QuickTime™ Conferencing
Technical Backgrounder

Introduction

QuickTime™ Conferencing (QTC), a new technology from Apple Computer Inc., brings networked multimedia capabilities to both end-users and developers. QTC extends the capabilities of the desktop computer and transforms it into a multimedia communications engine. As author George Gilder has stated, the power of a computer grows exponentially with the number of connections it makes to other computers; this is especially true if those are multimedia connections. There are a variety of multimedia connections that end-users and developers want to be able to make when using their networks. These types of connections are described below.

Users want to make multimedia connections from one computer to another easily, to order to work together, to collaborate and to share multimedia data in real-time. Sharing of all data types—text, pictures, digital audio, bitmaps, digital movies and virtual scenes is desired. Working collaboratively, users may want to archive all of the elements of the collaboration—the conversations that take place, the annotations, the physical objects which get viewed and the media data which gets shared. The archiving of all of these items makes useful for the long term the real-time media communication which has taken place on the network.

Users need to be able to use their computers on a network to both broadcast and view multimedia content. Broadcasting of content allows a user to take their ideas (as speech, music or video) and to distribute that media in real-time to any number of users on the network in an efficient manner. Anyone on the network can “tune in” to these broadcasts. Any machine on the network can watch these broadcasts, and multiple broadcasts can be viewed at a time. This capability allows for bringing lectures, classes, seminars, news and speeches directly to the desktop via a local or wide area network.

When communicating from one computer to another, users want to be able to connect to each other, independent of what type of network, multimedia capability or computer they might have. Independent of whether you are on the worldwide internet, basic rate ISDN, an Ethernet local area network or even ATM, you should be able to make a connection. Similarly, you might have one user with full AV capability, and another user with only a microphone; they should be able to do useful work together collaboratively on a network. And it should not matter if you have a desktop machine or a portable computer; indeed it should not matter if you have a Mac or a PC. Making a multimedia connection should be easy, fast, productive and fun. A user in the United States should double-click the software installer and begin media conferencing with a European user thousands of miles away on the internet, or listen to digital music being broadcast on a local area network in Japan, within minutes of getting started.

Previous Systems

Previous desktop conferencing and networked multimedia systems have typically been proprietary, where a single vendor system can communicate only with another system from the same vendor. The systems are often not only incompatible between different platforms, but are sometimes incompatible even on the same platform. Previous conferencing systems have also tended to be monolithic—large pieces of software and hardware tightly coupled together, and difficult to modify in order to support new features (such as a new network type or improved video or audio compressor). Often these conferencing systems are tied directly to a particular network, or use only a single compression scheme. If a user wishes to run on a different network to connect to somebody new, they need to purchase a different conferencing package. And so the situation has become a veritable Tower of Babel, with many conferencing systems unable to work with each other, all speaking different and hard to understand languages. Yet, everyone wants to communicate with each other in a seamless manner, and a worldwide network infrastructure is rapidly being developed. Now is an optimal time to develop a better solution.

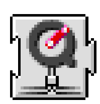
QuickTime Conferencing has taken a different approach. QTC is a general purpose, system software approach to supporting desktop conferencing and networked multimedia. The QTC framework is an open architecture, where it is easy to add support for new networks, codecs and protocols. For interoperability, Apple is supporting the worldwide standard for teleconferencing (H.320) allowing for interoperability between Mac, PC, UNIX and room based systems. In addition, the QTC architecture allows adding support for new conferencing standards more easily than alternative systems because of its component based design. Focus has also been placed on providing a low-cost software-only solution which takes advantage of the convergence of PowerPC performance, built-in AV, networking and multimedia support. On most other platforms, it is necessary to purchase add-in cards and additional software to match Apple's solution right out of the box. For this reason, Apple can deliver solutions to the end-user for desktop conferencing that will be hard to match.

