ParCo 2005
Malaga, Spain

Building Interoperable Grid-aware ASSIST Applications via Web Services

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ISTITUTO DI SCIENZA E TECNOLOGIE DELL'INFORMAZIONE "A. FAEDO"

IN SUPREMÆ DIGNITATIS 1343

CoreGRID

Grid.it project

Outline

- Motivating ...
  - high-level programming for the grid
  - application adaptivity for the grid
- ASSIST basics
- WS as transport in ASSIST apps
- Grid.it components & WS ports
- Concluding remarks

The grid

*"... coordinated resource sharing and problem solving in **dynamic**, multi institutional virtual organizations."*

Foster, Anatomy

"1) coordinates resources that are not subject to centralized control ..."
*"2) ... using **standard**, open, general-purpose protocols and interfaces"*
*"3) ... to deliver nontrivial **qualities of service**."*

Foster, What is the Grid?

The grid

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Foster, What is the Grid?

Moreover, since this is not **SeqCo**, I assume applications we are focusing on should be **parallel** (and hopefully **high-performance**).

// progr. & the grid

- concurrency exploitation, concurrent activities set up, mapping/scheduling, communication/synchronization handling and data allocation, ...
- manage resources heterogeneity and unreliability, networks latency and bandwidth unsteadiness, resources topology and availability changes, firewalls, private networks, reservation and jobs schedulers, ...

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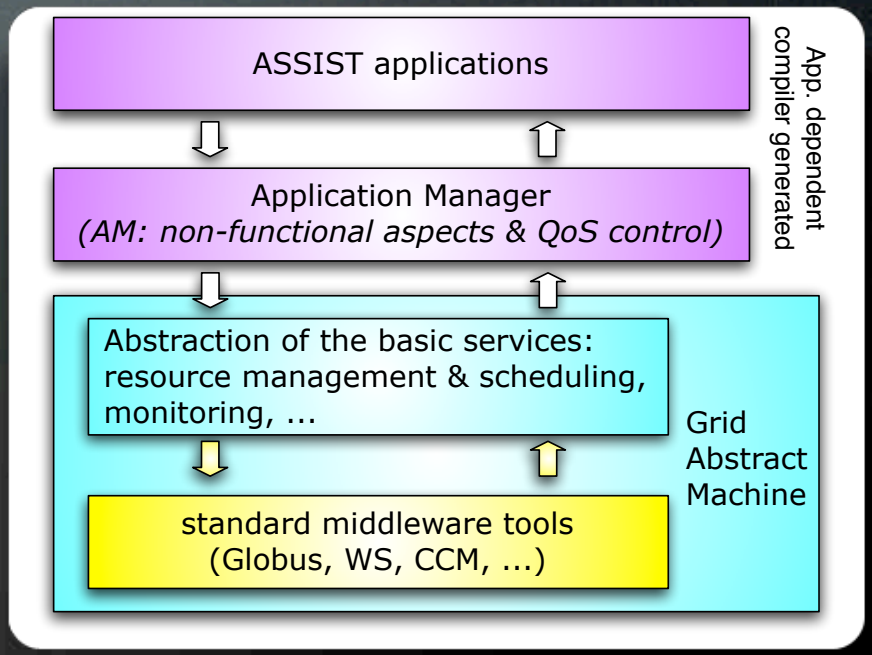
... and a non trivial QoS for **applications**

not easy leveraging only on middleware

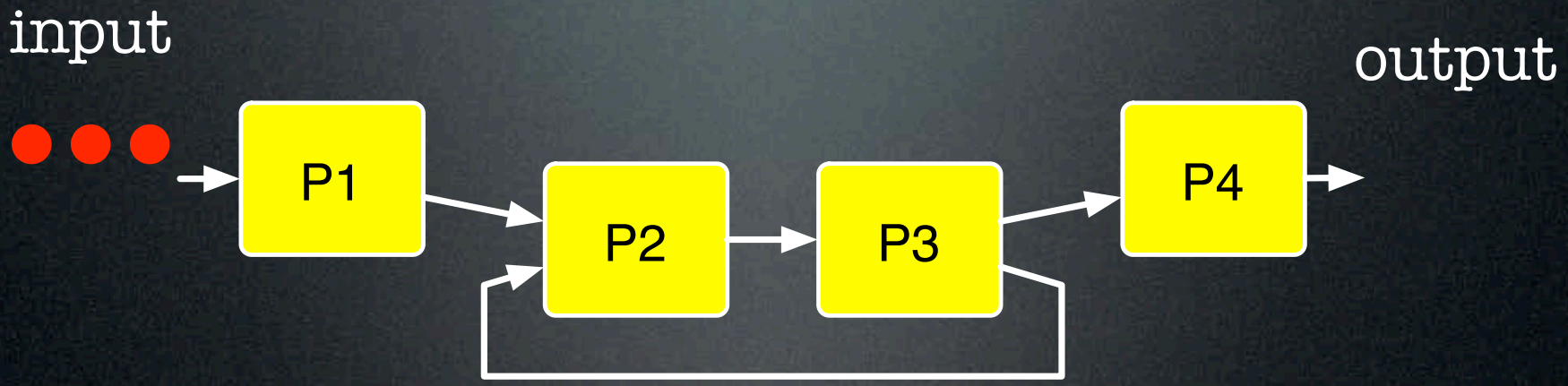
ASSIST idea

ASSIST is a high-level programming environment for grid-aware // applications. Developed at Uni. Pisa within several national/EU projects. First version in 2001. Open source under GPL.

"moving most of the Grid specific efforts needed while developing high-performance Grid applications from programmers to grid tools and run-time systems"



app = graph of modules



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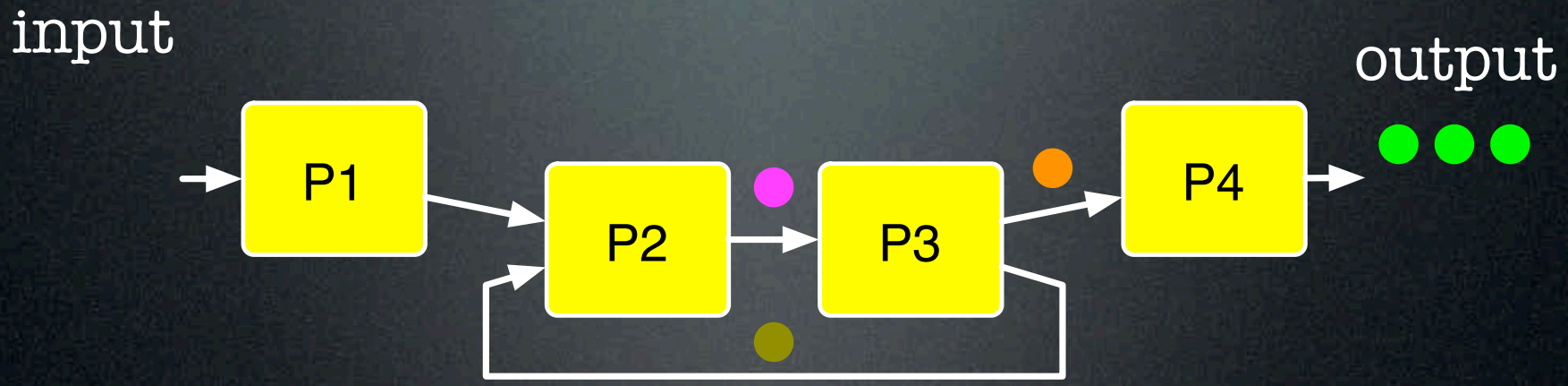
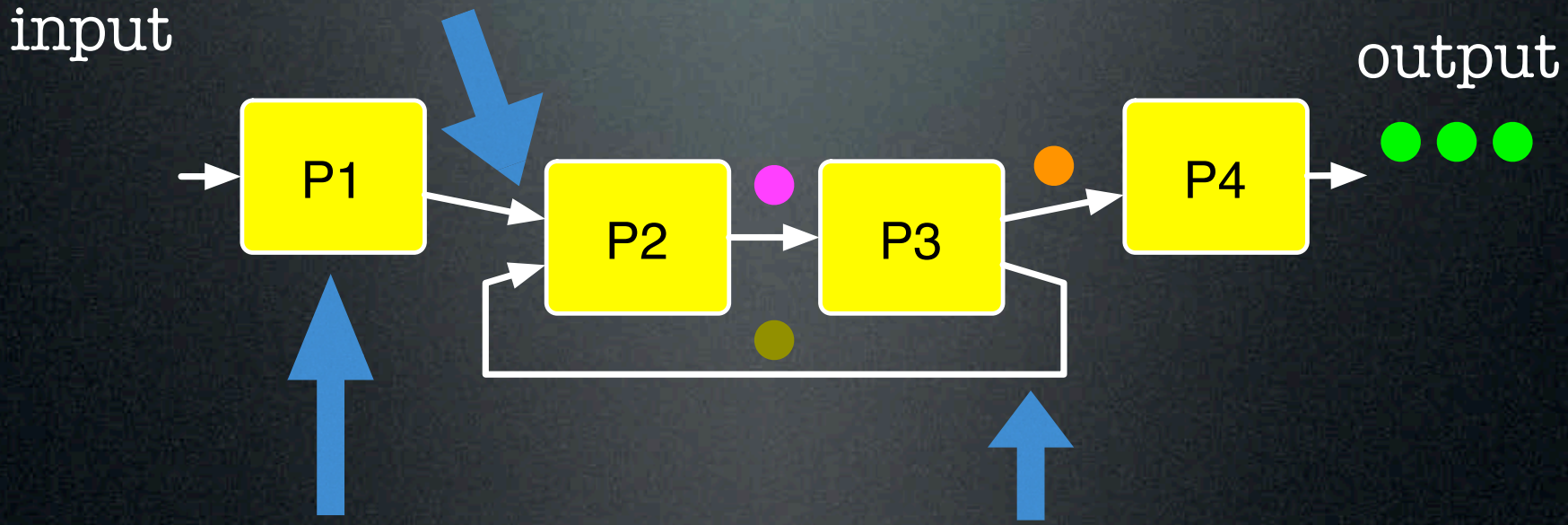
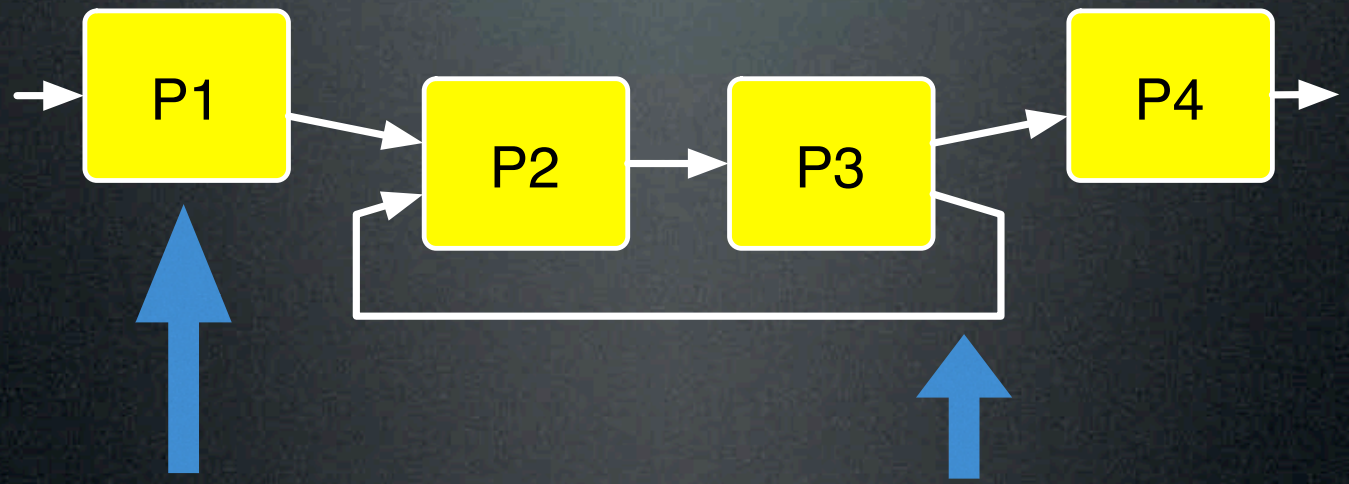


