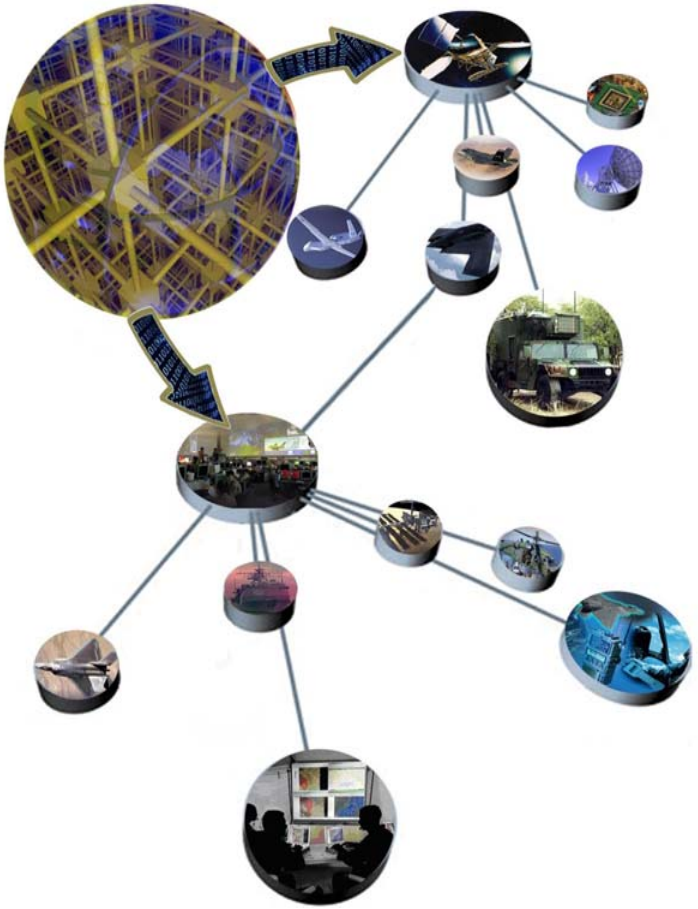
A Grid-of-Grids Service Architecture for Net-Centric Operations



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Ground System Architectures Workshop

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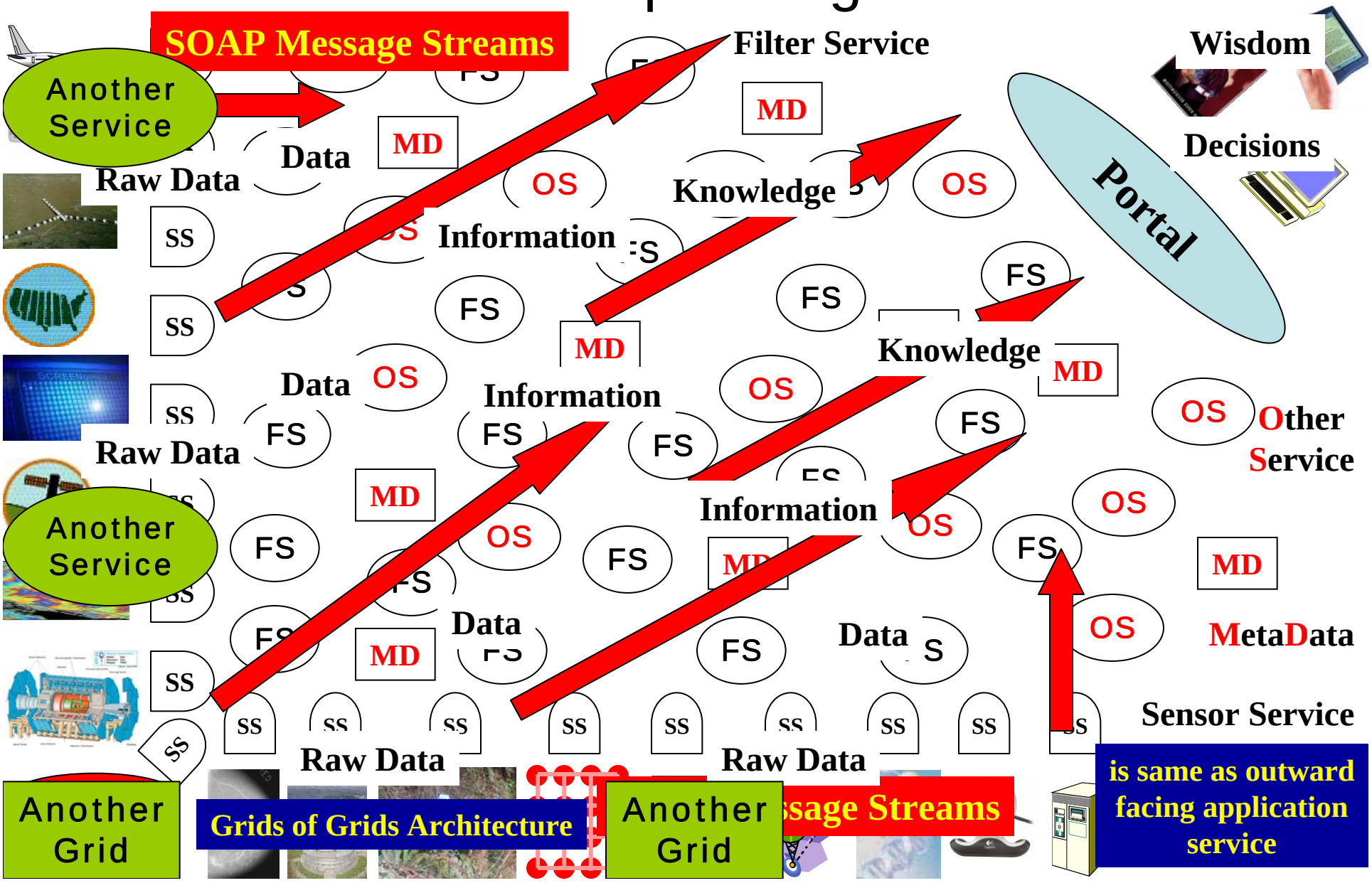
Semantically Rich Services with a Semantically Rich Distributed Operating Environment



