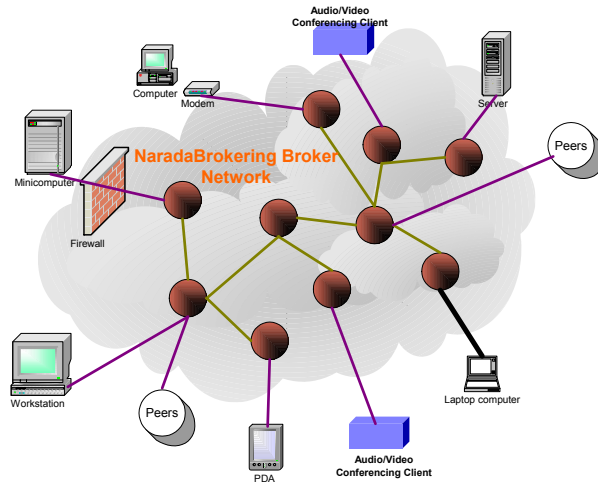


1. NaradaBrokering

NaradaBrokering is an open source technology supporting a suite of capabilities for reliable/robust flexible messaging; given the message based service architecture of Grids, this project is aimed at providing for the transport of messages between services and between services and clients. NaradaBrokering is designed around a scalable distributed network of cooperating message routers and processors.

Special features available in the current release include

- Publish-subscribe metaphor with general XML based topics
- Support for multiple protocols including TCP/IP (both blocking and non-blocking), UDP, Multicast, SSL, HTTP, RTP, HHMS (optimized for PDA and cell-phone access) and GridFTP with protocol chosen independently at each link
- The protocols can be chosen to tunnel through many firewalls and authenticating proxies.
- Interface to reliable storage and guaranteed order-preserving message delivery
- Support for message compression and decompression.
- Fragmentation and Coalescing of large files (>1 Gigabytes).
- JMS compliance and support for JXTA interactions.



Functionality	WebSphereMQ	Pastry	NaradaBrokering
Max number of nodes	Medium	Very large	Very large
Robust Messaging	Yes	Yes	Yes
Robust delivery of >1 Gigabyte files	Yes	No	Yes
Support for routing P2P Interactions	No	Yes	Yes (JXTA)
A/V Conf. and raw RTP clients	NA	NA	Yes
Proxies/firewalls tunneling	Yes	No	Yes
Dynamic Topics	No	No	Yes
XPath queries/subscriptions	No	No	Yes
Performance Monitoring	No	No	Yes
End-to-End security	Yes	No	Yes. (Dec 2003)
Support for Workflow	Yes.	No.	No.
Support for distributed caching	No.	Yes (Squirrel)	No.
Maturity of Software	Extremely mature	Fair	Fair

The NaradaBrokering software has been used extensively in several projects described below:

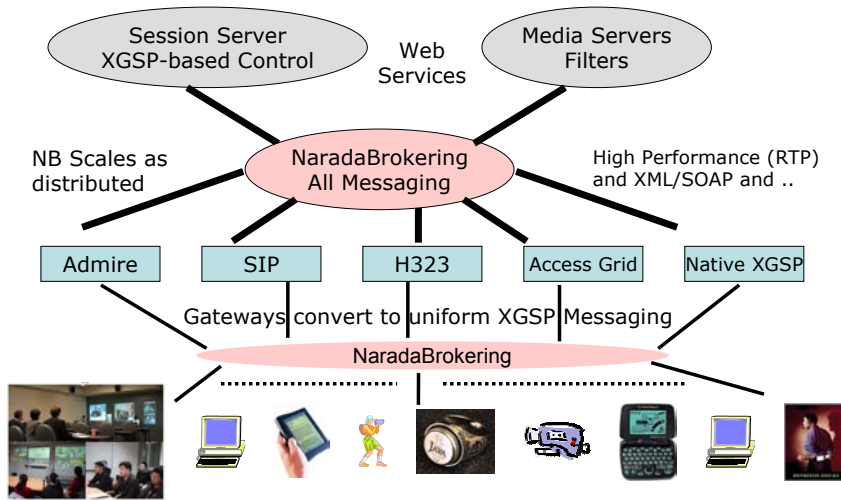
2. GlobalMMCS

The GlobalMMCS technology is a new collaboration environment built around systematic use of Web (Grid) services and NaradaBrokering messaging. In particular it converts SIP, H323 and Access Grid protocols to a common Web service protocol XGSP. GlobalMMCS uses NaradaBrokering in all its communication whether it is in form of



CollabMMCS Web Service MCU Architecture

Use Multiple Media servers to scale to many codecs and many versions of audio/video mixing



control packets or RTP based multimedia streams. It features Web/Grid services for session control, media type conversion, audio mixing and video mosaicing.

