Dagstuhl Seminar 04451 - Future Generation Grids 2004
November 4th, 2004

Rendering Grid Heterogeneity Harmless

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ISTI - National Research Council
Pisa - Italy

with S. Campa, M. Danelutto, C. Zoccolo

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Rendering Grid *(performance)* Heterogeneity *(mostly)* Harmless

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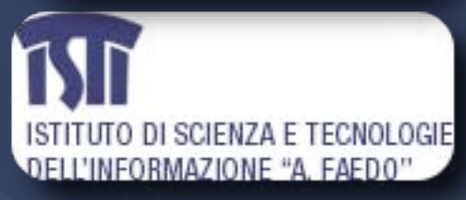


Outline

- Motivation
- Grid as collection of heterogeneous resources
  - Presenting experimental results
  - A simple, even simplistic model
  - Defining the asymptotic performance
- Detect Grid current status and react
- Re-distributing work & load through WS

Motivation

- Researchers in the Grid community hardly agree
  - programming model (and either if it should exists)
  - components (and either if they are an useful vehicle)
  - legacy code existence …
- but them all agree
  - **THE GRID IS A HIGHLY HETEROGENEOUS, HIGHLY DYNAMIC EXECUTION ENVIRONMENT**

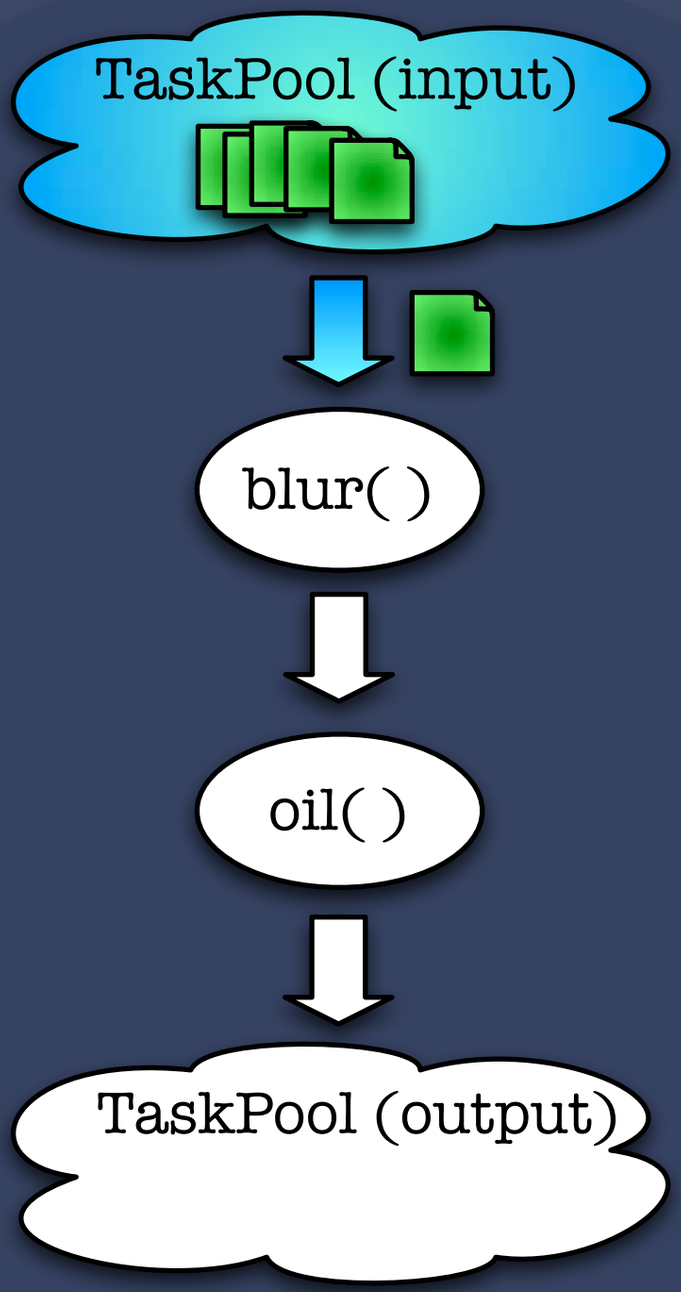
However …

	Experimental results on >2 PEs	Performance figures for >2 heterogeneous PEs
EuroPar 04 (Grid & P2P) LNCS 3149	2–4/20	1? (as far I known)
Grid Computing 04 LNCS 3165	3/30	No (as far I known)
Grid & Cooperative Computing 04 LNCS 3251	6/150	No (as far I known)

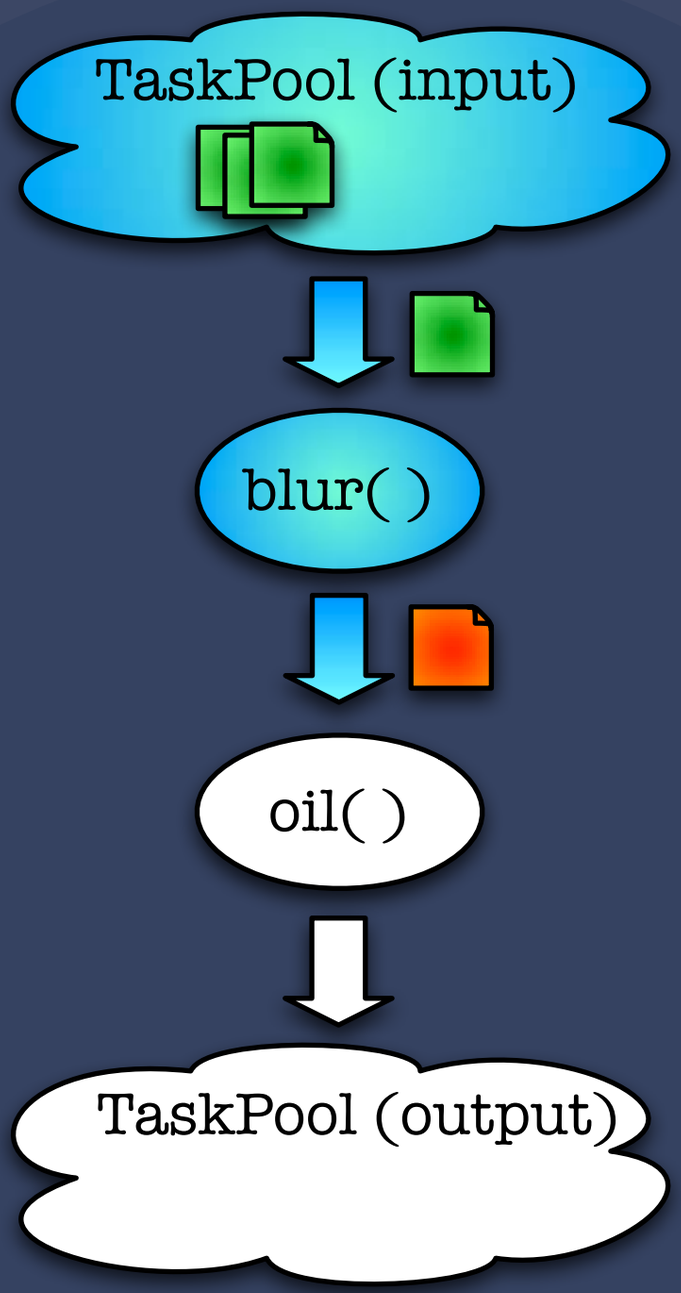
- How many platforms GTx supports?
- Java seems to be the panacea for heterogeneity:
  - Maybe we relying too much on Sun's researchers
- Look at conference proceedings:
  - few of them present experimental results
  - very few of them present result for heterogeneous environments
- we agreed on heterogeneity, thought

Testbed:

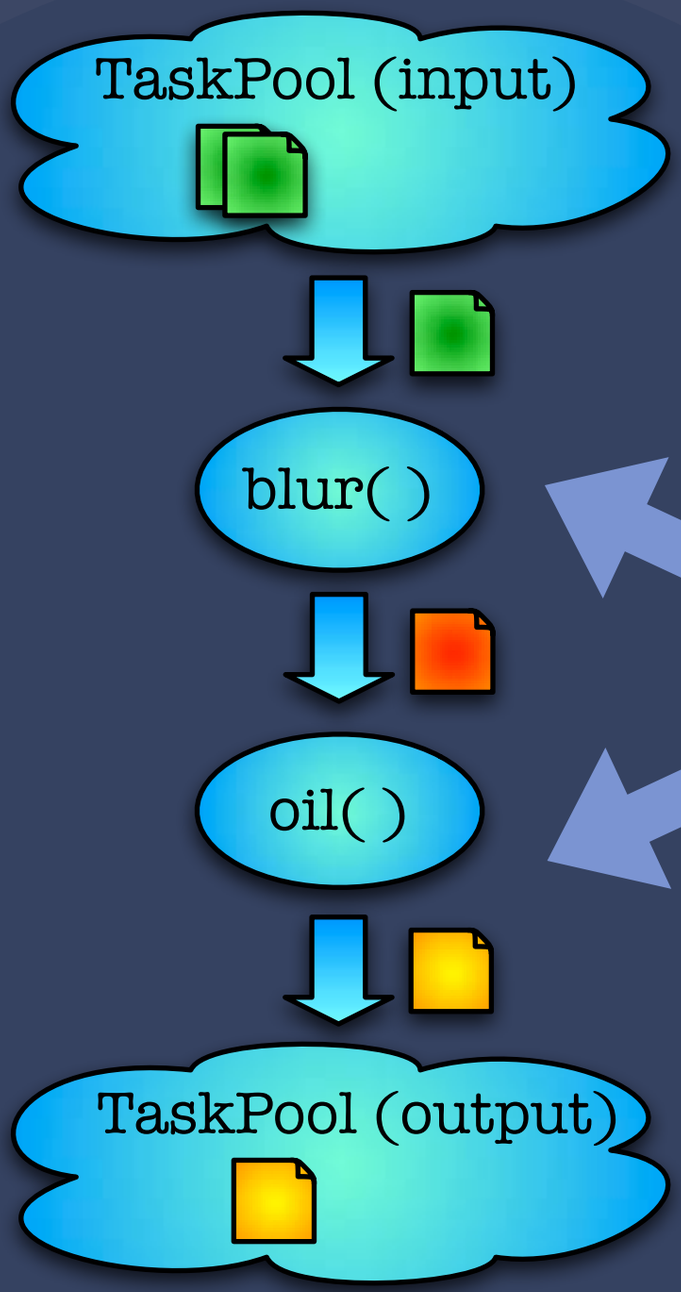
```
wait(4*365*24*60*60);
unfortunately();
```