Why are Grids Important

- Here we use Grid as in "Global Grid Forum" and apply to Grids as in "Global Information Grid"
  - Distributed Internet scale Managed Services
- Grids are important for DoD because they more or less directly address DoD's problem and have made major progress in the core infrastructure that DoD has identified rather qualitatively
- Grids are important to distributed simulation because they address all the distributed systems issues except simulation and in any sophisticated distributed simulation package, most of the software is not to do with simulation but rather the issues Grids address
- DoD and Distributed Simulation communities need to use technology that industry will support and enhance

Different Visions of the Grid

- Grid just refers to the technologies
  - Or Grids represent the full system/Applications
- DoD's vision of Network Centric Computing can be considered a Grid (linking sensors, warfighters, commanders, backend resources) and they are building the GiG (Global Information Grid)
- Utility Computing or X-on-demand (X=data, computer ..) is major computer Industry interest in Grids and this is key part of enterprise or campus Grids
- e-Science or Cyberinfrastructure are virtual organization Grids supporting global distributed science (note sensors, instruments are people are all distributed
- Skype (Kazaa) VOIP system is a Peer-to-peer Grid (and VRVS/GlobalMMCS like Internet A/V conferencing are Collaboration Grids)
- Commercial 3G Cell-phones and DoD ad-hoc network initiative are forming mobile Grids

Philosophy of Web Service Grids

- Much of Distributed Computing was built by natural extensions of computing models developed for sequential machines
- This leads to the distributed object (DO) model represented by Java and CORBA
  - RPC (Remote Procedure Call) or RMI (Remote Method Invocation) for Java
- Key people think this is not a good idea as it scales badly and ties distributed entities together too tightly
  - Distributed Objects Replaced by Services
- Note CORBA was considered too complicated in both organization and proposed infrastructure
  - and Java was considered as "tightly coupled to Sun"
  - So there were other reasons to discard
- Thus replace distributed objects by services connected by "one-way" messages and not by request-response messages

The Grid and Web Service Institutional Hierarchy

4: Application or Community of Interest Specific Services such as “Run BLAST” or “Look at Houses for sale”	
3: Generally Useful Services and Features Such as “Access a Database” or “Submit a Job” or “Manage Cluster” or “Support a Portal” or “Collaborative Visualization”	**OGSA GS-* and some WS-* GGF/W3C/….**
2: System Services and Features Handlers like WS-RM, Security, Programming Models like BPEL or Registries like UDDI	**WS-* from OASIS/W3C/ Industry**
1: Container and Run Time (Hosting) Environment	**Apache Axis .NET etc.**

