Advanced Streaming Format (ASF) Specification

February 26, 1998
Public Specification Version 1.0

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Errata

The following changes have been made to the November 12, 1997 version of this specification:

The final paragraph of Section 1.2 was modified to indicate that the semantics of the ASF Header Object must be received before the ASF Data Object can be interpreted. Previous versions inadvertently implied that the header object format itself must be transmitted which would have precluded the use of session announcement protocols to convey this information.

The text was changed in Section 3.2 to indicate that the Header Object should be the first object in an ASF file.

Clarifications were made within Section 5.3 (Stream Properties Object) concerning the implementation of the following fields:

- The specific timeline reference of Start Time and End Time
- Guidelines for the computation of Maximum Bit Rate and Average Bit Rate
- Guidelines for the computation of Average Data Unit Size and Maximum Data Unit Size
- Clarification of the purpose of preroll
- Clarification on the semantics of the Seekable Flag
- An explanation is provided as to why zero is not a valid Stream Number value to refer to a specific media stream.
- Removed an assumption in the Full Data Unit Presentation time flag field that the presentation time is in milliseconds.

In Section 5.6 (Marker Object) it was stated that the same invalid offset value as that used in the Index Object (Section 7) is also used in the Marker Object to signify invalid offsets.

The Index Entry Time Interval of Section 5.14 (Index Parameters Object) was changed to be a UINT 32 (instead of 16) to make it conform to the Index Entry Time Interval of the Index (i.e., Section 7). The text was also changed in to indicate the indexing indices are in terms of presentation time.

The text was altered to state in Section 6.1 (ASF Data Unit) that if an object containing a clean point flag is fragmented, the clean point flag is set for all fragments of that object.

An explanation is given to what the Block Position and Index Entry Count fields refer in the Index Object of Section 7. An invalid offset value is defined for sparse indexes. Also, made explicit that the Entry offsets are ordered according to the ordering specified by the Index Parameters Object, thereby permitting the same stream to be potentially indexed by multiple Index Types (e.g., Nearest Clean Point, Nearest Object, Nearest Data Unit).

Clarified that the Seek to Marker command (of Section 8.8) was in reference to indices to the Markers field of the Marker Object defined in Section 5.6.

Corrected the typographical error within Section 8.8 that gave the same definition for „vertical resolution“ as was previously given for „horizontal resolution“. Also, an editorial comment referring to earlier versions of the specification was removed from the Command Entry Structure Notes.

Open issues:

- When the size of a Data Unit is computed, does that size include the Data Unit’s header? Currently the answer is „yes“.
- Do we need a Data Unit Count field within the SPO?
- How should we word a statement that the decision whether or not the Data Unit Header information is sent across the wire or not is a data communications protocol decision and is therefore outside of the scope of this specification?

The following changes have been made to the September 30, 1997 version of this specification:

It should be explicitly noted that length fields of Unicode Strings indicate the number of Unicode „characters“ within the field, while length fields of ASCII or character strings indicate the number of bytes within the field.

In Section 5.4 (Content Description Object):

- Added Field Type values for recording RTP and RTCP information (in other words, see RFC 1889).

In Section 6.1 (ASF Data Unit):

- Renamed the *Object ID* to *Object Number* to avoid confusion arising from the fact that all other Object ID instances refer to GUID values.
- Made explicit our original intention that fragmentation and grouping could not coexist in the same ASF Data Unit instance.
- Made explicit that if objects containing clean points were grouped, then the clean point flag would only refer to the first object in the grouping.
- Explicitly noted that grouped objects may have different send times and that the difference is indicated in the 16-bit Delta Time.
- Explicitly noted that if an object containing a clean point was fragmented, the clean point flag would only be set for the first fragment.

In Appendix A (GUID values):

- Added in the GUID for the Extension Object.
- Added in the GUID for the „RTP Extension Data“ Extension Object.
- Added in the GUID for the ASF Placeholder Object.

