Framework for High Performance Grid and Web Services

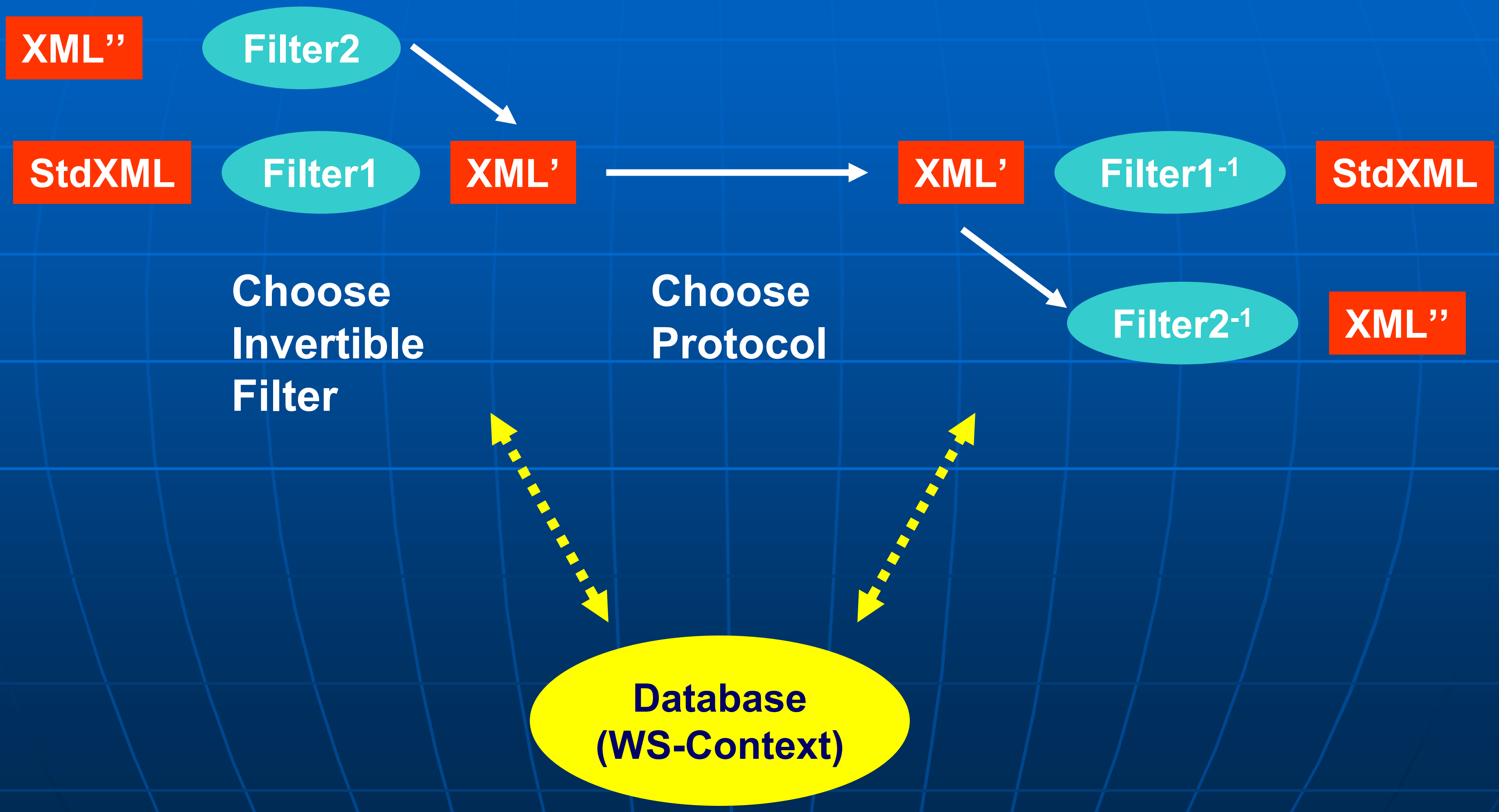
GGF15 October 2 2005

Geoffrey Fox

Computer Science, Informatics, Physics
Pervasive Technology Laboratories
Indiana University Bloomington IN 47401