app = graph of modules

Programmable, possibly nondeterministic input behaviour



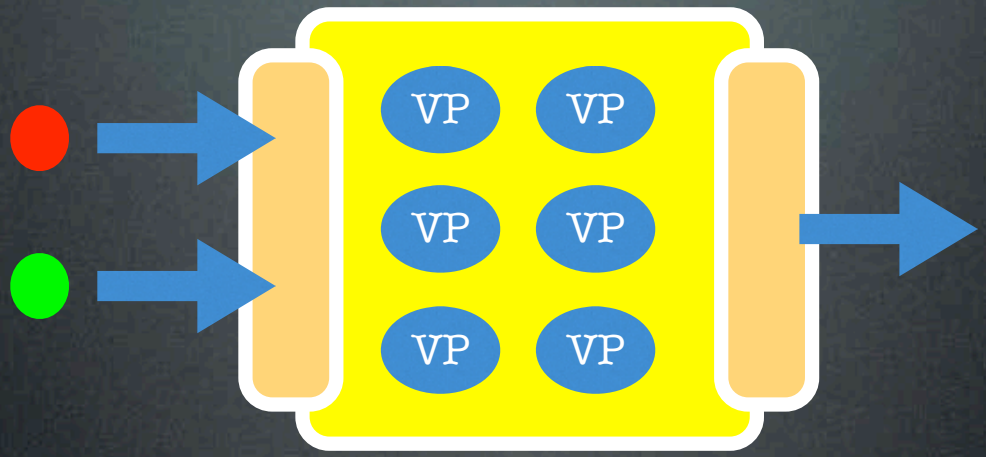
native + standard



ASSIST native or wrap
(MPI, CORBA, CCM, WS)

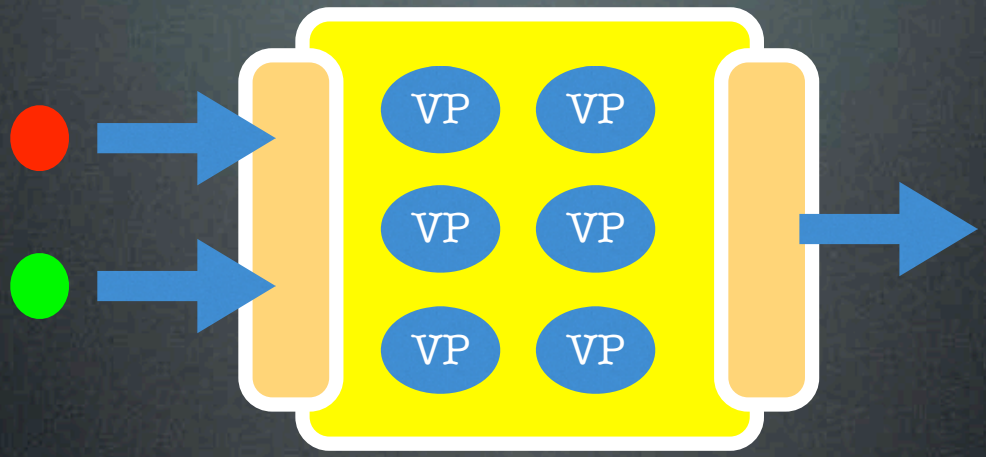
TCP/IP, Globus,
IIOP CORBA,
HTTP/SOAP

ASSIST native parmod



ASSIST native parmod

An “input section” can be programmed in a CSP-like way



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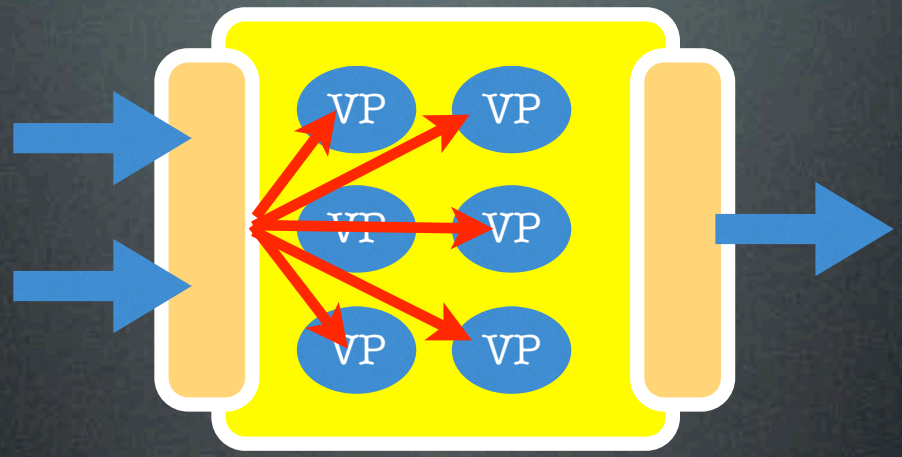

Data items can be distributed (scattered, broadcasted, multicasted) to a set of **Virtual Processes** which are named accordingly to a topology

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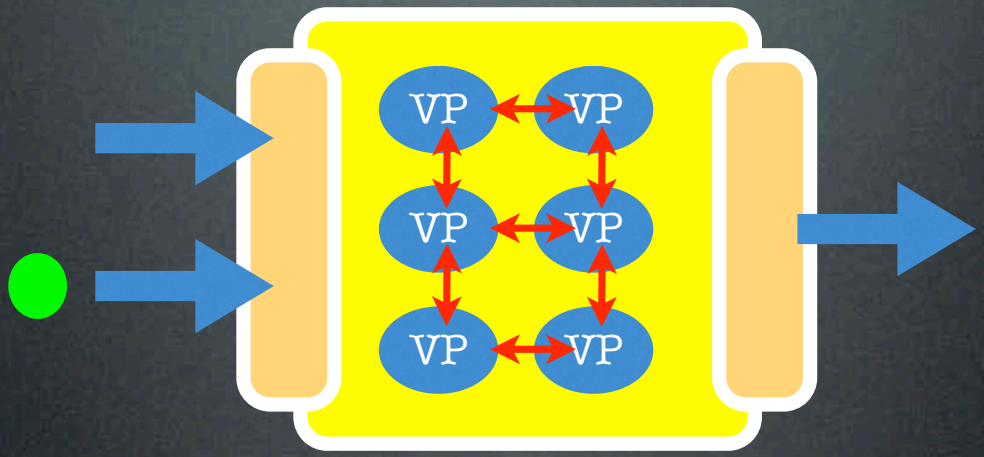

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Data items partitions are elaborated by VPs, possibly in iterative way

```
while(...)
  forall VP(in, out)
  barrier
```

data is logically shared by VPs (owner-computes)

