Building Interoperable Grid-aware ASSIST Applications via Web Services

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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

“... 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?

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, ...
// progr. & the grid

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• manage resources heterogeneity and unreliability, networks latency and bandwidth unsteadiness, resources topology and availability changes, firewalls, private networks, reservation and jobs schedulers, ...

... and a non trivial QoS for applications
// progr. & the grid

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- manage resources heterogeneity and unreliability, networks latency and bandwidth unsteadiness, resources topology and availability changes, firewalls, private networks, reservation and jobs schedulers,

... 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
app = graph of modules
app = graph of modules

Programmable, possibly nondeterministic input behaviour

input

Sequential or parallel module

Typed streams of data items

output
native + standard

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

TCP/IP, Globus, IIOP CORBA, HTTP/SOAP
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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Data items can be distributed (scattered, broadcasted, multicasted) to a set of Virtual Processes which are named accordingly to a topology.

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

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

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

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

data is logically shared by VPs (owner-computes)

Data is eventually gathered accordingly to an user defined way.
An “input section” can be programmed in a CSP-like way.

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

Data items partitions are elaborated by VPs, possibly in an iterative way while(...)

forall VP(in, out) barrier

data is logically shared by VPs (owner-computes)

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

input manager

VP manager (VPM)

input manager

VP manager (VPM)

VP manager (VPM)

processes

VP Virtual Processes
// matrix mul

send1
A
send2
B
C = AB
matrix_mul
recv
// matrix mul

1 paramd 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 {
15                f_mul (in A[i][], B[][j] output_stream ris);
16            }
17            output_section {
18                collects ris from ALL Pv[i][j] {
19                    int elem; int Matrix_ris_[N][N];
20                    AST_FOR_EACH(elem) {
21                        Matrix_ris_[i][j]=elem;
22                    }
23                    assist_out(M3, Matrix_ris_);
24                }
26            $c++{
27                register long r=0;
28                for (register int k=0; k<N; ++k)
29                    r += A[k]*B[k];
30                assist_out(Res,r); }c++$
parmod matrix_mul (input_stream long M1[N][N], long M2[N][N]
output_stream long M3[N][N]) {

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attribute long B[N][N] scatter B[*ib][*jb] onto Pv[ib][jb];

stream long ris;

do input_section {
    guard1: on , , M1 && M2 {
        distribution M1[*i0][*j0] scatter to A[i0][j0];
        distribution M2[*i1][*j1] scatter to B[i1][j1];
    }
}

virtual_processes {
    elab1 (in guard1 out ris) {
        VP i, j {
            f_mul (in A[i][] , B[][j] output_stream ris);
        }
    }

output_section {
    collects ris from ALL Pv[i][j] {
        int elem; int Matrix_ris_[N][N];
        AST_FOR_EACH(elem) {
            Matrix_ris_[i][j]=elem;
        }
        assist_out(M3, Matrix_ris_);
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parmod matrix_mul (input_stream long M1[N][N], long M2[N][N]
output_stream long M3[N][N]) {
topology array [i:N][j:N] Pv;
attribute long A[N][N] scatter A[i1][j1] onto Pv[i1][j1];
attribute long B[N][N] scatter B[i2][j2] onto Pv[i2][j2];
stream long ris;
do input_section {
  guard1: on , , M1 && M2 {
    distribution M1[i0][j0] scatter to A[i0][j0];
    distribution M2[i1][j1] scatter to B[i1][j1];
  } } while (true)
virtual_processes {
elab1 (in guard1 out ris) {
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    f_mul (in A[i][j], B[i][j] output_stream ris); }
}}
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attribute long B[N][N] scatter B[*ib][*jb] onto Pv[ib][jb];
stream long ris;
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        distribution M1[*i0][*j0] scatter to A[i0][j0];
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    } } while (true)
    virtual_processes {
        elab1 (in guard1 out ris) {
            VP i, j {
                f_mul (in A[i[]], B[j][] output_stream ris);
            }}}
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// matrix_mul

