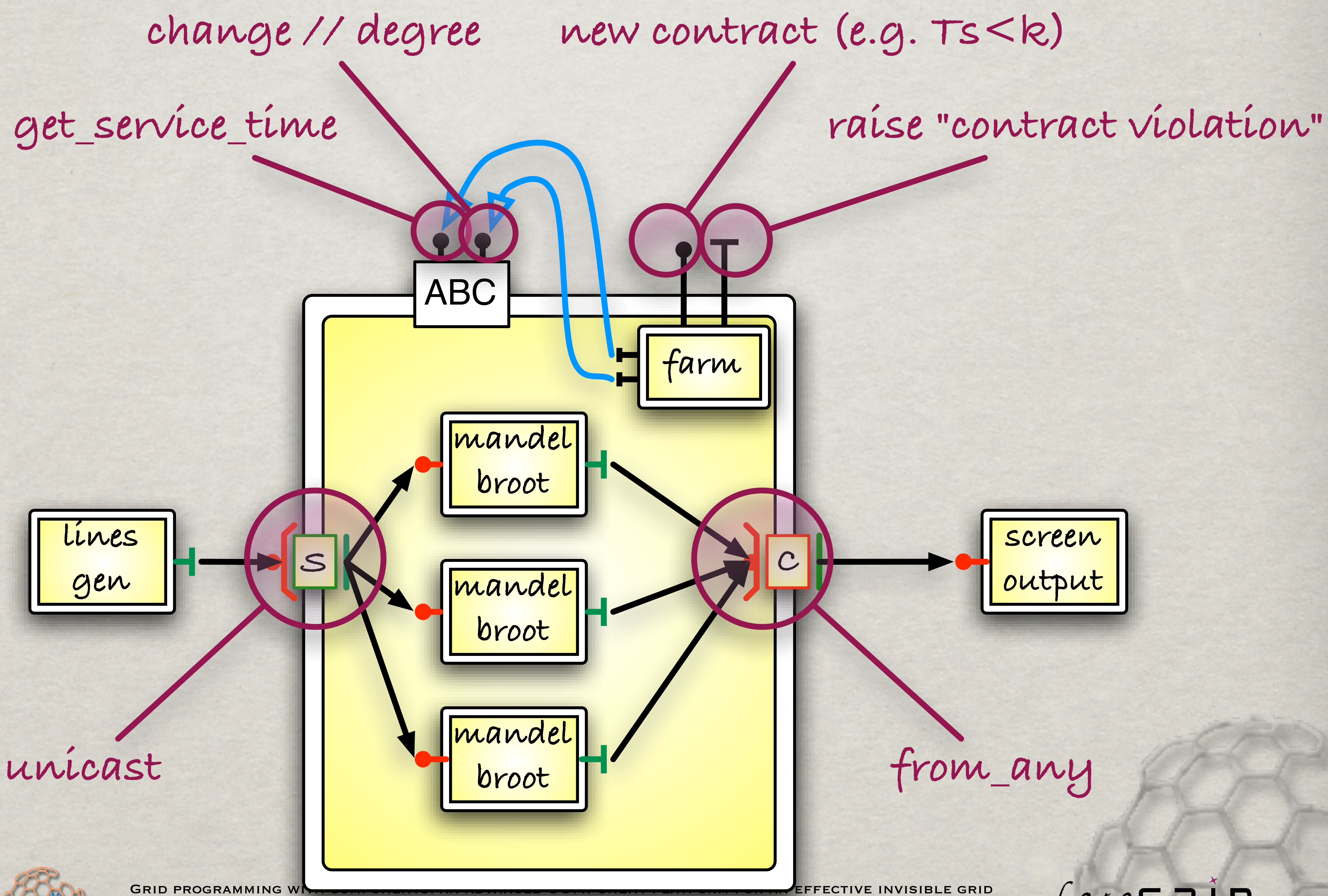
GCM IMPLEMENTATION

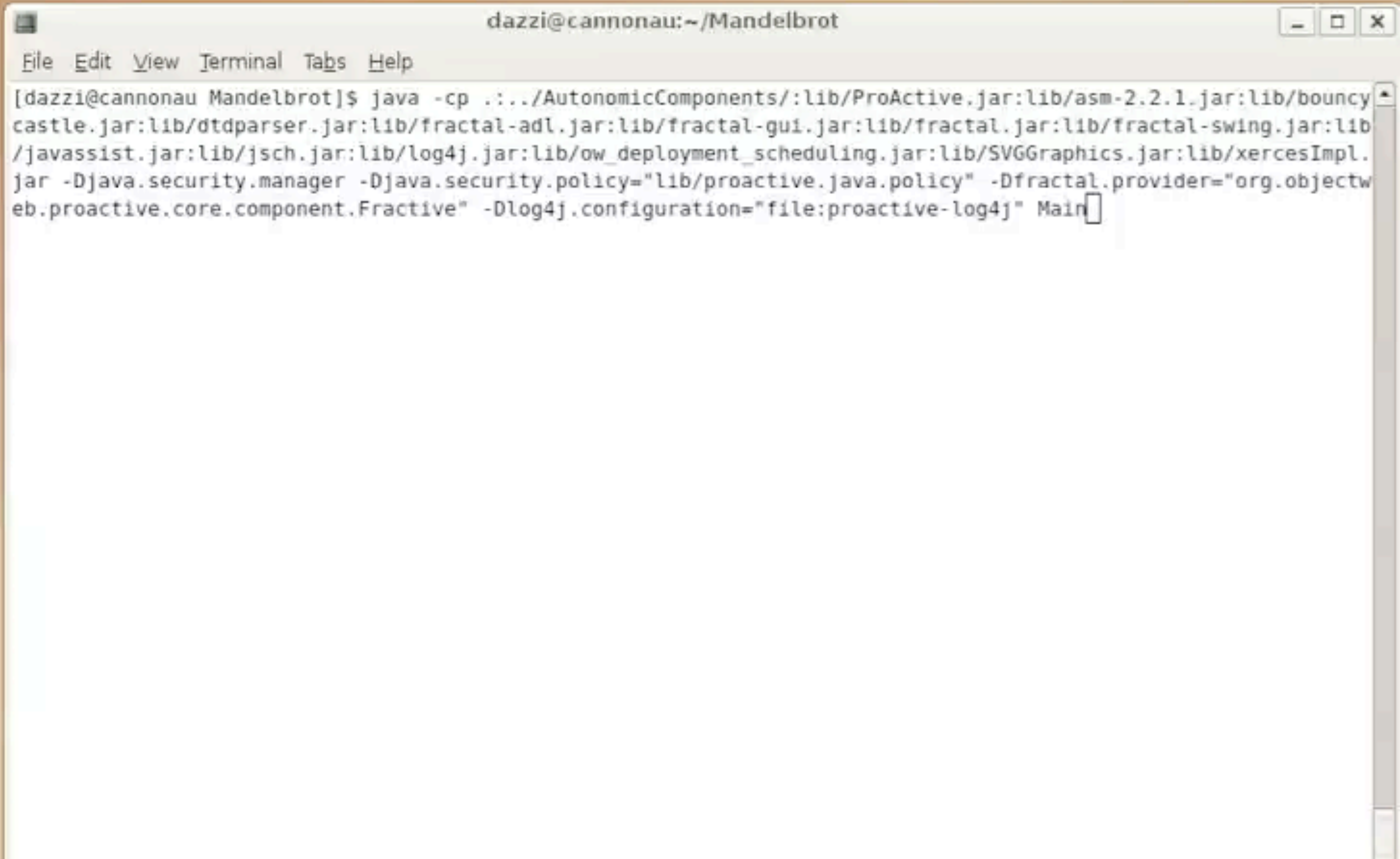


1. Choose a schema (.e.g. functional replication) ABC API is chosen accordingly
2. Choose an inner component (compliant to Be-Ske constraints)
3. Choose behavior of ports (e.g. unicast/from_any, scatter/gather)
4. Wire it in your application. Run it, then trigger adaptations
5. Possibly, automatize the process with a Manager

ABC = Autonomic Behaviour Controller (implements mechanisms)
AM = Autonomic Manager (implements policies)
B/LC = Binding + Lifecycle Controller

Farm example (Mandelbroot)



