GMSME: An Architecture for Heterogeneous Collaboration with Mobile Devices

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Abstract:
The importance of network-ready personal devices in collaborative systems is becoming apparent. The participants of a collaborative environment use mobile devices to overcome the physical constraint of using a conventional PC. However, the integration of disparate devices like mobile devices and PCs is difficult, because of the connectivity and the computing power limitations of a mobile device. We believe a dedicated middleware layer that supports universal access, event mapping, user management, and content adaptation is a great help to integrate mobile devices into the collaborative system. In this paper, we propose a ubiquitous computing environment architecture for a collaborative system called Garnet Message System Micro Edition (GMSME). This architecture provides the environment to resolve those issues and is designed efficiently considering the computing resource limitations of mobile devices.

Key Words: collaboration, mobile, universal access, filtering, middleware

1. INTRODUCTION

Collaborative systems enable people to communicate and cooperate remotely. The Garnet Collaborative system [1] [2] is a universal access collaboration environment, which uses the NaradaBrokering Event system [3] as a messaging system.

In recent years the use of network-ready mobile devices like Personal Digital Assistants (PDAs) and Smart phones as client devices has emerged as a major focus in collaborative systems. The combination of personal devices with conventional PCs in the collaborative system makes a great impact on the degree of collaboration. For instance, the universal access model of the Garnet system is extendable to more general universal access through personal devices. But it is not an easy goal to achieve. In many projects aiming at such integration, the limitation of the personal devices in terms of the connectivity and computing power has been an unavoidable issue.

Even though there are many improvements recently, personal devices still lack in computing resources. We claim that the middleware layer between the collaborative system and the mobile devices resolves this drawback by efficiently mapping event messages and adapting content of messages. The middleware layer is a NaradaBrokering node that filters shared events and reposts them to a different stream [4].

In this paper, we propose an extensible and scalable architecture that provides universal accessibility and efficient server side computing. To make the architecture concrete, we have implemented a version, called Garnet Message System Micro Edition (GMSME) on the Garnet Collaborative System. The basic design issues and requirements for GMSME as a middleware layer are discussed in detail in Section 3. We present the architecture overview in Section 4.

2. GARNET AND NARADABROKERING

The Garnet collaboration system [5] supports distance education, collaborative computing and building electric communities. It provides rich features of collaboration such as a video conferencing with SIP VoIP [6] and H.323 and a shared export with SVG. With the experience of developing TANGO [7] and using commercial collaboration system, for instance WebEx [8], Centra [9], the Garnet system integrates synchronous and asynchronous collaboration systems that are based on the publish/subscribe mechanism. For publish/subscribe semantics, we build on the NaradaBrokering system, which is a Java Message Service (JMS) [10] compliant message brokering system. NaradaBrokering is an event brokering system designed to run on a large network of cooperating broker nodes. It was originally designed to provide uniform software multicast to support real-time collaboration linked by publish/subscribe. As noted above, it is JMS compliant and provides supports not only for JMS clients, but also peer-to-peer communication providing JXTA interactions. NaradaBrokering provides a transport framework that supports the various choices of protocols between nodes.

GMSME adds the universal connectivity to the Garnet collaboration system, which primarily focuses on the traditional desktop client. GMSME supports heterogeneous protocols for mobile client, message conversion between NaradaBrokering messages and HHMS, and customizing contents of the message to make them appropriate to PDAs or smart phones.

3. DESIGN ISSUES

In the collaborative system, personal devices like PDAs and Smart phones are drawing more interest for two major reasons. One is that the devices are performing better than before. They are now sufficiently capable to be a collaborative client device. The other reason is better network availability. There are more buildings and rooms that have WLAN connection for your PDA, and more products and service plans for cellular phones by which people can connect to the Internet.

However, there is a gap between PC and personal device, because of the nature of the latter, which is portable and convenient to use. The middleware, GMSME, fills the gap. The overview of GMSME architecture is depicted in Figure 1.

The challenges we worked on are:

Heterogeneity:
Heterogeneous device support is a core concern to the middleware layer in the ubiquitous or pervasive computing environment. The issues include universal connection support, event mapping and content adaptation. GMSME provides connection management and user management that are encapsulated in a universal interface to the personal mobile device. The implementation is presented in Section 3.1.