Must set standards to get interoperability

The Ten areas covered by the 60 core WS-* Specifications

WS-* Specification Area	Examples
1: Core Service Model	XML, WSDL, SOAP
2: Service Internet	WS-Addressing, WS-MessageDelivery; Reliable Messaging WSRM; Efficient Messaging MOTM
3: Notification	WS-Notification, WS-Eventing (Publish-Subscribe)
4: Workflow and Transactions	BPEL, WS-Choreography, WS-Coordination
5: Security	WS-Security, WS-Trust, WS-Federation, SAML, WS-SecureConversation
6: Service Discovery	UDDI, WS-Discovery
7: System Metadata and State	WSRF, WS-MetadataExchange, WS-Context
8: Management	WSDM, WS-Management, WS-Transfer
9: Policy and Agreements	WS-Policy, WS-Agreement
10: Portals and User Interfaces	WSRP (Remote Portlets)

RTI and NCOW needs all of these?

Activities in Global Grid Forum Working Groups

GGF Area	GS-* and OGSA Standards Activities
1: Architecture	High Level Resource/Service Naming (level 2 of fig. 1), Integrated Grid Architecture
2: Applications	Software Interfaces to Grid, Grid Remote Procedure Call, Checkpointing and Recovery, Interoperability to Job Submittal services, Information Retrieval,
3: Compute	Job Submission, Basic Execution Services, Service Level Agreements for Resource use and reservation, Distributed Scheduling
4: Data	Database and File Grid access, Grid FTP, Storage Management, Data replication, Binary data specification and interface, High-level publish/subscribe, Transaction management
5: Infrastructure	Network measurements, Role of IPv6 and high performance networking, Data transport
6: Management	Resource/Service configuration, deployment and lifetime, Usage records and access, Grid economy model
7: Security	Authorization, P2P and Firewall Issues, Trusted Computing

RTI and NCOW needs all of these?

The Global Information Grid Core Enterprise Services

Core Enterprise Services	Service Functionality
CES1: Enterprise Services Management (ESM)	including life-cycle management
CES2: Information Assurance (IA)/Security	Supports confidentiality, integrity and availability. Implies reliability and autonomic features
CES3: Messaging	Synchronous or asynchronous cases
CES4: Discovery	Searching data and services
CES5: Mediation	Includes translation, aggregation, integration, correlation, fusion, brokering publication, and other transformations for services and data. Possibly agents
CES6: Collaboration	Provision and control of sharing with emphasis on synchronous real-time services
CES7: User Assistance	Includes automated and manual methods of optimizing the user GiG experience (user agent)
CES8: Storage	Retention, organization and disposition of all forms of data
CES9: Application	Provisioning, operations and maintenance of applications.

Some Conclusions I

- One can map 7.5 out of 9 NCOW and GiG core capabilities into Web Service (WS-*) and Grid (GS-*) architecture and core services
  - Analysis of Grids in NCOW document inaccurate (confuse Grids and Globus and only consider early activities)
- Some "mismatches" on both NCOW and Grid sides
- GS-*/WS-* do not have collaboration and miss some messaging
- NCOW does not have at core level system metadata and resource/service scheduling and matching
- Higher level services of importance include GIS (Geographical Information Systems), Sensors and data-mining

Some Conclusions II

- **Criticisms of Web services in a recent paper by Birman seem to be addressed by Grids or reflect immaturity of initial technology implementations**
- **NCOW does not seem to have any analysis of how to build their systems on WS-*/GS-* technologies in a layered fashion; they do have a layered service architecture so this can be done**
  - **They agree with service oriented architecture**
  - **They seem to have no process for agreeing to WS-* GS-* or setting other standards for CES**
- **Grid of Grids allows modular architectures and natural treatment of legacy systems**
  - **Note Grids, Services and Handlers are all "just" entities with distributed message-based input and output interfaces**