blur( ) it



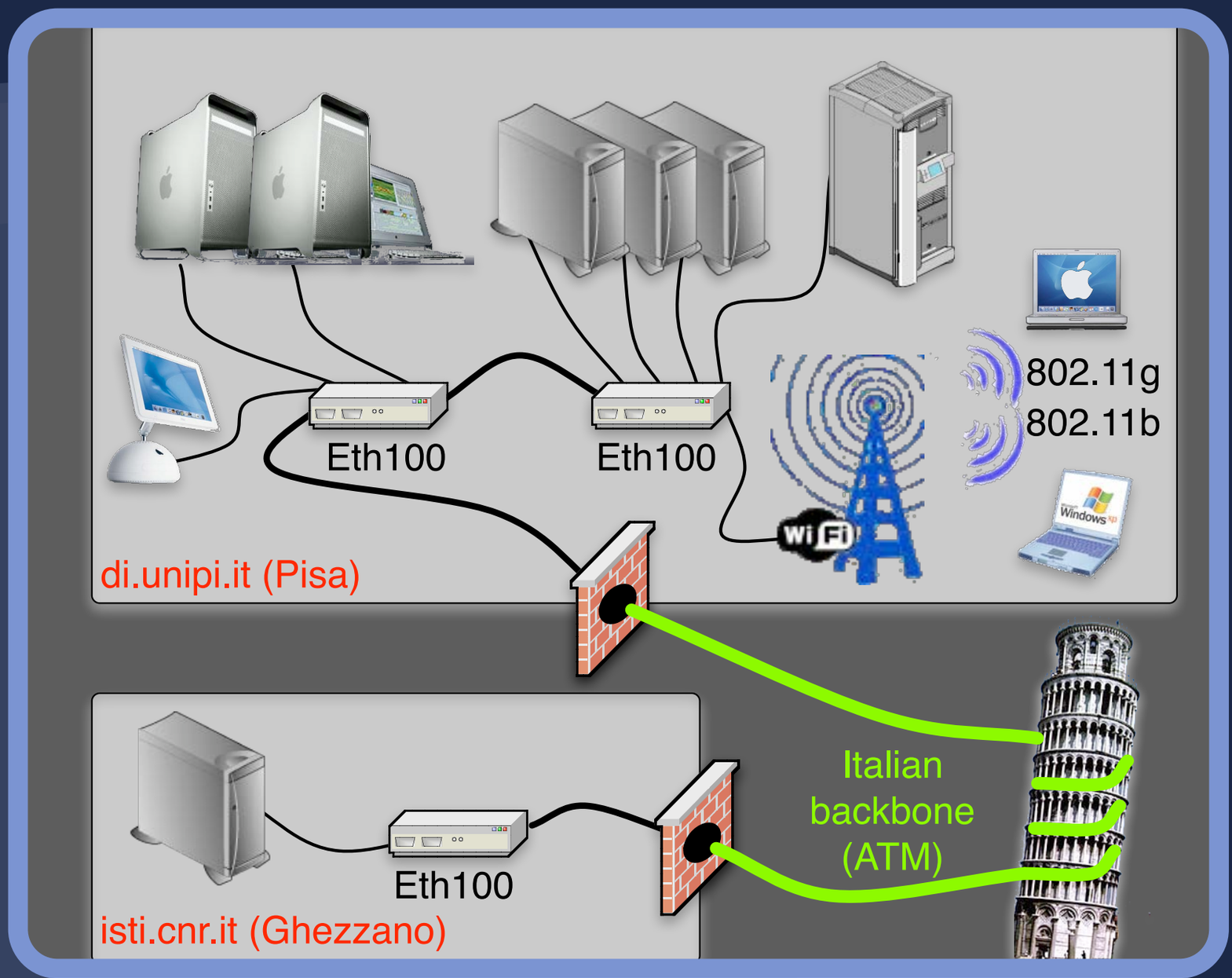
oil( ) it



These can be parallel as well

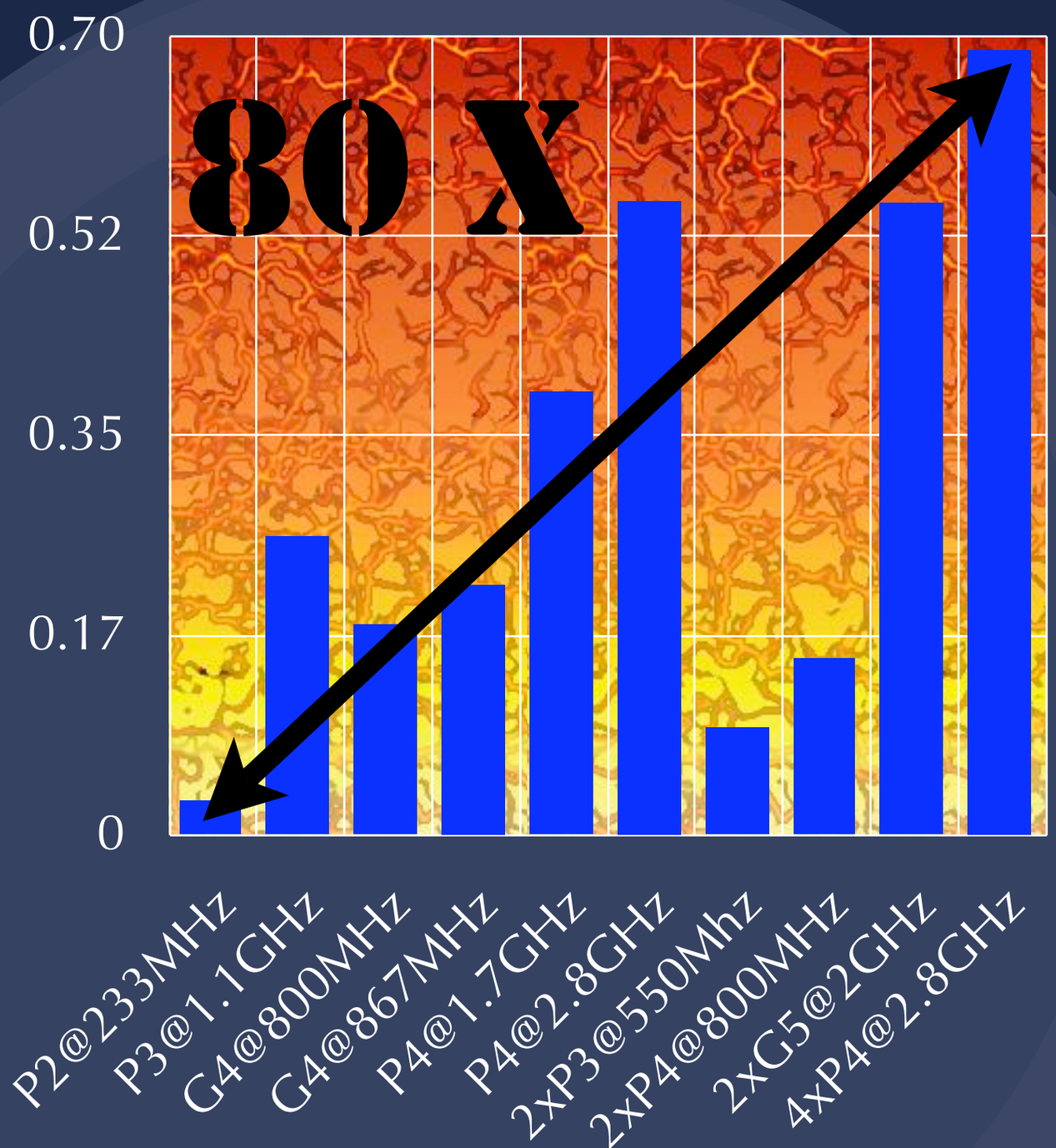
Why speedup is important

- We would like deploy HPC applications on Grid
  - not just seti@home
  - they may have time/performance/memory/... critical requirements
- Known in advance what I can expect from my run, at least as asymptotically optimal curve
  - speedup for example (widely used in COW)
  - any measure able to give informations on the *quality* of the algorithm, implementation, configuration, ...