The Garnet collaborative system and GMSME have different event models. The Personal Server of GMSME, which is illustrated in Section 3, maps the event between the asynchronous JMS based NaradaBrokering [10] [11] and synchronous Hand Held Message Service (HHMS).

Content adaptation has been explored by many research groups [12] [13]. For collaborative systems, it is a vital design issue to adapt those devices to collaborate together with the conventional PC, which has more computing and display strength. We use a Garnet XML Object Specification (GXOS) based User Profile. GXOS [14] is the primary specification to define objects in the Garnet collaborative system. Depending on the user profile and device type of his current machine, GMSME adapts the content of messages appropriate to the user device. Shared display applications and Scalable Vector Graphics (SVG) [15] applications on the mobile device heavily rely on this idea, since using those graphic native applications on a small display device and processing large images costs heavily in computing resources. For more discussion of how a SVG document, say, can be adapted for a PDA's display see for example [16]

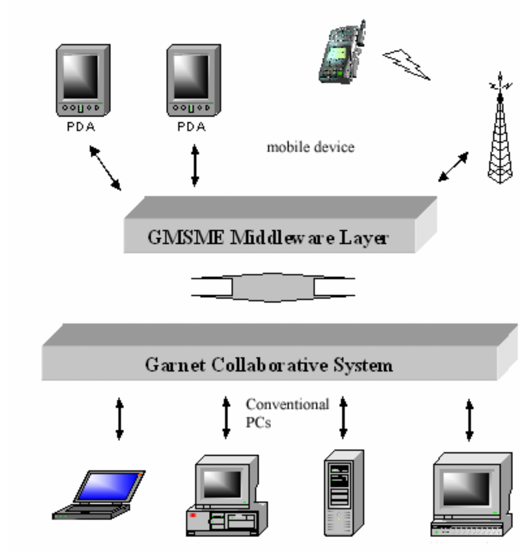

Figure 1. *Overview architecture of GMSME with Garnet Collaboration system and mobile devices*

Scalability:
Our approach to support the user is to provide a Content Adaptor and a Connection Manager per user. Since Connection Manager is multithreaded and non-blocking, both receiving messages and sending messages do not interrupt each other; this ensures a large number of users can share a GMSME middle layer. The NaradaBrokering event system as a primary event broker on the Garnet collaborative system guarantees that multiple GMSME middleware layer communicate, thus each GMSME instance can serve a large number of mobile device users at the same time.

Efficiency:
We have two detailed design issues about efficiency. The first is server side computing. We move computation that is required to support the heterogeneous device to the middleware layer to reduce the burden on the personal device. When a Content Adaptor gets the event message from the collaborative server, each corresponding application module processes the message and delivers only vital parts of the message to the Connection Manager. The other is the communication protocol. Since we are stripping down the original message from the collaborative

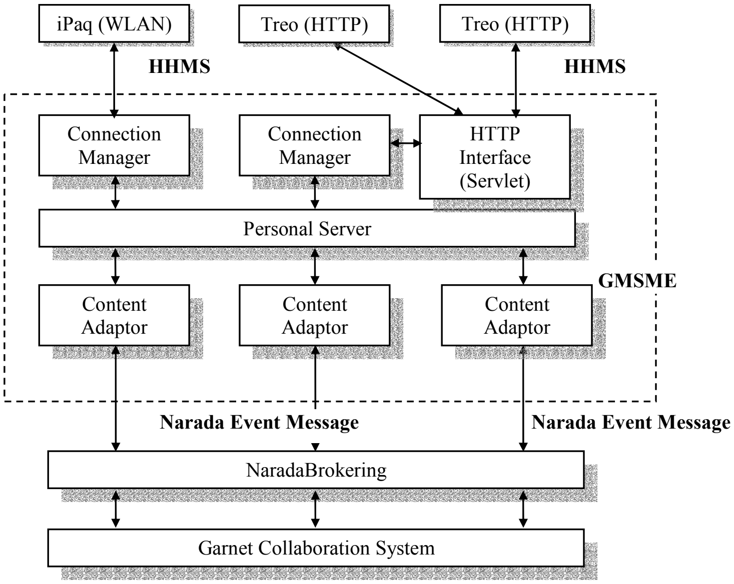

Figure 2. *Internal Component of GMSME middleware layer and protocols between components*