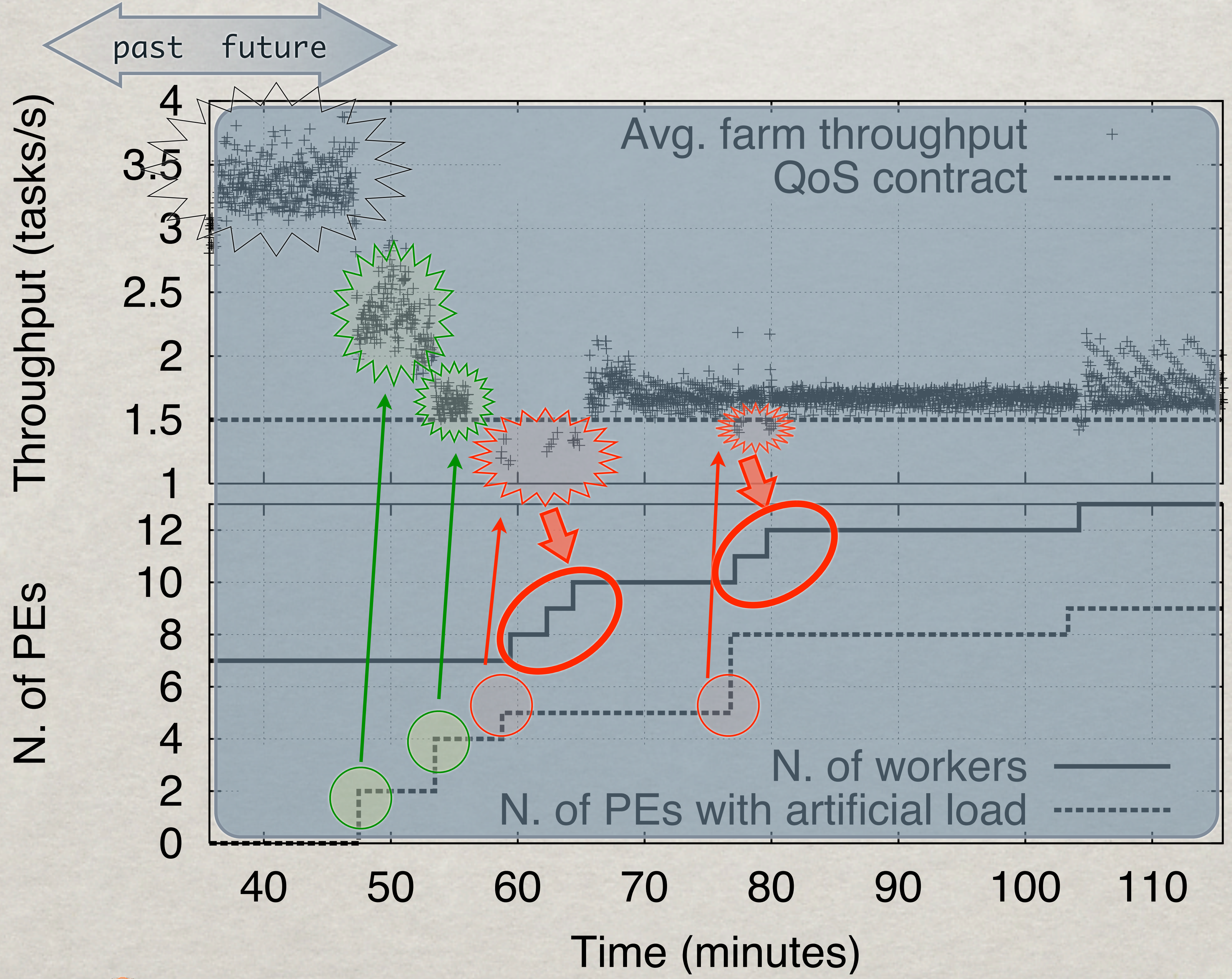


```
[dazzi@cannonau Mandelbrot]$ java -cp .:../AutonomicComponents/:lib/ProActive.jar:lib/asm-2.2.1.jar:lib/bouncy
castle.jar:lib/dtdparser.jar:lib/fractal-adl.jar:lib/fractal-gui.jar:lib/fractal.jar:lib/fractal-swing.jar:lib
/javassist.jar:lib/jsch.jar:lib/log4j.jar:lib/ow_deployment_scheduling.jar:lib/SVGGraphics.jar:lib/xercesImpl.
jar -Djava.security.manager -Djava.security.policy="lib/proactive.java.policy" -Dfractal.provider="org.objectw
eb.proactive.core.component.Fractive" -Dlog4j.configuration="file:proactive-log4j" Main
```