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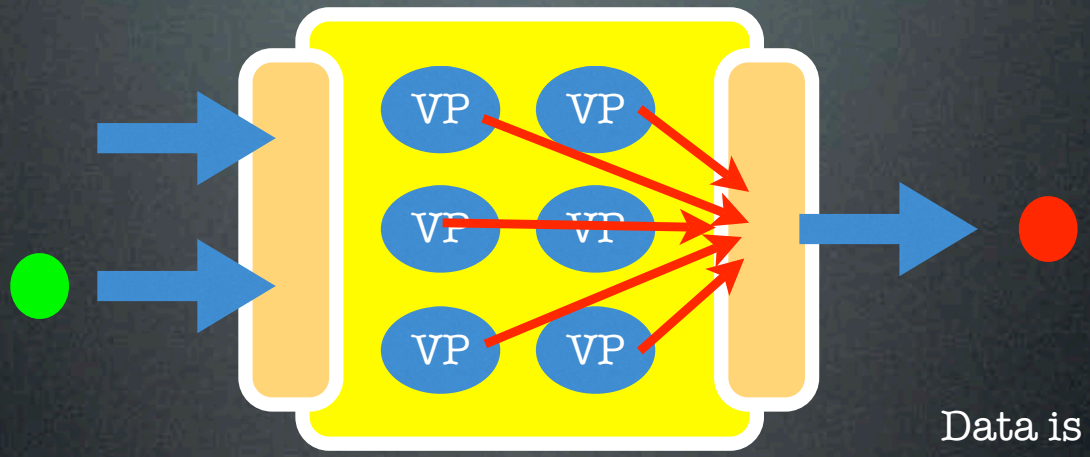

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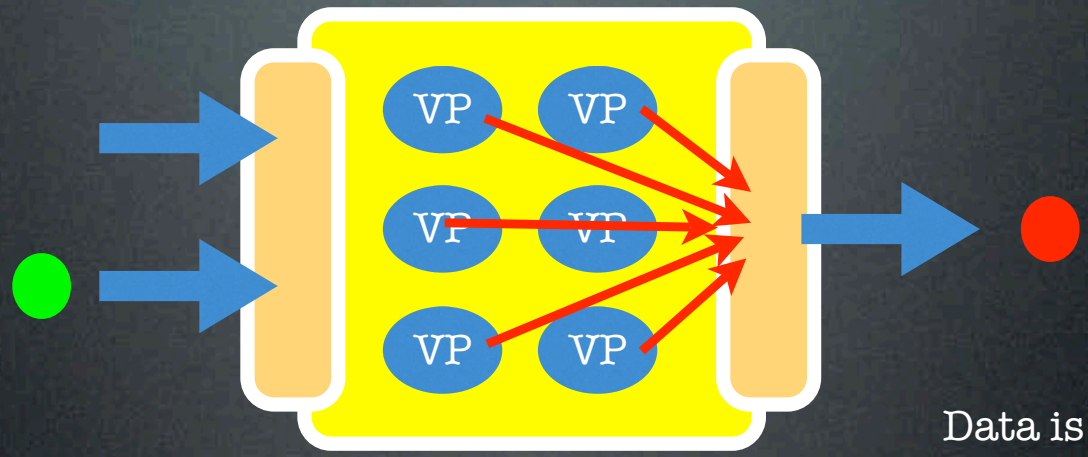

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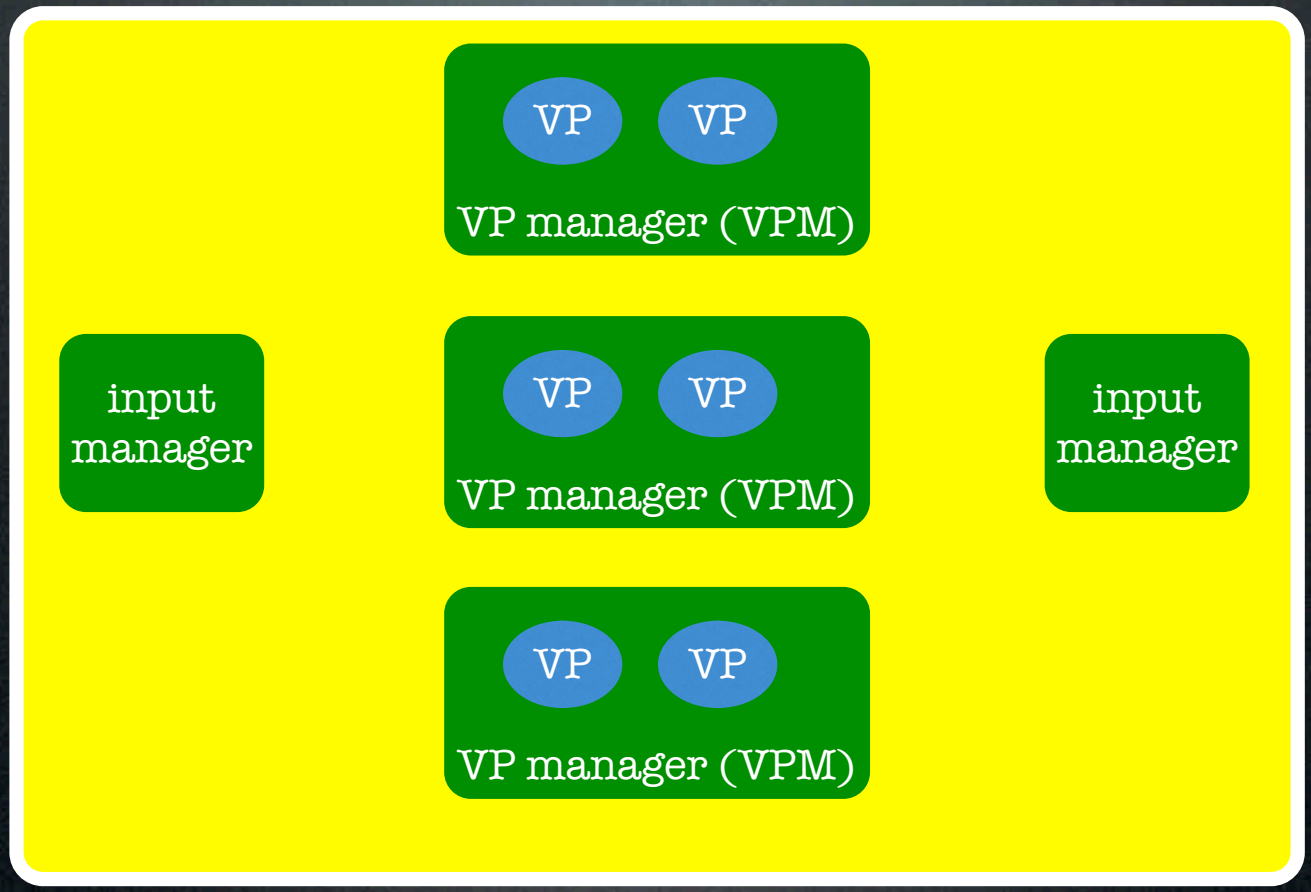
Data is eventually gathered accordingly to an user defined way

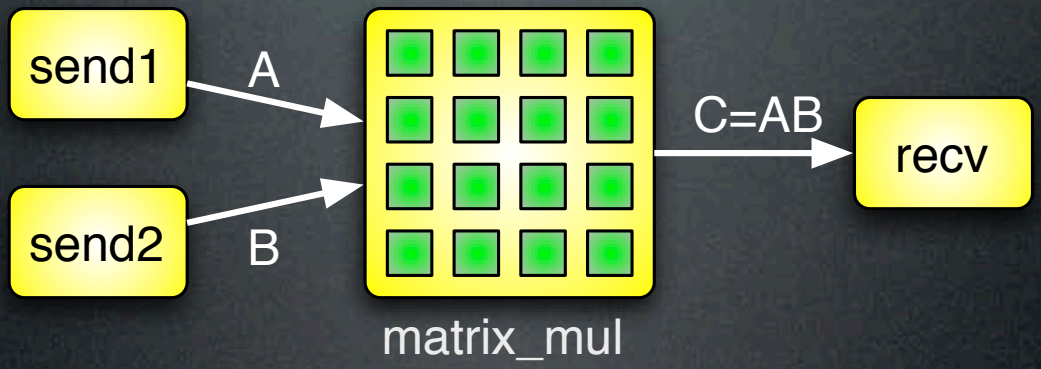
Easy to express standard paradigms (skeltons), such as **farm, deal, haloswap, map, apply-to-all, forall**, ...

