Action Plan Background: QuickTime

Author: Carol Chou
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Preface:

QuickTime is a comprehensive multimedia technology developed by Apple Computer Inc. Its main components include the QuickTime file format, software development kits for developers (QuickTime SDK) and various applications such as QuickTime media player and browser plug-ins. This document purposes to describe the QuickTime file format pertaining to the QuickTime movie files.

1 General Description

1.1 Format Name:

QuickTime File Format

1.2 Version:

Apple does not version the QuickTime file format specification. There is no version information associated with the QuickTime file format.

1.3 MIME Media Type Name:

Video

1.4 MIME Sub-type:

There is no IANA-registered MIME type for QuickTime files. The QuickTime file format specification indicates that QuickTime files are served under the MIME-type "video/quicktime" on the Internet [Apple 2001].

1.5 Short Description:

The QuickTime file format is a general-purpose multimedia file format that may contain video, audio, still images, animated images (sprites), graphic, text and many other media streams including virtual reality data. It may also contain references to media data stored in other files.

1.6 Common Extensions:

.mov or .qt

1.7 Color Depth:

For color images in QuickTime video stream, values of 1, 2, 4, 8, 16, 24, and 32 are allowed in the QuickTime movie files where 32 is used if the image contains an alpha channel. QuickTime also supports 2-, 4-, and 8-bit grayscale images.

1.8 Color Space:

For uncompressed video, the following encoding formats are supported [Apple 2001]:

- RGB, depths 1, 2, 4 and 8: The pixel values are the indexes into the color table.

- RGB 16: Each pixel uses a 16-bit integer in 5-5-5 RGB format where the high bit of the 16-bit integer is set to 0.
- RGB 24: 8 bits for each color component, in RGB order.
- RGB 32: Each pixel contains an 8-bit alpha channel, followed by 8-bit RGB color components.
- YUV2: Two adjacent pixels on the same scan line are encoded into a 4-byte packet. Each packet contains a 1-byte luminance value for each pixel and 2 bytes chromatic values shared by both pixels.

1.9 Compression:
QuickTime file format does not define the compression schemes for QuickTime movie files. The QuickTime movie files are served as the containers of various types of video and/or audio data. It is designed such that any third party vendor can add application-specific formats by incorporating their QuickTime components with QuickTime.

The audio and video data contained in a QuickTime movie file could be either uncompressed or compressed with a number of different formats. The current QuickTime file format specification lists 12 video formats and 21 audio formats that are typically wrapped in the QuickTime movie files. However, there could be innumerable number of video or audio formats to be included in the QuickTime movie files.

[Sammtleben 2005] lists the various types of compressed media that can be encoded in a QuickTime file and the compatibility with different versions of QuickTime media players.

1.10 Animation:
Yes (the *sprite* feature in QuickTime).

1.11 Magic Number(s):
For QuickTime movie files, the magic number of “6D6F6F76” (ASCII “moov”) is expected, starting from the fifth byte of a QuickTime movie file.

1.12 Byte Order:
Although Apple suggests that all data stored in a QuickTime movie file follow the big-endian byte ordering, only the header information is expected to be in the big-endian format. The actual bit-stream data (such as sound or movie clip) can be in the little-endian format [Apple 2001].

1.13 Specification Requirements
The basic building block in QuickTime files is called the “atom”. An atom can contain other atoms to form a hierarchical structure of atoms.

Atoms have the following requirements:
- All atoms are required to have a header, followed by atom data. The header must contain the information on the size and type of the atom . Both of the size

and type fields are 32-bit integers. The type field is typically a four-character code.
- Four-character codes consisting of only lowercase letters are reserved by Apple.
- Atoms inside the container atoms can be in any order except the handler description atoms, which must appear before the atoms that contain their data.
- If the size of the atom exceeds 2^32 bytes, a 64-bit extended size field could be added to the header and the size field will be set to 1.