A number of elements are falling into place to make networked multimedia pervasive. The internet is evolving to support real-time media streams, basic rate ISDN to the home, school and office is now a reality, and the cable and telephone companies are building ATM-based broadband networks to support multimedia applications. The personal computer is now RISC based, providing new levels of performance required for the demanding and requisite work of compressing and decompressing multiple streams of real-time media to and from networks. AV capabilities are built-in directly to CPUs, so that with addition of only a camera, you can teleconference with another user, right "out of the box". And users want to work together and to share multimedia data from different locations as easily as possible. QTC has been developed to exploit the convergence of all of these trends and to make multimedia networking and desktop conferencing a reality.

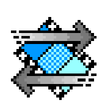
QuickTime Conferencing Software

QuickTime™ Conferencing is an end-user and developer software technology for multimedia networking from Apple Computer Inc.

The developer technology is an operating system extension and set of application programming interfaces (API) which support real-time networked multimedia on both local and wide area networks. The QTC extension makes it easy for developers to add real-time media communications to their applications. Unlike many existing conferencing systems, QTC technology is an open architecture and software infrastructure; it is compression, network and protocol independent. As a result, the technology can use a variety of connection models, over a range of networks, with a large set of audio and video codecs. QTC allows support for the worldwide H.320 standard for teleconferencing, allowing for cross-platform communications between Macintoshes, PCs, UNIX and room based conferencing systems.



The end-user deliverable of QTC is an easy to use software application called Apple Media Conference. Apple Media Conference allows users to work together on multimedia data across a network, to save the results of their multimedia collaboration, and provides the ability to show and watch multimedia broadcasts on a network. Apple Media Conference together with QTC transform a traditional desktop Macintosh into a multimedia communications machine.



The following sections review these components of QTC in detail.

QuickTime™ Conferencing Operating System Extension

The QuickTime Conferencing system extension can be used to add real-time media communications to software applications. Targeted developers include networking and communications providers, multimedia, collaboration and groupware authors, along with and mainstream software and hardware developers. The QTC system extension can be used both by Apple and third parties to build networked multimedia applications.

Open Architecture

QuickTime Conferencing is an open architecture for multimedia networking and desktop conferencing. QTC is built as a set of software components, each dedicated to a different functional area of multimedia networking. These components are based on the QuickTime component manager, which allows the development of software modules which use “run-time functional binding”. This means that you can drop new QTC components (such as a software teleconferencing compressor or new network protocol) into your system folder and they will run with any QTC applications, without the need for rewriting or recompiling the application. QTC has an API for every component in the system, allowing developers to directly control any software component, or to rewrite any software component if desired.

Rich Set of Functionality:

QuickTime Conferencing provides the following feature set as part of the operating system extension:

- easy to create and to use different types of multimedia connections
- point to point, multipoint and broadcast connections
- transport, compressor and media independent
- synchronization of AV streams on packet and switched networks
- flow control, prioritization and bandwidth management for media streams
- data transmission and sharing among multiple conference users
- support for a number of software AV codecs and specific network supports
- standard human interface elements for controlling media streams
- network browsing and address book components
- recording of connections and conferences into multi-track QuickTime movies

End-User Software Application	Apple Media Conference: Provides real-time AV multiparty conferencing, multimedia collaboration, shared whiteboarding, recording of connections into QuickTime movies, and the ability to show and watch media broadcasts on the network
System Software	QuickTime Conferencing APIs: Provides developer API services corresponding to the following components: • multiparty conferencing “Conference” • media stream control “Stream Director” • media communications protocols “Transport” • network layers “Network” • browsing networks “Browser” • recording connections “Recorder” • bandwidth management “Flow Control” • playback of media streams “Stream Player”
Software Codecs	H.261: worldwide standard for video teleconferencing. Native PowerPC software implementation runs at QCIF resolution at 10-15fps, at bit rates between 64 kbit/sec to 384 kbit/sec.
Communication Protocols	H.320: worldwide standard for AV teleconferencing. Runs at CIF resolution at 15fps, at bit rates between 64 kbit/sec to 128 kbit/sec using an AV plug-in card. Used on circuit-switched isochronous networks. MovieTalk: multimedia communications protocol for managing real-time AV streams and control messages on packet-switched local and wide area networks AppleTalk Multicast: extensions to the AppleTalk protocol to support multicast transmission of media streams on enterprise networks, including a protocol for multicast routing. This protocol is available for license to network infrastructure providers.
Human Interface	Stream Controller: provides standard human interface element to developers for user control of media streams (snapshot, record, play/pause, volume and gain control, etc.) Business Cards: provides standard human interface element for storing network address information in digital business cards for AV conferencing users and broadcast media services

