Service-oriented Grids for Dynamic E-Learning Environments

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Abstract

Modern Grids are moving towards Service-Oriented Architectures (SOAs) to cope with new distributed applications, beyond traditional massive computing for scientific research. Resource sharing across different e-learning domains in a transparent, seamless and secure way, with wireless support, is the goal of the Grid architecture we have developed. In the first part of the paper we describe Grid Services which cooperate to perform the above task, including discovery and streaming of multimedia objects, content update, and QoS management. The second part of the paper is devoted to the Peer-to-Peer approach we are exploiting to realize a new conception of Grid, where all nodes are potential service providers and contribute to service sharing, discovery and delivery.

1 Introduction

Providing a rich communication medium for work or interest groups, community support systems are gaining more and more attention in application areas ranging from leisure and customer support to knowledge management. ICT, in particular, is becoming of paramount importance for the so-called Informal Learning, which includes all the activities taking place outside classes and courses that aim at understanding, creation of knowledge and skills acquisition.

The ever increasing joint availability of portable devices and wireless technologies and their forthcoming functional integration are changing both the way in which students attend their education in the university, and the way the institution and the professors communicate with the students as well as the way in which students communicate to each other (*i.e.* Mobile Learning). In this time devoted to consolidation of notions and self-confidence development, students will obtain great advantage by a 24/7 access to instructional material, lecture notes, and multimedia contents, such as video recordings of previous classes, made available by teachers and instructors or even by other students.

In this context, our research activity focusing on service-oriented Grids is, for many aspects (*e.g.* mobility), challenging. In our contribution to UMOCEC 2003 we depicted a hierarchy of levels for community-oriented services, and presented a survey on state-of-art technologies for sharing and interoperability of e-learning resources [1]. In this paper we illustrate our results in the design and development of a campus-wide service-oriented infrastructure for multimedia content access. Moreover, we illustrate our P2P-based approach to service sharing, discovery and delivery. Our contribution is concluded by some remarks and an outline of further work.

2 An Orchestration of Multimedia Services

As multimedia content distribution is rapidly becoming one of the most important network applications, several universities around the world have already deployed or are experimenting solutions for multimedia content distribution over their TCP/IP wired/wireless networks and the Internet. In a campus-wide e-learning scenario, recordings of class lectures, seminars, lab sessions are made available in digital format to be streamed and viewed either off or on-campus.

In this context we exploited the Open Grid Service Architecture (OGSA) [4], to hide environment complexity and eterogeneity, providing an omogeneus access to resources through standard service-oriented interfaces. The set of e-learning OGSA-based services we have deployed provides support for discovery and streaming of multimedia objects available on distributed video servers, content update, QoS management, user authentication and authorization. In particular, the user interested in a video content submits his/her query to the *Multimedia Discovery Service (MDS)*. The MDS activates several *Search Service*s to process user query on remote video servers listed by the *Video Server Index*. Search results (e.g. title, format, length, location) are collected by the MDS and returned to the user, which can then select the desired multimedia object. Additionally, the user can request the reservation of network resources through the *Bandwidth Broker Service* or obtain information about the current quality of the relevant network path using the *Monitoring Service*.

We have evaluated our prototype on a typical campus-wide e-learning scenario, in which Several RTSP streaming servers, based either on Darwin or Helix packages, are distributed across the university LANs. The experiments performed so far have validated the overall system in terms of correctness, robustness, and performance. For example, we set up a MDS connected with five video servers, each one managing a database of more than 200 content metadata, to evaluate its performance and to estimate factors affecting service response time. The average execution time is as low as 300ms when the MDS replies to a single query. The minimum answer time is influenced by the number of matching entries returned by the video servers. While the time spent in the execution of Search Service is approximatively constant, the delivery and handling of returned data increase the average response time to a couple of seconds for queries returning more than 100 items. A larger number of concurrent queries to the MDS, as could be foreseen, increases the service response time. Nevertheless, the relation between the number of queries and the response time remains satisfactory, as processing 30 concurrent queries still requires less than three seconds.

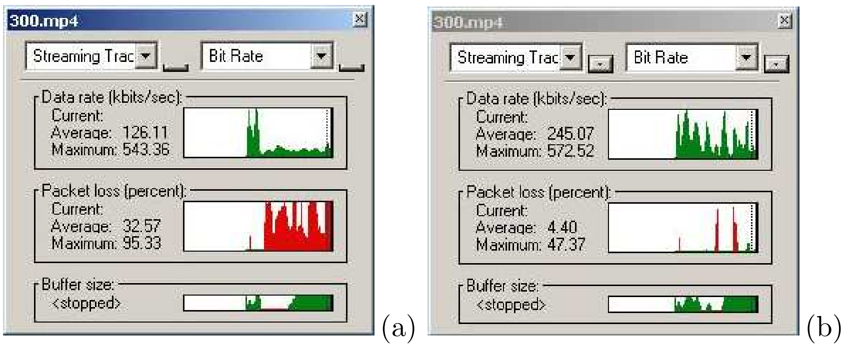

Figure 1: *Quicktime network statistics for best delivery (a) and QoS enabled (b) streaming sessions for a 802.11b wireless client.*

As an excerpt of experimental results obtained for streaming sessions, figure 1 reports some network performance data for a best-effort delivery (a) and a QoS-enabled (b) sessions. Both refer to the same 300 Kbps MPEG-4 stream served by one of the Darwin RTSP Servers to a Quicktime player of a 802.11b wireless client. In order to assess the effectiveness of QoS support in presence of network resource scarcity, these test streaming sessions have been performed while injecting a synthetic UDP stream along the server-client path. This competing stream has a high bitrate of 8Mbps so as to exhaust completely the minimum capacity link along the path, namely the 802.11b wireless access network. In the case of best-effort delivery (figure 1 (a)), the streaming session is sensibly perturbed by the competing traffic as made clear particularly by the large packet loss and by the insufficient average bandwidth in the player statistics. When the streaming session has obtained end-to-end QoS guarantees from the multimedia service and the Bandwidth Broker enables the prioritization of its traffic, the user experiences smooth playback of his/her multimedia content, as testified by the much improved streaming statistics (figure 1 (b)).