The newer parts of QuickTime file format use QT atoms, which are designed to allow for easier traversing through the atom tree. QT atoms have the following additional requirements:

- The QT atom header contains additional fields including Atom ID that must be unique among its sibling atoms.
- Each QT atom contains either its own data (Leaf Atom) or other atoms (Container Atom), but not both.

Movie content in QuickTime movie files are contained in the movie atoms. A movie atom is a container atom consisting of a movie header atom that specifies the characteristics of the movie, plus additional atoms such as track atoms, clip atoms, and color table atoms. The child atoms may contain other atoms or be self-contained with its own data. QuickTime does not require any specific order of those atoms, but some atoms are required to contain other types of child atoms. For example, a track atom is required to contain at least a track header atom, a media atom and may optionally includes a clipping atom, an edit atom, etc.

Table 1. Format Requirement of QuickTime Movie Files

Atom	***Atom Type***	***Obligation (R-required, O-optional)***	***Nesting Requirement***	***Cardinality***
Movie	Container	R	Top-level	1
Movie Header	Leaf	R*	Within Movie Atom	1
Track	Container	R	Within Movie Atom	Multiple
Color Table	Leaf	O	Within Movie Atom	1
Clipping	Container	O	Within Movie Atom or Track Atom	1
Clipping Region	Leaf	O	Within Clipping Atom	Multiple
Track Header	Leaf	R	Within Track Atom	1
Track Matte	Container	O	Within Track Atom	1
Compressed Matt	Leaf	O	Within Track Matte Atom	1
Edit	Container	O	Within Track Atom	1
Edit List	Leaf	O	Within Edit Atom	Multiple
Track reference	Container	O	Within Track Atom	1
Track Reference Type	Leaf	O	Within Track Reference Atom	Multiple
Track Load Settings	Leaf	O	Within Track Atom	1
Track Input Map	Container	O	Within Track Atom	1
Track Input	Container	O	Within Track Input Map atom	Multiple

Atom	*Atom Type*	*Obligation (R-required, O-optional)*	*Nesting Requirement*	*Cardinality*
Input Type	Leaf	R	Within Track Input Atom	1
Object ID	Leaf	O	Within Track Input Atom	1
User-defined Data	Container	O	Within Track, Movie or Media Atom	1
User Data List	Leaf	R	Within User-defined Data Atom	Multiple
Media	Container	R	Within Track Atom	1
Media Header	Leaf	R	Within Media Atom	1
Handler Reference	Leaf	O – in Media Atom R – in Video/Sound Media Information Atom	Within Media Atom, Video/Sound Media Information Atom	1
Media Information	Container	O	Within Media Atom	1
Video Media Information	Container	O	Within Media Information Atom	1
Video Media Information Header	Leaf	R	Within Video Media Information Atom	1
Sound Media Information	Container	O	Within Media Information Atom	1
Sound Media Information Header	Leaf	R	Within Sound Media Information Atom	1
Data Information	Container	O	Within Video Media Information or Sound Media Information atom	1
Data Reference	Leaf	O	Within Data Information Atom	1
Sample Table	Container	O	Within Video Media Information or Sound Media Information atom	1
Sample Description	Leaf	O	Within Sample Table	1
Time-to-sample	Leaf	O	Within Sample Table	1
Sync sample	Leaf	O	Within Sample Table	1
Sample-to-chunk	Leaf	O	Within Sample Table	1
Sample size	Leaf	O	Within Sample Table	1
Chunk Offset	Leaf	O	Within Sample Table	1
Shadow Sync	Leaf	O	Within Sample Table	1
Base Media Information	Container	O	Within Media Information Atom	1
Base Media Information Header	Leaf	R	Within Base Media Information Atom	1
Base Media Info	Leaf	R	Within Base Media Information Atom	1
Reference Movie	Container	R*	Within Movie Atom	1
Reference Movie Descriptor	Container	R	Within Reference Movie Atom	Multiple
Data Reference	Leaf	O	Within Reference Movie Descriptor	1
Data Rate	Leaf	O	Within Reference Movie	1