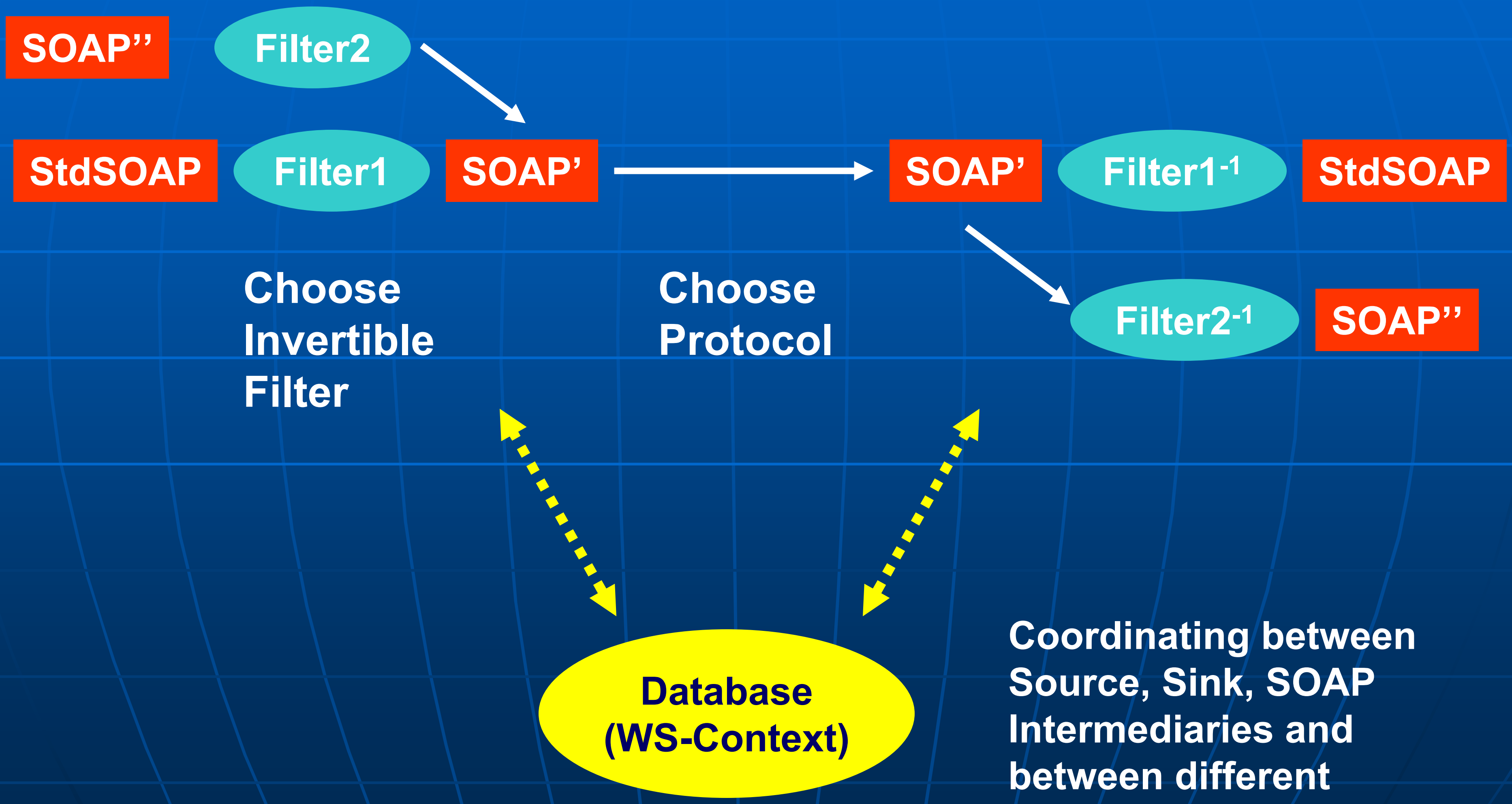
Support for Messages

- Optimize XML representation and transport protocol



Support for Streams

- Optimize Stream representation and transport protocol



Coordinating between Source, Sink, SOAP Intermediaries and between different messages in a stream

Basic Idea

- Bind SOAP to message-oriented middleware that virtualizes representation and protocol
- Build handlers that convert representation and support different protocols
- Specify methodology and specific parameters as meta-data stored in a meta-data (context) service
- Combination of message and context is self-describing
  - Message has a URI referencing context
- Target Axis2 as it supports SOAP Infoset and has a reasonable handler model
  - Some complicated issues here – initially porting technology to Axis2 – might do as Apache project
- Initial targets sensors, mobile devices and audio-video conferencing