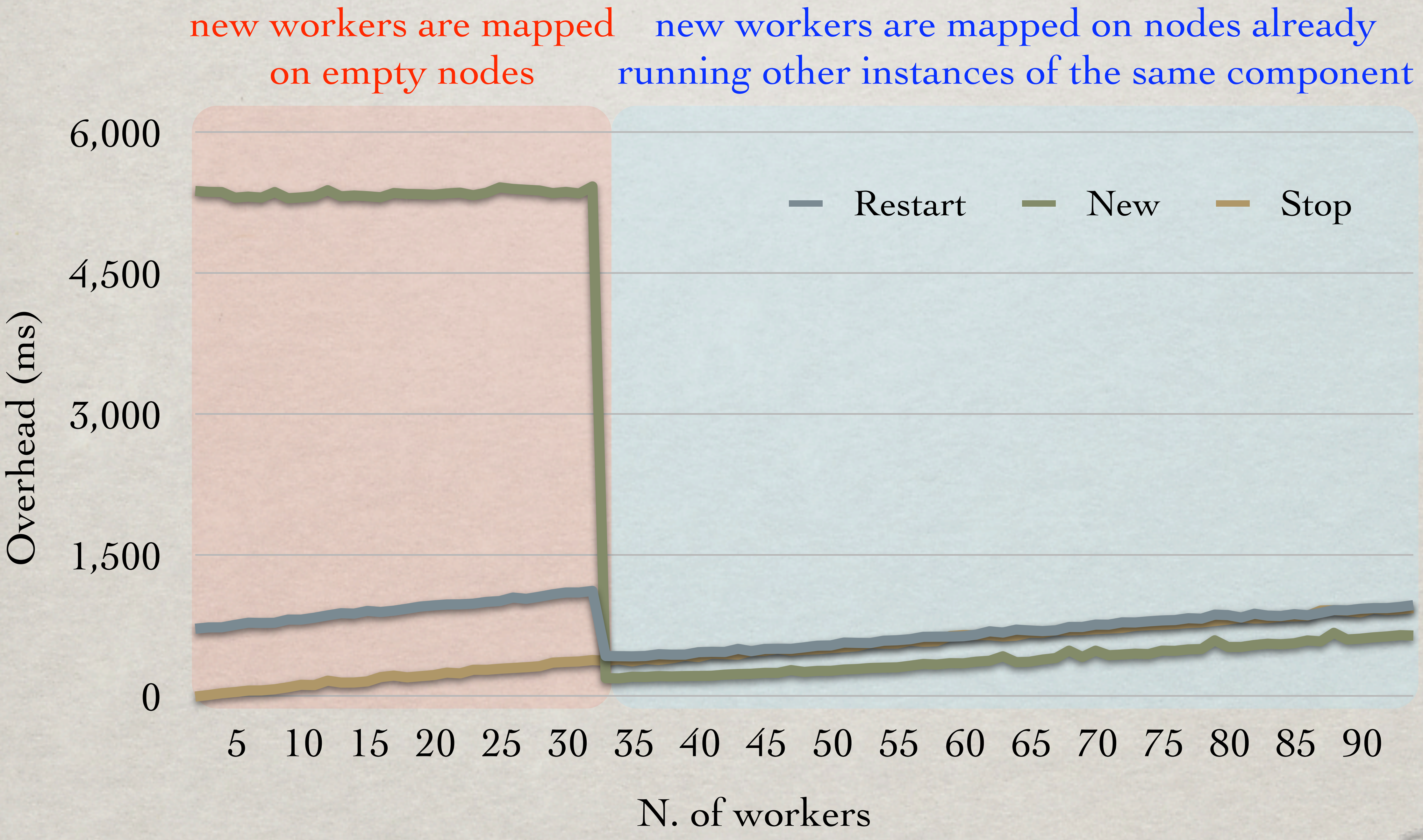
Not just farm (i.e. param sweep)

- Many other skeletons already developed for GCM
  - some mentioned before
- Easy extendible to stateful variants
  - imposing inner component expose NF ports for state access
- Policies not discussed here
  - expressed with a `when-event-if-cond-then-action` list of rules
  - some exist, work ongoing ...

Log of the Run (Explained)