1 Introduction

1.1 Disclaimer

This document presumes a basic level of multimedia and networking knowledge on the part of the reader. Anyone not familiar with basic multimedia concepts such as audio and video compression, multimedia synchronization, and so on. may misunderstand some of the terminology or arguments presented in this document.

1.2 What is ASF?

Advanced Streaming Format (ASF) is an extensible file format designed to store synchronized multimedia data. It supports data delivery over a wide variety of networks and protocols while still proving suitable for local playback. The explicit goal of ASF is to provide a basis for industry-wide multimedia interoperability, with ASF being adopted by all major streaming solution providers and multimedia authoring tool vendors.

Each ASF file is composed of one or more media streams. The file header specifies the properties of the entire file, along with stream-specific properties. Multimedia data, stored after the file header, references a particular media stream number to indicate its type and purpose. The delivery and presentation of all media stream data is synchronized to a common timeline.

The ASF file definition includes the specification of some commonly used media types (see Section 8). The explicit intention is that if an implementation supports media types from within this set of standard media types (in other words, audio, video, image, timecode, text, MIDI, command, or media object), then that media type must be supported in the manner described in Section 8 if the resulting content is to be considered to be „content compliant“ with the ASF specification. Implementations are free to support other media types (in addition to the currently defined standard media types) in any way they see fit.

Finally, ASF is said to support the transmission of „live content“ over a network. This refers to multimedia content which may or may not ever become recorded upon a persistent media source (for example, a disk, CD-ROM, DVD, etc). This use explicitly and solely means that information describing the multimedia content must have been received before the multimedia data itself is received (in order to interpret the multimedia data), and that this information must convey the semantics of the ASF Header Object. Similarly, the received data must conform to the format of the ASF data units. No additional information should be conveyed by this term. Specifically, this use explicitly does not refer to (or contain) any information about network control protocols or network transmission protocols. It refers solely to the order of information arrival (header semantics before data) and the data format .

1.3 Design Goals

ASF was designed with the following goals:

- To support efficient playback from media servers, HTTP servers, and local storage devices.
- To support scalable media types such as audio and video.
- To permit a single multimedia composition to be presented over a wide range of bandwidths.
- To allow authoring control over media stream relationships, especially in constrained-bandwidth scenarios.
- To be independent of any particular multimedia composition system, computer operating system, or data communications protocol.

1.4 Scope

ASF is a multimedia presentation file format. It supports live and on-demand multimedia content. It can be used as a vehicle to record or play back H.32X (for example, H.323 and H.324) or MBONE conferences. ASF files may be edited. ASF data is specifically designed for streaming and/or local playback.

ASF is not:

- ASF is not a wire format. Rather, ASF is data communications „agnostic.“ Theoretically, ASF data units may be carried by any conceivable underlying data communications transport. ASF is similarly agnostic about how the data is packetized by network protocols (for example, whether the multimedia data is sent in an interleaved or non-interleaved fashion).

- ASF is not a network control protocol. However, ASF files contain information that should prove useful to control protocols.
- ASF is not a replacement for MPEG. Rather, encoded MPEG content can be contained within ASF files and optionally synchronized with other media.

2 ASF Features

2.1 Extensible Media Types

ASF files permit authors to easily define new media types. The ASF format provides sufficient flexibility to allow the definition of new media stream types that conform to the file format definition. Each stored media stream is logically independent from all others unless a relationship to another media stream has been explicitly established in the file header.

2.2 Component Download

Stream-specific information about playback components (for example, decompressors and renderers) can be stored in the file header. This information enables each client implementation to retrieve the appropriate version of the required playback component if it is not already present on the client machine.

2.3 Scalable Media Types

ASF is designed to express the dependency relationships between logical „bands" of scalable media types. It stores each band as a distinct media stream. Dependency information among these media streams is stored in the file header, providing sufficient information for clients to interpret scalability options (such as spatial, temporal, or quality scaling for video) in a compression-independent manner.