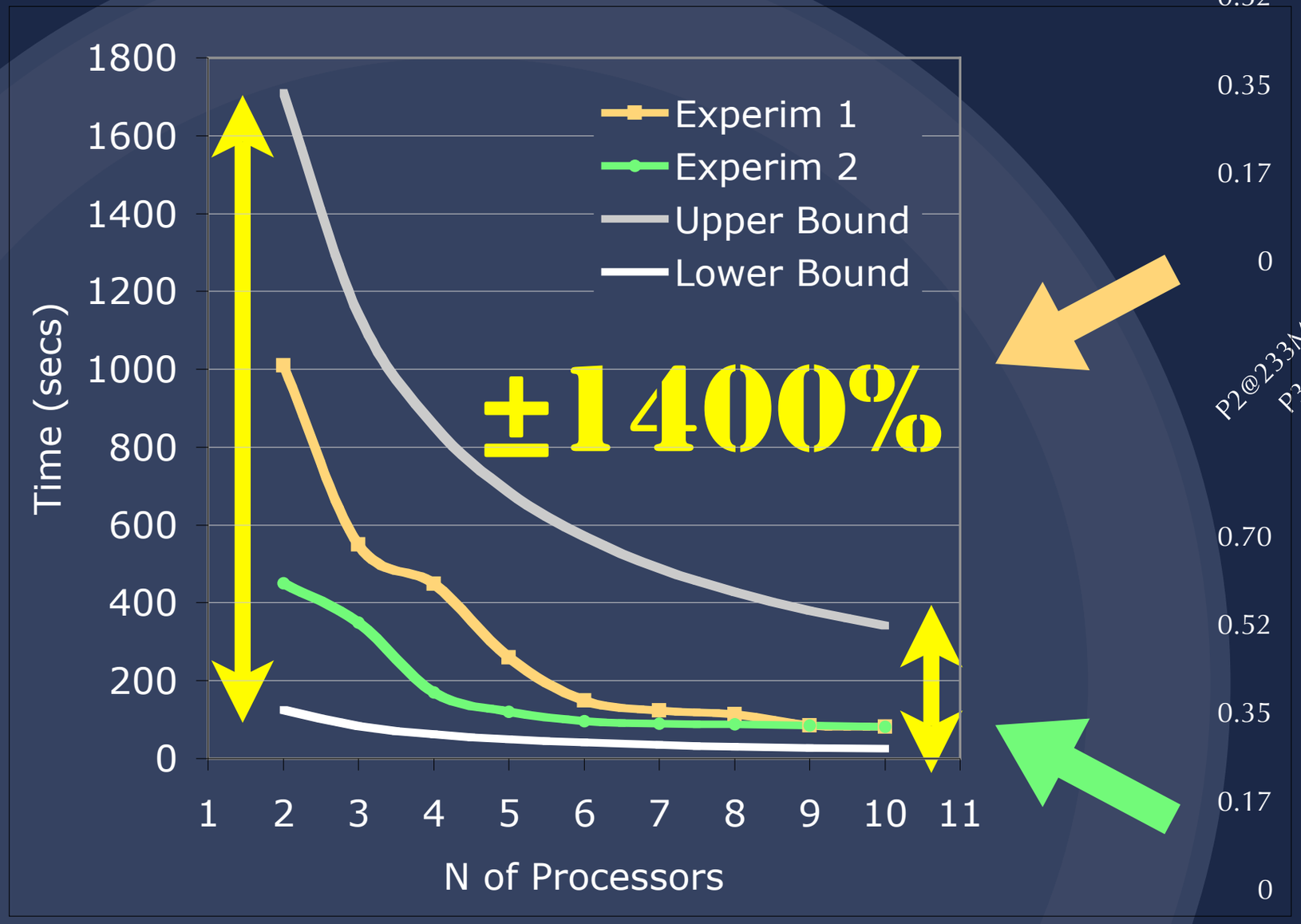
Experimental env: a home-made Grid

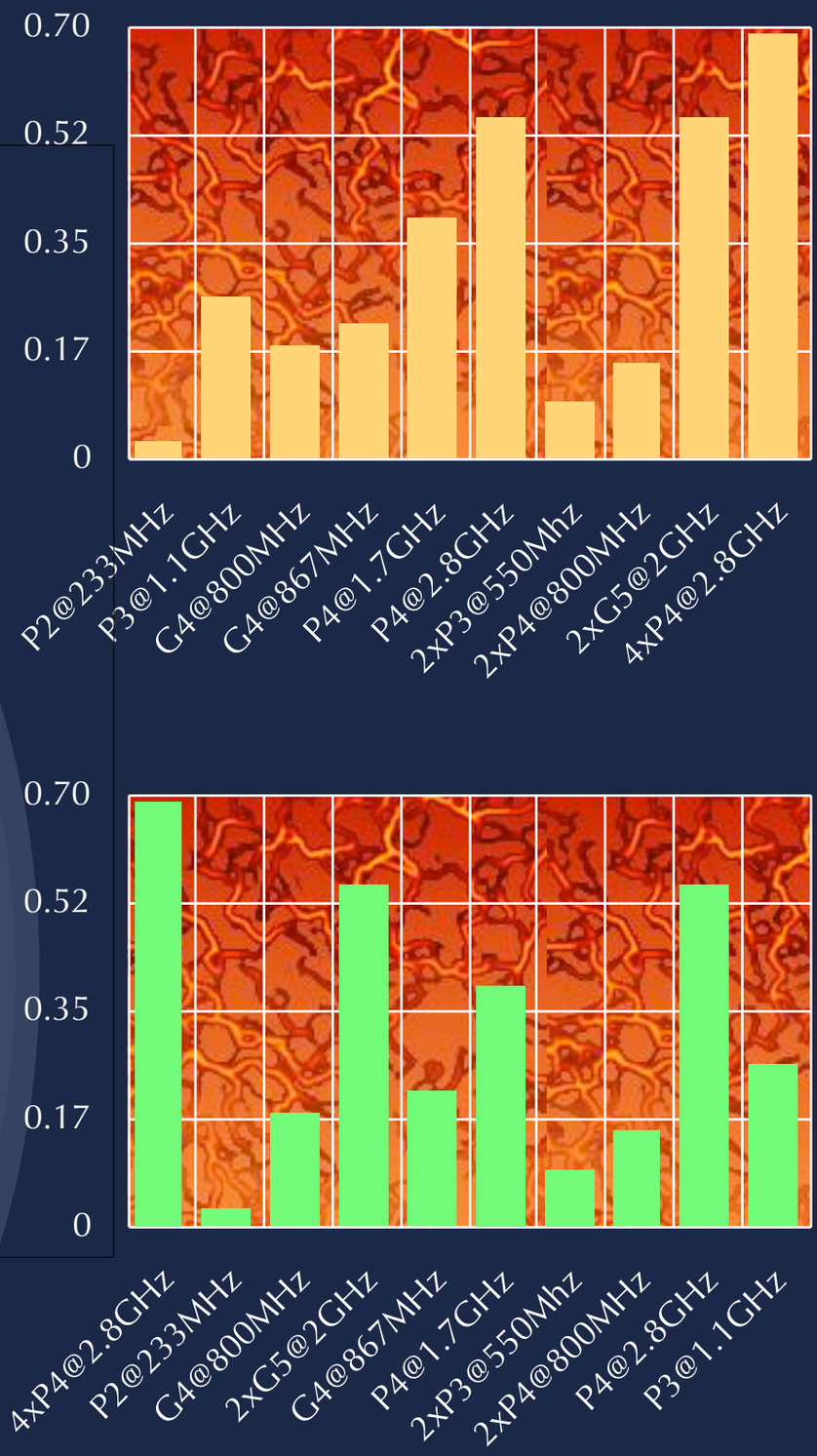
BogoPower



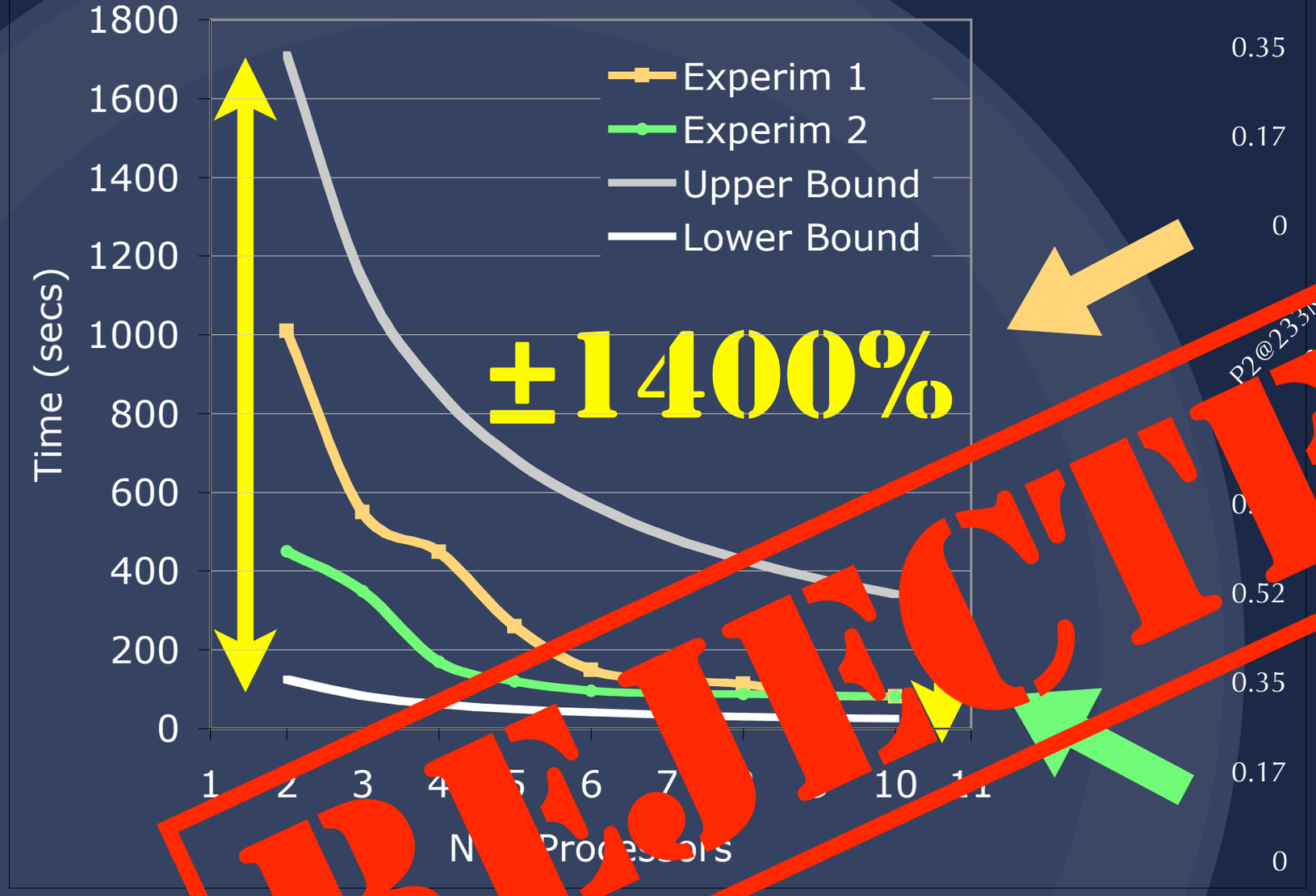
- BogoPower:
  - Models machine power on (tasks/sec) on a single PE
  - neglect net performance
- What speedup means in this scenario?
  - another metric is needed …

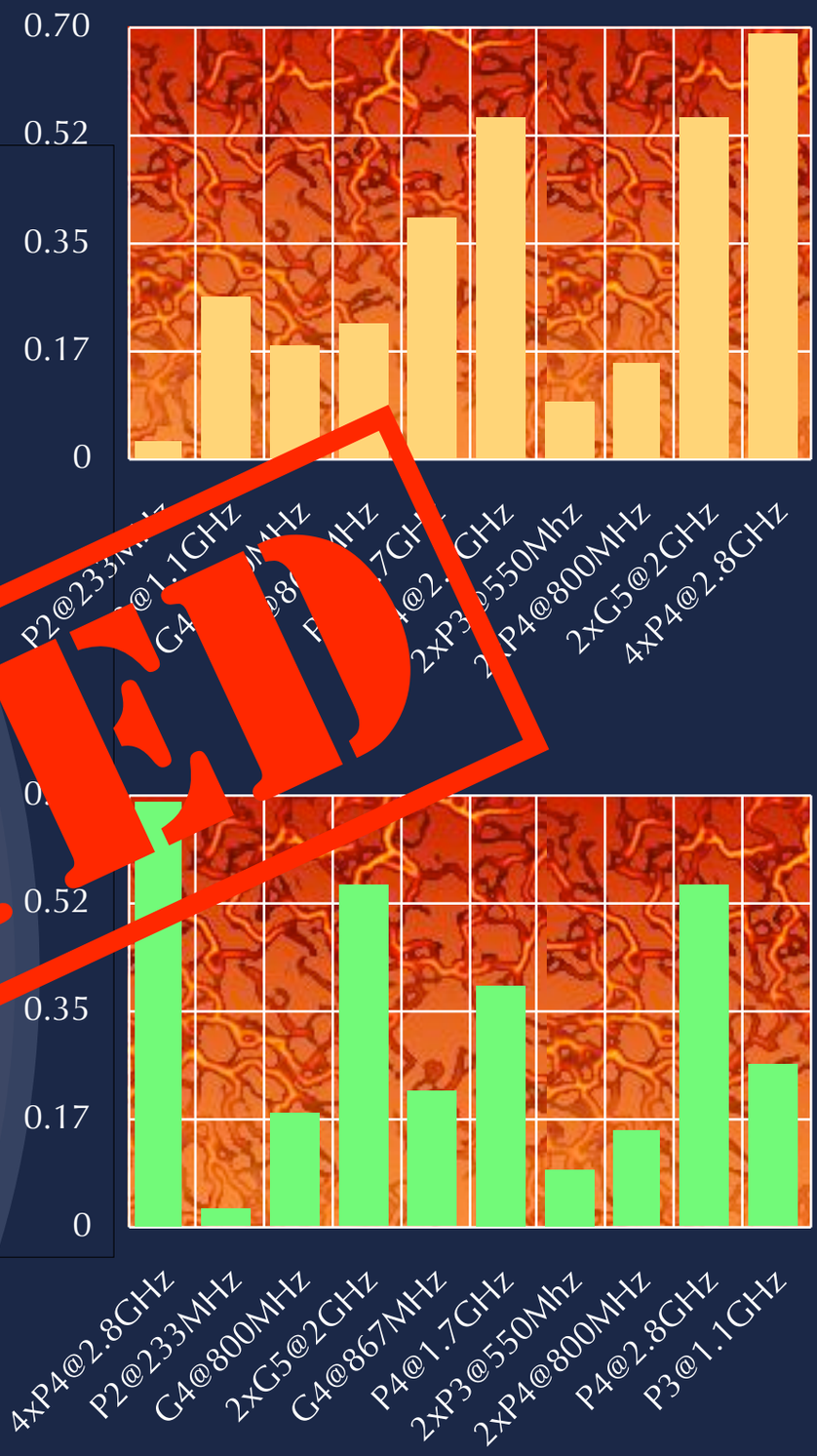
Two experiments





Two experiments





REJECTED

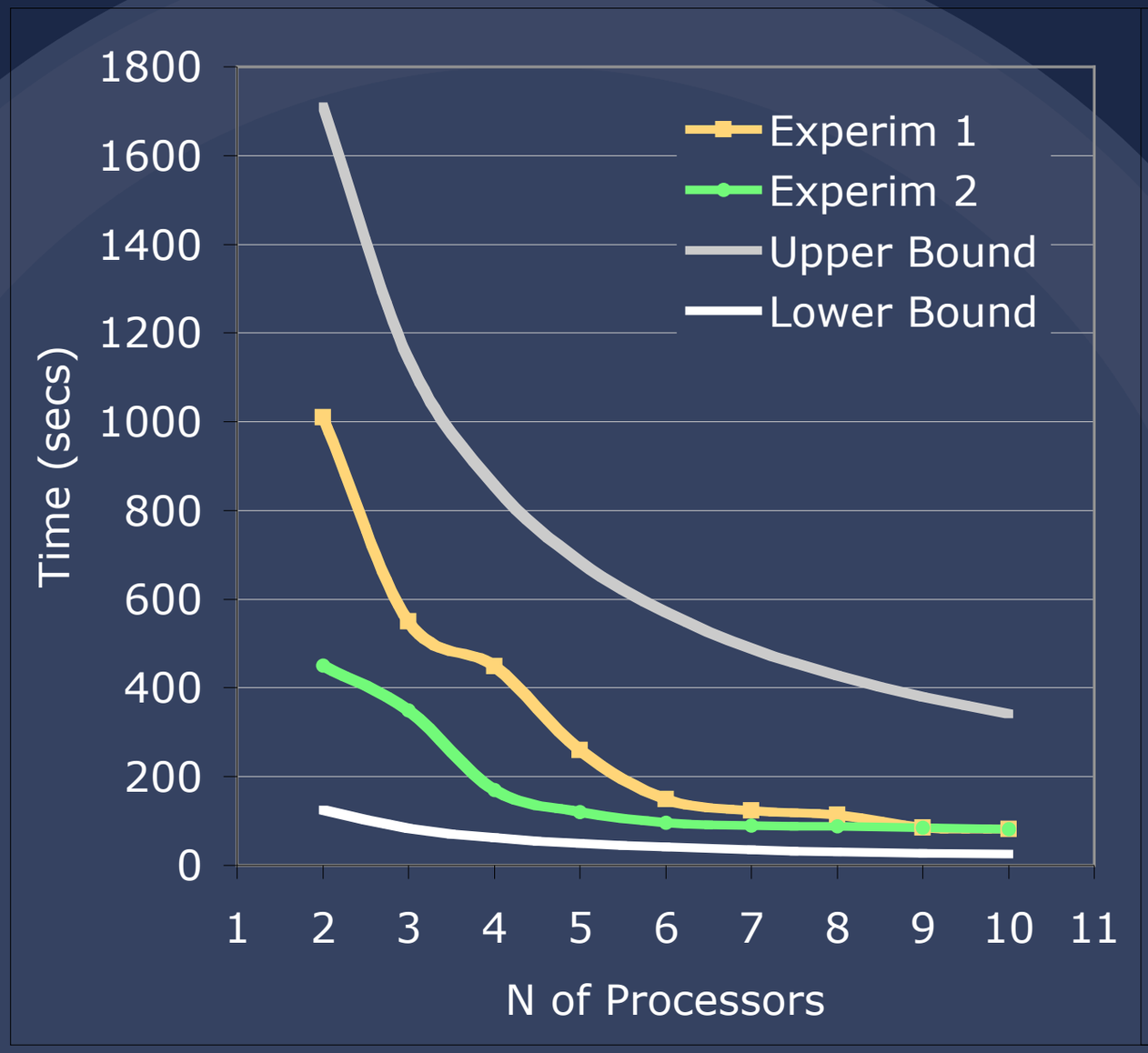
Speedup … ?