Figure 1. QuickTime Conferencing end-user and developer technology components.

These services provided by the QTC API are shown within the context of the layered architecture diagram below.

Applications	Apple Media Conference	Third Party Applications		
Application Services	Conference Management	Network Browsing	Recording of connections	Human Interface
AV Services	Audio: G.711	Video: H.261, JPEG, Indeo		
Stream Management	AV stream control, display, playback			
Flow Control	Bandwidth management, stream scaling			
Communication Protocols	H.320, RTP, MovieTalk			
Network Components	AppleTalk, TCP/IP, X.25, OpenTransport			
Physical Links	Ethernet, ISDN, Token-Ring, isoEthernet, ATM			

Figure 2. QuickTime Conferencing layered architecture illustrating both built-in and potential components

Easy to Develop Applications:

The QuickTime Conferencing architecture encapsulates considerable complexity within the multi-layered architecture. Nevertheless, to add real-time networked media and data sharing to a software application with QTC is easy. Developers can use only the conference component API to manage multimedia connections. A typical developer needs to only use this single API, with a small number of function calls, to control a full-blown multiparty conference with multimedia data sharing, or to add broadcast viewing to an application. This capability is achieved, because the QTC architecture is hierarchical, where the highest level component (the conference component) transparently manages the interactions of a number of lower level components (stream directors, transport components, etc.). As a result of this simple interface for a developer, a basic AV conferencing application can be easily created in a matter of days or weeks.

Transport, Compressor and Media Independence:

A major objective of developing QTC as an open architecture was to facilitate the use of different networks, codecs and media input devices. This was done so that users and developers could use those capabilities resident on their platform for conferencing, but more importantly, to allow the plugging-in of higher performance networks/codecs or newly popular communications standards, as they become available over time. This situation is analogous to the development of the original version of QuickTime where a simple compression scheme was available initially, which was supplanted by a higher performance algorithm identified shortly thereafter. When that happened, because the new video compressor was created as a QuickTime component, it “just worked” with all QuickTime applications—no QuickTime application needed to be recompiled or rewritten to use the compressor. A major assumption for QTC is that the nascent information highway is highly volatile and evolving in a somewhat chaotic fashion. Since it is unclear which audio, video and network standards will prevail, it made sense to develop a system extension which could easily adapt to new standards as needed. QuickTime Conferencing is transport independent, compression independent and media device independent. QuickTime Conferencing can use:

- different physical networks (ISDN, ethernet, isoEthernet, ATM)
- different network protocols (AppleTalk, TCP/IP, X.25)
- different media communications protocols (H.320, RTP, MovieTalk)
- different audio and video codecs (H.261, JPEG, Apple Video, etc.)

Each of the functional areas shown above corresponds to a specific QTC software API and component. For example, the functionality of a media communications protocol is typically encapsulated in the transport component. A new network layer can be added by writing a network component. A new video compressor can be developed by using the QuickTime compressor interface. Apple and third parties can easily add these new modules and they can be used with any QTC savvy application.

QuickTime Conferencing places special emphasis on transport independence. In this case, the QTC architecture supports existing communications APIs (such as AppleTalk and MacTCP), as well as the upcoming OpenTransport API from Apple. This allows QTC applications to be both backwards compatible and “future ready”. A developer creating an OpenTransport module will find that their network support will “just work” with QTC. QuickTime Conferencing has the same message as OpenTransport—transport independence is a fundamental element for networking software in the 1990’s. Finally, the intention is to support today’s networking infrastructure, such as ISDN and Ethernet, and to scale up to emerging network infrastructure more appropriate for real-time media streams, such as isoEthernet and ATM.