server, as well as other message servers, such as Jabber [17], we defined a new efficient mobile device specific protocol, HHMS. It is a natural modification of the event service of GMSME considering the constraints of the personal device. HHMS is byte-oriented messaging protocol, which includes information about the machine type, application type, event type, and event body.

4. EVENT MAPPING AND INTEGRATION WITH CONVENTIONAL COLLABORATIVE ENVIROMENT

This section describes the implementation of architecture, GMSME. The components and data flows are depicted in Figure 2. A dashed-box wraps GMSME components, which are integrated in a single application. GMSME communicates via messages to outside the box. To PDAs, it is linked with HHMS and to the Garnet system, it linked with NaradaBrokering messages.

4. 1. CONNECTION MANAGER

Connection Manager has network interfaces to the protocols that personal mobile devices use most: HTTP and 802.11b. HTTP support is crucial in GMSME and the Garnet system, since most cellular phones access internet through it. A dilemma with HTTP is that it was designed specifically as a stateless protocol. This is a mismatch with the design of synchronous collaborative systems. To settle this problem, we apply a polling technique to the communication of Connection Manager and collaboration application on the personal device. A Java Servlet is added as a mediator to route HTTP message to the general Connection Manager, described in [16]. In general, the Connection Manager provides the same communication interface to the various protocols. There is a demon server component per protocol. It creates a Connection Manager when a mobile device attempts to join the collaborative session. We introduced the job-queue to balance the job-load of mobile devices in a previous paper [16]. The job-queue is well matched with the polling technique. When the mobile application polls, the Connection Manager checks the job-queue and delivers a ready message individually to the application.

In a different project, we have a web service implementation of the collaborative system. Initially, the SVG interface is implemented to have more choice of participation from the user [18].

4. 2. PERSONAL SERVER (ADAPTER)

This is the main component of GMSME middleware. It sits between the applications on the mobile device and Garnet collaborative system. It looks like a typical Garnet client to the Garnet collaborative server. And it manages mobile users by a User Table. With a new connection from a mobile device, Personal Server creates a Content Adaptor module and assigns it to the user. The message routing is another key function of Personal Server. Because it routes messages internally and the entire user list is in memory, plainly Personal Server links the matching Connection Manager instance with the user message to route them.

4. 3. CONTENT ADAPTOR

Content Adaptor is responsible for processing the collaborative event message. It listens to the entire collaborative message on behalf of the mobile participants and maps the message to HHMS. Personal Server routes a HHMS message to corresponding Connection Manager. Each application on the mobile device has a process module in the Content Adaptor. A collaborative application developer appends an additional module by following the GMSME application API. There are four application modules at this time: Instant Messenger, Textchat, Shared Display, and SVG. The implementations of applications are described in detail in [19].

4. 4. APPLICATIONS

The instant messenger and textchat transport module in the personal server connects to the Jabber open server to deliver a message as well as check presence of other users when it gets request from the client device through the personal server. Textchat client on PDAs and Smart phone works in a similar fashion but it publishes messages to the NaradaBroker instead of connecting the Jabber server.

Shared exports are one of the core applications of the collaboration system. The SVG module in the personal server gets the URL of a SVG file and processes the image based on the user profile. And the personal server sends the filtered image to PDAs client through communication manager over HHMS. The Shared display module works the same way, except it captures the raw image of a shared image and process image filtering.

5. CONCLUSION AND FUTURE WORK

To validate the GMSME architecture, we've implemented it for the desktop PC, local wireless (802.11b) and a cellular phone that has internet access. On the client side, the software is MyProfessor for Windows CE iPaq and Palm OS Cell-PDA combination device. This integrates client side collaboration applications (shared display, SVG, Text chat, Instant Messenger using Jabber). Through the implementation, we illustrated the importance of a middleware layer supporting heterogeneous devices in the collaborative system. We believe our approach — to push down more computing on the middleware side and use a simple and efficient protocol between a mobile application and the middleware — is suitable for most pervasive environments, as well as to the Garnet collaborative system.