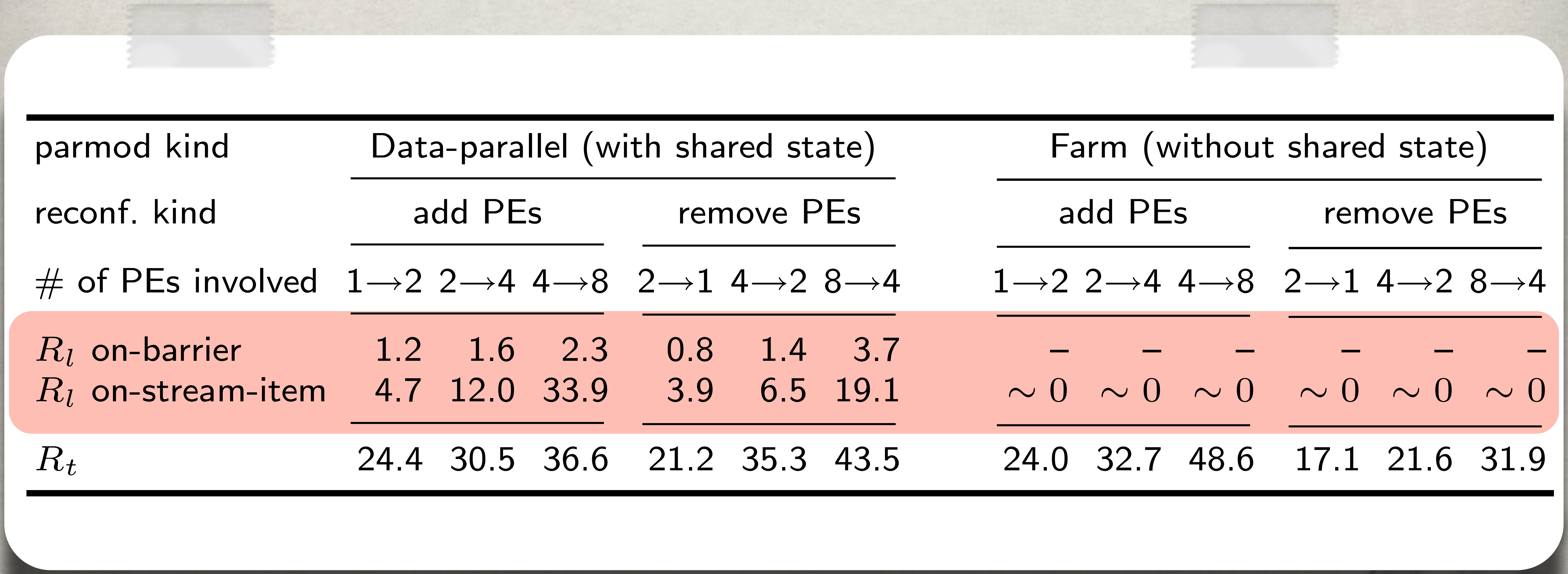
Overheads


new workers are mapped on empty nodes
new workers are mapped on nodes already running other instances of the same component
Restart
New
Stop
Overhead (ms)
6,000
4,500
3,000
1,500
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
N. of workers

ProActive/Java appears quite heavyweight w.r.t. other approaches

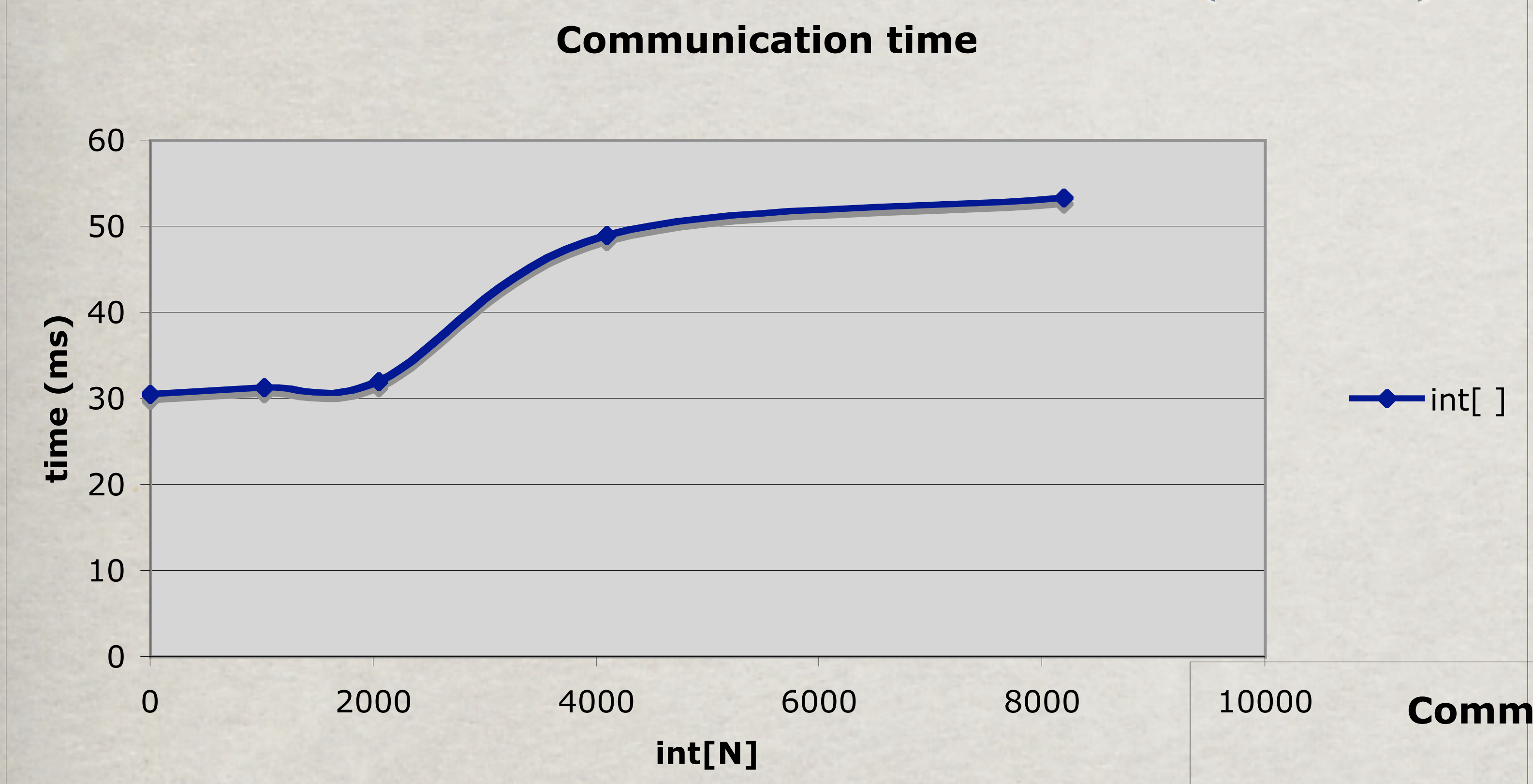
ASSIST/C++ overheads (ms)