parmod matrix_mul (input_stream long M1[N][N], long M2[N][N]
output_stream long M3[N][N]) {

topology array [i:N][j:N] P;
attribute long A[N][N] scatter A[*ia][*ja] onto Pv[ia][ja];
attribute long B[N][N] scatter B[*ib][*jb] onto Pv[ib][jb];
stream long ris;
do input_section {
  guard1: on , , M1 && M2 {
    distribution M1[*i0][*j0] scatter to A[i0][j0];
    distribution M2[*i1][*j1] scatter to B[i1][j1];
  } } while (true)
virtual_processes {
elab1 (in guard1 out ris) {
  VP i, j { f_mul (in A[i[]], B[][j] output_stream ris);
}}
output_section {
  collects ris from ALL P[i][j] {
    int elem; int Matrix_ris[N][N];
    AST_FOR_EACH(elem) {
      Matrix_ris[i][j]=elem;
    }
    assist_out(M3, Matrix_ris_);
  }
}
$c++$ { register long r=0;
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Compiling & Running

ASSIST compiler
Compiling & Running

QoS contract

ASSIST compiler

resource description

XML

ASSIST program

executable code
(linux, mac, uindoz)
Compiling & Running

QoS contract

ASSIST compiler

resource description

XML

executable code

(linux, mac, windows)

Run

query new resources

launch

reconf commands

Grid execution agent (GEA)

Managers AM+MAMs

Network of processes
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
BPEL distributed orchestration

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

send1

send2

recv

matrix_mul

A

B

C = AB
<ComponentConfiguration>
  <Assembly>
    <ComponentSection>
      <Component name="send1" com="ws" kind="xml" file="./xmls/send1.xml"/>
      <Component name="send2" com="ws" kind="xml" file="./xmls/send2.xml"/>
      <Component name="matrix_mul" com="ws" kind="xml" file="./xmls/matrix_mul.xml"/>
      <Component name="recv" com="ws" kind="xml" file="./xmls/rec.xml"/>
    </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>
<ComponentConfiguration>
  <Assembly>
    <ComponentSection>
      <Component name="send1" com="ws" kind="xml" file="/xmlns/send1.xml"/>
      <Component name="send2" com="ws" kind="xml" file="/xmlns/send2.xml"/>
      <Component name="matrix_mul" com="ws" kind="xml" file="/xmlns/matrix_mul.xml"/>
      <Component name="recv" com="ws" kind="xml" file="/xmlns/recv.xml"/>
    </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>
<ComponentConfiguration>
   <Assembly>
      <ComponentSection>
         <Component name="send1" com="ws" kind="xml" file="/xmls/send1.xml"/>
         <Component name="send2" com="ws" kind="xml" file="/xmls/send2.xml"/>
         <Component name="matrix_mul" com="ws" kind="xml" file="/xmls/matrix_mul.xml"/>
         <Component name="recv" com="ws" kind="xml" file="/xmls/recv.xml"/>
      </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>
<ComponentConfiguration>
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      <Component name="send1" com="ws" kind="xml" file="/xmls/send1.xml"/>
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    </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

matrix_mul
Generating WS

expose
send_a(A)

WS

matrix_mul
Generating WS

expose
send_a(A)

WS

expose
send_b(B)

WS

matrix_mul
Generating WS

expose send_a(A)

expose send_b(B)

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

expose a “config” method to overwrite “address” field of the WSDL

expose send_a(A)
expose send_b(B)

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

WS are implemented by means of gSOAP embedded server

expose send_a(A)

expose send_b(B)

expose a “config” method to overwrite “address” field of the WSDL

client calling

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

generated at wiring time starting from the WSDL of X

WS are implemented by means of gSOAP embedded server
A simple farm with WS
A simple farm with WS
A simple farm with WS

30-50% communication slowdown

N. of Worker Modules (n)
Time (ms)

WS (gSOAP)
raw TCP/IP
ideal

[Graph showing communication slowdown with labeled axes]
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
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. Słominski
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 co-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

1 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 ...