DoD Core Services and WS-* plus GS-* I

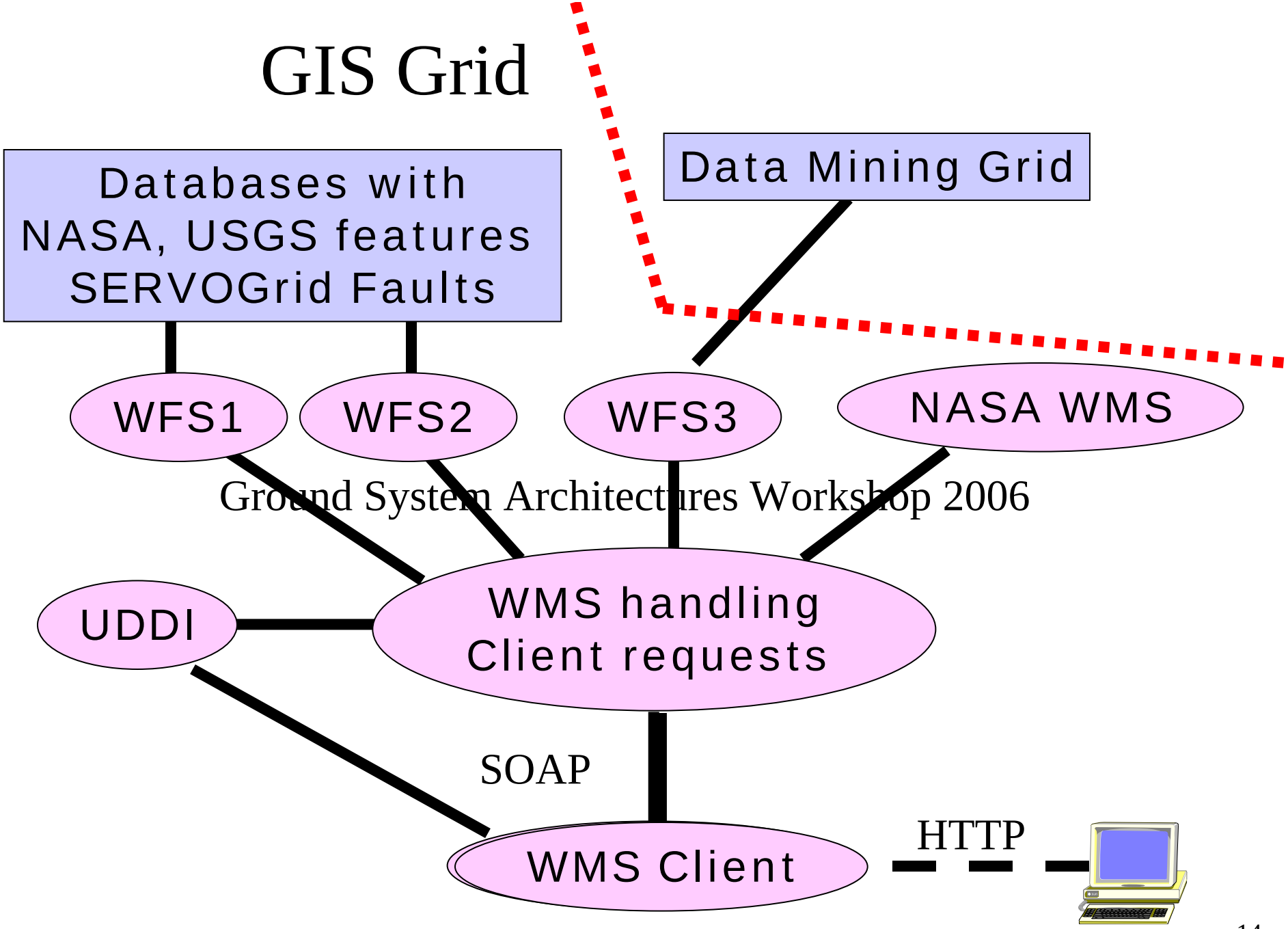
NCOW Service or Feature	WS-* Service area	GGF	Others
A: General Principles			
Use Service Oriented Architecture	WS-1: Core Service Model	Build Grids on Web Services	Industry Best Practice (IBM, Microsoft …)
Grid of Grids Composition			Legacy subsystems and modular architecture
B: NCOW Core Services (to be continued)			
CES 1: Enterprise Services Management	WS-8 Management	GS-6: Management	CIM
CES 2: Information Assurance(IA)/Security	WS-5 WS-Security	GS-7 Security (Authorization)	Grid-Shib, Permis Liberty Alliance etc.
CES 3: Messaging	WS-2, WS-3 Service Internet Notification		NaradaBrokering, Streaming/Sensor Technologies
CES 4: Discovery	WS-6 UDDI	Extended UDDI	
CES 5: Mediation	WS-4 Workflow		Treatment of Legacy systems. Data Transformations
CES 6: Collaboration	Shared Web Resources	Asynchronous Virtual Organizations	XGSP, Shared Web Service ports, Anabas
CES 7: User assistance	WS-10 Portlets	GridSphere	NCOW Capability Interfaces, JSR168