2.4 Author-specified Stream Prioritization

Modern multimedia delivery systems can dynamically adjust to changing constraints (for example, available bandwidth). Authors of multimedia content must be able to express their preferences in terms of relative stream priorities as well as a minimum set of streams to deliver. Stream prioritization is complicated by the presence of scalable media types, since it is not always possible to determine the order of stream application at authoring time. ASF allows content authors to effectively communicate their preferences, even when scalable media streams are present.

2.5 Multiple Languages

ASF is designed to support multiple languages. Media streams can optionally indicate the language of the contained media. This feature is typically used for audio or text streams. A multilingual ASF file indicates that a set of media streams contains different language versions of the same content, allowing an implementation to choose the most appropriate version for a given client.

2.6 Bibliographic Information

ASF provides the capability to maintain extensive bibliographic information in a manner that is highly flexible and very extensible. All bibliographic information is stored in the file header in Unicode and is designed for multiple language support, if needed. Bibliographic fields can either be predefined (for example, author and title) or author-defined (for example, search terms). Bibliographic entries can apply to either the whole file or a single media stream.

3 File Format Organization

3.1 ASF Object definition

The base unit of organization for ASF files is called the *ASF Object*. It consists of a 128-bit globally unique identifier (GUID) for the object, a 64-bit integer object size, and variable length object data. The value of the object size field is the sum of 24 bytes plus the size of the object data in bytes.

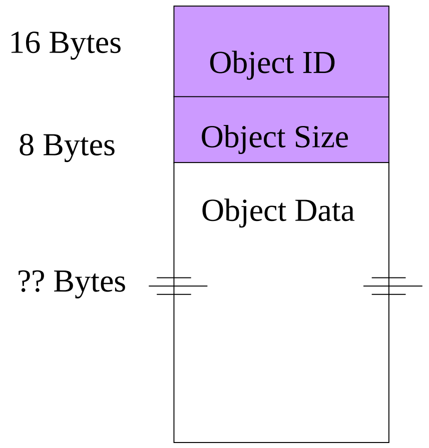


Figure 1 ASF Object

This unit of file organization is similar to the Resource Interchange File Format (RIFF) chunk, which is the basis for AVI and WAV files. The ASF object enhances the design of the RIFF chunk in two ways. First, there is no need for a central authority to manage the object identifier system, since any computer with a network card can generate valid, unique GUIDs (see Appendix C). Second, the object size has been chosen to be large enough to handle the very large files needed for high-bandwidth multimedia content.

All ASF objects and structures (including data unit headers) are stored in little-endian byte order (the inverse of network byte order). However, ASF files can contain media stream data in either byte order within the data unit.

3.2 High-level File Structure

ASF files are logically composed of three top-level objects: the Header Object, the Data Object, and the Index Object. The Header Object is mandatory and must be placed at the very beginning of every ASF file. The Data Object is also mandatory, and should normally follow the Header Object. The Index Object is optional, but it is strongly recommended that it be used.

Implementations will support files containing out-of-order objects, but in certain cases the resulting ASF files will not be usable from certain sources such as HTTP servers. Also, additional top-level objects may be defined by implementations and inserted into ASF files. It is recommended that they follow the Index Object (in object placement order).

A requirement of ASF is that the Header Object must have been received for the contents of the Data Object to be interpreted. ASF does not address how this information arrives at the client. Rather, „arrival mechanisms“ are deemed to be a „local implementation issue,“ which is explicitly out of the scope of the file specification. It is similarly a local implementation issue whether or not the Header Object is transferred „in band“ or „out of band“ (vis-a-vis the Data Object’s data units) or whether the Header Object is sent once or is repeatedly sent. Implementations may choose to meet this order requirement (in other words, the Header Object must arrive before ASF data units can be interpreted) in many possible ways including: (A) include the Header Object information as part of the „session announcement“; (B) send the Header Object in a different „channel“ (for example, link) than the data object; (C) send the Header Object immediately before the ASF data units; and so on.