We will extend this architecture so it can be integrated into the general NaradaBrokering framework. As noted in Section 2, NaradaBrokering has transport framework to choose appropriate protocols separately on an each hops between nodes. After this integration, HHMS will become the choice for the message to PDA.

REFERENCES

[1] G. C. Fox. "Architecture and Implementation of a Collaborative Computing and Education Portal", ERDC Technical Report, May 2001.

[2] G. Fox, W. Wu, A. Uyar, H. Bulut, and S. Pallickara. "Global Multimedia Collaboration System", Proc. of the 1st International Workshop on Middleware for Grid Computing co-located with Middleware 2003 (MGC2003). June 17, 2003 Rio de Janeiro, Brazil.

[3] G. C. Fox and S. Pallickara. "The Narada Event Brokering System: Overview and Extensions", Proc. of the 2002 International Conference on Parallel and Distributed Processing Techniques and Applications (PDPTA`02). CSREA Press (2002) edited by H.R. Arabnia Volume I pages 353-359.

[4] G. Fox, "Solving Some of the Problems in Collaboration" Presentation at ARL Aberdeen, April 22 2003.

[5] G. Fox, "Overview of Garnet Collaboration System", Proc. of the AG Technical Retreat 2001, Jan. 30 - 31 2001, in Argonne National Laboratory, Chicago, IL, USA.

[6] National Institution of Standards and Technology, "SIP", http://snad.ncsl.nist.gov/proj/iptel

[7] L. Beca, G. Cheng, G. Fox, T. Jurga, K. Olszewski, M. Podgorny, P. Sokolowski, T. Stachomiak and K. Walczak, "TANGO-A Collaborative environment for the World-Wide Web", Proc. of the 5th High Performance Distributed Computing (HPDC `96), Aug 6 - 9. 1997, in Syracuse, NY, USA.

[8] WebEx, http://www.webex.com

[9] Centra, http://www.centra.com

[10] M. Happner, R. Burridge and R. Sharma, "Java Message Service Specification" Sun Microsystems, Inc. http://java.sun.com/products/jms/

[11] R. Monson-Haefel and D. Chappell. *Java Message Service,* Sebastopol, CA: O'Reilly &Associates, Inc., 2000.

[12] R. Han, P. Bhagwat, R. LaMaire, T. Mummert, V. Perret, and J. Rubas. "Dynamic Adaptation in an Image Transcoding Proxy for Mobile Web Browsing", IEEE Personal Communications Magazine, vol. 5, no. 6, Dec. 1998, pp. 8-17.

[13] T. Phan, G. Zorpas, and R. Bagrodia, "An Extensible and Scalable Content Adaptation Pipeline Architecture to Support Heterogeneous Clients", Proc. of the 22nd International Conference on Distributed Computing Systems (ICDCS '02), July 2-5, 2002, in Vienna, Austria.

[14] O. Balsoy and G. Fox, "Garnet XML Object Specification", http://www.gxos.org/

[15] W3C. "Scalable Vector Graphics", http://www.w3.org/Graphics/SVG/Overview.htm8

[16] G. Fox, S. Ko, K. Kim, S. Oh and S. Lee, "Integration of Hand-Held Devices into Collaborative Environments", Proc. of the 2002 International Conference on Internet Computing (IC-02), June 24-27, in Las Vegas, NV, USA.

[17] Jabber, Inc. "Jabber Software Foundation", http://www.jabber.org/

[18] S. Lee, S. Ko, G. Fox, K. Kim and S. Oh, "A Web Service Approach to Universal Accessibility in Collaboration Services", Proc. of the 1st International Conference on Web Services (ICWS`03), June 2003, in Las Vegas, NV, USA.

[19] K. Kim, G. Fox, S. Ko and S. Oh, "Mobile Application Paradigm for Ubiquitous Computing: Universal Collaboration and Access" May, 2003.