10
8
6
4
2
0
Ideal
1 2 3 6 7 8 9 10
45
36
27
13
0
Ideal
1 2 3 4 5 6 7 8 9 10
REJECTED

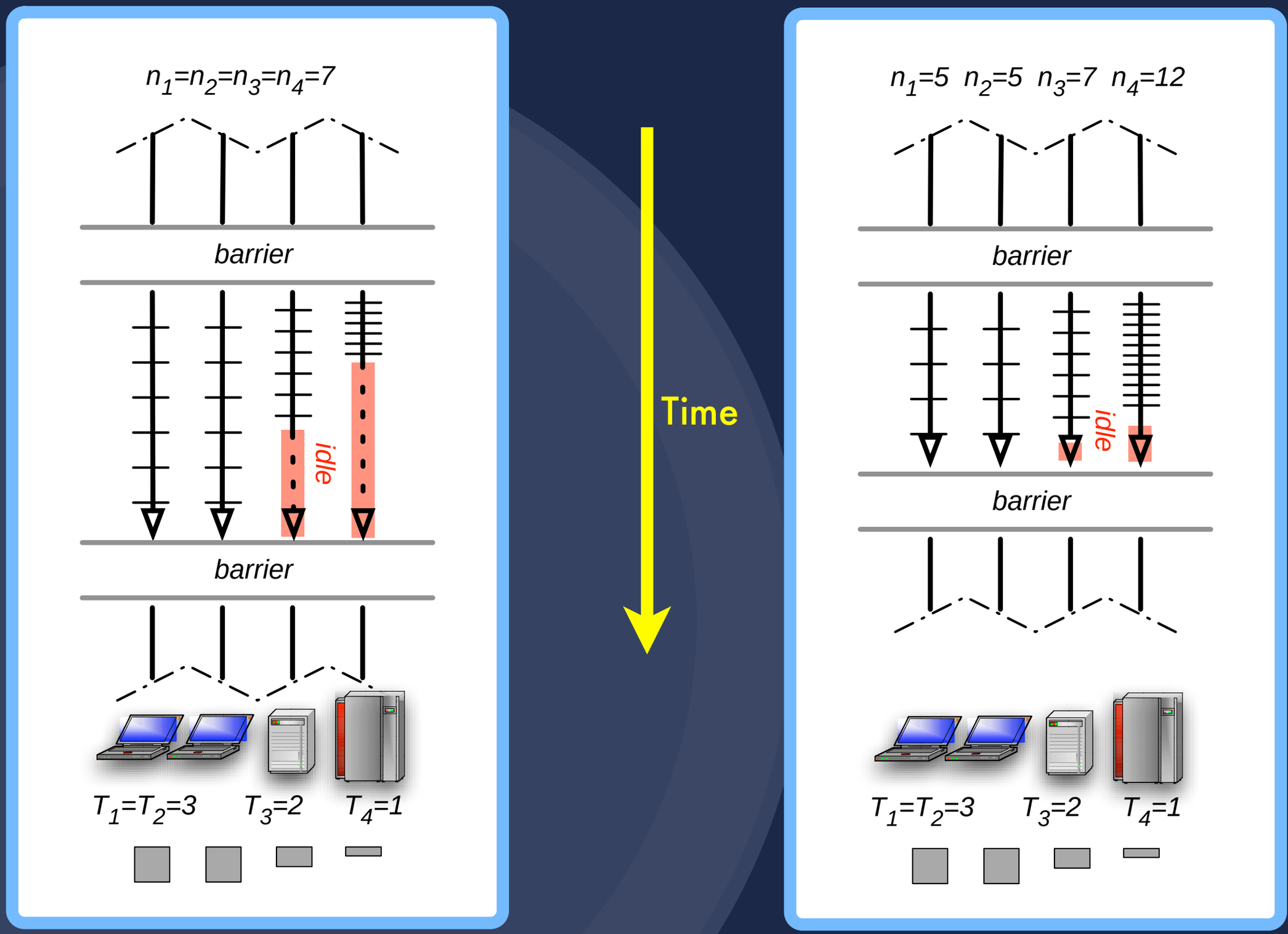
As simple as speedup

- Speedup does not give any information
  - does not provide any reference curve, i.e. an upper bound for algorithm and implementation quality
- It can be replaced with another simple measure
  - with the same features in order to keep the intuition
  - suitable for heterogeneous (in power) envs
- BogoPower can be used (sometime)

Two experiments revised



Naive scheduling (and not)



Describing sub-optimal Performance

- Suppose to have an idea of the performance T (time) of a given task T on a given platform
  - i.e. platform BogoPower - it maybe figured out from any suitable measure of performance, e.g. GridBench, GGF BenchGroup, ...
  - if task haven't constant time consider the average of a bulk of tasks
  - dynamically adapt knowledge through monitoring, adjusted by current load
- compute a scheduling, miming on-demand policy
  - that is sub-optimal, but easy to compute, to understand and to present as "ideal" performance in a paper

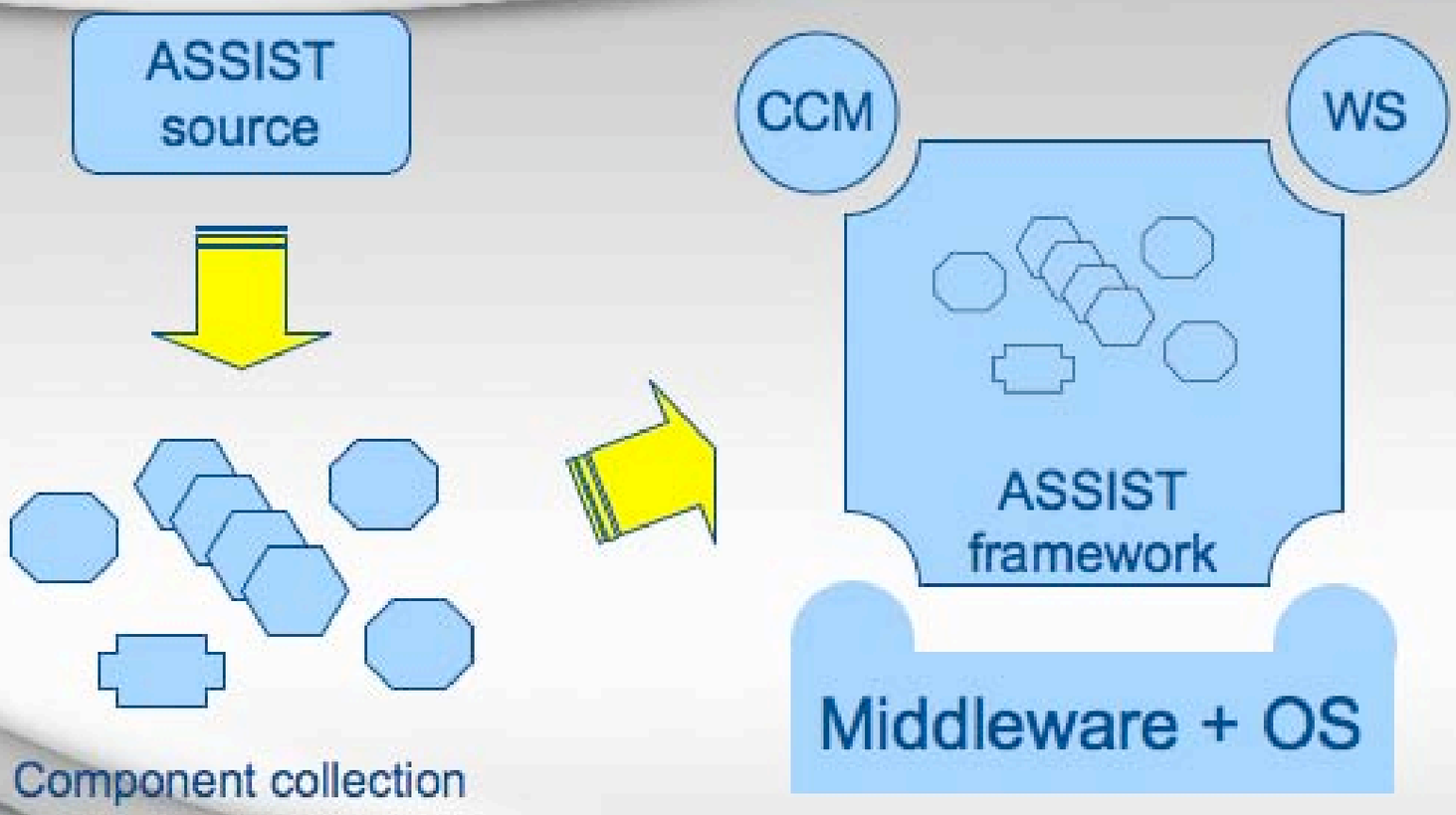
$$n_i = \frac{N \; H(T_1, \cdots, T_n)}{n \; T_i} \quad \begin{cases} N = \# \text{ of tasks} \\ H = \text{Harmonic Mean} \\ T_i = \text{Time for 1 task on } PE_i \\ n_i = \text{optimal number of tasks for } PE_i \end{cases}$$

Outline

- Motivation
- Grid as collection of heterogeneous resources
- Detect Grid current status and react
  - The ASSIST framework
  - A service to find them, a GTx to bring them all and in the darkness bind them, a model to rule them all …
- Re-distributing work & load through WS

It is not a joke,
it is *e-fantasy* !