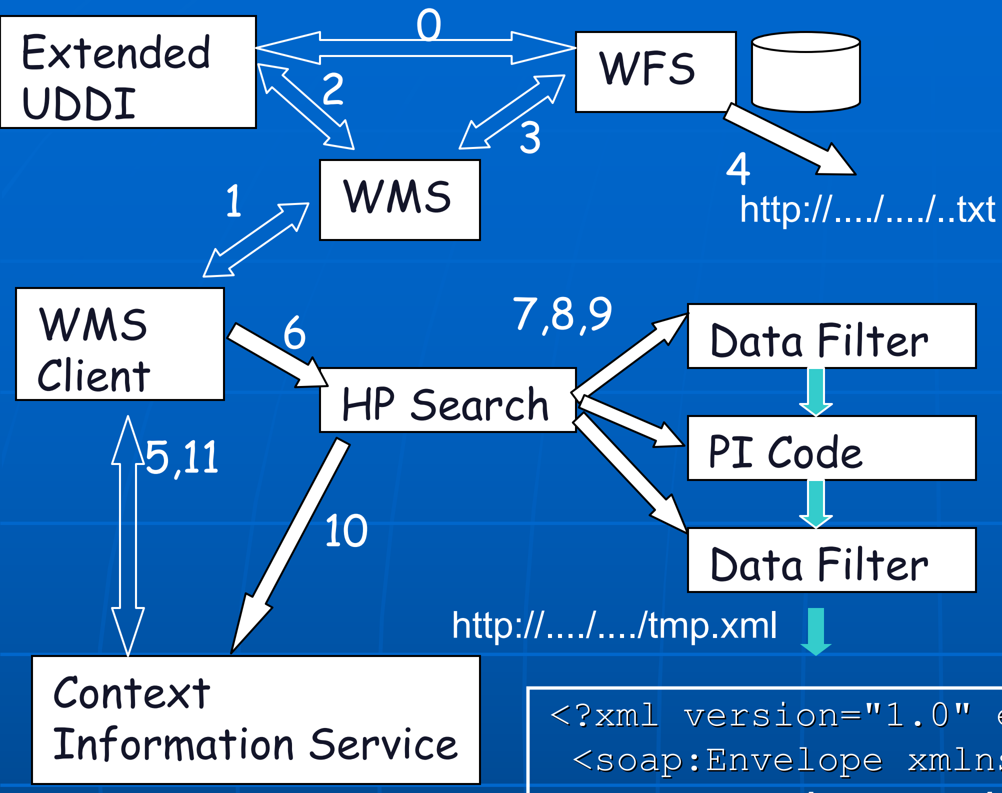
Metadata and Service Context

- Consider a collection of services working together
  - Workflow tells you how to specify service interaction but more basically there is shared information or context specifying/controlling collection
- WS-RF and WS-GAF have different approaches to contextualization – supplying a common "context" which at its simplest is a token to represent state
- More generally core shared information includes dynamic service metadata and the equivalent of configuration information.
- One can supports such a common context either as pool of messages or as message-based access to a "database" (Context Service)
- Two services linked by a stream are perhaps simplest example of a collection of services needing context
- Note that there is a tension between storing metadata in messages and services.
  - This is shared versus distributed memory debate in parallel computing

Role of WS-Context

- There are many WS-* specifications addressing meta-data and both many approaches and many trade-offs
- There are Distributed Hash Table based systems (Chord) to achieve scalability in large scale networks
- Managed dynamic workflows as in sensor integration and collaboration require
  - Fault-tolerance and ability to support dynamic changes with few millisecond delay
  - But only a modest number of involved services (up to 1000's in a session)
  - Need Session NOT Service/Resource meta-data so don't use WS-RF
- We have built a WS-Context compliant metadata catalog supporting distributed or central paradigms
- Use for OGC Web catalog service with UDDI for slowly varying meta-data
- 3 XML Databases: UDDI WS-Context WFS stored as SQL

The Pattern Informatics GIS SOA-based workflow application



5,6: WMS starts a session, invokes HPSearch to run workflow script for PI Code with a session id

7,8,9: HPSearch runs the workflow script and generates output file in GML format (& PDF Format) as result

10: HPSearch writes the URI of the of the output file into Context

11: WMS polls the information from Context Service

12: WMS retrieves the generated output file by workflow script and generates a map