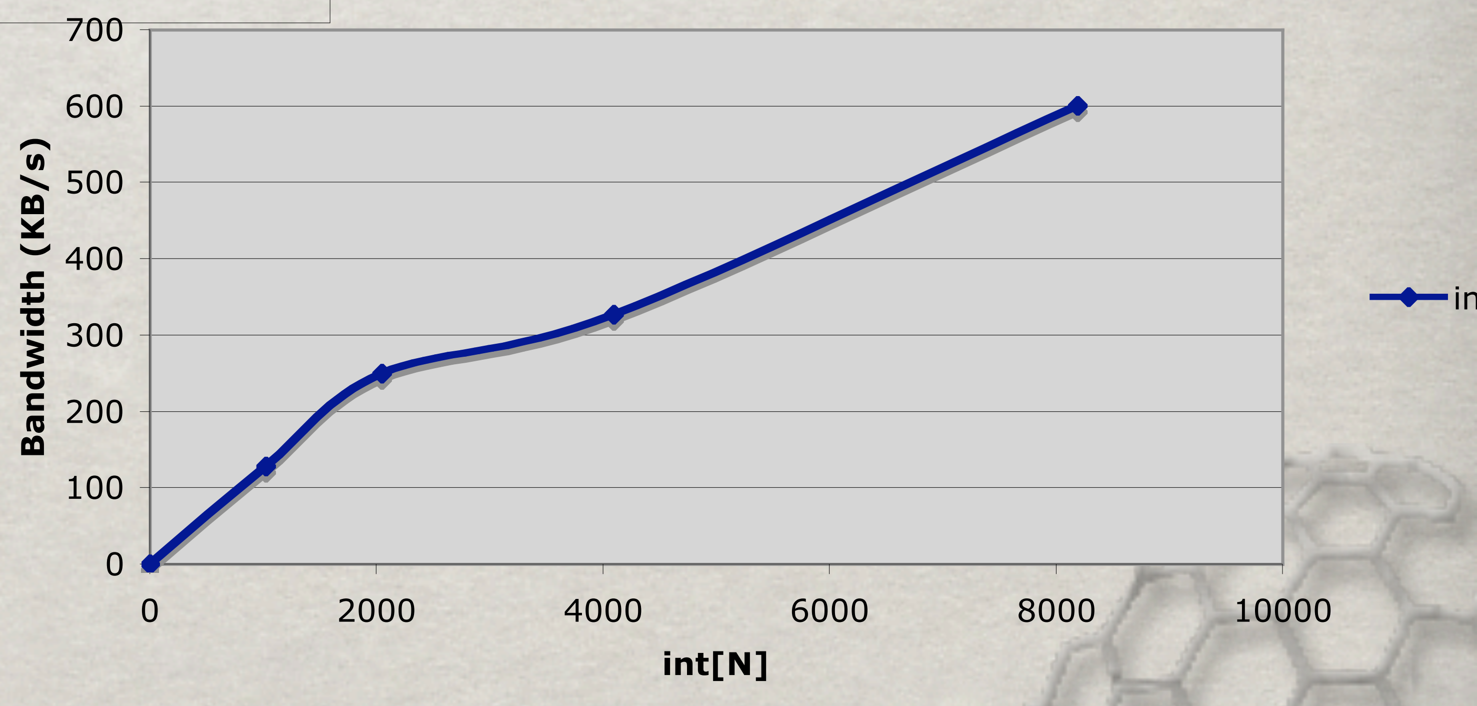
M. Aldinucci, A. Petrocelli, E. Pistoletti, M. Torquati, M. Vanneschi, L. Veraldi, and C. Zoccolo.
Dynamic reconfiguration of grid-aware applications in ASSIST.
Euro-Par 2005, vol. 3648 of LNCS, Lisboa, Portugal. Springer Verlag, August 2005.