The QuickTime Conferencing architectural view is that the user and third party developer should need to know as little as possible about lower level distinctions of compressors, media input devices and networks. This is so that they can focus on what is really important—making multimedia connections happen.

• Interoperability

The open architecture approach taken with QuickTime Conferencing facilitates interoperating with both proprietary and standards based systems on other computing and communications platforms. Apple is working together with third parties to build interoperable QTC components which can communicate with systems on other platforms. The QuickTime Conferencing philosophy is that there will be a variety of standards which will evolve over time. The best approach is to have a flexible architecture which can easily accommodate the ability to communicate with these different standards.

An initial example of the use of the QTC open architecture for the purposes of interoperability is the effort of Apple working together with a third party to deliver a set of H.320 QTC components. In this case, a developer has created H.320 transport and network components, along with an H.261 QuickTime video compressor and a G.711 Sound Manager audio compressor. When these components are used, QTC can interoperate with PC, UNIX and room based systems which support the H.320 worldwide standard for teleconferencing.

Additionally, any developer who writes a QTC application adhering to the standard API for conferencing will be compatible with all other QTC conferencing applications. This means that conferencing applications can now communicate with each other easily. Apple is working together with third parties to build a set of conferencing applications, all of which are interoperable, just by adhering to the QTC API. Because of a software development environment targeted for interoperability, the QTC team along with third parties, can add support for additional proprietary and standards based systems over time.

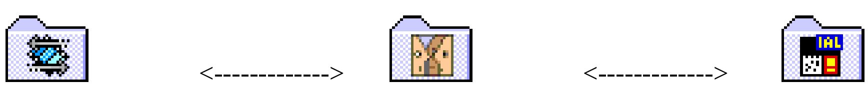


Figure 3. Interoperability between QTC applications

Move Processing into Software

Traditionally, AV conferencing systems have been hardware based, generally involving a compressor box external to the computer in the past, and more recently requiring the use of high performance add-in boards with sufficient power to compress digital audio and video to relatively low bit rates. With the advent of RISC processing in the personal computer, it is now feasible to start moving considerable amounts of functionality directly onto the main CPU. The QTC software-only solution provides for features such as:

- full-duplex AV compression and decompression

- processing of low bit rate compression algorithms
- managing multiple AV streams concurrently
- flow control, prioritization and bandwidth management
- multicast protocols for efficient distribution of media streams
- echo reduction algorithms
- guaranteed service for selected media streams
- negotiation of stream formats among conference machines

This is a significant list of tasks to consume the main processor of a personal computer, especially considering that collaborative computing demands that other conventional software applications (i.e., word processing, e-mail, spreadsheets) also run concurrently so that data can be shared amongst conference participants. However, with RISC based computing, this is now practical, and will become more so in the coming years as RISC architectures scale up to even higher speeds.

Scalability

QuickTime Conferencing was designed to adapt to available resources, whether it be network bandwidth, processing power, media input devices or the type of computer in a conference. The more environments that QTC adapts to, the more transparent the experience will be for a user, hiding the considerable lower level complexities of making multimedia connections. QTC will adapt to available bandwidth, connectivity and processing power and runs over a good-sized product family of personal computers.