DoD Core Services and WS-* and GS-* II

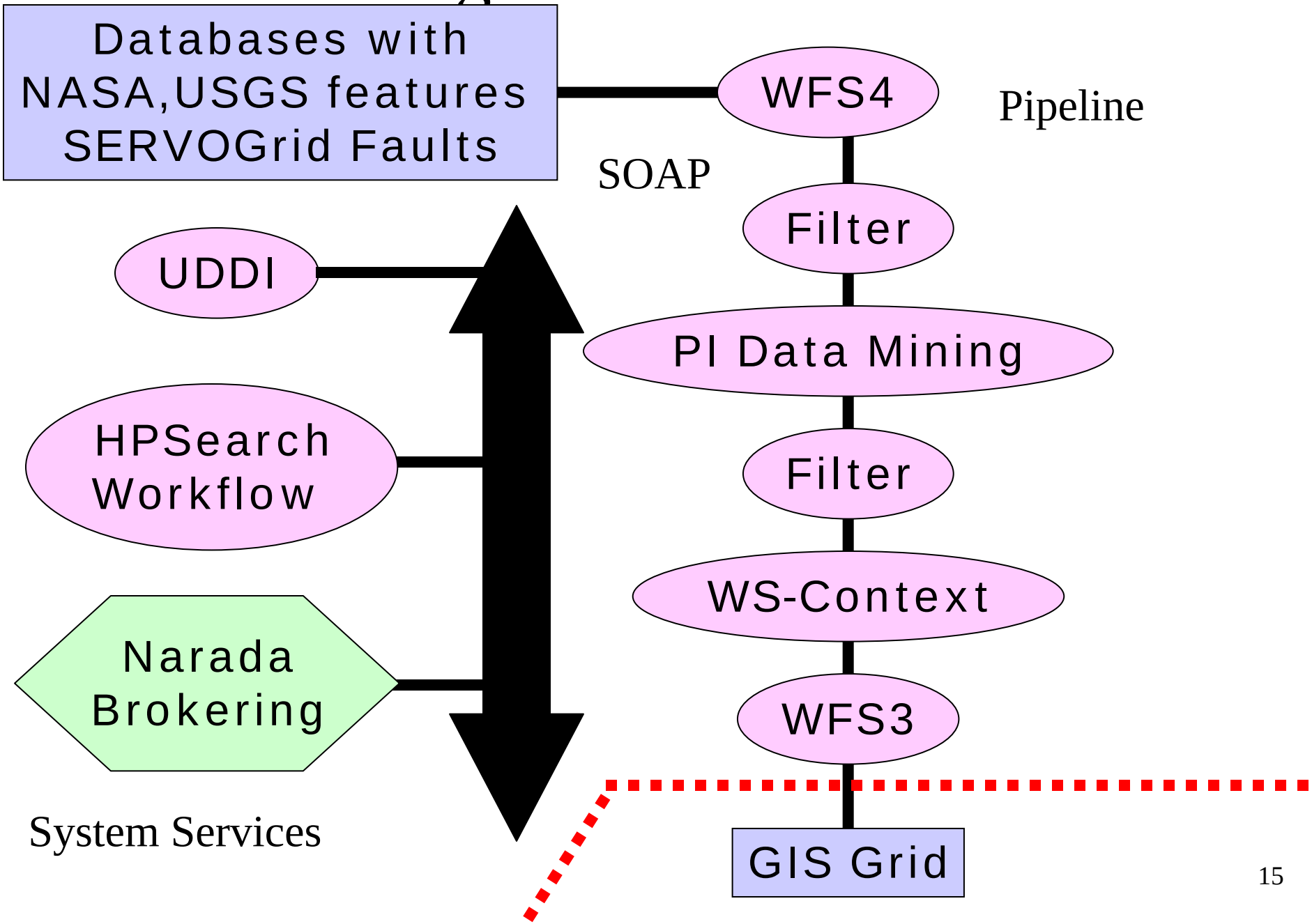
NCOW Service or Feature	WS-* Service area	GGF	Others
B: NCOW Core Services Continued			
CES 8: Storage (not real-time streams)		GS-4 Data	NCOW Data Strategy
CES 9: Application		GS-2; invoke GS-3	Best Practice in building Grid/Web services (proxy or direct)
Environmental Control Services ECS	WS-9 Policy		
C: Key NCOW Capabilities not directly in CES			
System Meta-data	WS-7	Semantic Grid Globus MDS	C2IEDM, XBML, DDMS, WFS
Resource/Service Matching/Scheduling		Distributed Scheduling and SLA's (GS-3)	Extend computer scheduling to networks and data flow
Sensors (real-time data)		Work starting	OGC Sensor standards
Geographical Information Systems GIS			OGC GIS standards