parmod implementation



processes VP Virtual Processes

// matrix mul



// matrix mul

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1  parmod matrix_mul (input_stream long M1[N][N], long M2[N][N]
2                     output_stream long M3[N][N]) {
3    topology array [i:N][j:N] Pv;
4    attribute long A[N][N] scatter A[*ia][*ja] onto Pv[ia][ja];
5    attribute long B[N][N] scatter B[*ib][*jb] onto Pv[ib][jb];
6    stream long ris;
7    do input_section {
8      guard1: on , , M1 && M2 {
9        distribution M1[*i0][*j0] scatter to A[i0][j0];
10       distribution M2[*i1][*j1] scatter to B[i1][j1];
11     }   } while (true)
12   virtual_processes {
13     elab1 (in guard1 out ris) {
14       VP i, j {          f_mul (in A[i][], B[][j] output_stream ris);          }}}
15   output_section {
16     collects ris from ALL Pv[i][j] {
17       int elem; int Matrix_ris_[N][N];
18       AST_FOR_EACH(elem) {
19         Matrix_ris_[i][j]=elem;
20       }
21       assist_out(M3, Matrix_ris_);
22     }<>; } }
23 proc f_mul(in long A[N], long B[N] output_stream long Res)
24 $c++{ register long r=0;
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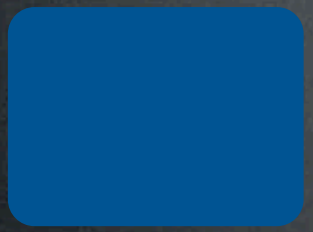
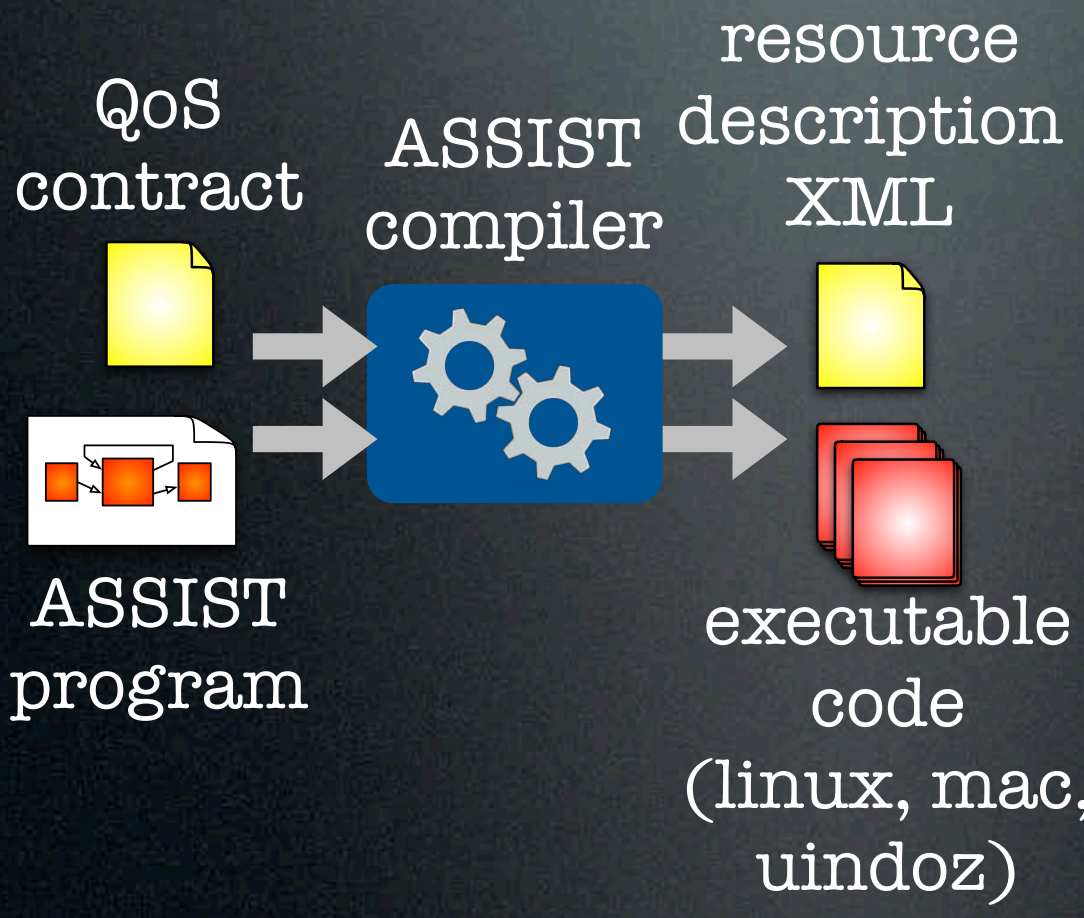
Compiling & Running

ASSIST
compiler



Compiling & Running



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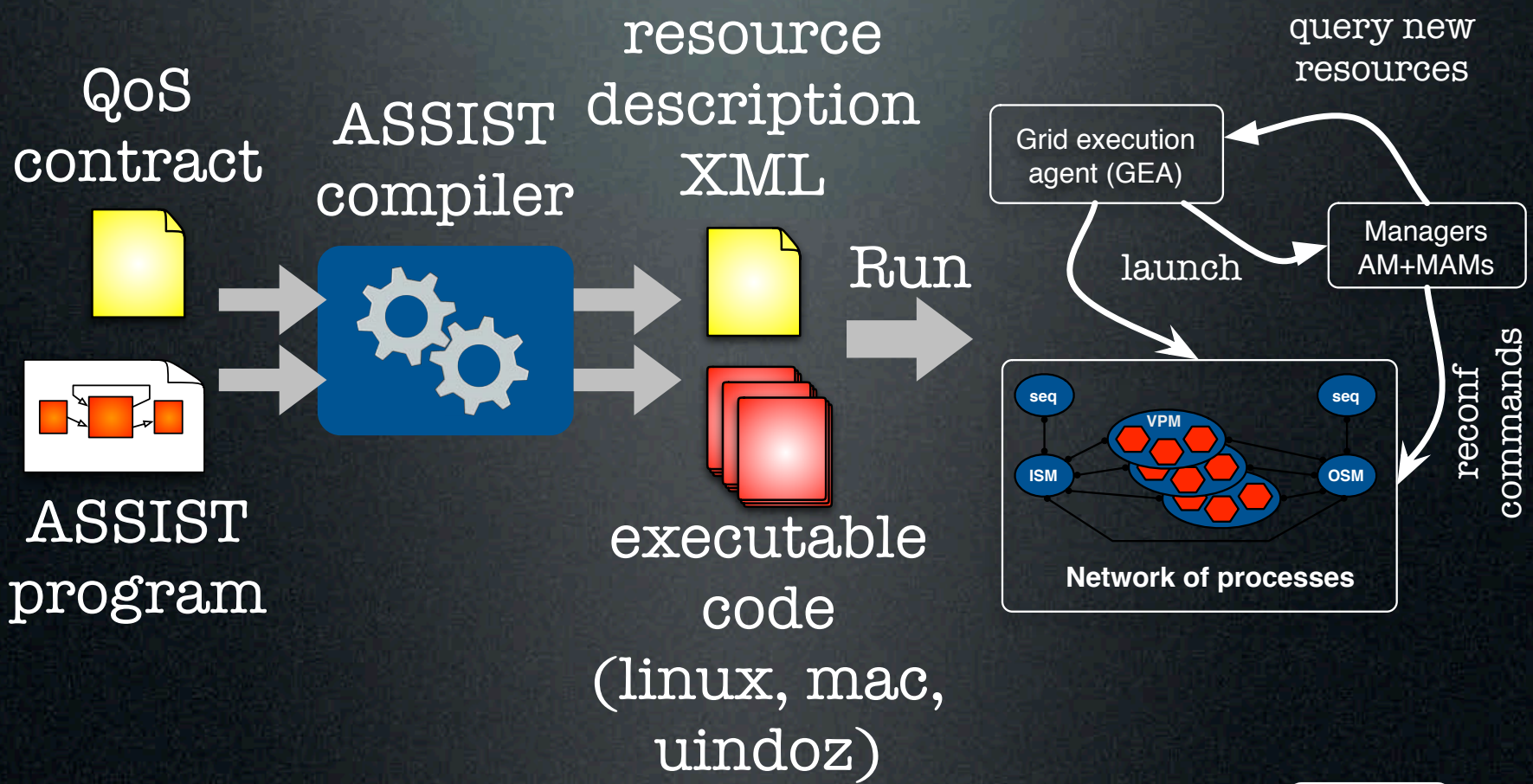
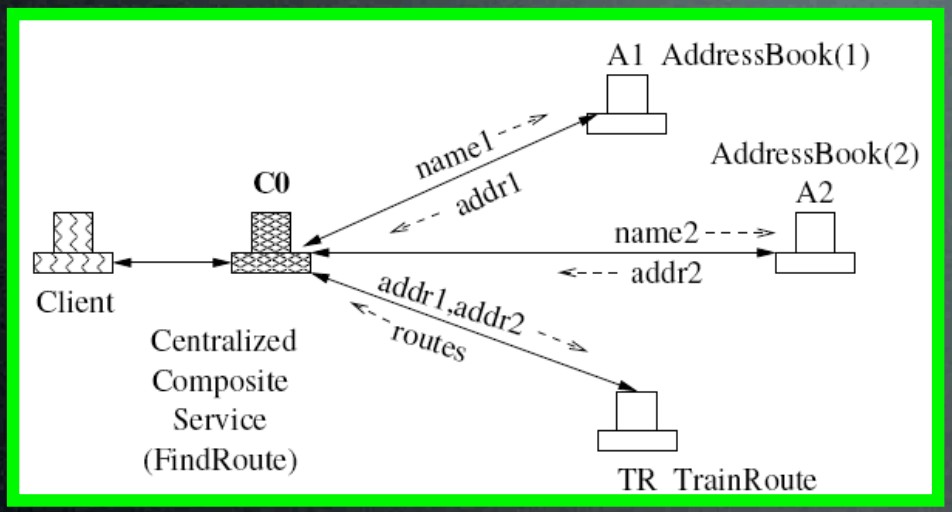


WS as transport

- ASSIST can use WS as transport for streams
- provide interoperability with standards
  - automatically generated
  - helps in dealing with firewalls
- on the whole, an ASSIST app with WS can be considered a composite service with distributed orchestration

BPEL distributed orchestration



Nanda et al. (IBM)
Decentralizing Execution
of Composite Web Services
OOPSLA 2004

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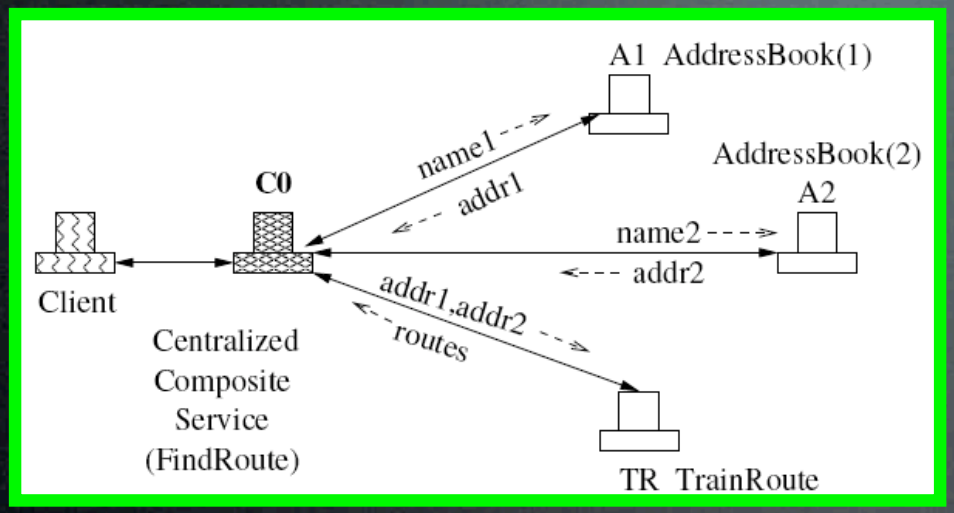