activity

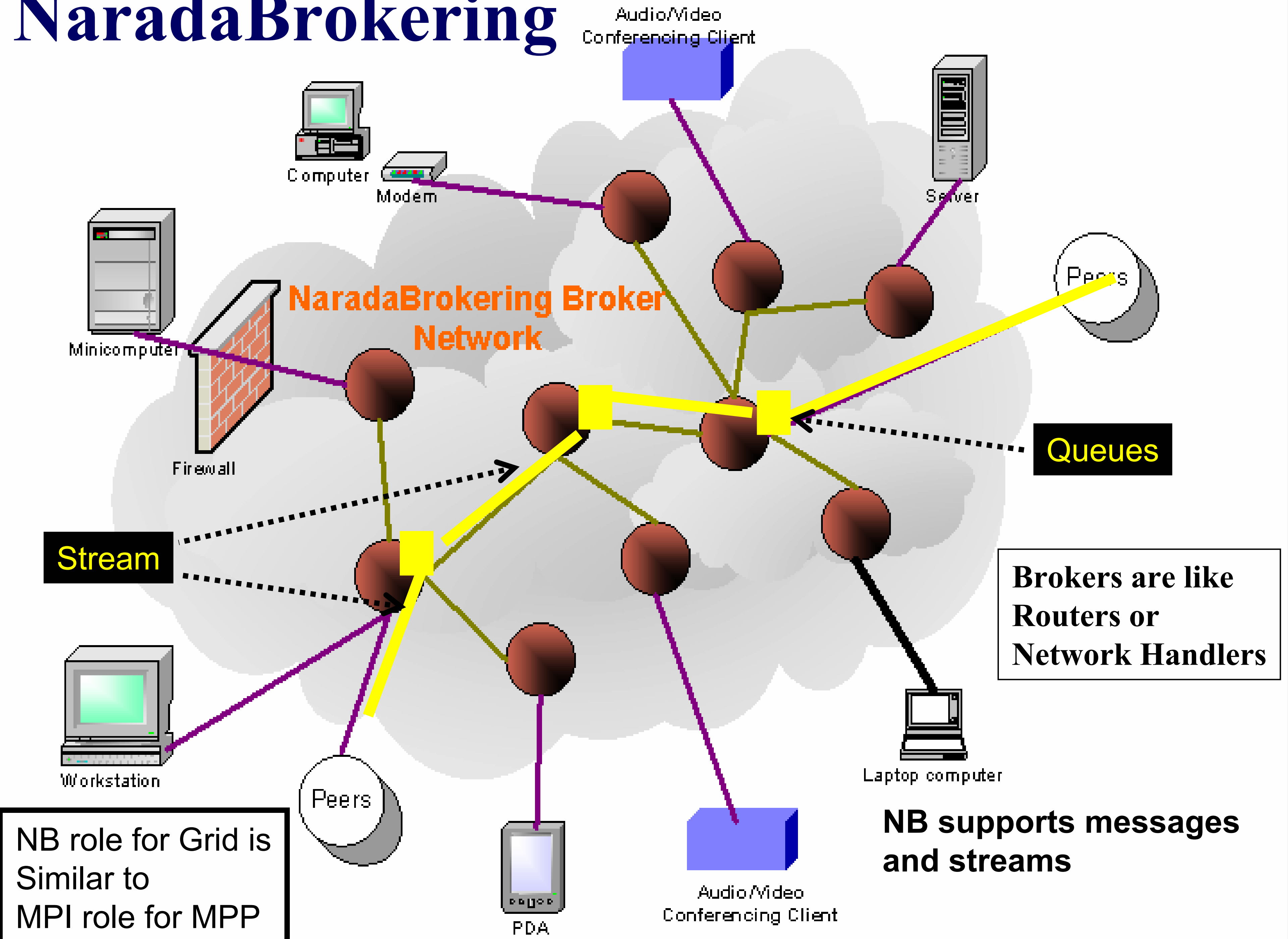
shared state / session / user profile

associated

SOAP header for Context

```
<?xml version="1.0" encoding="UTF-8"?>
 <soap:Envelope xmlns:soap="http://www.w3...">
  <soap:Header encodingStyle="WSCTX URL"
       mustUnderstand="true">
   <context xmlns="ctxt schema" timeout="100">
<context xsd:type="ContextType" timeout="100">
 [illegible] <context-service>http://../HPSearch</context-service>
  <parent-context>http://../abcdef:012345<parent-context/>
  <content>shared data for HPSearch activity </content>
<context-service>http://.../HPSearch</context-service>
  <activity-list mustUnderstand="true" mustPropagate="true">
   <service>http://.../WMS</service>
   <service>http://.../DataFilter1</service>
   <service>http://.../PICode</service>
   <service>http://.../DataFilter2</service>
  </activity-list>
  <content>http://danube.ucs.indiana.edu:8080\x.xml</content>
  </context>
</context>
</context>
```
[illegible]

NaradaBrokering


Audio/Video Conferencing Client
Computer
Modem
Server
Minicomputer
Peers
NaradaBrokering Broker Network
Firewall
Queues
Stream
Workstation
Peers
PDA
Audio/Video Conferencing Client
Laptop computer