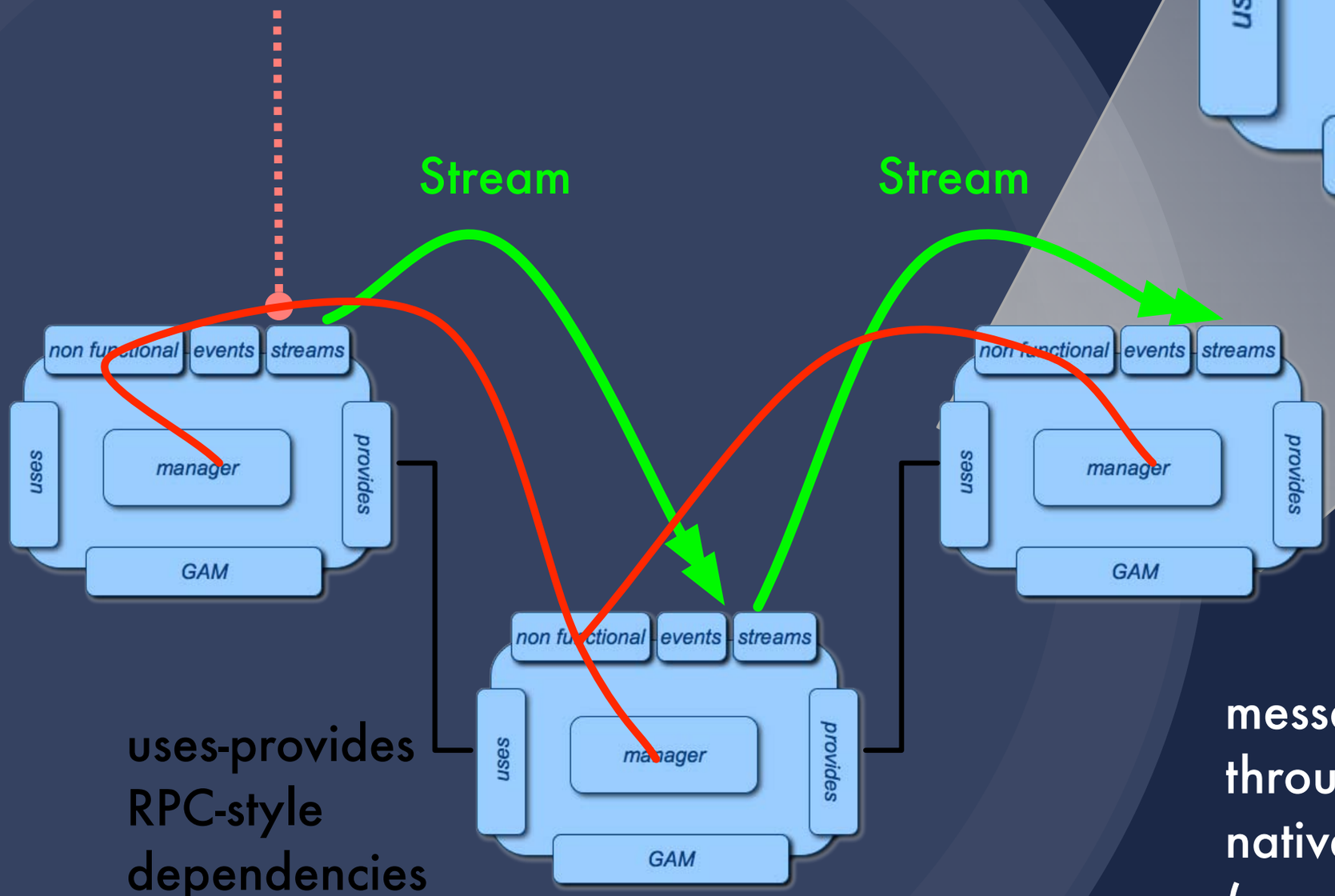
The ASSIST way



from Danelutto's yesterday talk

Application Manager

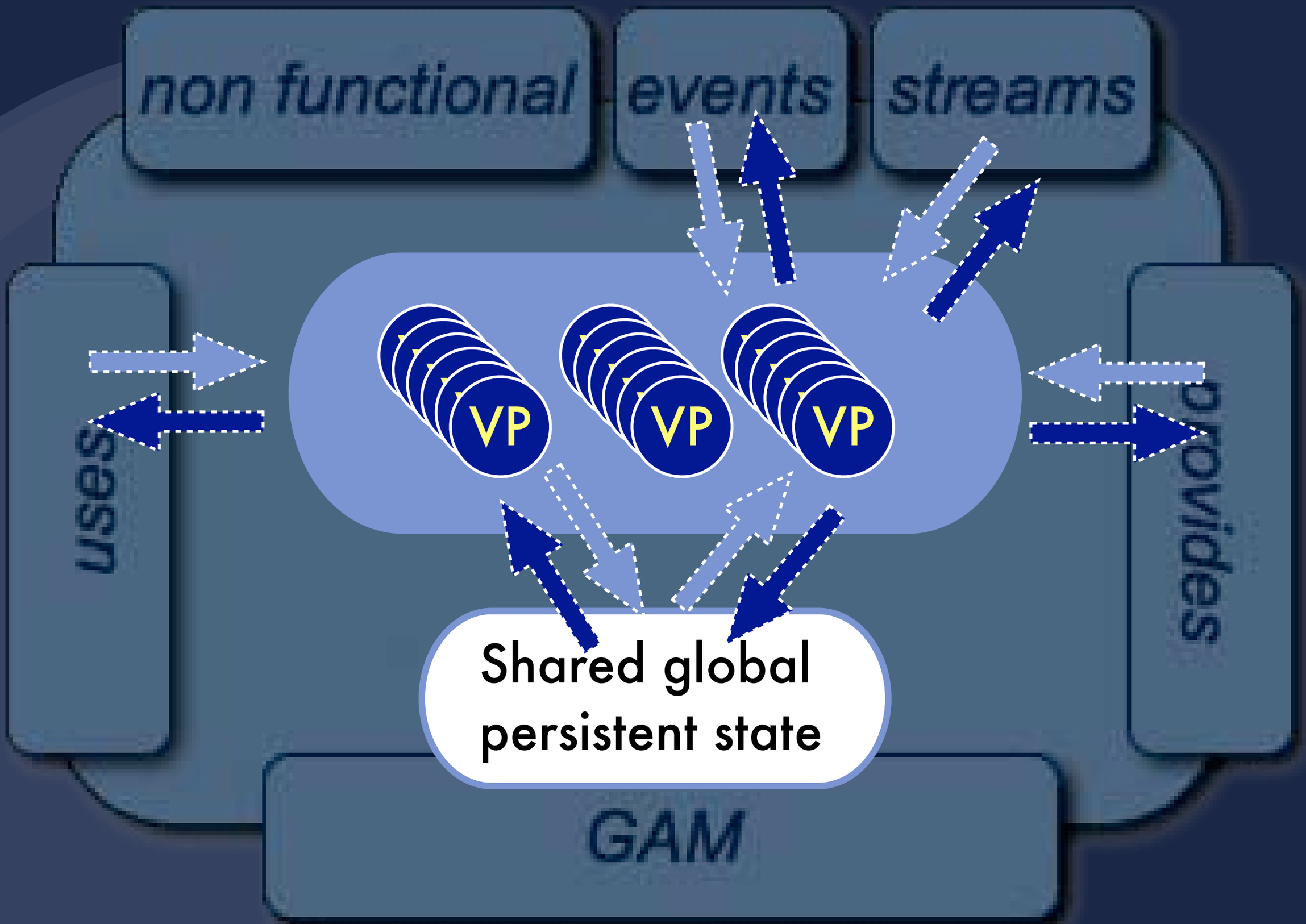
Managers may interact through non functional interfaces realizing a global, distributed control for the application.
I.e. the **Application Manager** (AM)



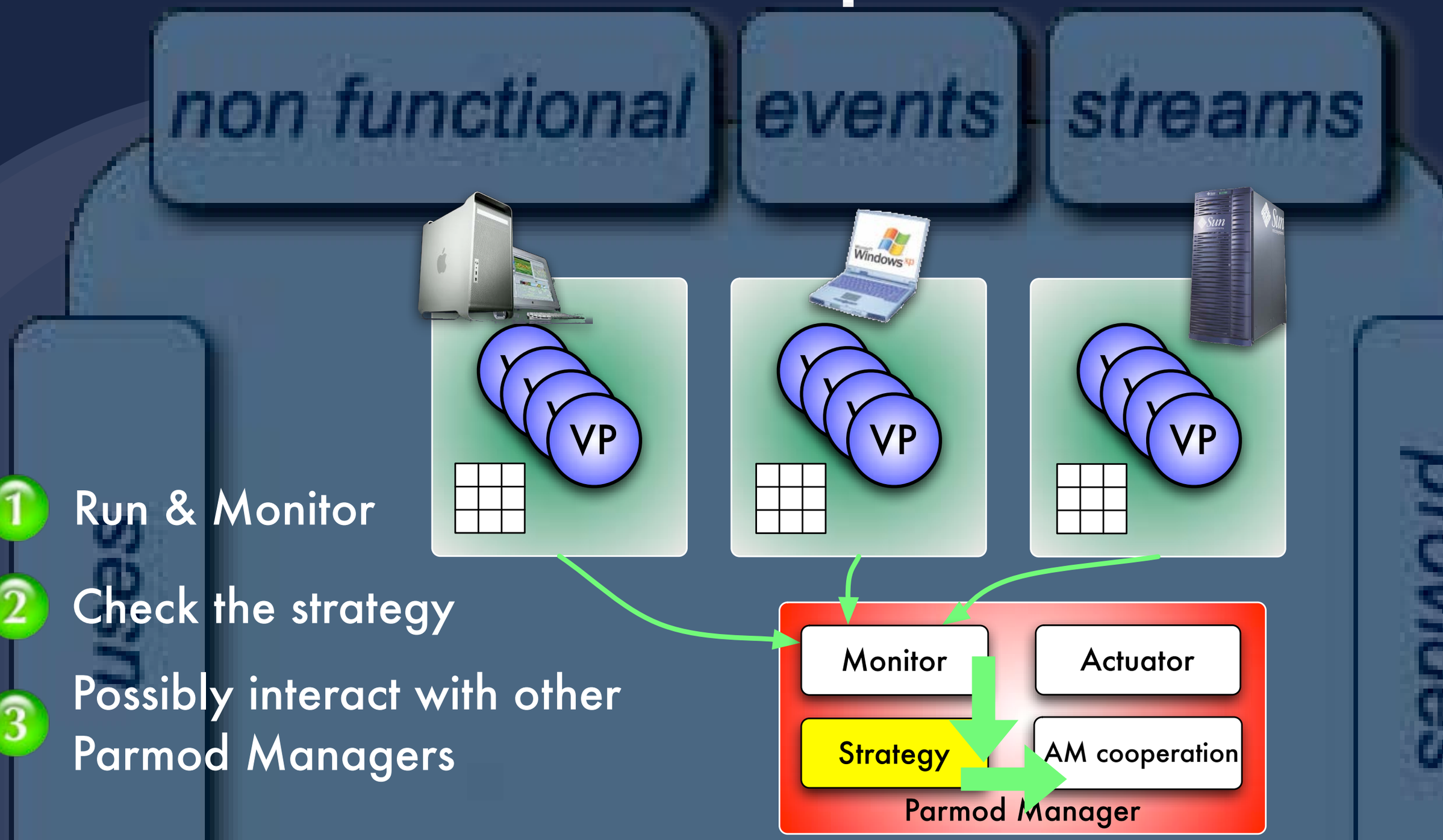
uses-provides
RPC-style
dependencies

messages may flow
through different media:
native, WS/SOAP, Corba streams
(compiler provides the full support)