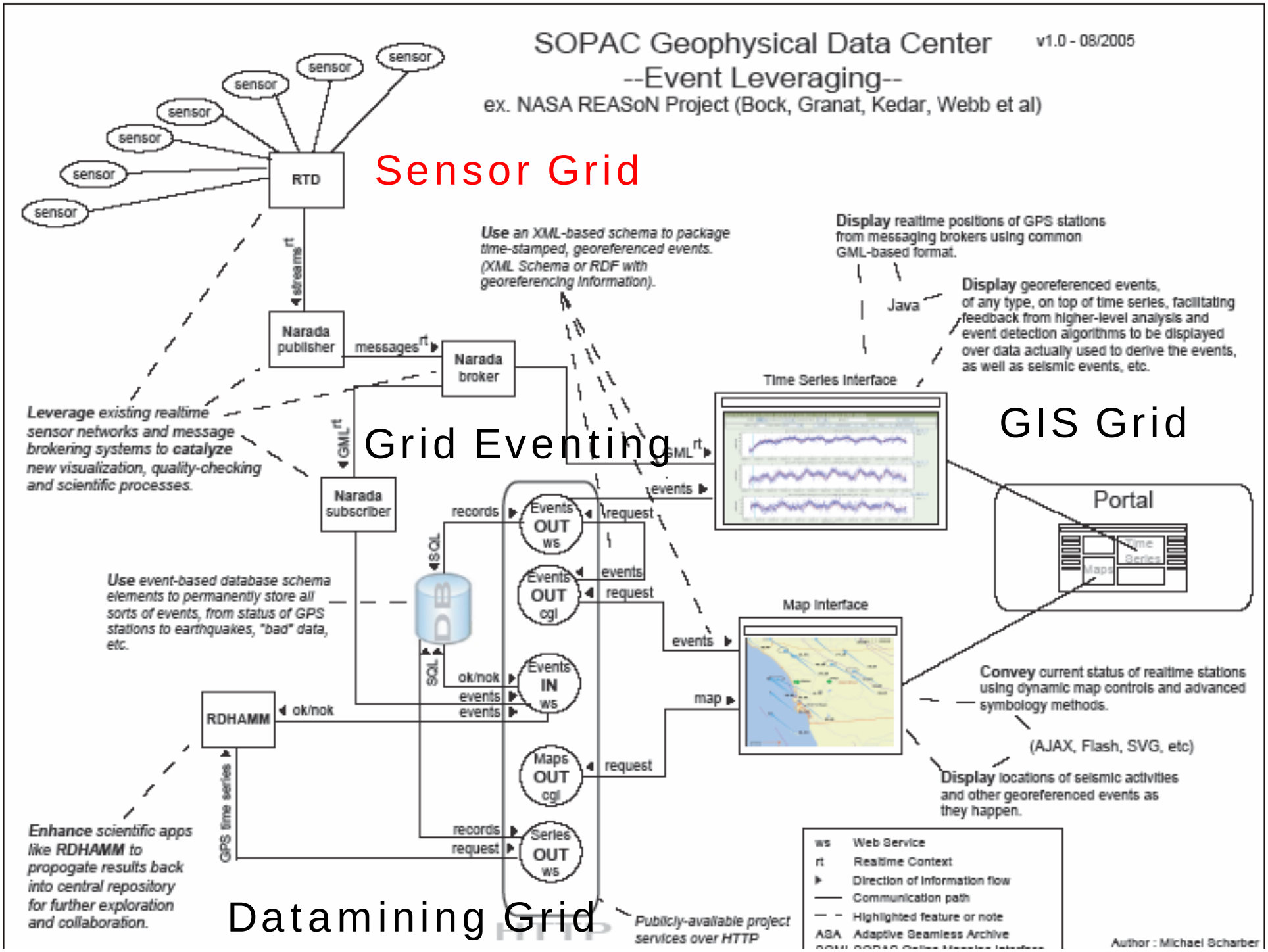
See http://grids.ucs.indiana.edu/ptliupages/publications/gig for details