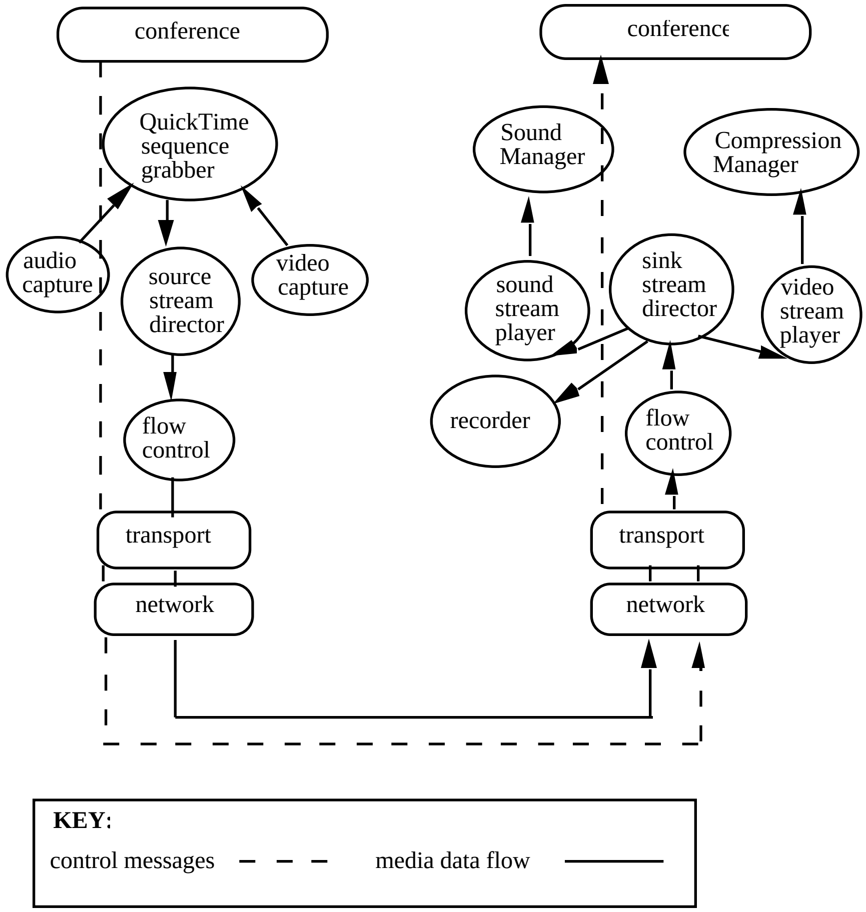


Figure 4. Media stream data flow shown in one direction, from the media "source" to the media "sink". The flow of both control messages and media data is shown in the diagram, along with each component managing the data flow through the computer(s) and across the packet or isochronous network.

Built on Foundation Technologies

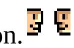
Apple has developed a strong foundation for multimedia communications. QTC builds upon a number of existing Apple software and hardware technologies:

- QuickTime for real-time capture, compress/ decompress of media data
- Sound Manager for managing digital audio
- PowerTalk for network browsing and personal address books
- OpenTransport for transport independent networking
- Multi-protocol network services (AppleTalk, MacTCP, ISDN, etc.)
- AV input for digitizing audio and video
- PowerPC for high performance processing
- built-in Ethernet for send/receive of media streams

QuickTime Conferencing takes advantage of the tight software/hardware integration that Apple is well known for. The combination of these technologies is significant, and QTC is a good opportunity to tie them all together into a powerful solution.

Support for a Variety of Connection Models

There are several different kinds of QuickTime Conferencing connections, and each is useful in a variety of applications.

The first is a standard two-entity connection, or point-to-point connection. 

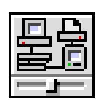
Control and media information flow across the connection bidirectionally. This is generally useful for videophone communications, collaborative work and for client-server applications.

The second type of connection is called a multipoint connection. 

In this case the QuickTime Conferencing entities may be connected to more than one other entity on the network. Control and media data flow between each connected entity. Typically, these connections are considered “fully connected,” meaning that each entity has a direct link to each other entity in the connection. This is most often used in small conference and workgroup situations.

The third type of connection is called a broadcast connection. 

In this case the data flows one-way from a sender to receiver(s). This type of connection is used in situations where one entity needs to send data to potentially many receivers. For example in a lecture or “broadcast” application, it may be desirable to transmit both video and sound across an enterprise network. It should be noted that multicast data will typically go only to those receivers requesting the data, and will consume only one stream of network bandwidth per data source.