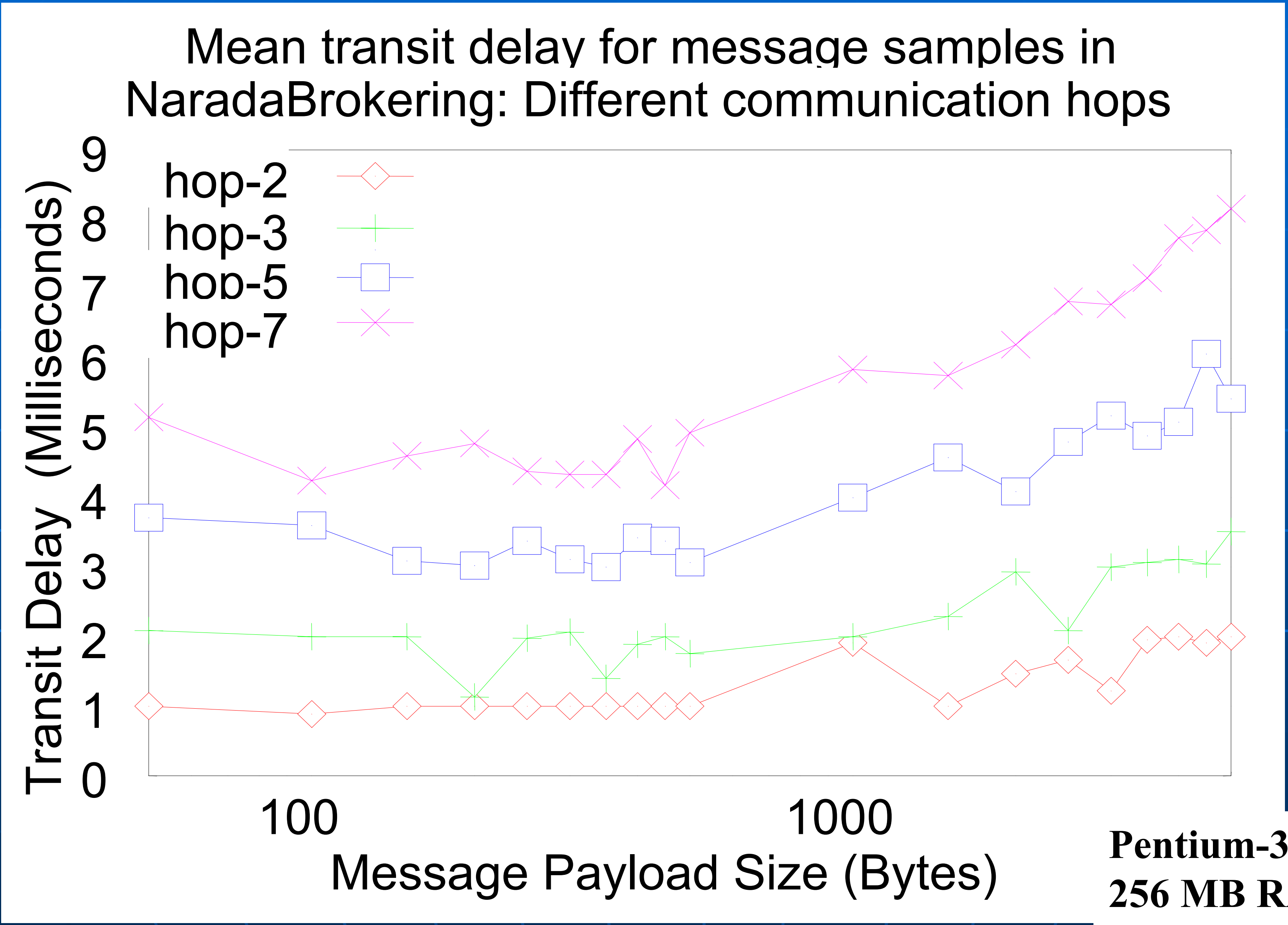
Brokers are like Routers or Network Handlers