Parmod component

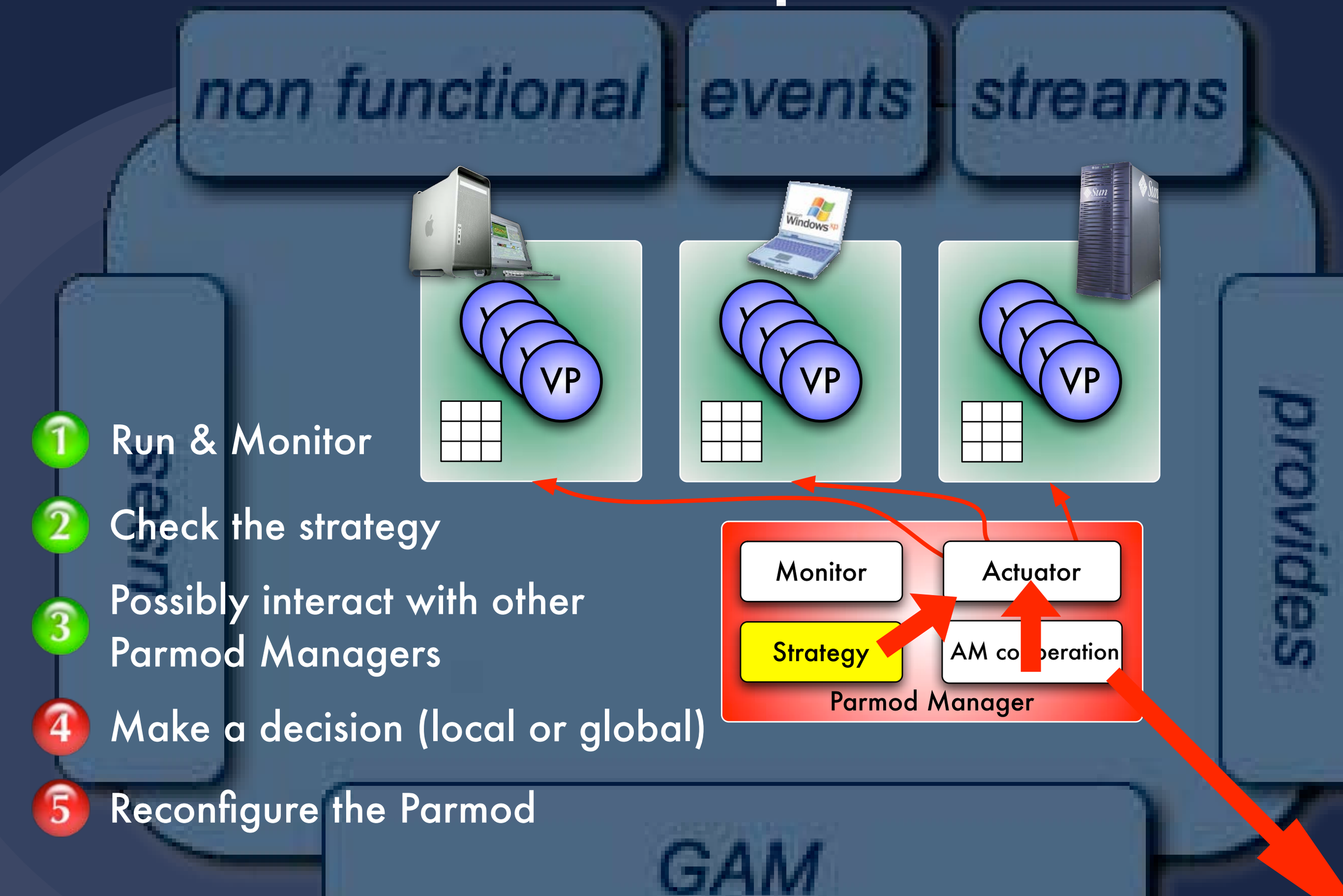


Parmod component



1. Run & Monitor
2. Check the strategy
3. Possibly interact with other Parmod Managers

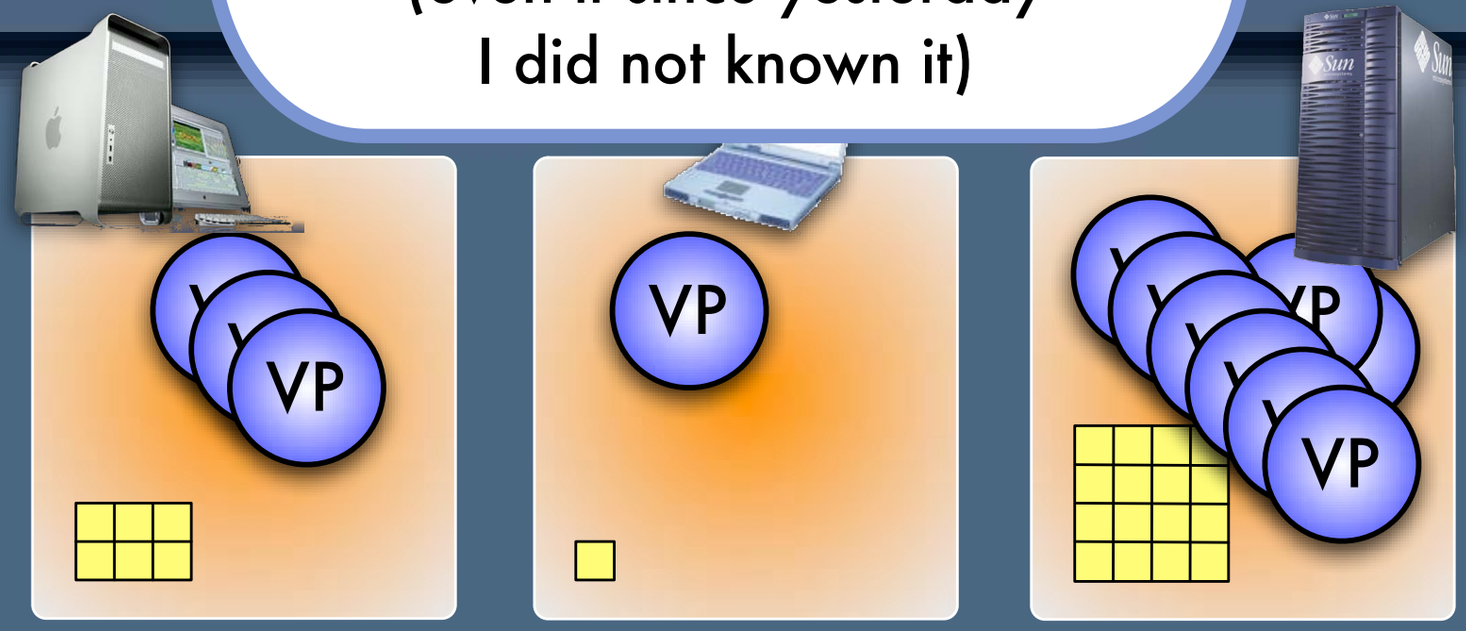
Parmod component

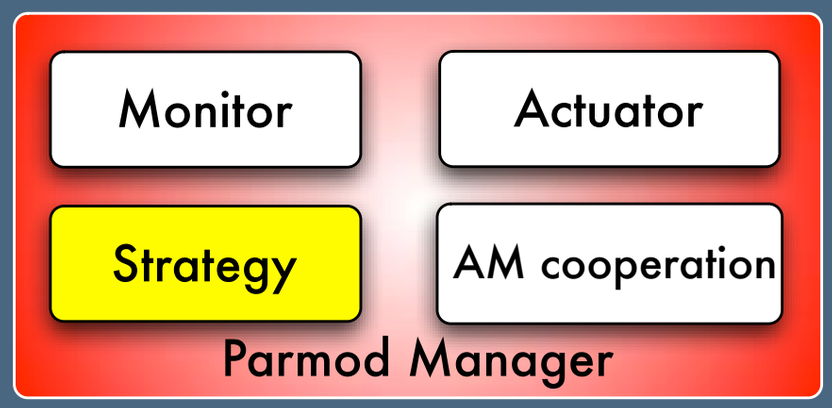


1. Run & Monitor
2. Check the strategy
3. Possibly interact with other Parmod Managers
4. Make a decision (local or global)
5. Reconfigure the Parmod

Parmod component

This maybe is
e-autonomous-computing
(even if since yesterday
I did not known it)



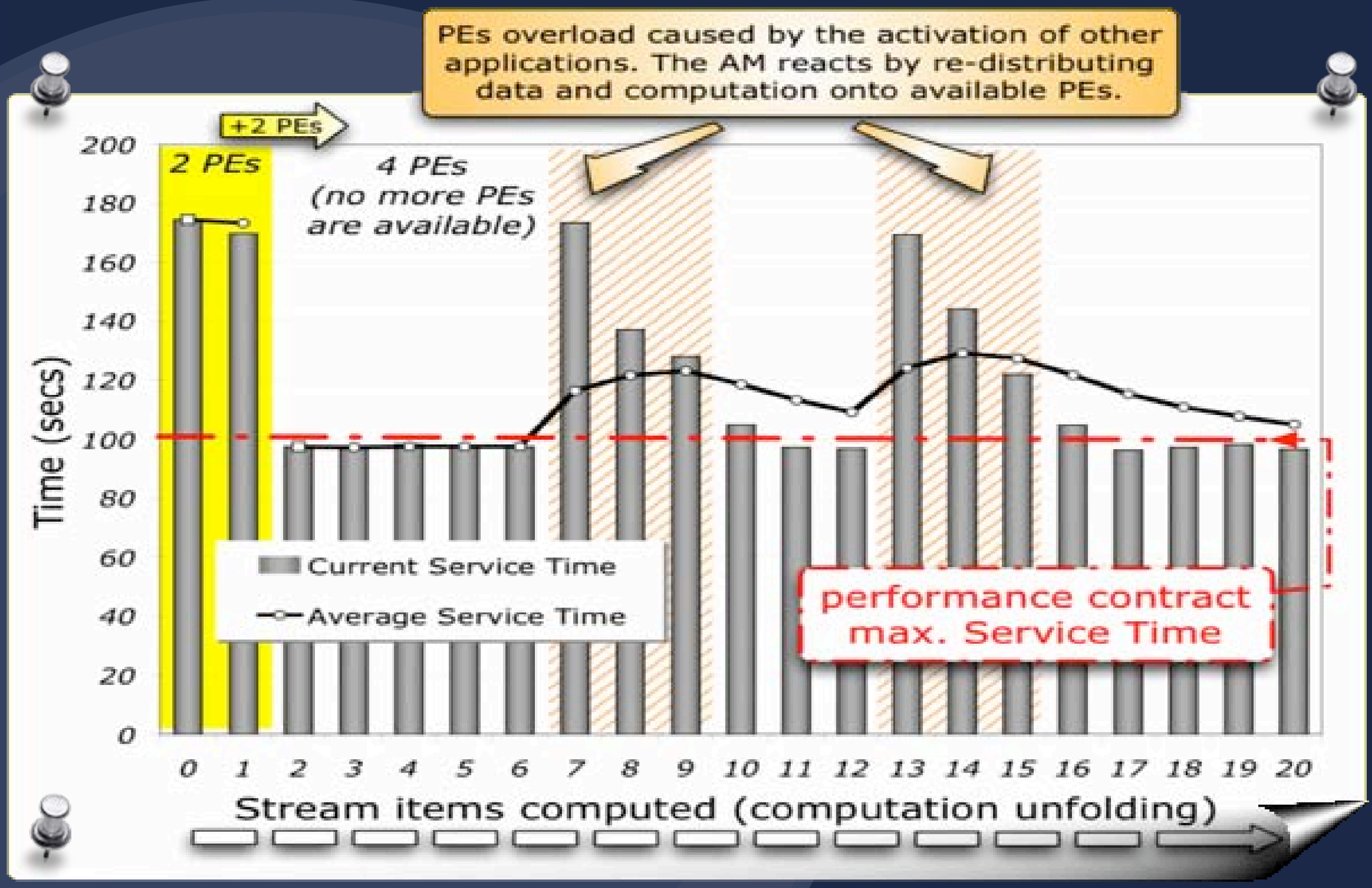


1. Run & Monitor
2. Check the strategy
3. Possibly interact with other Parmod Managers
4. Make a decision (local or global)
5. Reconfigure the Parmod
6. Parmod reconfigured !

Two key issues

2. Check the strategy
   - simulate possible scenarios by using the suitable model
     - respect the performance contract: service time, resources, …
   - e.g. the one I've presented seems quite efficient for HPF "do parallel" or BSP style computations
   - we already working to support other paradigms
5. Reconfigure the parmod
   - keep the shared state in a "storage component" that is distributed, persistent, WS accessible, high-performance
   - E.g. HOC / WS-HOC already available as part of ASSIST

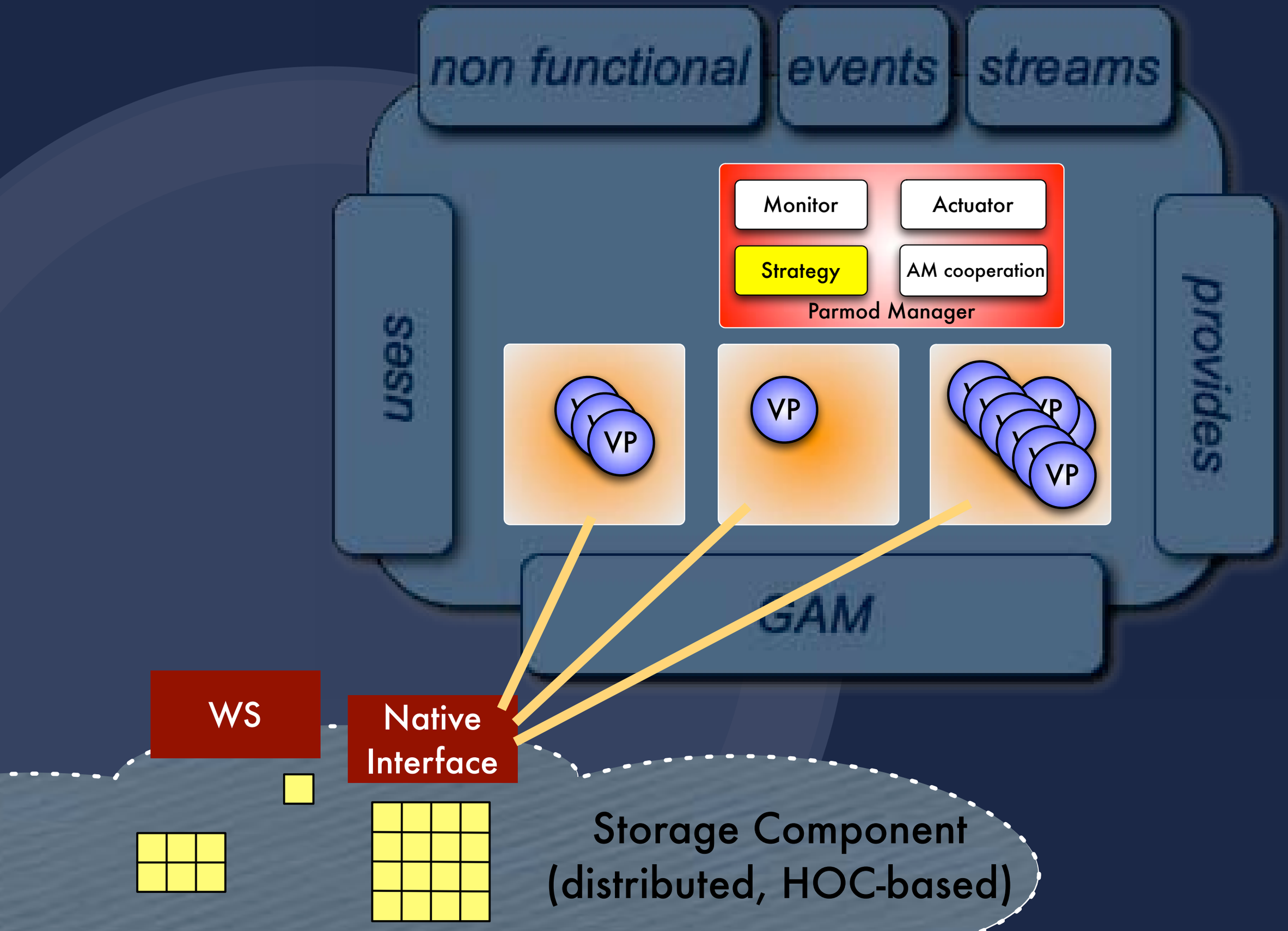
… and it work


PEs overload caused by the activation of other applications. The AM reacts by re-distributing data and computation onto available PEs.
+2 PEs
2 PEs
4 PEs
(no more PEs are available)
Time (secs)
200
180
160
140
120
100
80
60
40
20
0
Current Service Time
Average Service Time
performance contract
max. Service Time
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Stream items computed (computation unfolding)