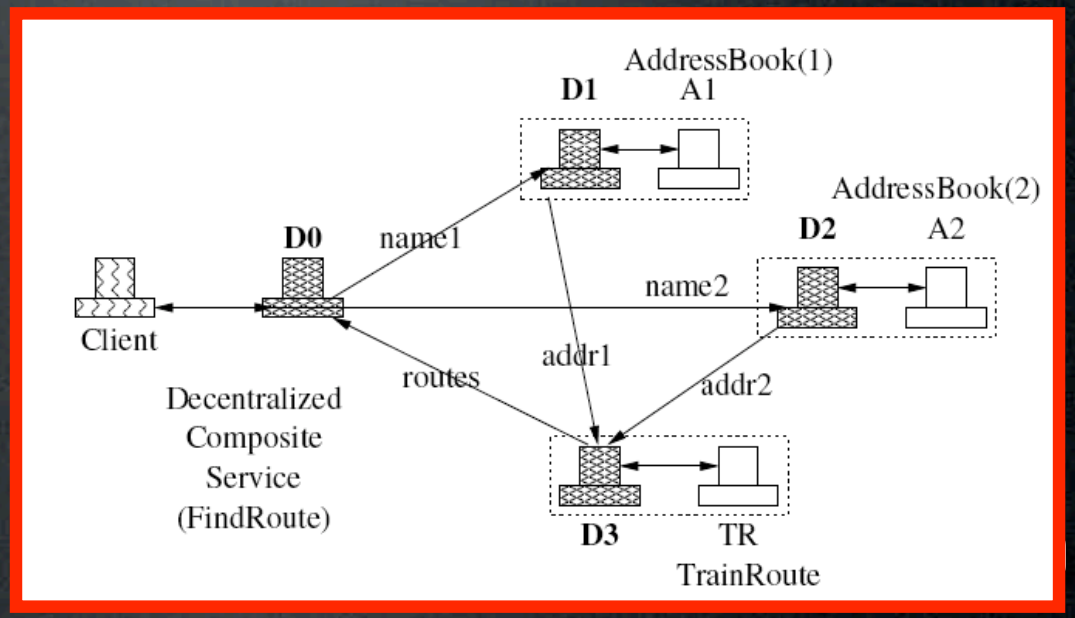

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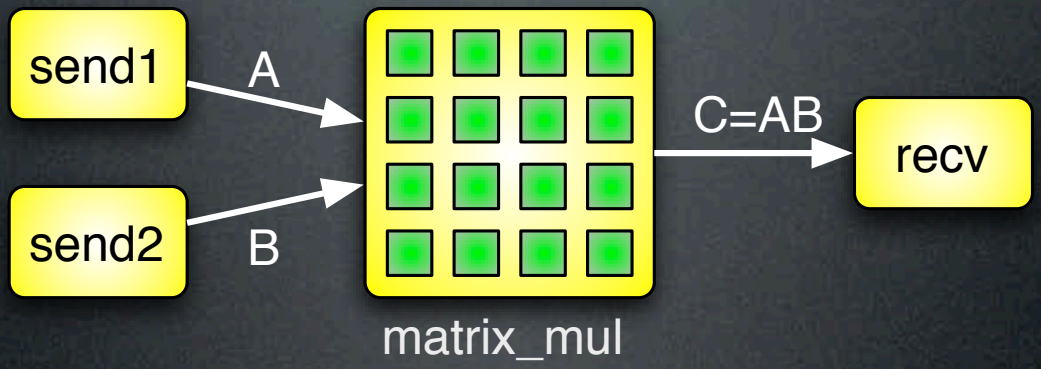
// matrix mul



WS composition

```
<ComponentConfiguration>
 <Assembly>
  <ComponentSection>
   <Component name="send1"  com="ws" kind="xml" file="./xmls/send1.xml"> </Component>
   <Component name="send2"  com="ws" kind="xml" file="./xmls/send2.xml"> </Component>
   <Component name="matrix_mul"  com="ws" kind="xml" file="./xmls/matrix_mul.xml"> </Compo
   <Component name="recv"  com="ws" kind="xml" file="./xmls/rec.xml"> </Component>
  </ComponentSection>
  <ConnectionSection>
   <Connection>
    <Output component="send1" interface="Matrix1"/>
    <Input component="matrix_mul" interface="Matrix1"/>
   </Connection>
   <Connection>
    <Output component="send2" interface="Matrix2"/>
    <Input component="matrix_mul" interface="Matrix2"/>
   </Connection>
   <Connection>
    <Output component="matrix_mul" interface="Matrix_ris"/>
    <Input component="recv" interface="Matrix"/>
   </Connection>
  </ConnectionSection>
 </Assembly>
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WS composition

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  <ComponentSection>
   <Component name="send1"  com="ws" kind="xml" file="./xmls/send1.xml"> </Component>
   <Component name="send2"  com="ws" kind="xml" file="./xmls/send2.xml"> </Component>
   <Component name="matrix_mul"  com="ws" kind="xml" file="./xmls/matrix_mul.xml"> </Compo
   <Component name="recv"  com="ws" kind="xml" file="./xmls/rec.xml"> </Component>
  </ComponentSection>
  <ConnectionSection>
   <Connection>
    <Output component="send1" interface="Matrix1"/>
    <Input component="matrix_mul" interface="Matrix1"/>
   </Connection>
   <Connection>
    <Output component="send2" interface="Matrix2"/>
    <Input component="matrix_mul" interface="Matrix2"/>
   </Connection>
   <Connection>
    <Output component="matrix_mul" interface="Matrix_ris"/>
    <Input component="recv" interface="Matrix"/>
   </Connection>
  </ConnectionSection>
 </Assembly>
</ComponentConfiguration>
```
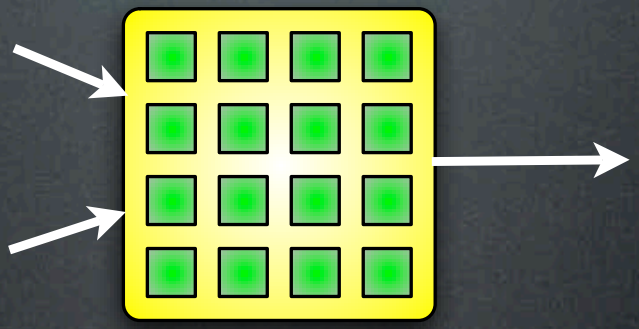
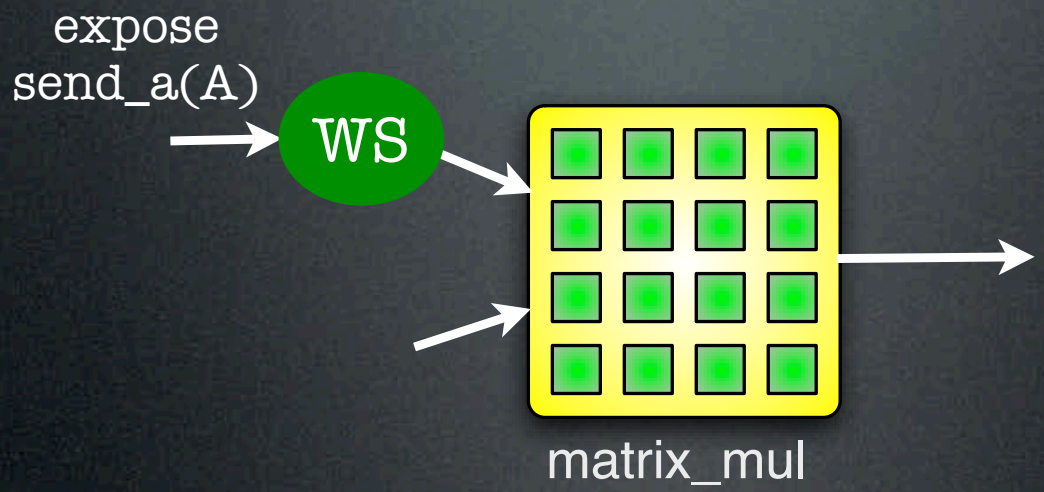

WS composition

```
<ComponentConfiguration>
 <Assembly>
  <ComponentSection>
   <Component name="send1"  com="ws" kind="xml" file="./xmls/send1.xml"> </Component>
   <Component name="send2"  com="ws" kind="xml" file="./xmls/send2.xml"> </Component>
   <Component name="matrix_mul"  com="ws" kind="xml" file="./xmls/matrix_mul.xml"> </Compo
   <Component name="recv"  com="ws" kind="xml" file="./xmls/rec.xml"> </Component>
  </ComponentSection>
  <ConnectionSection>
   <Connection>
    <Output component="send1" interface="Matrix1"/>
    <Input component="matrix_mul" interface="Matrix1"/>
   </Connection>
   <Connection>
    <Output component="send2" interface="Matrix2"/>
    <Input component="matrix_mul" interface="Matrix2"/>
   </Connection>
   <Connection>
    <Output component="matrix_mul" interface="Matrix_ris"/>
    <Input component="recv" interface="Matrix"/>
   </Connection>
  </ConnectionSection>
 </Assembly>
</ComponentConfiguration>
```