Network Bandwidth Management

If QuickTime Conferencing is running on a shared network such as Ethernet, then QuickTime Conferencing will have an impact on the network. If QuickTime Conferencing is running on an isochronous network (such as ISDN or isoEthernet) where a specific dedicated link or channel is used, there is no impact on other users on the network. When QuickTime Conferencing is in use on a shared network, special care has been taken to minimize network impact for other users on the network who are not engaged in conferencing or real-time media usage.

QuickTime Conferencing has five major features to assist in the area of providing efficient and manageable network bandwidth for real-time media streams on local and wide area packet-based networks. These features are:

Flow Control for Real-Time Media.

QuickTime Conferencing provides flow control algorithms which control network bandwidth when using real-time media streams. The algorithm will scale the bandwidth of selected media streams down as the network traffic increases, and will scale selected streams up if there is little or light traffic on the network.

The scaling techniques maintain audio quality while concurrently varying video quality, since people are more sensitive to maintaining continuous audio quality. The flow control algorithm works independently for each direction of a connection; it uses a time-weighted statistical metric of network interface performance and throughput to derive a suggested transmission rate for the source of the media data. In addition to varying video data flow, audio data is only transmitted if the audio energy level is above a certain threshold, reducing network bandwidth further. If many users are sharing a network for media conferencing, along with e-mail, server access and printing, then QuickTime Conferencing will adjust the rates of all of the conferencing users accordingly, so that there is a low packet loss rate. This will ensure a reasonable throughput for the users involved in typical use, while maintaining integrity of the conferences as well. QuickTime Conferencing has been tested in heavy traffic campus environments, with normal usage taking place and media conferences going through numerous routers and hubs with reasonable performance.

Multicast Media Distribution.

QuickTime Conferencing provides multicast capability for efficient distribution of media streams on enterprise networks. Multicast distribution of media means that data only goes to those machines which request the data, not to all machines situated on the network. Multicast protocols are an efficient means to provide media broadcast services, along with multi-party conferencing on packet based networks.

Prioritizing Media Streams within the Network Router.

Commercial routers for enterprise networks often support the notion of traffic prioritization. Traffic prioritization of media streams at the router results in real-time media traffic being given a higher (or lower) priority than other types of data traffic flowing through the router. Network administrators who wish to make real-time media streams more important than other traffic can do so; similarly, administrators wishing to reduce the importance of real-time media can do so as well. QTC data streams can be identified for prioritization at the network router.

Low Bit Rate Video Coding Algorithms

Apple is providing a baseline software implementation of the worldwide video coding standard H.261. The H.261 algorithm can generate video at bit rates as low as 64 kbits/sec. The full scaling of the bandwidth for H.261 is 64 kbits/sec to 384 kbits/sec, which is relatively low compared to other coding schemes such as motion-JPEG, Apple Video and Indeo. The low bit rate of the H.261 coding algorithm will result in a far lower impact on the network overall, as well as other network users (who may not use real-time media services). In addition, Apple is working with third parties to provide alternative low bit rate video coding algorithms as well.