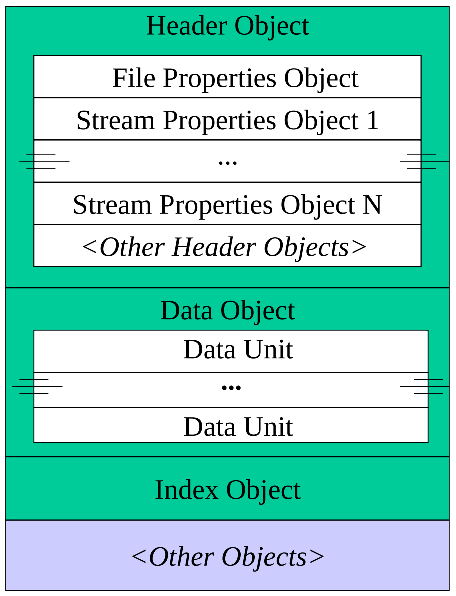


Figure 2. High-level ASF File Structure

3.3 ASF Header Object

Of the three top-level ASF objects, the Header Object is the only one that contains other ASF objects. The header object may include many objects including the following:

- File Properties Object – global file attributes
- Stream Properties Object – defines a media stream and its characteristics
- Content Description Object – contains all bibliographic information
- Component Download Object – provides playback component information
- Stream Groups Object – logically groups media streams together
- Scalable Object – defines scalability relationships among media streams containing bands
- Prioritization Object – defines relative stream prioritization
- Mutual Exclusion Object – defines exclusion relationships such as language selection
- Inter-Media Dependency Object – defines dependency relationships among mixed media streams
- Rating Object – defines the Rating of the file in terms of W3C PICS
- Index Parameters Object – supplies the information necessary to regenerate the index of an ASF file

The role of the Header Object is to provide a well-known byte sequence at the beginning of ASF files (its GUID) and to contain all other header information. This information provides global information about the file as a whole as well as specific information about the multimedia data stored within the Data Object.

3.4 ASF Data Object

The Data Object contains all the multimedia data of an ASF file. This data is stored in the form of ASF data units. Each ASF Data Unit is of variable length, and contains data for only one media stream. Data units are sorted within the Data Object based on the time at which they should be delivered (send time). This sorting results in an interleaved data format.

3.5 ASF Index Object

The Index Object contains a time-based index into the multimedia data of an ASF file. The time interval that each index entry represents is set at authoring time and stored in the Index Object. Since it is not required to index into every media stream in a file, a list of the media streams that are indexed follows the time interval value.

Each index entry consists of one data unit offset per media stream being indexed. This information allows stream-specific index operations to occur.

3.6 Minimal Implementation

A minimal ASF implementation consists of a Header Object containing only a File Properties Object, one Stream Properties object, and one Language List Object, as well as a Data Object containing only a single ASF data unit.

4 Additional Considerations

4.1 Time Units

All time fields in ASF objects and ASF data units use the same timeline, which begins at time zero. Send Times (see Section 4.2) are expressed in granularities of milliseconds. Presentation Times (see Section 4.2) are expressed in Rational Time units. Other timecode systems (such as SMPTE) are supported through the use of a timecode media stream that binds alternate timecode values to each data unit (see Section 8.4). This stream binding is achieved using the Inter-Media Dependency Object. This allows authoring and editing tools to keep alternate timestamps while permitting client/server implementations to ignore them. In all cases, all time references are to the same timeline.