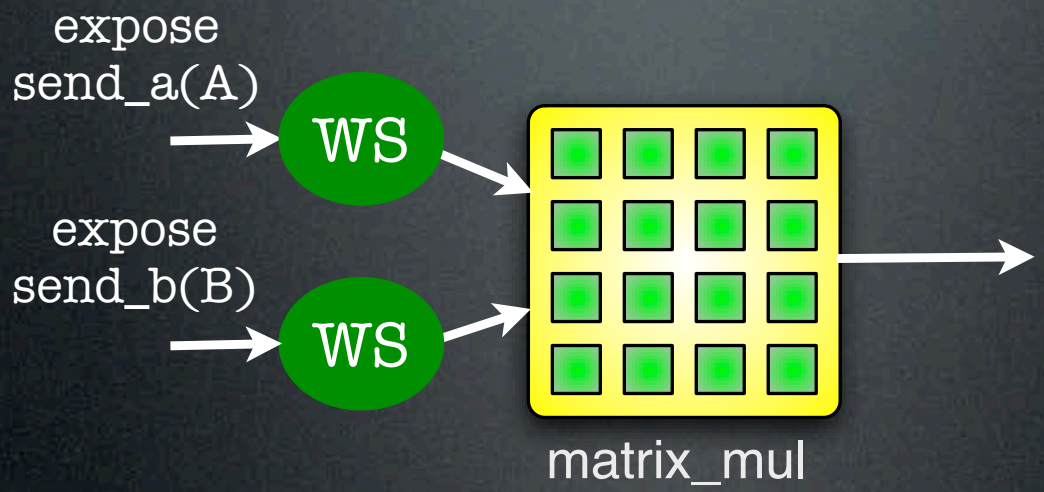
Generating WS



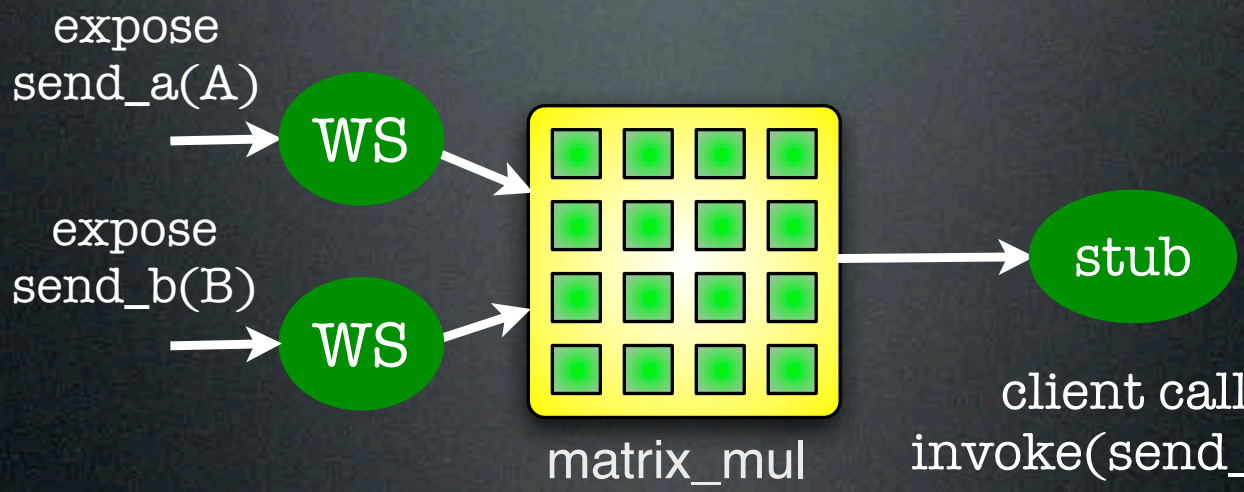
Generating WS



Generating WS



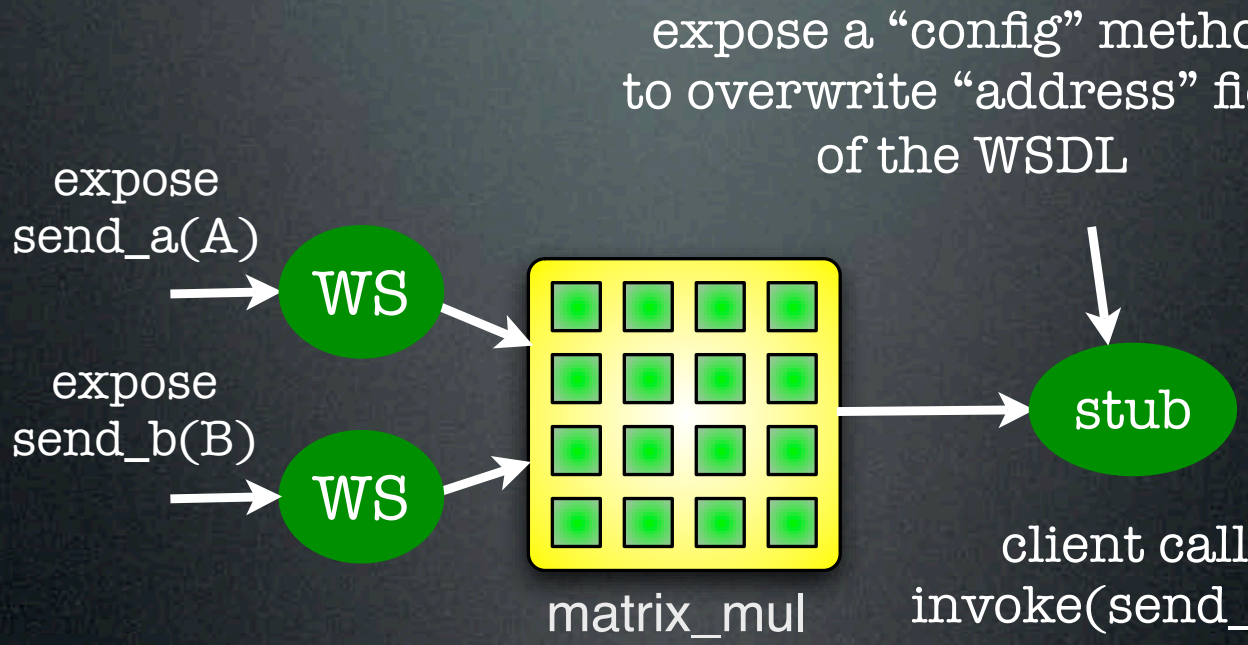
Generating WS



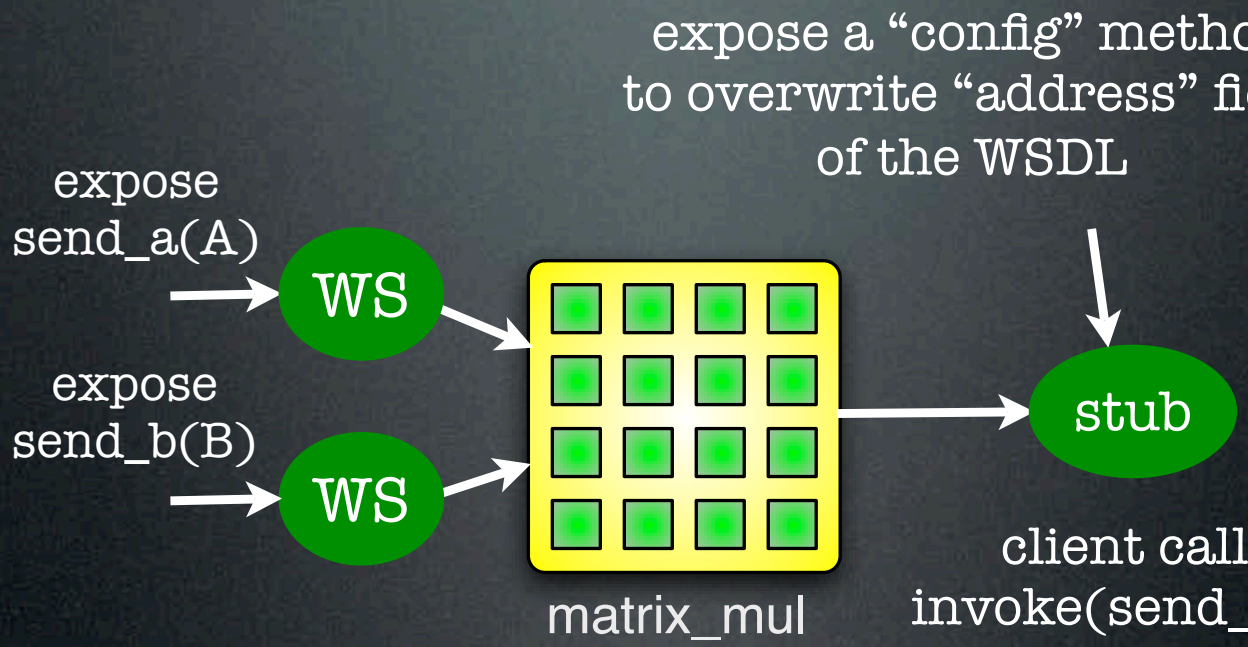
client calling
invoke(send_x(X)),
where X is decided
at wiring time

generated at wiring time
starting from the WSDL of X

Generating WS



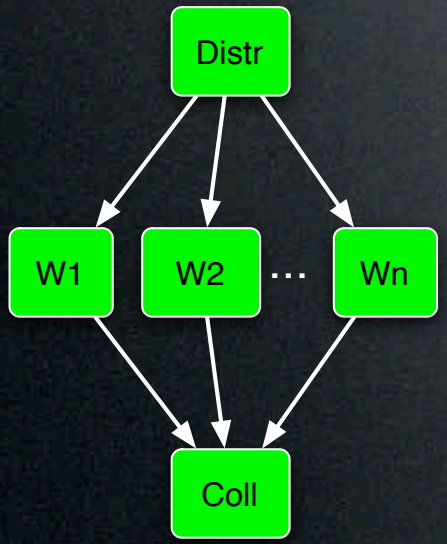
Generating WS



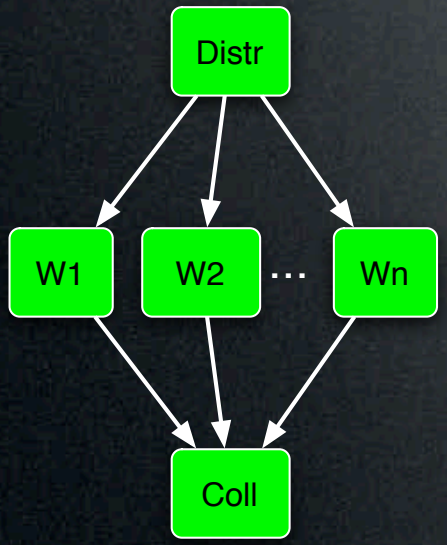
WS are implemented by means of gSOAP embedded server