NB supports messages and streams

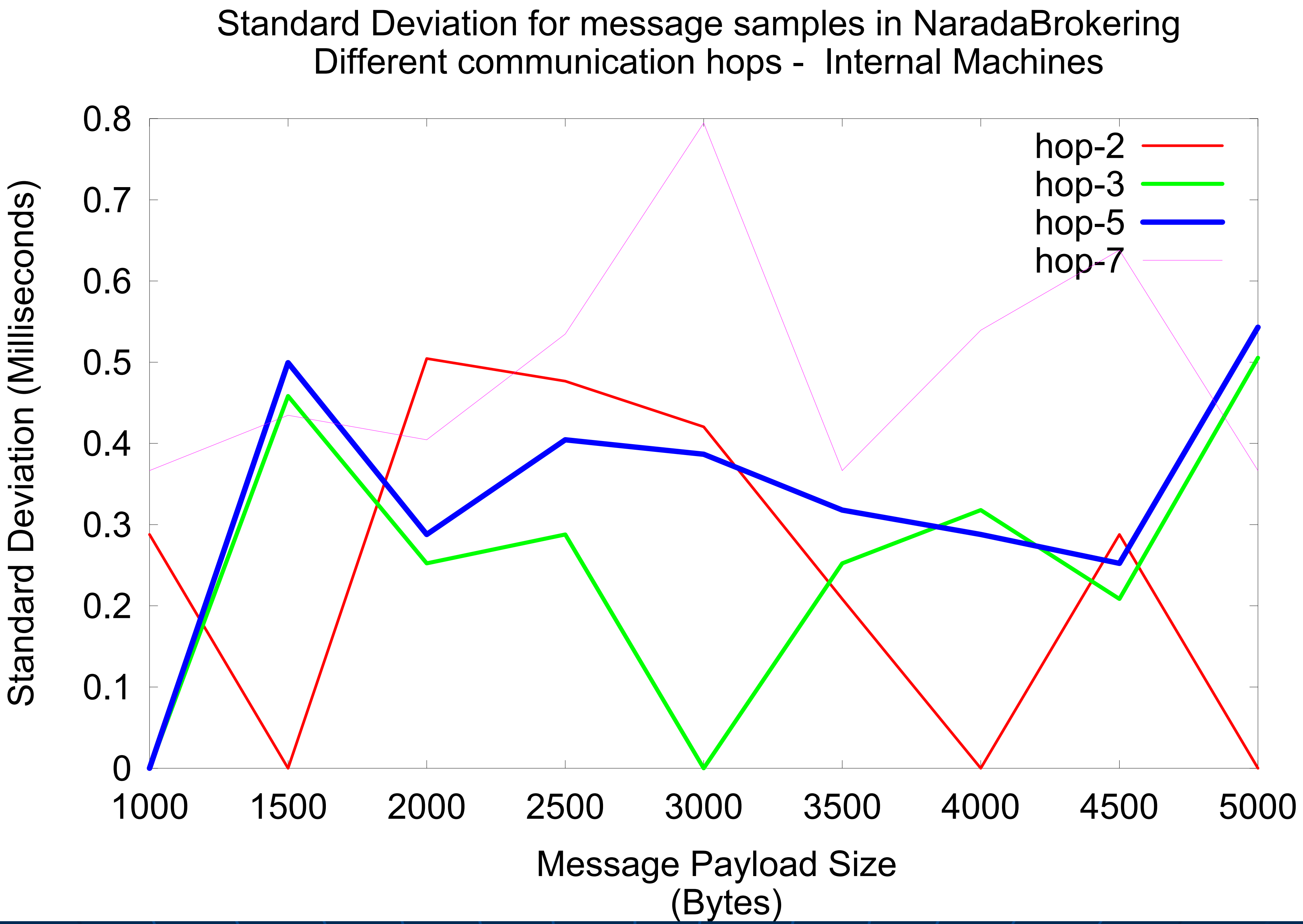
NB role for Grid is Similar to MPI role for MPP

Traditional NaradaBrokering Features

Multiple protocol transport support In publish-subscribe Paradigm with different Protocols on each link	Transport protocols supported include TCP, Parallel TCP streams, UDP, Multicast, SSL, HTTP and HTTPS. Communications through authenticating proxies/firewalls & NATs. Network QoS based Routing Allows Highest performance transport
Subscription Formats	Subscription can be Strings, Integers, **XPath** queries, **Regular Expressions**, **SQL** and tag=value pairs.
Reliable delivery	**Robust** and **exactly-once delivery** in presence of failures
Ordered delivery	**Producer Order** and **Total Order** over a message type. **Time Ordered** delivery using Grid-wide **NTP based absolute time**
Recovery and Replay	**Recovery from failures** and disconnects. **Replay** of events/messages at any time. **Buffering** services.
Security	**Message-level WS-Security** compatible **security**
Message Payload options	**Compression** and **Decompression** of payloads **Fragmentation** and **Coalescing** of payloads
Messaging Related Compliance	Java Message Service (**JMS**) 1.0.2b compliant Support for routing P2P **JXTA** interactions.
Grid Feature Support	NaradaBrokering enhanced **Grid-FTP**. Bridge to **Globus GT3**.
Web Services supported	Implementations of **WS-ReliableMessaging, WS-Reliability and WS-Eventing.**



Pentium-3, 1GHz, 256 MB RAM 100 Mbps LAN JRE 1.3 Linux


Standard Deviation for message samples in NaradaBrokering
Different communication hops - Internal Machines
Standard Deviation (Milliseconds)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
1000
1500
2000
2500
3000
3500
4000
4500
5000
Message Payload Size
(Bytes)
hop-2
hop-3
hop-5
hop-7