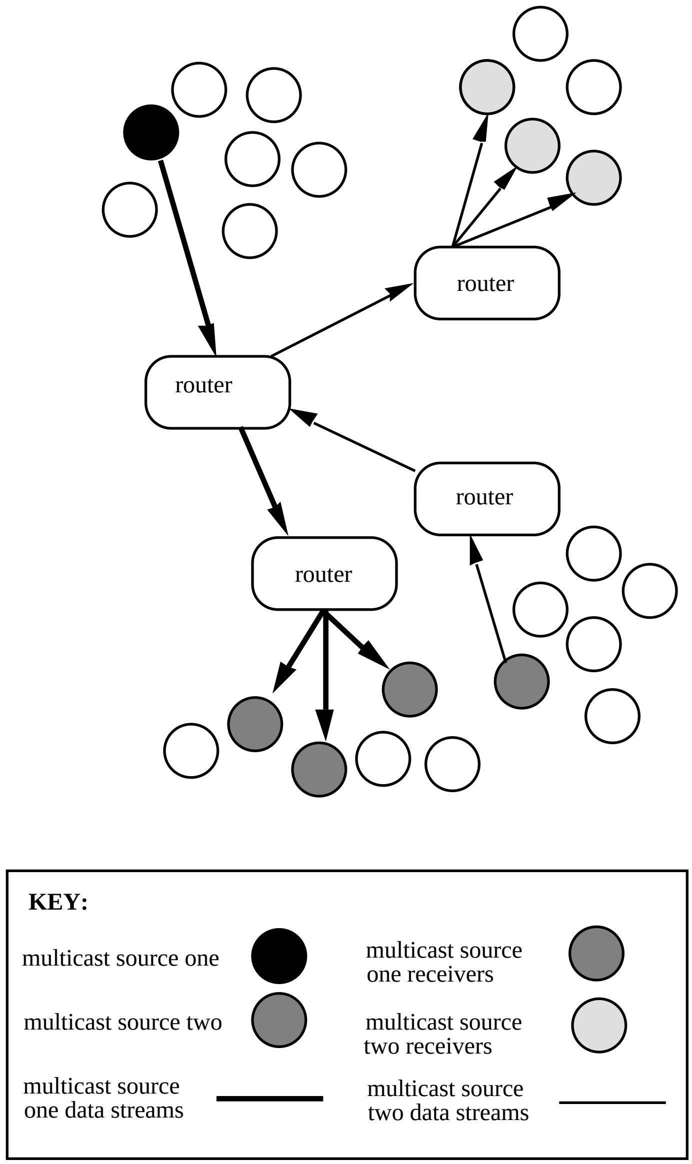


Figure 5. QuickTime Conferencing using multiple multicast source(s) and receivers on an enterprise network.

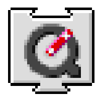
Network Bandwidth Monitoring & Management

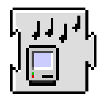
An additional QuickTime Conferencing component is under development that will allow a network administrator to monitor the current bandwidth being used by QTC applications; monitor the number of active QTC applications; and monitor the number of active QTC connections. Additionally, the network administrator will be able to set the maximum allowed bandwidth of a node via SNMP (Simple Network Management Protocol). If SNMP is not used by the network administrator, the QTC system extension will use a default maximum allowed bandwidth to limit the impact on the network.

Software Codecs for Teleconferencing

The first release of QuickTime Conferencing will support the international compression standard for video conferencing, the H.261 video coding algorithm. The QTC implementation of H.261 is designed to run at a variety of bit rates, from 64 kbit/sec up to 384 kbit/sec. The current Apple implementation runs at QCIF resolution (176 x 144) at 10-15 fps on a PowerPC 601 processor. Because of the high performance of the PowerPC 601 and 604 processors, software based encoding and decoding of H.261 is now truly practical. Using H.261 within the QuickTime Conferencing environment will produce acceptable AV performance on ISDN, the worldwide TCP/IP internet and enterprise networks for multiple conferencing users. The inclusion of an H.261 software video compressor is an advantage of a QuickTime Conferencing based solution, as most systems have typically required expensive hardware to provide this capability. Instead, Apple is providing a low-cost, software-only, standards-based solution using the power of PowerPC.

Extending the QuickTime Architecture





QuickTime Conferencing is the most recent extension to the original QuickTime architecture. To date, QuickTime has been enhanced significantly from the original set of point releases to include additions such as:

- QuickTime for Windows
- QuickTime MIDI
- QuickTime VR, and now
- QuickTime Conferencing

All of these are built on top of the component manager foundation established by the original version of QuickTime. Each QuickTime extension is a modular architecture of its own, allowing for various types of plug-ins from third parties and for new functionality. QuickTime is now growing as a product family to incorporate a broad range of digital multimedia functionality, from CDROM playback to virtual scene navigation, and from digital music to teleconferencing and multimedia collaboration.