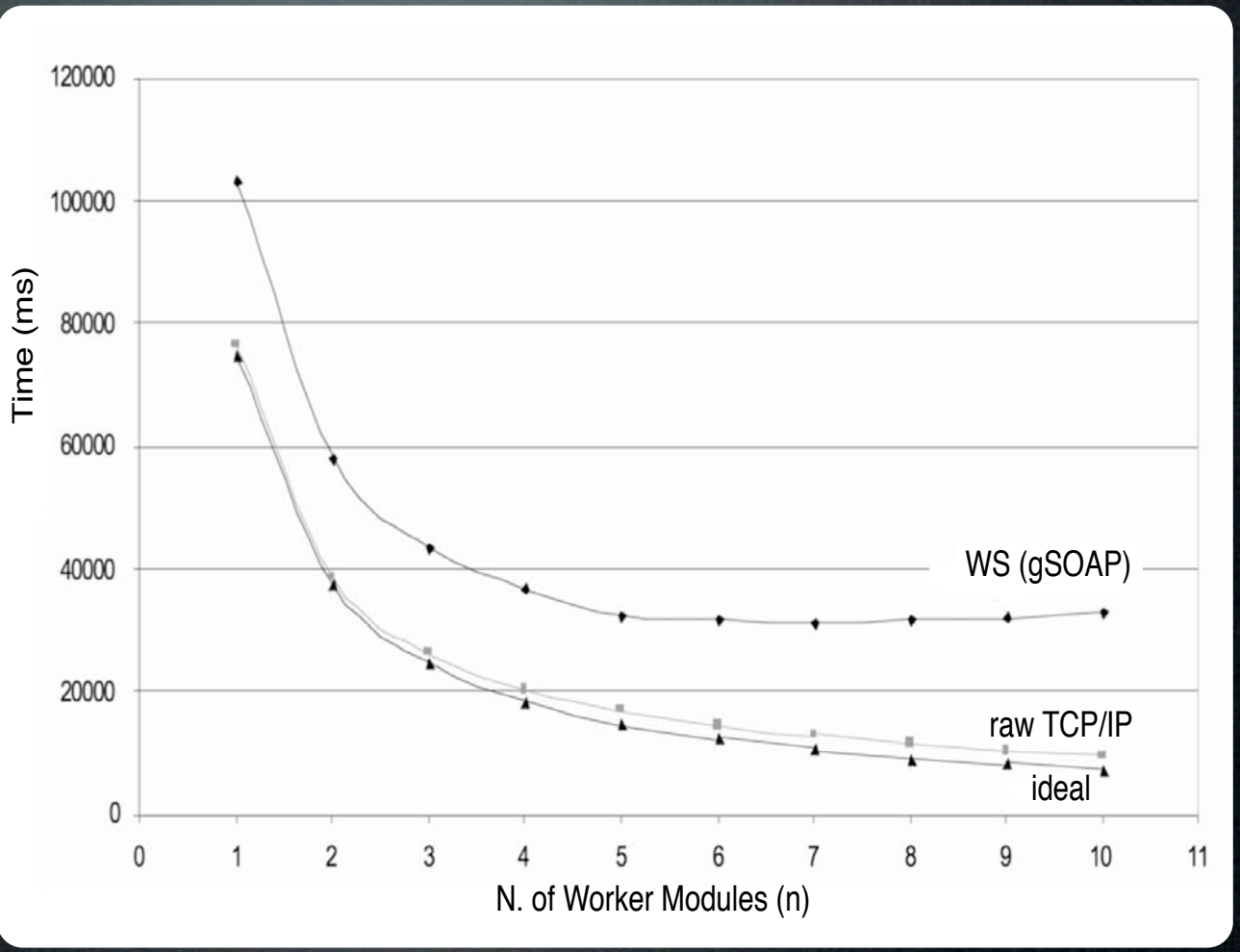
generated at wiring time starting from the WSDL of X

A simple farm with WS

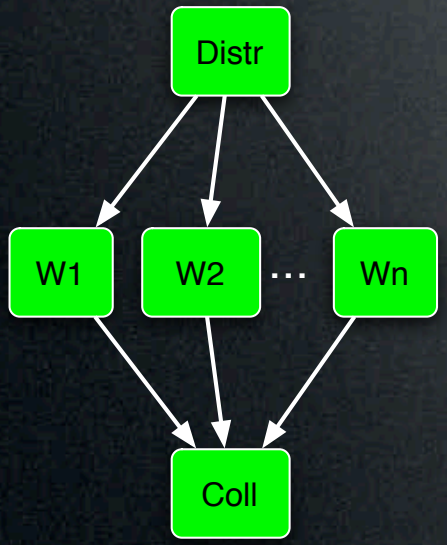


A simple farm with WS

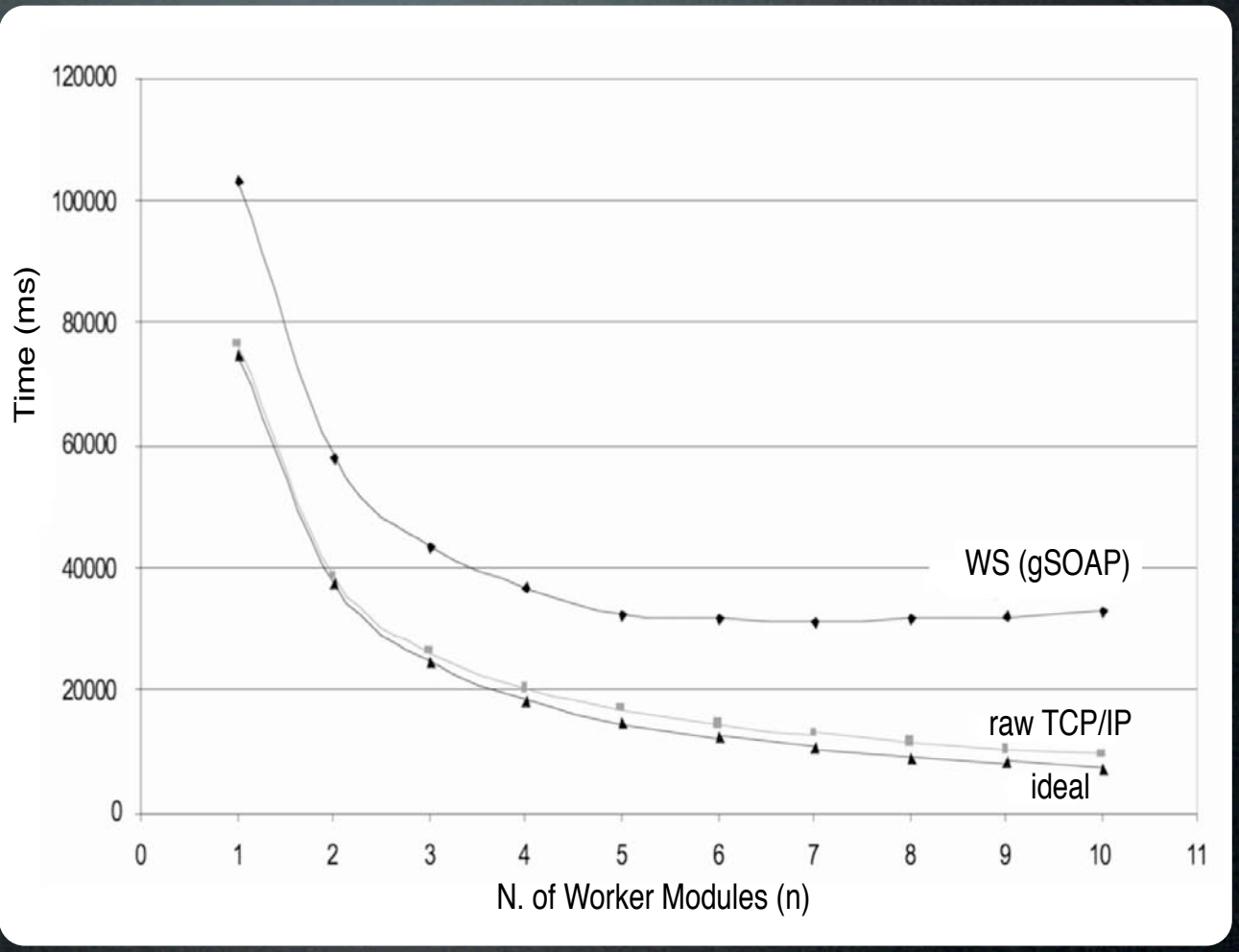




A simple farm with WS



30-50% communication slowdown



Composite WS & ASSIST

- Differently from BPEL, we start from the graph
- not a big deal, however not fully compliant with pragmatic approach to WS
  - we also would like to provide full interoperability with RPC WS

ASSIST & components

- moving towards component approach
- an ASSIST module of a graph of them may be defined as Grid.it component
  - stream ports (use/provide)
  - RPC ports (use/provide)
- component wiring through ASSIST native, HTTP/SOAP, IIOP/CORBA (for CCM components)

By the way ...