NB Features Released 2005-2006

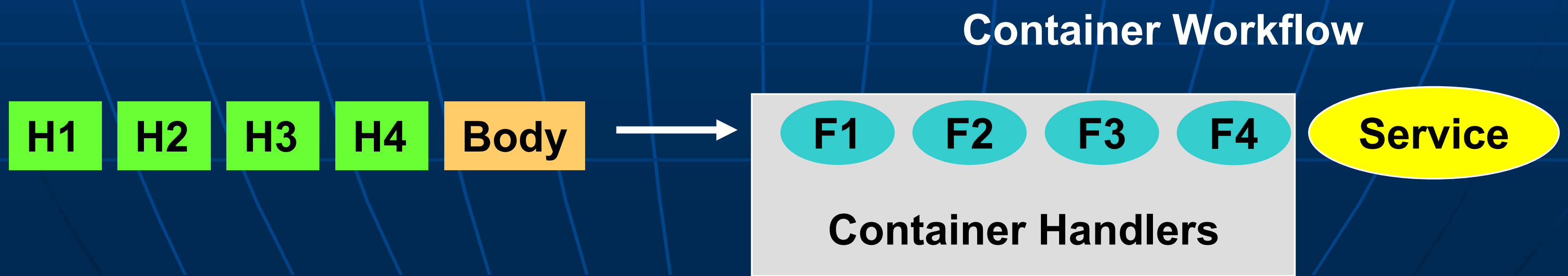
- Production implementations of WS-Eventing, WS-RM and WS-Reliability.
  - WS-Notification when specification agreed
- SOAP message support and NaradaBrokers viewed as SOAP Intermediaries
- Active replay support: Pause and Replay live streams.
- Stream Linkage: can link permanently multiple streams – using in annotating real-time video streams
- Replicated storage support for fault tolerance and resiliency to storage failures.
- Management: HPSearch Scripting Interface to administer streams and brokers (uses WS-Management)
- Broker Topics and Message Discovery: Locate appropriate
- Support of IBM MQSeries functionality and Legacy MQSeries Systems as a Grid of Grids gateway

Possible NaradaBrokering Futures

- Clarification and expansion of NB Broker to act as a WS container
- Integration with Axis 2.0 as Message Oriented Middleware infrastructure
- Support for High Performance transport and representation for Web Services
- Performance based routing
  - The broker network will dynamically respond to changes in the network based on metrics gathered at individual broker nodes.
- Replicated publishers for fault tolerance
- Pure client P2P implementation (originally we linked to JXTA)
- Security Enhancements for fine-grain topic authorization, multi-cast keys, Broker attacks

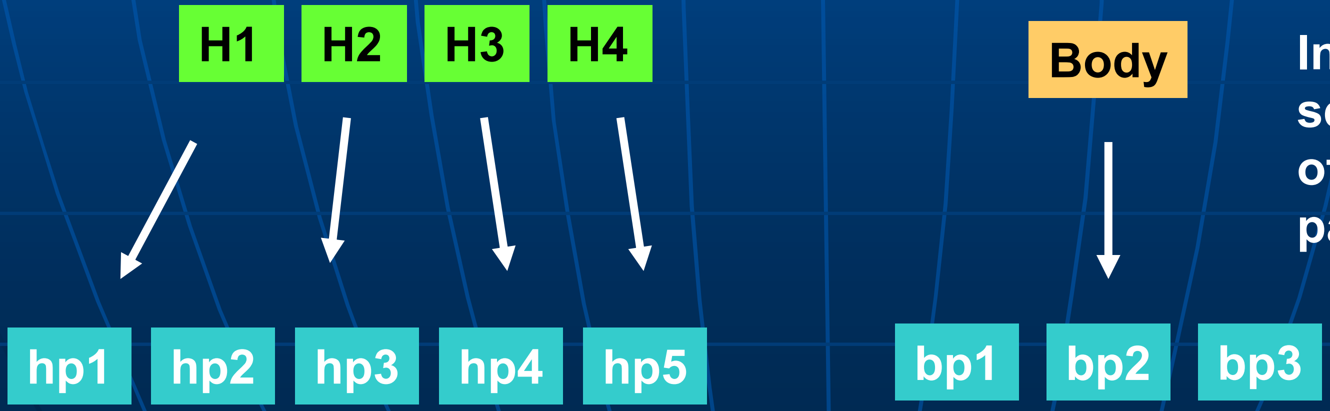
SOAP Message Structure I

- SOAP Message consists of headers and a body
  - Headers could be for Addressing, WSRM, Security, Eventing etc.
- Headers are processed by handlers or filters controlled by container as message enters or leaves a service
- Body processed by Service itself
- The header processing defines the "Web Service Distributed Operating System"
- Containers queue messages; control processing of headers and offer convenient (for particular languages) service interfaces
- Handlers are really the core Operating system services as they receive and give back messages like services; they just process and perhaps modify different elements of SOAP Message – WS standards specify handler structure



SOAP Message Structure II

- Content of individual headers and the body is defined by XML Schema associated with WS-* headers and the service WSDL
- SOAP Infoset captures header and body structure
- XML Infoset for individual headers and the body capture the details of each message part
- Web Service Architecture requires that we capture Infoset structure but does not require that we represent XML in angle bracket <content>value</content> notation