GIS Grid


Databases with
NASA, USGS features
SERVOGrid Faults
Data Mining Grid
WFS1
WFS2
WFS3
NASA WMS
Ground System Architectures Workshop 2006
UDDI
WMS handling
Client requests
SOAP
WMS Client
HTTP

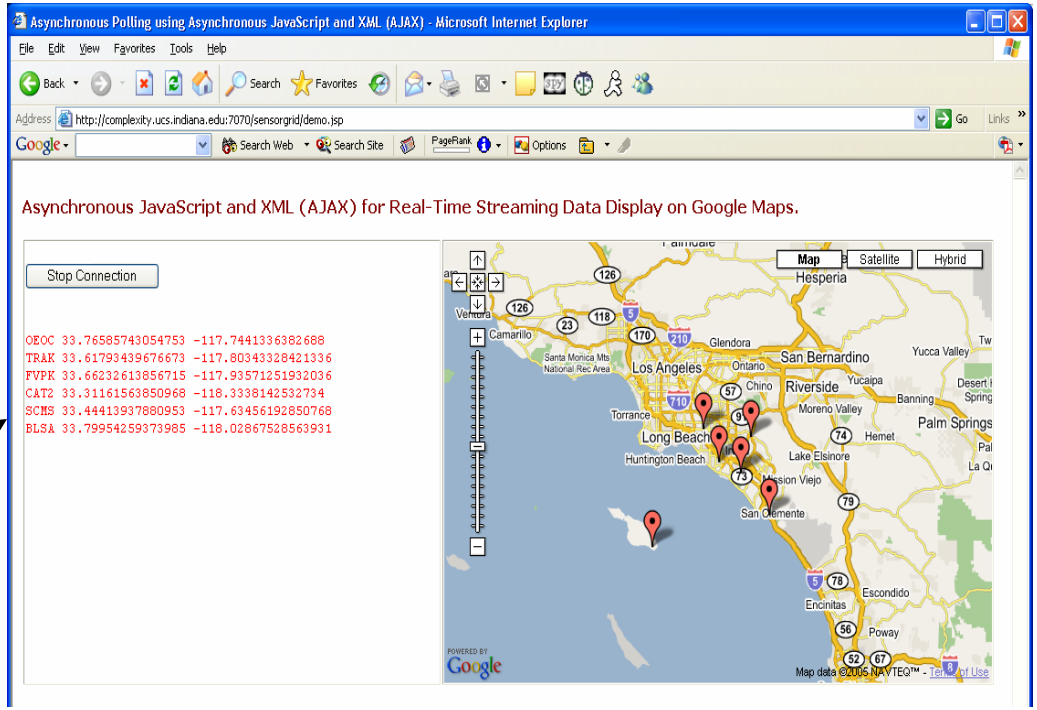
Data Mining Grid in Grid of Grids

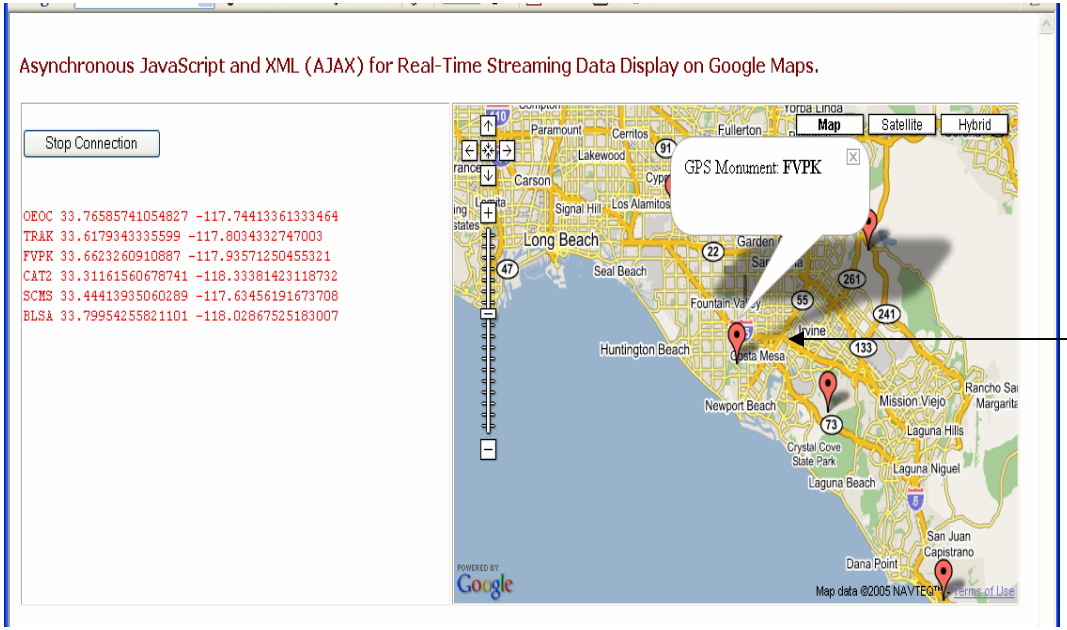



SOPAC Geophysical Data Center
v1.0 - 08/2005
--Event Leveraging--
ex. NASA REASoN Project (Bock, Granat, Kedar, Webb et al)
Sensor Grid
sensor
RTD
streams rt
Narada publisher
messages rt
Narada broker
Use an XML-based schema to package time-stamped, georeferenced events. (XML Schema or RDF with georeferencing information).
Display realtime positions of GPS stations from messaging brokers using common GML-based format.
Java
Display georeferenced events, of any type, on top of time series, facilitating feedback from higher-level analysis and event detection algorithms to be displayed over data actually used to derive the events, as well as seismic events, etc.
Time Series Interface
GIS Grid
Leverage existing realtime sensor networks and message brokering systems to catalyze new visualization, quality-checking and scientific processes.
GML rt
Grid Eventing
Narada subscriber
events
records
request
Events OUT ws
Events OUT cgi
Portal
Time Series
Maps
SQL
DB
Use event-based database schema elements to permanently store all sorts of events, from status of GPS stations to earthquakes, "bad" data, etc.
Map Interface
ok/nok
Events IN ws
map
RDHAMM
Convey current status of realtime stations using dynamic map controls and advanced symbology methods.
(AJAX, Flash, SVG, etc)
Maps OUT cgi
Display locations of seismic activities and other georeferenced events as they happen.
GPS time series
Series OUT ws
Enhance scientific apps like RDHAMM to propogate results back into central repository for further exploration and collaboration.
Datamining Grid
Publicly-available project services over HTTP
ws Web Service
rt Realtime Context
Direction of Information flow
Communication path
Highlighted feature or note
ASA Adaptive Seamless Archive
Author : Michael Scharber

Real Time GPS and Google Maps

Subscribe to live GPS station. Position data from SOPAC is combined with Google map clients.