By the way ...

- is a WS a component?
  - following the Szyperski's definition

By the way ...

- is a WS a component?
  - following the Szyperski's definition
- Dennis Gannon said yes!
  - Europar 2004 invited talk
  - we also believe that

Euro-Par, Pisa 2004

BUILDING GRID APPLICATIONS AND PORTALS:
An Approach Based on Components, Web Services and Workflow Tools.

D. Gannon, B. Plale
Ph.D. Students: S. Krishnan, L. Fang, G. Kandaswamy, Y. Simmhan,
A. Slominski
Indiana University

CCA components as Web Services

- A natural extension of the model:
  - Each Provides port can be a complete web service
  - Uses ports become web service "client stubs".
- A Connection is then a binding between a client stub and the WSDL for the some provides port.
- XCAT3 implements this feature.
  - Uses python as the scripting language.
- Also based on the OGSI standard.

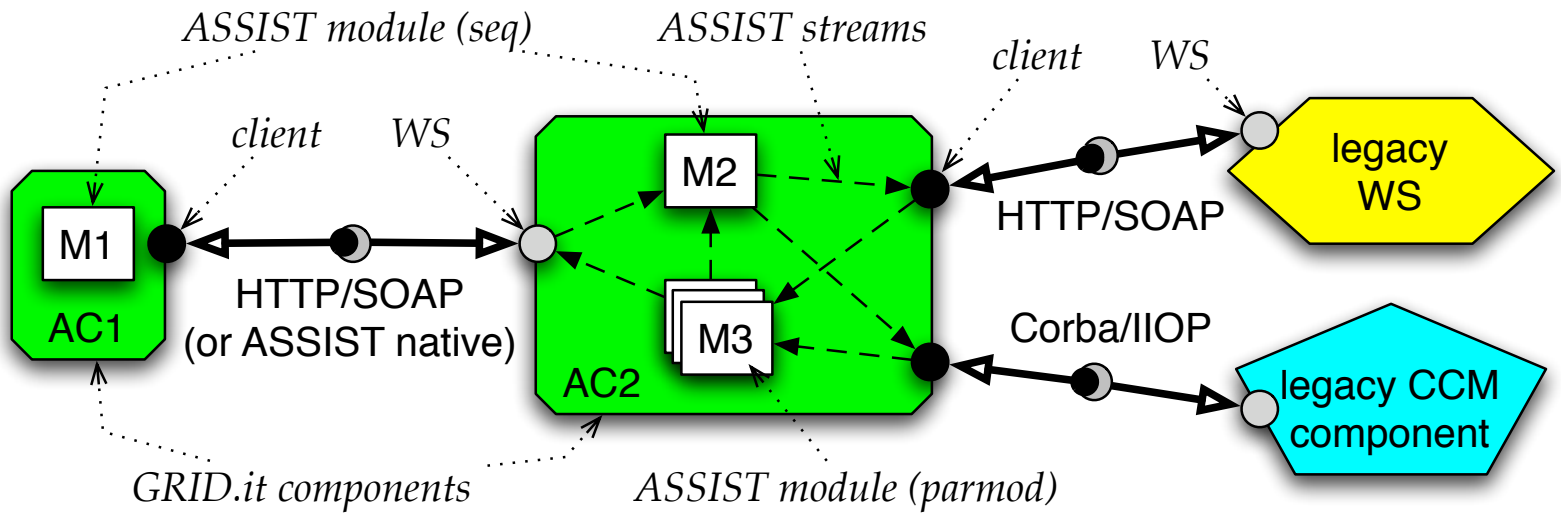
Web Services as CCA components

- Can we use the Google web service as a CCA component?
- Message oriented and not RCP based.
  - Send a message to the service
    - You may get a response or you may not.
      - Depends upon the service semantics.
- No concept of "uses port".
  - However some serves generate messages in response to messages sent.
  - Web service addressing allows a reply to be forwarded to a "3rd party" receiver.

Predicting Severe Storms

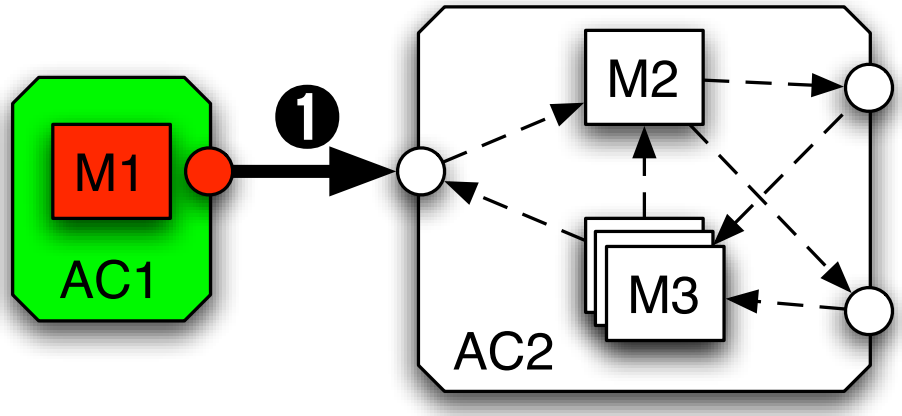
- To deliver better than real-time predictions
  - Data mining of live instrument streams and historical storm metadata
  - Requisition large computational resources on demand to start a large number of simulations
    - Mine simulation outputs to see which track real storm evolution.
    - Refine scenarios that match incoming data.
  - May Need to requisition bandwidth to make the needed data analysis possible.
  - May require real-time re-alignment of instruments.
  - Workflows may run for a long time and they must be adaptive and very dynamic

Components: the big picture



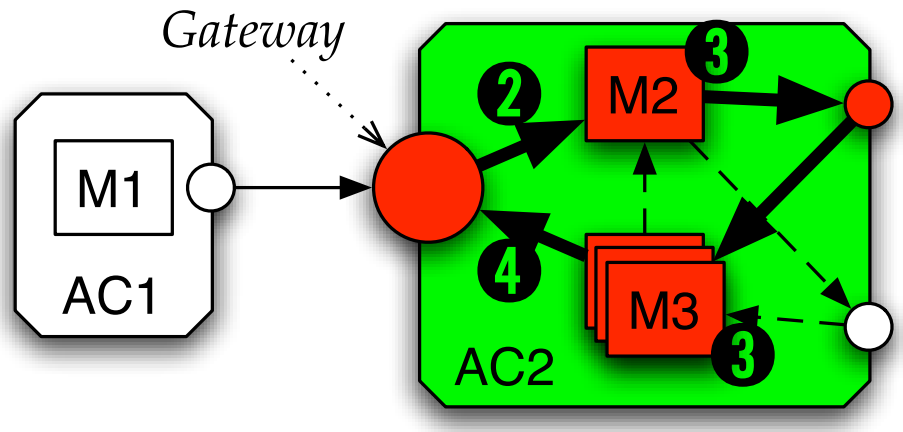
Components: the big picture

❶ A method invocation arrives to RPC provide port of AC2



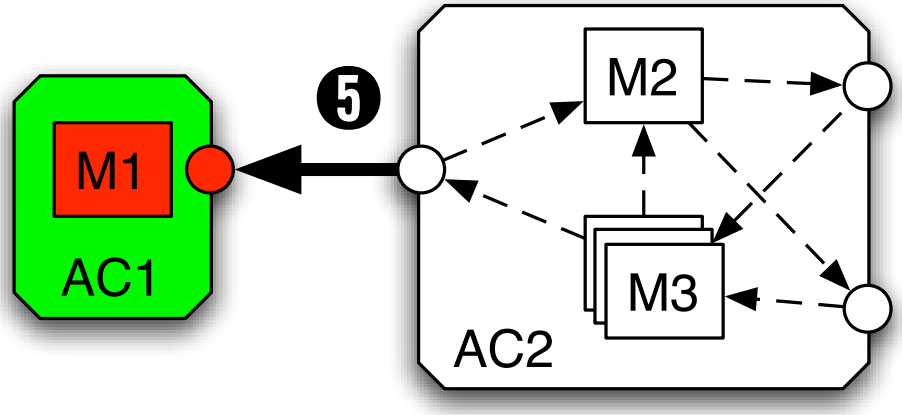
Components: the big picture

1. A method invocation arrives to RPC provide port of AC2
2. Parameters are injected in a input stream together with an unique id
3. Computation is performed
4. As soon as a matching id arrive to the same port a reply message is prepared



Components: the big picture

1. A method invocation arrives to RPC provide port of AC2
2. Parameters are injected in a input stream together with an unique id
3. Computation is performed
4. As soon as a matching id arrive to the same port a reply message is prepared
5. The method invocation is finalized with a result message



Conclusions

- WS extension is not rocket science, but being compliant to standards may make the difference for real applications
- ASSIST provide high-level programming for grid
  - dynamic adaptivity, autonomic QoS control, fault-tolerance (ongoing), ... and this is rocket science
- interoperability with WS & CCM
  - transparent to the programmer, automatic generation of the needed adaptors
  - distributed orchestration of workflows
  - the run-time exploits standard middleware (POSIX/TCP, Globus, ...), it provide to the programmer higher-level view of it

Thank you

The ASSIST programming toolkit has been designed at the University of Pisa, Italy ...