Atom	*Atom Type*	*Obligation (R-required, O-optional)*	*Nesting Requirement*	*Cardinality*
			Descriptor	
CPU	Leaf	O	Within Reference Movie Descriptor	1
Version Check	Leaf	O	Within Reference Movie Descriptor	Multiple
Component Detect	Leaf	O	Within Reference Movie Descriptor	Multiple
Quality	Leaf	O	Within Reference Movie Descriptor	1
Compressed Movie	Container	R*	Within Movie Atom	1
Data Compression	Leaf	R	Within Compressed Movie Atom	1
Compressed Movie Data	Leaf	R	Within Compressed Movie Atom	1
Movie Data	Leaf	R	Top-level	1
Free	Leaf	O	Anywhere	Multiple
Skip	Leaf	O	Anywhere	Multiple
Preview	Leaf	O	Top-level	1

*: At least one of these atoms must be present in the movie atom

2 Essential and Distinguishing Characteristics

2.1 QuickTime Movie Technical Metadata

Technical Metadata Element ***(G = general file metadata, GM = general movie metadata, F = format specific medatadata)***	***Obligation (*** ***R = Required by spec., S= Defined in spec., D = Derived from spec., O = Optional)***	***Location***
When the movie was created [GM]	R	Movie Header
When the movie was changed [GM]	R	Movie Header
Duration of the movie [GM]	R	Movie Header
Preferred rate to play the movie (normal rate = 1.0) [GM]	R	Movie Header
Preferred volume for playing the movie sound (full volume = 1.0) [GM]	R	Movie Header
The time at which the preview begins [GM]	R	Movie Header
The duration of the movie preview [GM]	R	Movie Header
Whether there is a display matrix associated with the movie [F]	R	Movie Header
Whether the movie contains any user data that provides additional information about the movie such as copyright statement, the name of the producer, performers, ...etc. [GM]	R	Movie Atom
Whether the movie contains any color table (for devices that only support 256 colors) [GM]	R	Movie Atom
Whether there is any clipping atom specifying the clipping regions for the movie [F]	R	Movie Atom
Whether the movie contains any compressed movie atom [F]	R	Movie Atom
Whether the movie contains references to alternative movies [F]	R	Movie Atom
Number of media tracks in the movie [GM]	D	Movie Atom

2.2 QuickTime Video Track Technical Metadata

Technical Metadata Element ***(GS = general stream metadata, GV = general video metadata)***	***Obligation (*** ***R = Required by spec., S= Defined in spec., D = Derived from spec., O = Optional)***	***Location***
Stream Data Type (Video) [GS]	S	Video Media Information Atom
Encoding [GV]	S	Sample Description Atom
Frame Rate (frames/s) [GV]	D	Time-to-Sample and Media Header Atoms
Bits Per Pixel [GV]	S	Video Sample Description
Frame Height (pixels) [GV]	S	Video Sample Description
Frame Width (pixels) [GV]	S	Video Sample Description
Horizontal Resolution (pixels/inch) [GV]	S	Video Sample Description
Vertical Resolution (pixels/inch) [GV]	S	Video Sample Description
Length (frames) [GV]	D	Time-to-Sample Atom
Quality [GV]	R	Media Header Atom
Temporal Quality (0-1023, indicating the degree of temporal compression) [GV]	S	Video Sample Description
Spatial Quality (0-1024, indicating the degree of spatial compression) [GV]	S	Video Sample Description

2.3 QuickTime Audio Track Technical Metadata

Technical Metadata Element *(GS = general stream metadata, GA = general audio metadata)*	*Obligation (* *R = Required by spec., S= Defined in spec., D = Derived from spec., O = Optional)*	*Location*
Stream Data Type (Audio) [GS]	S	Sound Media Information Atom
Encoding [GS]	S	Sample Description Atom
Sample Rate (samples/s) [GA]	S	Sound Sample Description
Sample Size (bits/sample) [GA]	S	Sound Sample Description
Number of Channels (1 for mono, 2 for stereo) [GA]	S	Sound Sample Description
Length (samples) [GA]	D	Time-to-Sample Atom
Quality [GS]	R	Media Header Atom

3 Usefulness

3.1 Version Duration:

The latest QuickTime file format specification is dated as March 1, 2001. This makes it 4 years, 9 months old.