Select and zoom to GPS station location, click icons for more information.

Some Grid Performance

- From Anabas Phase I SBIR
- Reduction of message delay jitter to a millisecond.
- Dynamic meta-data access latency reduced from seconds to milliseconds using web service context service.
- The messaging is distributed with each low end Linux node capable of supporting 500 users at a total bandwidth of 140 Mbits/sec with over 20,000 messages per second.
- Systematic use of redundant fault tolerance services supports strict user QoS requirements and fault tolerant Grid enterprise bus supports collaboration and information sharing at a cost that scales logarithmically with number of simultaneous users and resources.
- Supporting N users at the 0.5 Mbits/sec level each would require roughly (N/500)log(N/500) messaging servers to achieve full capability.

Some Next Steps

- **Anabas Phase II SBIR:**
- **Produce a Grid-based implementation for 9 CES for NCOW adding ECS (Environmental Control Services) and Metadata support (UDDI and WS-Context for C2IEDM etc.)**
- **Produce typical Collaboration, Sensor, Datamining and GIS Grids**
- **Produce a Tool to allow composition of services and grids into (larger) Grids (Systems of Systems)**
- **Community Grids Laboratory:**
- **Continue Grids for Earth Science and Sensors with JPL**
- **Build an HLA runtime RTI for distributed event simulation in terms of Grid technology (more extensive than XMSF which links Web services to HLA)**

Location of software for Grid Projects in Community Grids Laboratory

- htpp://www.naradabrokering.org provides Web service (and JMS) compliant distributed publish-subscribe messaging (software overlay network)
- htpp://www.globlmmcs.org is a service oriented (Grid) collaboration environment (audio-video conferencing)
- http://www.crisisgrid.org is an OGC (open geospatial consortium) Geographical Information System (GIS) compliant GIS and Sensor Grid (with POLIS center)
- http://www.opengrids.org has WS-Context, Extended UDDI etc.
- The work is still in progress but NaradaBrokering is quite mature
- All software is open source and freely available