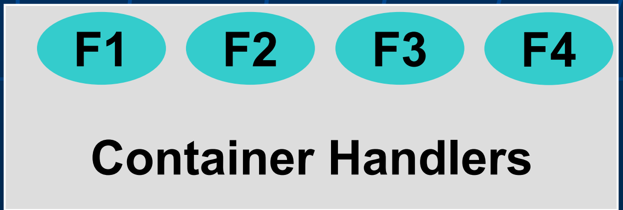
Infoset represents semantic structure of message and its parts

High Performance XML I

- There are many approaches to efficient “binary” representations of XML Infosets
  - MTOM, XOP, Attachments, Fast Web Services
  - DFDL is one approach to specifying a binary format
- Assume URI-S labels Scheme and URI-R labels realization of Scheme for a particular message i.e. URI-R defines specific layout of information in each message
  - DFDL from GGF quite interesting for this
- Assume we are interested in conversations where a stream of messages is exchanged between two services or between a client and a service i.e. two end-points
- Assume that we need to communicate fast between end-points that understand scheme URI-S but must support conventional representation if one end-point does not understand URI-S

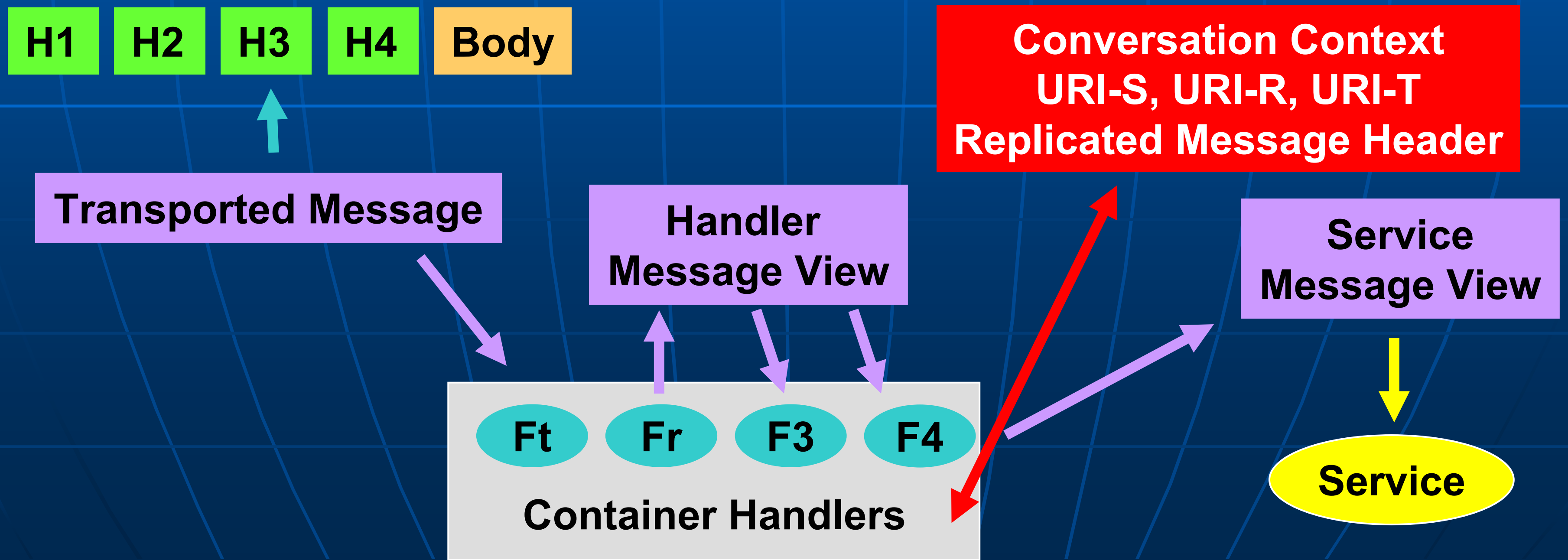
High Performance XML II

- First Handler Ft=F1 handles Transport protocol; it negotiates with other end-point to establish a transport conversation which uses either HTTP (default) or a different transport such as UDP with WSRM implementing reliability
  - URI-T specifies transport choice
- Second Handler Fr=F2 handles representation and it negotiates a representation conversation with scheme URI-S and realization URI-R
  - Negotiation identifies parts of SOAP header that are present in all messages in a stream and are ONLY transmitted ONCE
- Fr needs to negotiate with Service and other handlers illustrated by F3 and F4 below to decide what representation they will process



High Performance XML III

- Filters controlled by Conversation Context convert messages between representations using permanent context (metadata) catalog to hold conversation context
- Different message views for each end point or even for individual handlers and service within one end point
  - Conversation Context is fast dynamic metadata service to enable conversions
- NaradaBrokering will implement Fr and Ft using its support of multiple transports, fast filters and message queuing;



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
- 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