3.2 History of Prior Versions Duration:

QuickTime was first released on December 2nd, 1991 as a multimedia subsystem on System 7 [Wiki]. The file format itself is not versioned but has been revised since its first release. Apple does not provide older copies of the QuickTime file format specification on their web site. The current QuickTime file format specification indicates that the current specification supersedes the previous one published in June, 2000.

The QuickTime version is generally associated with the entire architecture, not the file format itself.

QuickTime 1.x – QuickTime 1.0 was first released on Dec 2nd, 1991 and was followed by several updates. It defined the basic architecture that is still in use today. It included codec supports for Apple Video codec, cinepak video, animation codec and graphic codec.
QuickTime 2.x – Originally released in February 1994. QuickTime 2.x added supports for music tracks and sprite tracks.
QuickTime 3.x – Originally released on March 30th, 1998. It included additional supports for low-bit rate codec, movie export through IEEE 1394, graphic import (from TIFF, JPEG and GIF), media access key and full Mac/Windows compatibility[Apple 2001A].

QuickTime 4.x – 4.0 was released on June 8th, 1999. QuickTime 4.x added supports for streaming, MP3, Java script, Apple script and graphic export features.
QuickTime 5.x – First released on April 23rd, 2001. It added supports for Flash 4, media skin, Sorenson 3 video codec and MPEG 1 playback on Windows.
QuickTime 6.x – First released on July 15th, 2002. It included supports for MPEG 4 (playback, import, streaming and export), MPEG video codec, ACC audio codec, Flash 5, JPEG 2000, 3GPP (3rd Generation Partnership Project), Adaptive Multi-Rate (AMR) and Apple Lossless audio codec.
QuickTime 7.0 – Released on April 29th, 2005. QuickTime 7.0 added supports for extensible metadata format, H.264 (MPEG 4 part 10) video codec and high resolution audio.

3.3 Expected Newer Versions:
None expected.

3.4 Existence of Publicly Available Complete Specifications:
Apple provides the current QuickTime file format specification on its web site for free download. The current QuickTime file format specification supersedes all previous ones. Older QuickTime file format specifications are not provided on Apple's web site. They are probably available as hard copies on some older prints of the specifications.

3.5 Specifications-controlling Body:
Apple Computer, Inc.

3.6 Related Legal Issues:
Apple holds the patent[1] and copyright of QuickTime file format. For applications that use QuickTime Software Development Kit (SDK) to access QuickTime movie files, there is no license required[2]. For hardware manufactures that use QuickTime file formats in their devices, they are required to sign license agreements with Apple Computer, Inc. The license is non-exclusive, worldwide, nontransferable and royalty-free. The license agreement specifically requires that "If licensee wishes to enable License Products to author and read digital video files, then Licensee agrees that the QuickTime File Format will be the exclusive file format used for such authoring and reading of digital video files in Licensee Products" [Apple 2005A].

Various encoding formats wrapped in QuickTime movie files may be subjected to additional licenses and royalties from the format owners[3].

