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Chapter III

The Design and Performance of a CORBA Audio/Video Streaming Service

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INTRODUCTION

Advances in network bandwidth and CPU processing power have enabled the emergence of multimedia applications, such as teleconferencing or streaming video, that exhibit significantly more diverse and stringent quality-of-service (QoS) requirements than traditional data-oriented applications, such as file transfer or email. For instance, popular Internet-based streaming mechanisms, such as Realvideo (RealNetworks, 1998) and Vxtreme (Vxtreme, 1998), allow suppliers to transmit continuous streams of audio and video packets to consumers. Likewise, non-continuous media applications, such as medical imaging servers (Hu et al., 1998) and network management agents (Schmidt and Suda, 1994), employ streaming to transfer bulk data efficiently from suppliers to consumers.

However, many distributed multimedia applications rely on custom and/or proprietary low-level stream establishment and signaling mechanisms to manage and control the presentation of multimedia content. These types of applications run the risk of becoming obsolete as new protocols and services are developed (Huard and Lazar, 1998). Fortunately, there is a general trend to move from programming custom applications manually to integrating applications using reusable components based on open distributed object computing (DOC) middleware, such as CORBA (Object Management Group, 1999), DCOM (Box, 1997), and Java RMI (Wollrath et al., 1996).

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Although DOC middleware is well-suited to handle request/response interactions among client/server applications, the stringent QoS requirements of multimedia applications have historically precluded DOC middleware from being used as their data transfer mechanism (Pyarali et al., 1996). For instance, inefficient CORBA Internet Inter-ORB Protocol (IIOP) (Gokhale and Schmidt, 1999) implementations perform excessive data-copying and memory allocation *per-request*, which increases packet latency (Gokhale and Schmidt, 1998). Likewise, inefficient marshaling/demarshaling in DOC middleware decreases streaming data throughput (Gokhale and Schmidt, 1996).

As the performance of DOC middleware steadily improves, however, the stream establishment and control components of distributed multimedia applications can benefit greatly from the portability and flexibility provided by DOC middleware. Therefore, to facilitate the development of standards-based distributed multimedia applications, the Object Management Group (OMG) has defined the CORBA Audio/Video (A/V) Streaming Service specification (OMG, 1997a), which defines common interfaces and semantics necessary to control and manage A/V streams.

The CORBA A/V Streaming Service specification defines an architecture for implementing open distributed multimedia streaming applications. This architecture integrates (1) well-defined modules, interfaces and semantics for stream establishment and control with (2) efficient data transfer protocols for multimedia data transmission. In addition to defining standard stream establishment and control mechanisms, the CORBA A/V Streaming Service specification allows distributed multimedia applications to leverage the inherent portability and flexibility benefits provided by standards-based DOC middleware.

Our prior research on CORBA middleware has explored the efficiency, predictability and scalability aspects of ORB endsystem design, including static (Schmidt et al., 1998a) and dynamic (Gill et al., 2001) scheduling, I/O subsystem (Kuhns et al., 1999) and pluggable ORB transport protocol ((O'Ryan et al., 2000) integration, synchronous (Schmidt et al., 2001) and asynchronous (Arulanthu et al., 2000) ORB Core architectures, event processing (Harrison et al., 1997), optimization principle patterns for ORB performance (Pyarali et al., 1999), and the performance of various commercial and research ORBs (Gokhale and Schmidt, 1996; Schmidt et al., 1998b) over high-speed ATM networks. This chapter focuses on another important topic in ORB endsystem research: *the design and performance of the CORBA A/V Streaming Service specification.*

The vehicle for our research on the CORBA A/V Streaming Service is TAO (Schmidt et al., 1998a). TAO is a high-performance, real-time Object Request Broker (ORB) endsystem targeted for applications with deterministic and statistical QoS requirements, as well as best effort requirements. The TAO ORB endsystem contains the network interface, OS I/O subsystem, communication protocol and CORBA-compliant middleware components and services shown in Figure 1.

Figure 1 also illustrates how TAO's A/V Streaming Service is built over the TAO ORB subsystem. TAO's real-time I/O (RIO) (Kuhns et al., 2001) subsystem runs in the OS kernel and sends/receives requests to/from clients across high-speed, QoS-enabled networks, such as ATM or IP Integrated (IETF, 2000b) and Differentiated (IETF, 2000a) Services. TAO's ORB components, such as its ORB Core, Object Adapter, stubs/skeletons and servants, run in user-space and handle connection management, data transfer, endpoint and request demultiplexing, concurrency, (de)marshaling and application operation processing. TAO's A/V Streaming Service is implemented atop its user-space ORB components. At the heart of TAO's A/V Streaming Service is its *pluggable A/V protocol framework*. This framework

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