Functionality	Polycom (H.323)	AccessGrid	GlobalMMCS
Protocol Support	Only H.323 clients	Only MBONE clients	H.323, SIP, MBONE
Server Architecture	Expensive H.323 Hardware/Software MCU	No conf. servers, Needs multicast support in the network	Software Servers solution. Based on Web Services
Network and Communication Environment	Internet / ISDN Firewall transversal under the support of VPN	High performance with multicast support No firewall tunneling	Publish/Subscribe with Firewall transversal (VPN optional)
A/V Interaction Capability	Client shows a few video streams	A client shows up to 50 streams	A client shows up to 50 streams
Conferencing scalability	Usually less than 20~30 sites	Limited to the area of multicast networks	>1000 sites distributed over Internet
Integ. of streaming & conferencing	Only supports conferencing	Only supports conferencing	Any A/V source can be Streamed
Archive & Replay	No built in H.323 service	Voyager: allows replay of multiple streams	Multiple A/V streaming archive & replay
Other Collaboration Tools	Limited although T120 could support other apps	Limited to PowerPoint and chat	XGSP allows full integration of all tools

3. Universal Accessibility Service with NaradaBrokering

Universal access refers to the capability that all users are able to access information systems (grids) independent of their access device and their physical capabilities. The Carousel project addresses this for mobile devices such as smartphones and PDAs. We provide the collaborative service which is accessible from the heterogeneous types of mobile devices through NaradaBrokering.

3.1 Participating Collaborative Session with Mobile device

Carousel project allows users to participate a collaborative session with the mobile device wherever there are. The mobile users in the collaborative session share the application such as Microsoft PowerPoint or Web site browsed by Internet Explorer running on PCs. During the session, the mobile users also interact with other participants by exchanging text messages.



3.2 Support 3G Network Communication with NaradaBrokering

We are developing optimized protocol, HHMP (Hand-Held Message Protocol) for emerging 3G (Third-Generation) Network communication. This service provides seamless access from the mobile devices to NaradaBrokering.

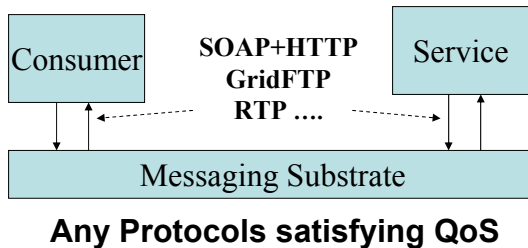
3.3 MVC based dynamic sharing

Moreover, as an advanced sharing application technology, we support shared export which provides collaboration with more abstract data. Instead of sharing the framebuffer images as in shared display, the shared export exchanges

abstract data such as vector graphics. We integrated W3C's 2D vector graphics format, SVG (Scalable Vector Graphics) and also provide the interface for mobile devices of collaborative SVG. Our collaborative SVG is designed based on the MVC (Model-View-Control) model therefore the presentation view of each user can be controlled individually. With the collaborative SVG service, mobile device also shares the display under its individual control in high-quality graphics.

4. NaradaBrokering-enhanced GridFTP

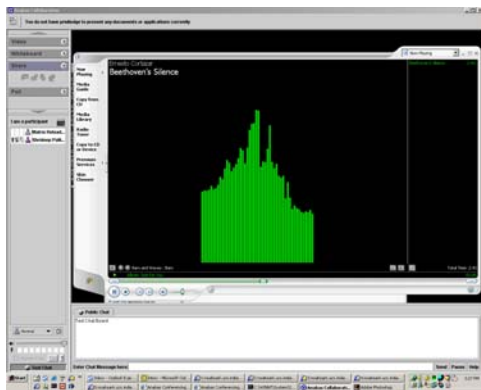
We have integrated GridFTP with the NaradaBrokering system. The advantage of this approach is that the source code of the GridFTP client need not be changed and existing client code can be used with NB system without any modification. Due to its integration with the NaradaBrokering system, files can be



recovered after failures or even prolonged disconnects. Files can be partially transmitted and if there is a failure the

transmission begins at a point closer to point where the failure occurred.