3.7 Application and Platform Support:
To provide an abstraction for the QuickTime file format, Apple provides QuickTime SDK as a standard interface for applications to access QuickTime files. The QuickTime SDK provides a comprehensive set of mechanisms for applications to render and author

1 US Patent: 5751281, http://patft.uspto.gov/netacgi/nph-Parser?u=/netahtml/srchnum.htm&Sect1=PTO1&Sect2=HITOFF&p=1&r=1&l=50&f=G&d=PALL&s1=5751281.WKU.&OS=PN/5751281&RS=PN/5751281
2 Email Contact: Paul Sonneberg, Apple Software Licensing, December 15, 2005
3 http://www.mpegla.com

QuickTime files that are encoded with various formats, either uncompressed or compressed. Through the use of QuickTime SDK, QuickTime applications can easily be backwardly compatible with files that were created by older QuickTime applications. The QuickTime SDK can be freely downloaded from Apple's web site and is available on Mac OS, Windows and Java.

In addition to QuickTime SDK, Apple also provides QuickTime players for rendering QuickTime movie files. The current QuickTime players are available on Mac and Windows XP/2000 with support for fifteen languages including several European and Asian languages. To support web streaming, QuickTime plug-ins are available for some of the popular web browsers such as FireFox, Internet Explorer, Safari and America Online[4]. Apple provides several QuickTime products for authoring(QuickTime Pro), broadcasting(QuickTime Broadcaster) and streaming (QuickTime Streaming server and Darwin Streaming Server) QuickTime movie files. In addition to Apple's own QuickTime products, Apple's web site also lists 38 third party QuickTime tools for authoring, broadcasting, editing and encoding QuickTime movie files[5].

QuickTime support on Linux was provided by many open source communities, including QuickTime4Linux and Open QuickTime libraries. The rendering, authoring, encoding and streaming of QuickTime movie on Linux are supported by several open-source tools such as MPlayer, mencoder, ffmpeg, Darwin Streaming Server and Java Media Framework.

3.8 Limitations:
The current QuickTime file format is very extensible with no obvious limitation. One possible limitation in the current QuickTime file format is the size of an atom, which can have the value of up to 2^64. As movie samples are contained in a movie data atom, this limits the size of a movie to be less than 2^64 (18,446,744,073,709,551,616) bytes.

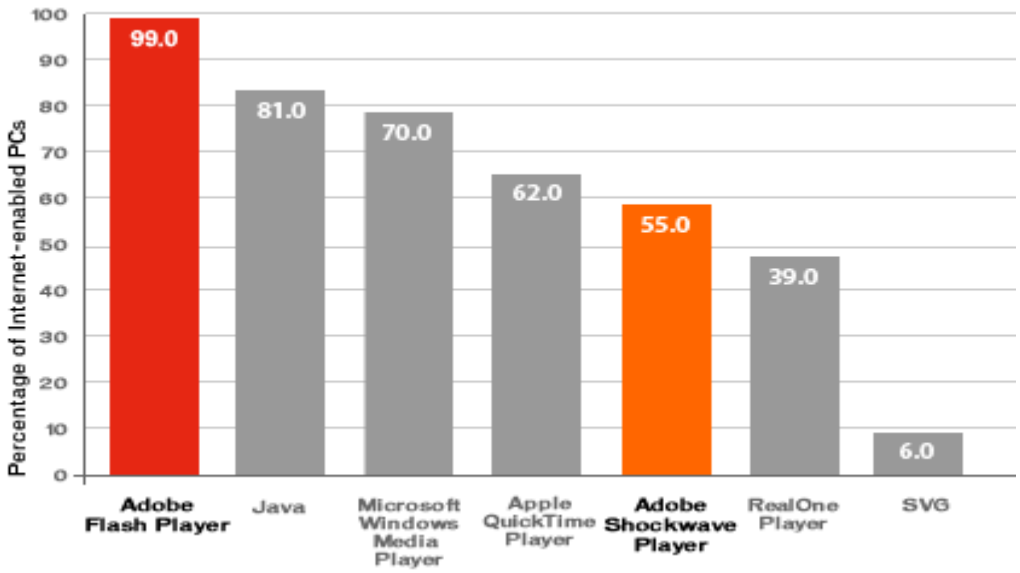
3.9 Perceived Popularity:
QuickTime is the native file format for storing multimedia data on Macintosh. Though not as popular as AVI, QuickTime is widely adopted especially in professional digital video studios. Since the introduction of QuickTime on Windows in 1994, QuickTime movies also became quite popular on the Windows platform.