Extensibility

The open architecture approach taken with QuickTime Conferencing will facilitate the addition of new networks, codecs and protocols over time. As the internet grows in popularity, support for internet multicasts could be added; as broadband field trials transform into readily available broadband services, ATM network components can be added. As PowerPC performance improves, the resolution of the conferencing windows will scale up accordingly, as will the frame rate of the displayed video images.

QuickTime Conferencing is a software foundation. It provides an open architecture framework, along with a basic set of built-in capabilities. Expect it to grow in richness and completeness of support for different networks, codecs and protocols; please join us for this journey.

End-User Application—Apple Media Conference

Apple Media Conference is Apple’s premiere end-user application which uses the QuickTime Conferencing operating system extension. Apple Media Conference was designed in tandem with the QTC APIs, in order to better drive an end-user experience for the QTC technology. Feedback from users has been extensive, human interface design has been a priority and ease of use was considered to be a primary objective. An emphasis on making media conferencing easy, fast, productive and fun has produced a software application which promises to make multimedia networking pervasive. Apple Media Conference allows users to:

- establish video connections as well as share and annotate multimedia information (text, images, screen capture, sounds, movies, virtual spaces) among multiple conference users

good chart, but still needs fixes

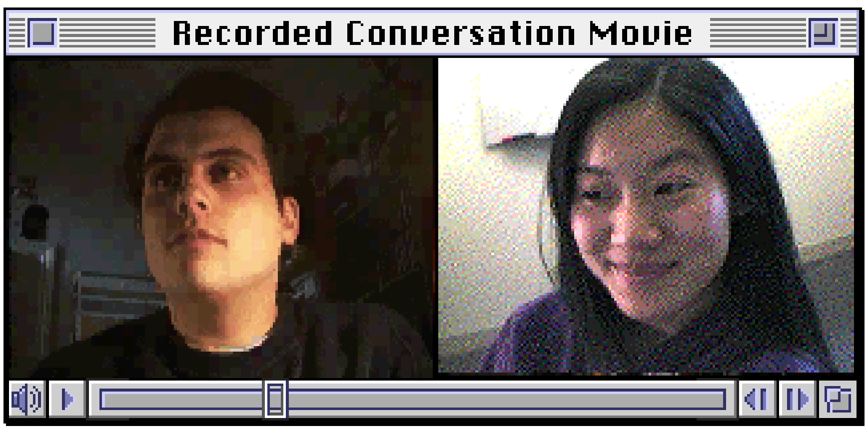
yes, it is close Kevin

Applications	Apple Media Conference	Third Party Apps		
Application Services	Conference Management	Network Browsing	Recording of connections	Human Interface
AV Services	Audio G.711 Video H.261, JPEG, Indeo			
Stream Management	AV stream control, display, playback			
Flow Control	Bandwidth management, stream scaling			
Communication Protocols	H.320, RTP, MovieTalk, Lakes			
Network Components	AppleTalk, TCP/IP, X.25, OpenTransport			
Physical Links	Ethernet, ISDN, Token-Ring, isoEthernet, ATM			

- broadcast live video and/or audio out onto the network for anyone to view

- watch any broadcast on the network that a QTC machine is showing

• permit the recording of broadcasts or conversations which take place during multiparty conferences into multi-track QuickTime movies



• “drag and drop” multimedia data into and out of a shared visual workspace

• be guided through an interactive tour of the setup and usage of media conferencing network and media settings within the end-user application

• use the worldwide internet, basic rate ISDN, Ethernet and ATM to make multimedia connections to other users or to show and watch network broadcasts

• select usage of the worldwide standard H.320 teleconferencing protocol (with additional hardware) for cross-platform media communications

• use PowerTalk for address book, digital business cards, network browsing, security and authentication services

• share the contents of the desktop, folder and application windows with remote users

• use all existing QuickTime video and sound codecs, as well as a newly developed H.261 software teleconferencing compressor

Because Apple Media Conference is built upon the QTC system technology, it will be easy to grow the features of the application in new directions for collaborative computing.

Important Note

Document by Eric M. Hoffert & Dean Blackketter

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