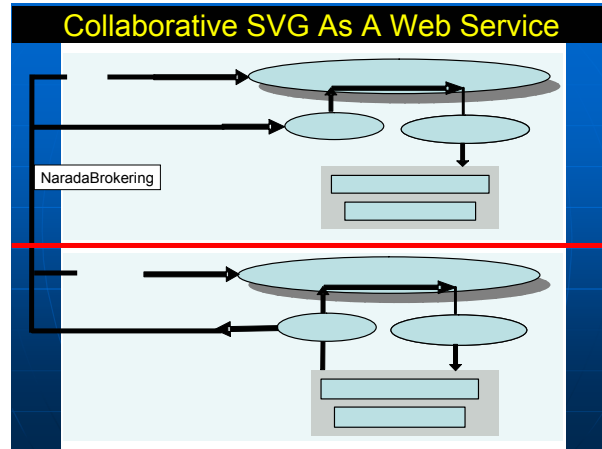
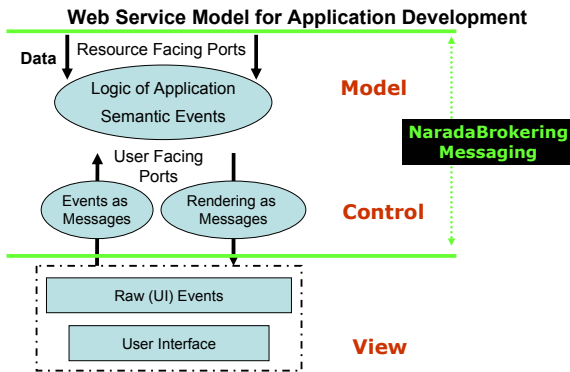
5. Anabas Web Conferencing



NaradaBrokering has also been deployed in real-time settings by providing back end support for the Anabas conferencing software running in JMS emulation mode. Several online seminars have been conducted using this Anabas-NaradaBrokering combination and the number of users collaborating concurrently has been in the excess of 30 users several times. Anabas uses NaradaBrokering to support shared display, text chats and all session control functions. Note shared display involves sharing large – sometime multi-megabit files specifying complete framebuffer. The messaging system must handle this, the very dynamic video frames and the short text buffers of control and text chat.

6. Applications as Web Services

One can use the Web service model to build “ordinary” applications in the Model-View-Control paradigm with NaradaBrokering playing the role of the “control”. Conventionally a user-interaction generates an interrupt to which one posts listeners. This is replaced by a “view” module sending messages to a “model”

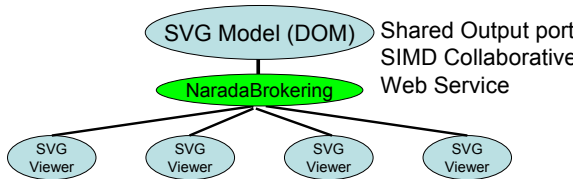


Interrupts in traditional monolithic applications become “real messages” not directly method calls
 Natural for collaboration and universal access

Web service where a subscriber plays role of listener. This way of building application has significant advantages over traditional bundled applications. We can retarget applications to multiple clients as with the PDA and universal access described in sec. 3. We can support multiple O/S more easily as only the view need be ported. Further it allows us to “automatically” build collaborative applications by sharing



Identical Programs receiving identical events. Token determines if browser is moving, waiting for opponent or an observer



either the input or output ports of the web service. We have applied this to the Java SVG (Scalable Vector Graphics) browser and to PowerPoint; the former is a complete Web service implementation using user-interaction events; the latter uses higher-level semantic events like “slide change”. We believe a complete Web Service architecture desktop can be built this way and that it will revolutionize client computing.

7. Federation in Peer-to-Peer Grids

NaradaBrokering can be used for federation between different distributed systems by acting as a distributed gateway intercepting messages between different styles of Grids and peer-to-peer networks. We have demonstrated this with the JXTA P2P network where we have modified their rendezvous peers to act as such gateways. This allows NaradaBrokering to federate many JXTA peer groups together.