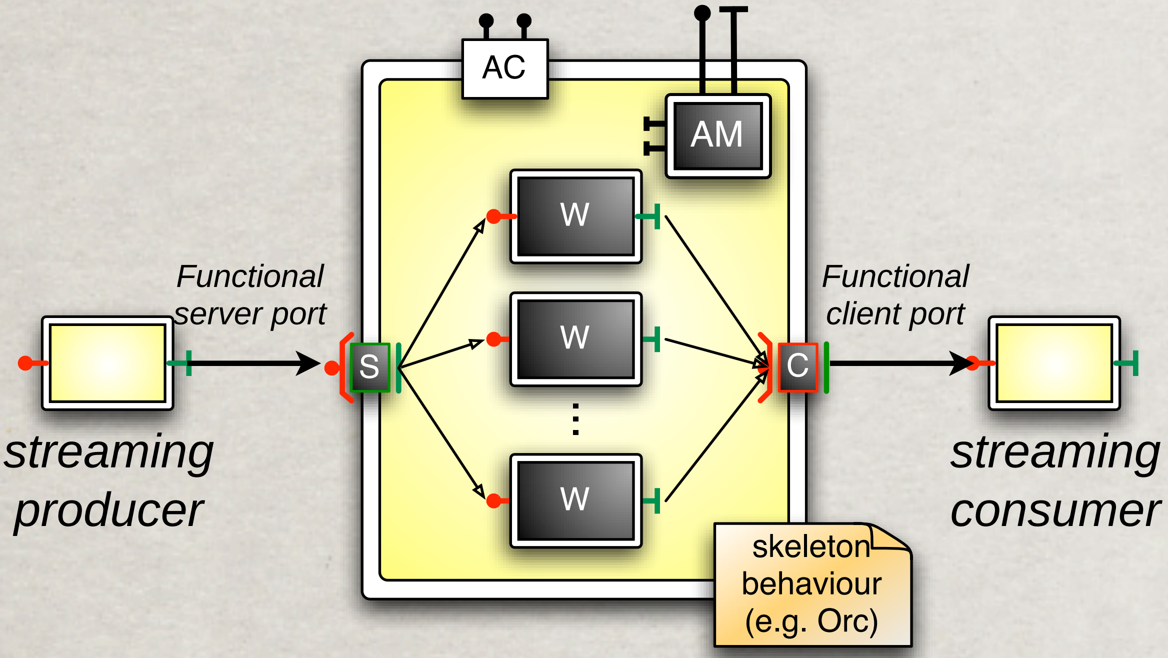
parmod kind	Data-parallel (with shared state)						Farm (without shared state)					
reconf. kind	add PEs			remove PEs			add PEs			remove PEs		
# of PEs involved	1→2	2→4	4→8	2→1	4→2	8→4	1→2	2→4	4→8	2→1	4→2	8→4
R_l on-barrier	1.2	1.6	2.3	0.8	1.4	3.7	–	–	–	–	–	–
R_l on-stream-item	4.7	12.0	33.9	3.9	6.5	19.1	~ 0	~ 0	~ 0	~ 0	~ 0	~ 0
R_t	24.4	30.5	36.6	21.2	35.3	43.5	24.0	32.7	48.6	17.1	21.6	31.9

Proactive Communication Time (Int)


Communication time


Communication Bandwidth (Theoretical 12800 KB/s)