Outline

- Motivation
- Grid as collection of heterogeneous resources
- Detect Grid current status and react
- Re-distributing work & load through WS
  - decouple management of data e computation
  - the “storage component” idea

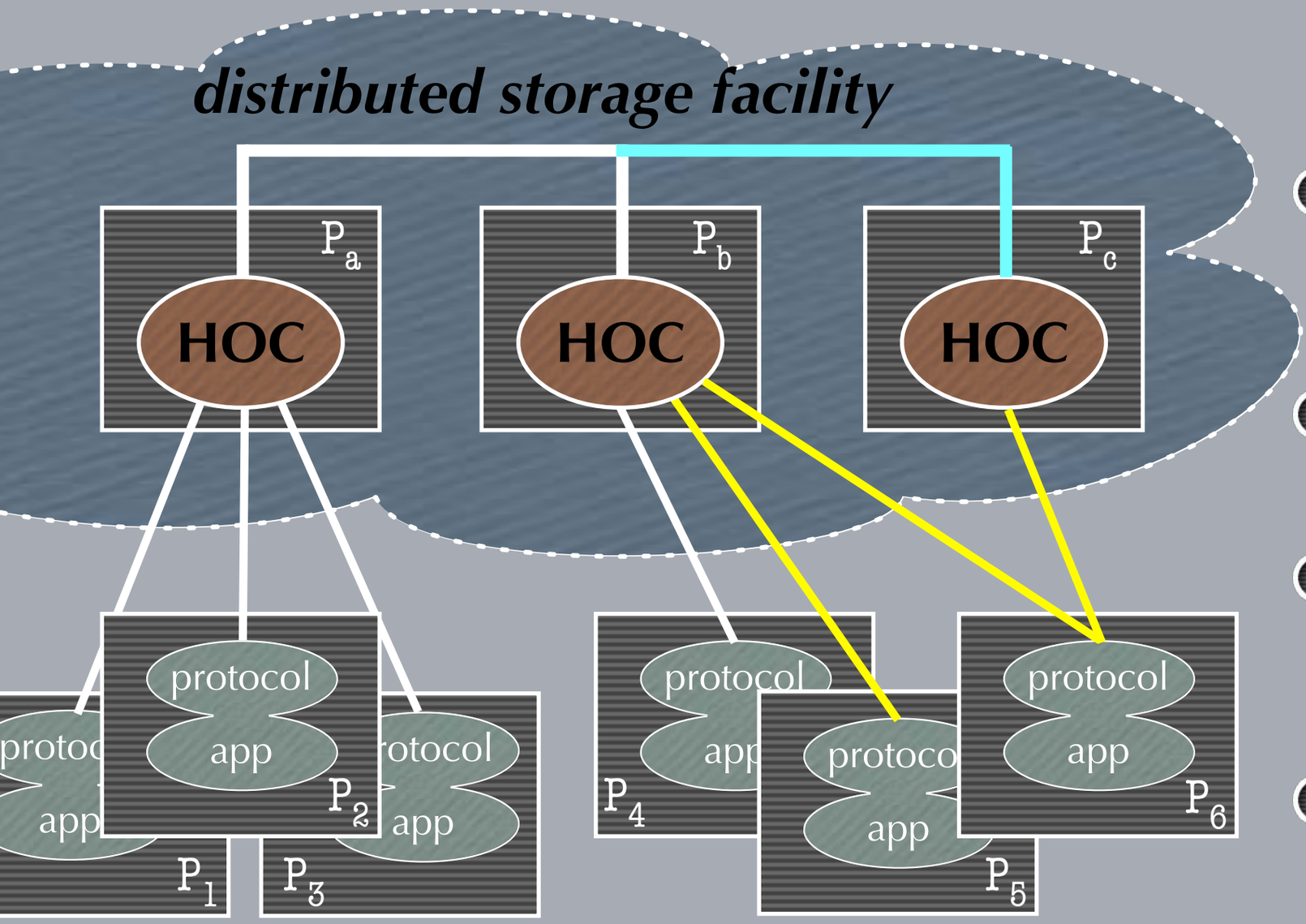
Redistribute data



HOC (Herd of Object Caches)

- A very basic storage facility
  - No hardwired policies for deployment, allocation, data coherence, ...
  - pluggable into different, third-party applications/frameworks
- proving ***data management*** as external service for applications
  - implemented as high-throughput distributed server
- decoupling computational and storage management in (distributed) application design
  - enforcing a structured development
- and exploiting persistency, scalability, re-configurability

Permanent, shared storage facility



- a facility (distributed server) providing permanent, shared storage to apps (clients)
- clients may dynamically join/ leave the storage facility
- HOC set may be hotly enlarged/ reduced on need - storage room change accordingly
- interaction with HOCs may be delegated to application-specific protocol

Why using HOC

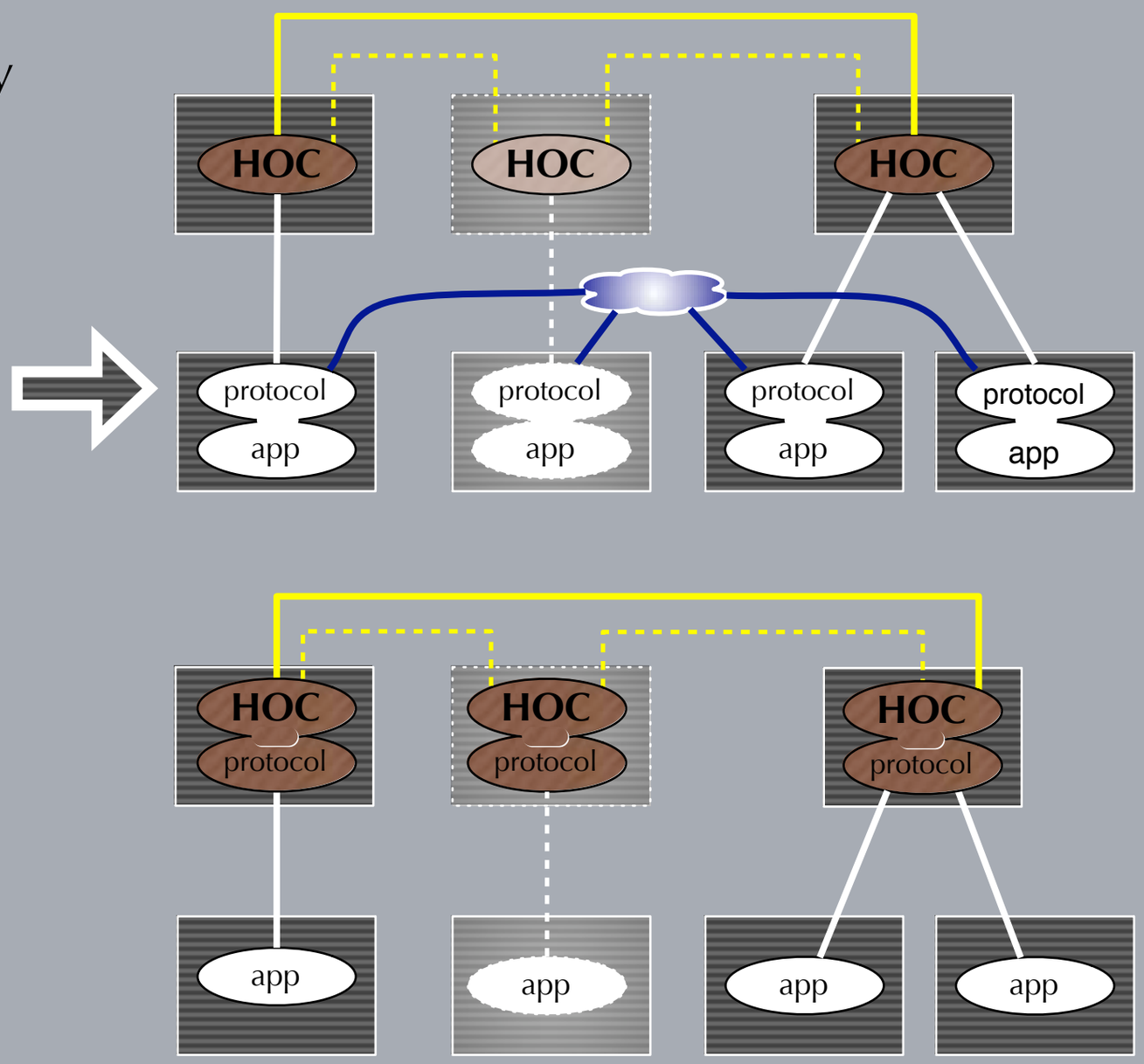
- is efficient (because essential)
  - HOC provide few primitives and no policies for data integrity (e.g. coherence, consistency, ...)
  - these are application specific and may be deployed upon HOC (at the **protocol** level)
- is a basic building block for broad class of applications
  - may be considered a storage component
  - massive storage, out-of-core applications, high-throughput data servers, shared memory support
  - extendible with application-specific primitives
- enhances both memory size and throughput by means of parallelism

… using HOC

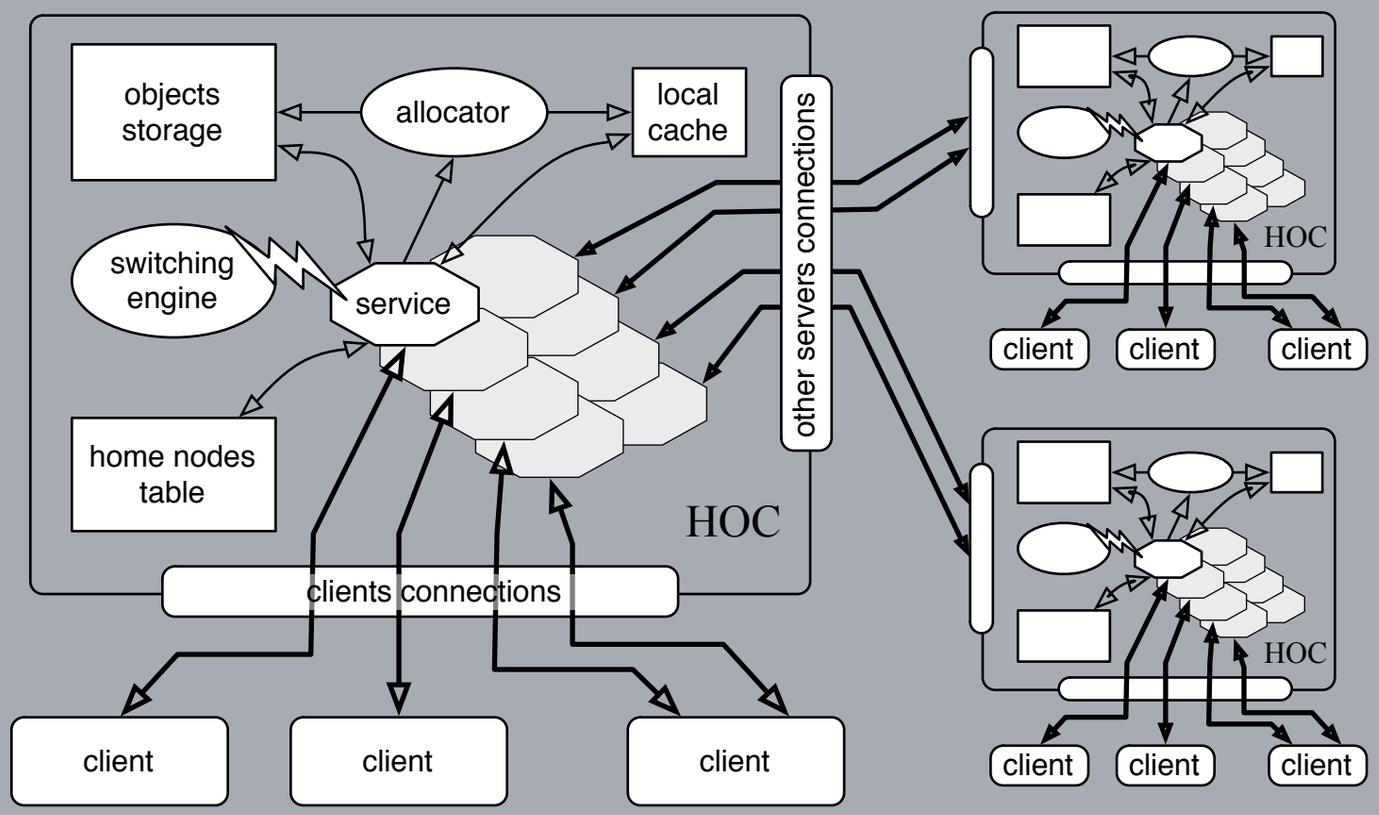
- protocol enforces application requirements on data integrity acting as mediator between the application and HOC
- it is linked to the application and use HOC API
- e.g. Apache module