One possible approach to evaluate the QuickTime popularity is perhaps by reviewing the popularity of QuickTime streaming servers and QuickTime players. According to Frost & Sullivan's 2004 Global Media Streaming Platform Report, QuickTime's global market share increased to 36.8% between 2002 and 2003 while Window Media Player held at 38.2% and RealPlayer declined to 24.9% [Apple 2004]. The QuickTime player is quite popular on both Mac and Window platforms.

Recently, the Macromedia Flash Player is getting huge publicity due to its lightweight and simple design. The NPD Online survey, conducted September 2005, shows the

4 http://developer.apple.com/quicktime/overview.html
5 http://www.apple.com/quicktime/resources/tools/authoring.html

Flash Player are installed on over 97.3% of Internet-enabled personal computers, compared to 84.8% for Microsoft Windows Media Player and 66% for Apple QuickTime Player [Macromedia 2005].



Unfortunately, QuickTime popularity on UNIX-based system is somewhat limited due to lack of QuickTime supports from Apple. Will this lack of QuickTime support from Apple on UNIX-based system and the emergence of Flash format threaten QuickTime's popularity? This remains to be an area that need to be closely monitored.

4 Related Formats

4.1 Specification and File Variations:

QuickTime VR File Format (QTVR) – Page 178 of the current QuickTime file format specification defines the QuickTime file format for panoramic imagery. QuickTime VR supports two types of virtual reality content: panoramic movie and object movie. The panoramic movie provides users the 360-degree view of the prerecorded scene while the object movie allows users to view an object from all angles [Chen 1995].

QuickTime Image File Format – QuickTime Image File Format uses the same atom structure as the QuickTime movie files for storing still images. Appendix A of QuickTime file format specification specifies the format requirement for QuickTime image files. QuickTime Image files are identified with ".gtif" file type on Mac OS platform and ".gif" file extension on other platforms.

5 Summary and Conclusions

QuickTime file format has been around since the infancy of multimedia systems. It is one of the first multimedia formats supported by rendering and authoring software, even Windows' VideoForWindow technology became available one year after QuickTime was introduced. Although the QuickTime file format has been improved over the years

to provide more features such as streaming, wireless and various encoding formats, the underlying architecture is very solid and has remained unchanged so far.

In addition, the QuickTime file format is flexible and extensible in storing movie content [Rogge 2004]. The file format can be extended to include additional data formats. It is scalable, capable of delivering multimedia data at any data rate. Perhaps it is due to QuickTime's extensibility and stability, the QuickTime file format was chosen by the International Organization for Standards (ISO) as the foundation for MPEG-4 file format.

Which multimedia file formats will be suitable for storing movie data in digital archives? Will the QuickTime file format be a likely candidate? Just like AVI, QuickTime is an open, stable, popular and well supported multimedia file format. It is also robust, capable of containing various types of data. However, its flexibility and extensibility also make it a complex file format. As there could be innumerable number of encoding formats wrapped in QuickTime files, it is nearly impossible to analyze and render every possible encoding format contained in QuickTime files.

Perhaps the biggest drawback of QuickTime is that it is a non-standardized, proprietary file format that is tightly intertwined with the prosperity of Apple Computer, Inc. Fortunately, unlike Microsoft which has stopped improving its AVI file format, Apple is still actively maintaining the QuickTime file format. Over the years, Apple has invested heavily in optimizing the QuickTime file format and its applications. Although the QuickTime file format is a proprietary file format owned by Apple, it is likely to remain as a popular movie file format as long as Apple continues to support QuickTime.

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