3 Peer-to-Peer Approach for a New Conception of Grid

The previously illustrated architecture can be easily deployed in a static environment, where Grid Services are hosted by always available servers (*e.g.* the teachers' ones) and clients know in advance where to find the Multimedia Discovery Service (MDS). In a more dynamic environment, users can be also service providers, *e.g.* students offering computational power, additional storage, etc. This kind of scenario requires to exceed the Client/Server approach of traditional Grids and considers a Peer-to-Peer (P2P) solution to realize a new conception of Grid. With the *Service-oriented Peer-to-Peer Architecture (SP^2A)* [2], we propose a P2P-based approach for service sharing, discovery, and provision. This solution meets the requirements of applications with a large number of users dynamically connecting to the system, and provides high levels of scalability, decentralization and interoperability. The SP^2A P2P overlay network is based on *JXTA*, a Sun Microsystems open P2P initiative [6]. JXTA standardizes a common set of protocols which define the minimum required network semantics allowing peers to form and join an unstructured peer-to-peer network based on supernodes.

Figure 2 illustrates how multimedia services can be shared and accessed in a typical SP^2A configuration. Each MDS has a list of Search Services (SSs), which is periodically updated through P2P discovery. In the proposed example, a peer finds a MDS which has two SSs in its list. MDSs are generally hosted by stable and recognized peers, while SSs may be provided also by volatile peers.

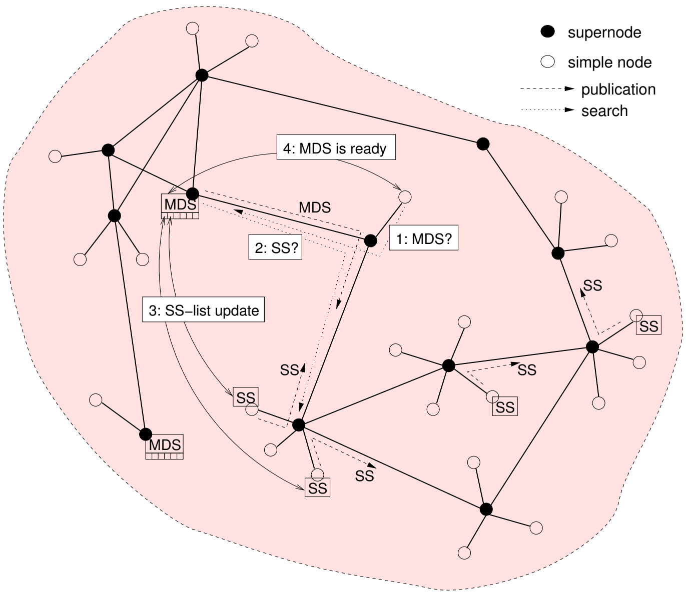

Figure 2: Example of service management across different peergroups in a SP^2A overlay network.

Each Grid Service shared in the SP^2A network has a WSDL interface which defines the allowed operations and expresses the binding information (*i.e.* how to interact with the service). We are investigating the use of OWL-S [5] descriptions to contextualize the service in an ontology shared among SP^2A peers. We plan to derive a single XML document named Grid Service Advertisement (GSA) from the OWL-S description and the WSDL interface of a service. The GSA extends the basic JXTA advertisement and could be obtained by (a possibly partial) mapping of the information contained in the OWL-S ServiceProfile and the WSDL descriptors into a set of (key, value) pairs, e.g. (Name, "MultimediaService"). Such a complete description would allow the peer to elaborate high-level queries, relying on the shared ontology. Complex queries can be translated to sequences of atomic queries for (key,value) pairs, corresponding to the GSA entries, which are directly managed by JXTA discovery protocols.

With the intention of allowing peers to run also on PDAs, cell phones and other wireless devices, we are developing the JXME (*i.e.* J2ME-based JXTA binding) version of the SP^2A prototype. The major issue is the introduction of QoS-constrained search capabilities as well as profile-based service adaptation, in order to cope with the limitations of mobile devices.

4 Conclusions and Future Work

Several open issues will be investigated in our future research. First of all, we are analyzing the *WS-Resource Framework (WSRF)* [3] which is a straightforward refactoring of the concepts and interfaces developed in the OGSI [7] specification in a manner that exploits recent developments in Web Services architecture (*e.g.*, WS-Addressing). We plan to adopt the forthcoming 4th release of the Globus Toolkit, supporting WSRF. Another primary issue we are concerned with is the introduction of security policies and mechanisms in the SP^2A system, aiming at integrating the somewhat contrasting security models of Grid and JXTA. Finally, we are improving the prototype implementation to allow peers to perform semantically-enriched searches for published services, *i.e.* on the basis of ontologies defining relationships between service-related concepts.

5 Acknowledgments

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