Variations and Flavours



Functional server port

Functional client port

AC

AM

W

W

W

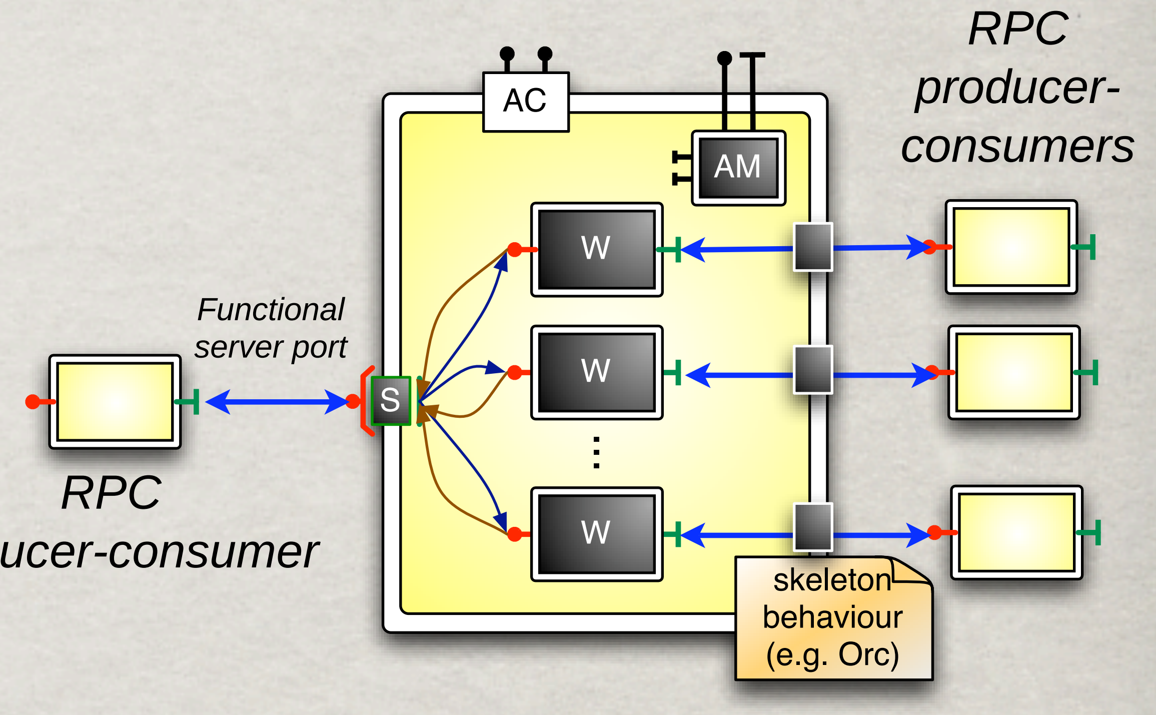
S

C

skeleton behaviour (e.g. Orc)

streaming producer

streaming consumer



RPC producer-consumers

Functional server port

AC

AM

W

W

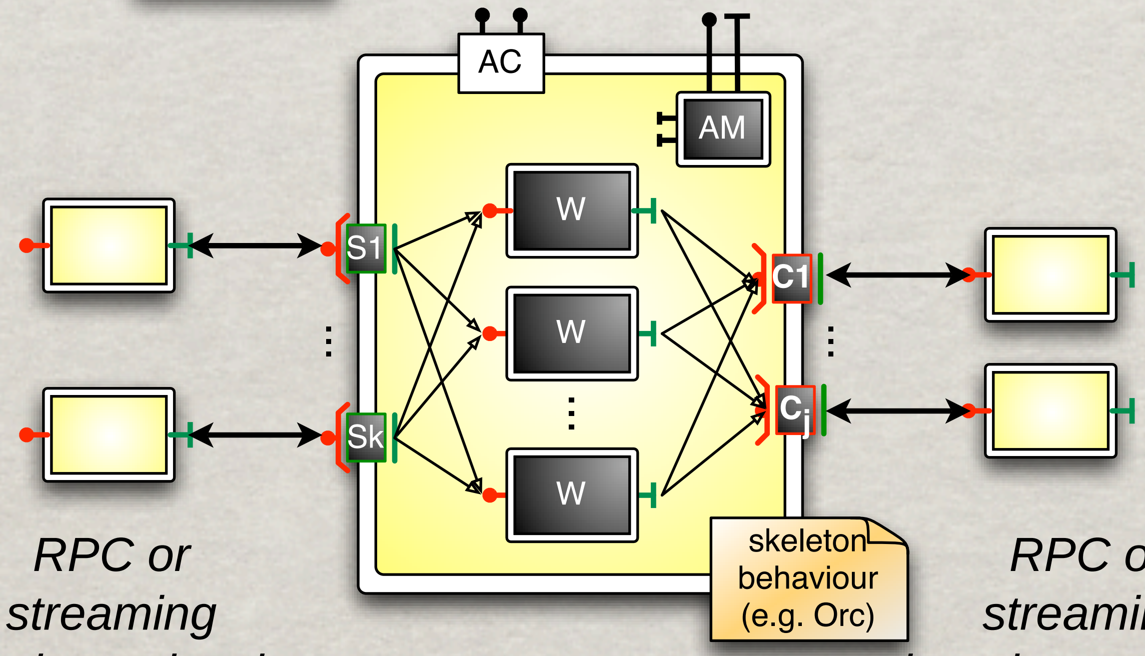
W

S

skeleton behaviour (e.g. Orc)

RPC producer-consumer

or in general ...



AC

AM

W

W

W

S1

Sk

C1

C

skeleton behaviour (e.g. Orc)

RPC or streaming data dependencies

RPC or streaming data dependencies

and even more ...

Abstracting Out Variants

- *n* client and *y* server ports
  - synchronous and/or asynchronous
  - stream and/or RPC
  - programmable, possibly nondeterministic, relations among ports
    - wait for an item on port_A ***and/or*** one item on port_B
    - in general, any CSP expression
- But ... be careful, this is the **ASSIST** model
  - all features described above + distributed membrane + autonomicity, QoS contracts, limited hierarchy depth (i.e. 2)
  - sophisticated C++ implementation, language not easy to modify
- GCM should be *enough* expressive and *not too* complex
  - we consider ASSIST as the complexity asymptote

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Conclusions

- Behavioural Skeletons
  - templates with built-in management for the App designer
  - methodology for the skeleton designer
    - management can be changed/refined
    - just prove your own management is correct against skeleton functional description
  - can be freely mixed with standard GCM components
    - because once instanced, they are standard
- Already implemented on GCM
  - not happy about GCM runtime performances (can be improved)
    - We also implemented in ASSIST with different performances

Thank you!
Questions?

谢谢!
问题?