Chapter 9
Mobile Agent-Based Services for Real-Time Multimedia Content Delivery

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ABSTRACT

Technologies and applications that enable multi-party, multimedia communications are becoming more and more pervasive in every facet of daily lives: from distance learning to remote job training, from peer-to-peer conferencing to distributed virtual meetings. To effectively use the evolving Internet infrastructure as ubiquitously accessible platform for the delivery of multi-faceted multimedia services, not only are advances in multimedia communications required but also novel software infrastructures are to be designed to cope with network and end-system heterogeneity, improve management and control of multimedia distributed services, and deliver sustainable QoS levels to end users. In this chapter, the authors propose a holistic approach based on agent-oriented middleware integrating active services, mobile event-driven agents, and multimedia internetworking technology for the component-based prototyping, dynamic deployment, and management of Internet-based real-time multimedia services. The proposed approach is enabled by a distributed software infrastructure (named Mobile Agent Multimedia Space – MAMS) based on event-driven mobile agents and multimedia coordination spaces. In particular, a multimedia coordination space is a component-based architecture consisting of components (players, streamers, transcoders, dumper, forwarders, archivers, GUI adapters, multimedia timers) that provide basic real-time multimedia services. The event-driven mobile agents act as orchestrators of the multimedia space and are capable of migrating across the network to dynamically create and deploy complex media services. The effectiveness and potential of the proposed approach are described through a case study involving the on-demand deployment and management of an adaptive cooperative playback service.

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INTRODUCTION

The global Internet is developed by using heterogeneous communication technologies (e.g., satellite, wireless, xDSL, and gigabit networks) in such a way to make it ubiquitously accessible on a world-wide scale by heterogeneous, even mobile end-systems (e.g. high-performance PC, low-cost lap-tops, 3G mobile phones, and handhelds). Heterogeneity and ubiquitous access allow the application service providers (ASP) to develop and timely deliver a wide gamma of diversified services and end-users to be rapidly notified and updated to connect to and utilize new available services.

In this context, it is challenging to dynamically build, deploy, and offer large-scale multimedia real-time services that are more and more exploited in application domains such as Education (e.g. distance learning), Business (e.g. remote meeting and continuous training) and, notably, Entertainment (e.g. video on-demand and virtual multimedia spaces).

Even though, from one perspective, "network" and "end-system" heterogeneity is the key enabling concept featuring ubiquitous service provision by content providers and service exploitation by users, on the other hand, such heterogeneity is the main barrier to the deployment of real-time multi-point multimedia infrastructures.

Network heterogeneity mainly concerns the bandwidth available between different unicast transmitter/receiver pairs or among multicast groups of interacting peers. In fact, while some hosts are connected by means of high-speed networks, others are attached through traditional LANs, ISDN and ADSL lines, slow speed dialup lines, or cellular networks of highly variable bandwidths. In addition the lack of efficient multipoint communication in the form of a widely available IP multicast infrastructure (McCanne, 1999) diminishes scalability and prevents an effective exploitation of multi-party real-time multimedia services.

End-systems heterogeneity concerns the multimedia computing capabilities, and, in particular, the different processing power and video/audio hardware configurations of the end-systems. In fact, while some end-systems are PCs equipped with powerful MPEG boards, others may be high-performance workstations with no specialized multimedia hardware or even handheld devices with constrained capabilities.

Both kinds of heterogeneity can be accommodated by exploiting the least common denominator solution, i.e., sustainable levels of Quality of Service, e.g., media flow rate (Busse, et al., 1996), video resolution, etc) are tuned to the lowest-performance host belonging to a multimedia session (e.g., conferencing, media broadcasts). However such a solution turns into a real problem as it is tuned to the lowest performance hosts so penalizing all the other hosts involved in a common multimedia session.

Network heterogeneity can be more fairly tackled by employing receiver-oriented end-to-end approaches, such as the Receiver-driven Layered Multicast (RLM) scheme (McCanne, 1999) for video transmission, which, even though easily deployable without enhancing the network system with additional functionality, provide a coarse-grained adaptation (e.g., on a media layer basis) and fulfill only a single dimension of heterogeneity (bandwidth) so not considering others (e.g., media format conversion).

Differently from end-to-end approaches, the approach centered on media gateways (Amir, et al., 1995) provides a more effective solution for masking of and finer-grained adaptation to network and end-systems heterogeneity.

Media gateways are multimedia agents placed at strategic points within the network system and basically perform format conversion (or transcoding), unicast/multicast tunneling, and rate limitation of real-time media streams. As the basic Internet service model has no native support for the dynamic deployment of agents such as media gateways, it is therefore crucial to build an effec-