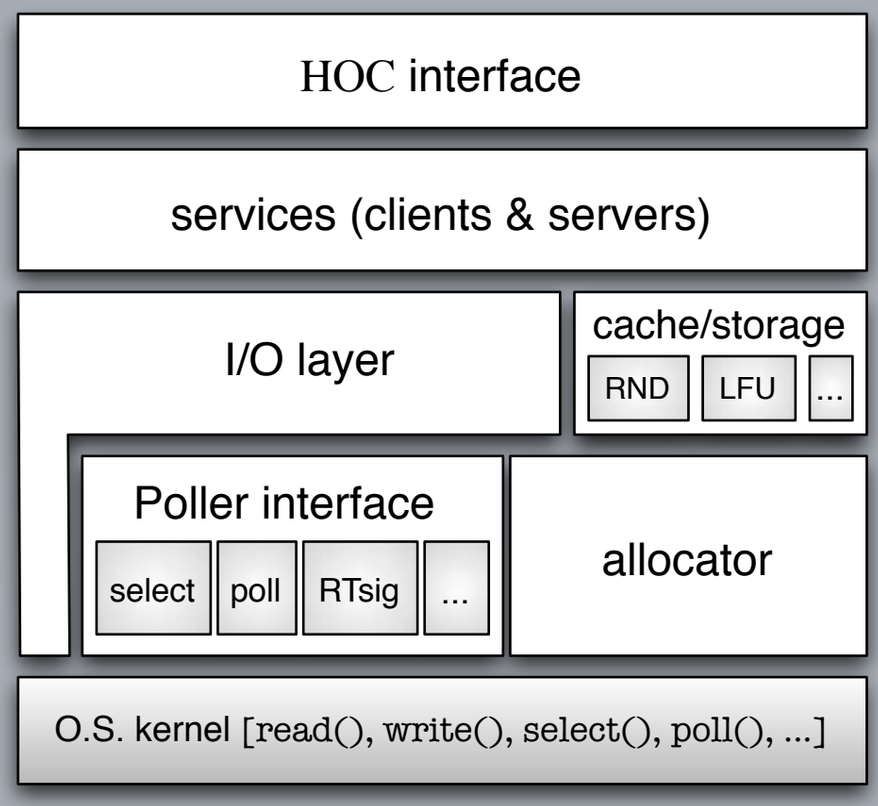
protocol may actually is a distributed application (e.g. reaching consensus, cache invalidation, ...)

HOC API may also be easily extended (provided some knowledge of HOC internals)



HOC internals





- C++, single-threaded, manage concurrent connections using non-blocking I/O based **services** (each of them being a state machine managing a single connection)
  - supporting both level-triggered (`select`, `poll`, ...) and edge-triggered (`RTsignal`, `kqueue`, ...) I/O events
- object storage may be managed either as a memory or a cache, remote objects may be cached in a separate write-through cache. Policies are configurable.
- tested on Linux, MacOS X, and heterogeneous cluster of them

HOC API

Why does the web work so well?
A language with few verbs (get, put, post) ...
Gannon said ... (Europar04, invited talk)

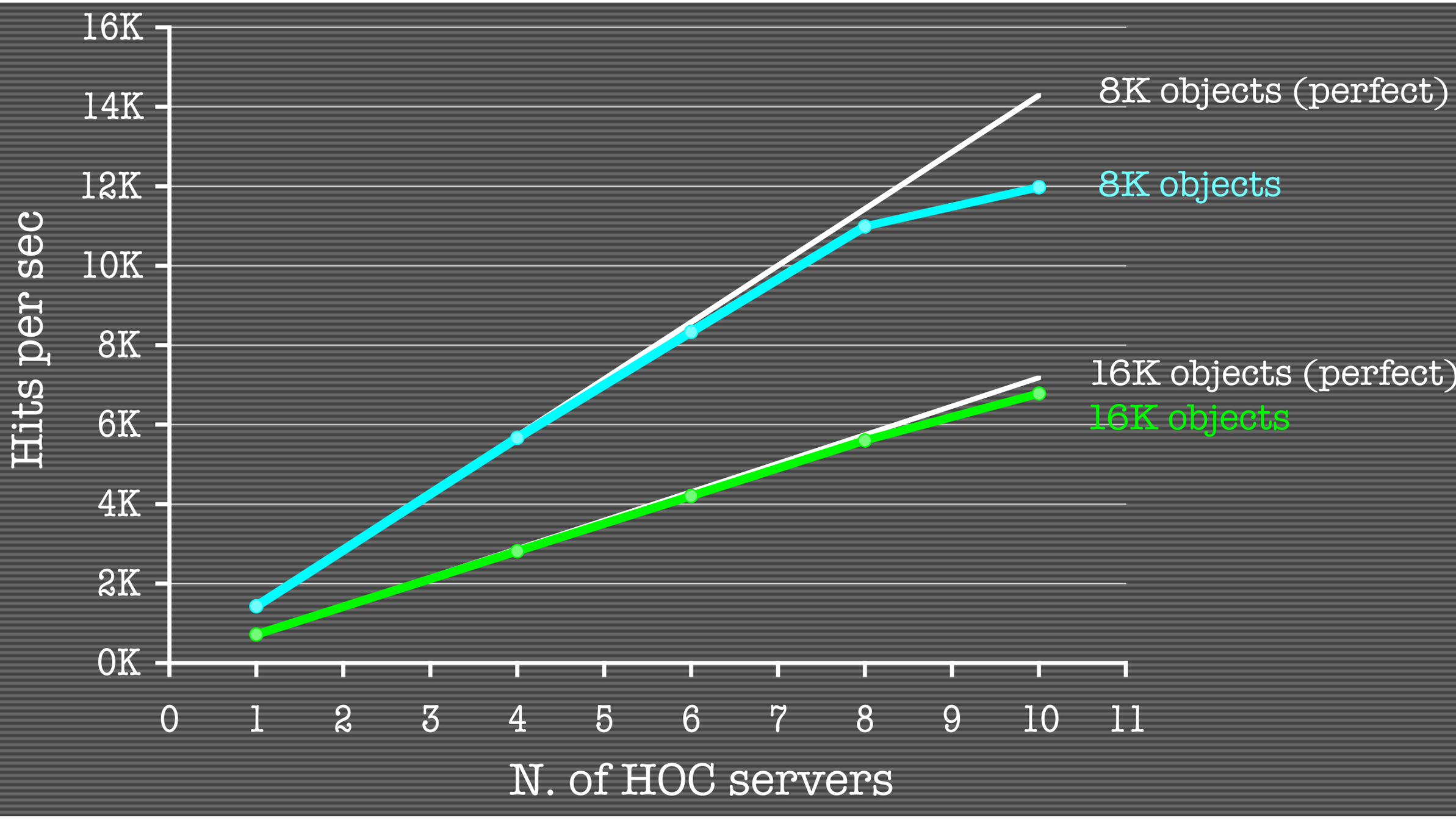
We also believe on such philosophy. As matter of a fact HOC have a four operations API

- `get`, `put`, `remove` arbitrary length objects. Each object is identified by a key and a home node
- `execute(key, op, data)` remotely execute method **`op`** with parameter **`data`** on object identified by **`key`**

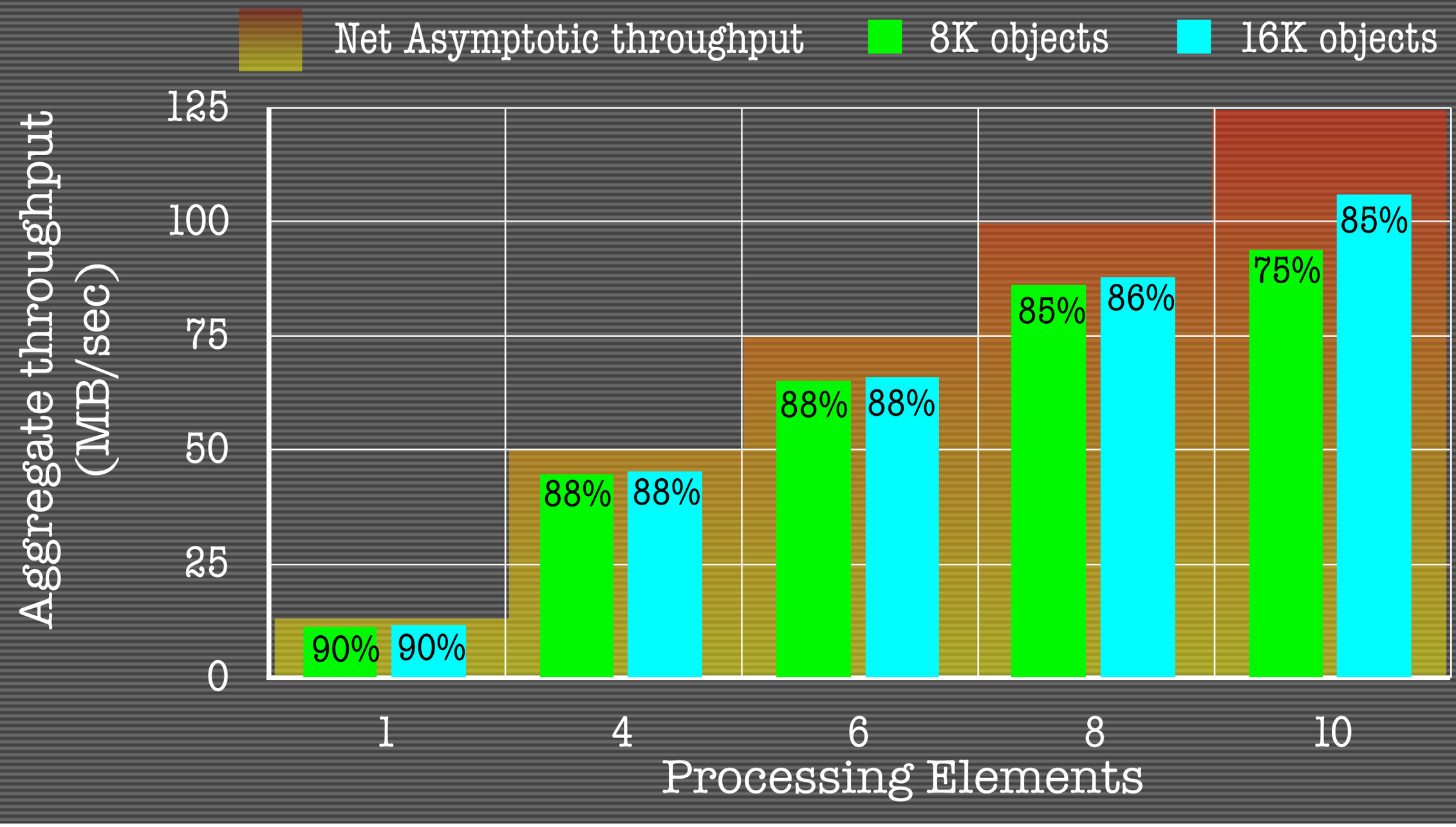
Performance figures (1PE)

Arch/Net/OS	concurrent connections	Msg size (Bytes)	Replies/Sec	net throughput (Bytes/Sec)	net throughput w.r.t. ideal
P4@2GHz Mem 512MB GigaEth Linux ker. 2.4.22	2048	1 M	91	91 M	96%
	3072	512	20 M	10 M	11%
P3@800MHz Mem 1GB FastEth Linux ker. 2.4.18	1024	8 K	1429	11.2 M	90%
	1024	16 K	718	11.2 M	90%

Speedup (Hit per sec VS N. servers)



Sustained aggregate throughput



Summarizing

- HOC is a building block for storage-oriented components
  - distributed caches, distributed memories, parallel repositories
  - configurable, hot-pluggable,
- very good performances
  - close-to-ideal net throughput over thousands of concurrent connections
  - close-to-ideal speedup

Conclusions

- A simple model able to describe what we can expect from our Grid applications
  - Usable as “Ideal performance” slope in papers
- A first effort toward a serious AM
  - A very ongoing work, as asked by Alexander
- Exploit the potentiality of ASSIST+WS+StorageComponent

THANK YOU!

QUESTIONS?

Some references

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