4.2 Send Time vs. Presentation Time

ASF Data Units all contain a millisecond timestamp, which is called the data unit's *send time*. This is the time on the ASF timeline at which this data unit should be delivered to the client. Sometimes, the media stream can explicitly store the fixed delta between send time and presentation time in the Stream Properties Object. If so, every data unit for that stream is presented at exactly the same amount of time after being sent. If this delta is zero, then the send time is equivalent to the presentation time. Otherwise, the data unit stores the presentation time in the data unit itself as either a delta value from the send time or as an explicit presentation timestamp. Using data unit-specific presentation times provides increased flexibility to authoring tools to reduce a stream's maximum bandwidth requirement by sending data before it is needed.

Unlike Send Time, Presentation Time is specified in Rational Time units, thereby permitting finer time granularities than is possible for millisecond units. The numerator and denominator values by which the specific Rational Time units are computed for each media stream are established in that media stream's Stream Properties Object.

4.3 Scalable Media Types

Information about each scalable media source (for example, audio or video) is stored in a Scalable Object in the header. If multiple types of scalable media are present in one ASF file, the header will contain multiple Scalable Objects.

Each Scalable Object contains the dependency information for all media streams that comprise bands of the same media source. Also included within the Scalable Object is an author-specified default sequence in which the media stream bands should be applied. This information is useful if a client is unable or unwilling to resolve the user's scalability preferences. The sequence also specifies the enhancement type of each media stream band. For scalable video, there are three common enhancement types: spatial (increasing frame size), temporal (increasing frame rate), and quality (increasing image quality without resizing). Similarly, scalable audio has number of channels (for example, stereo), frequency response, and quality. Additional user-defined enhancement types may also be defined.

4.4 Multimedia Composition

One of ASF's design goals is to be independent of any particular multimedia composition system. No information is provided in the ASF format concerning three-dimensional positions of streams or relative positioning information between streams. Using the Stream Group Object, ASF provides a general mechanism to group logically related media streams. Implementations will then determine how to render these streams (for example, the relative positioning of the grouped streams, stream mixing, Z-ordering and all other compositional issues, etc) by a mechanism that is outside scope of this file specification. This determination may be based on „out-of-band" techniques such as end user input, the client environment itself, or information contained within the media streams themselves (for example, MPEG-4, streaming Dynamic HTML content, and so on.).

It is anticipated that several different composition approaches can coexist and leverage the same piece of ASF content. An example is a TV scenario in which two video streams are grouped separately. One contains a large image of the anchorperson against a backdrop, and the other contains smaller footage of a news story. While the size of each rendering site could be calculated based on the natural size of each video stream in the group, the fact that the news story should be overlaid on the top right corner of the anchorperson video can not be determined without external composition information.

5 ASF Header Object

This section defines the various objects that comprise the ASF Header Object.

5.1 Header Object

Mandatory:	Yes
Quantity:	1 only

Field Name	Field Type	Size (bits)
Object ID	GUID	128
Object Size	UINT	64

Notes:
The Header Object is a container that can hold any combination of the following standard objects. Only the File Properties Object and the Stream Properties Object are required to be present. In addition, (non-standard) header objects that conform to the ASF Object Structure (see Section 3.1) may also be optionally defined and used as extension mechanisms for local implementations. Unlike the standard header objects defined below, there is no guarantee that the non-standard objects will be interpretable across vendor implementations. Implementations should ignore any non-standard object that they do not understand.

5.2 File Properties Object

Mandatory:	Yes
Quantity:	1 only

This object defines the global characteristics of the combined media streams found within the Data Object.

Object Structure:

Field Name	Field Type	Size (bits)
Object ID	GUID	128
Object Size	UINT	64
File ID	GUID	128
Creation Date	FILETIME	64
Content Expiration Date	FILETIME	64
Last Send Time	UINT	64
Play Duration	UINT	64
Flags	UINT	32
Live Flag		1 (LSB)
Huge Data Units Flag		1
Reserved		30
Minimum Bit Rate	UINT	32
Maximum Bit Rate	UINT	32
Average Data Unit Size	UINT	32
Maximum Data Unit Size	UINT	32
Total Data Units	UINT	32
Stream Count	UINT	16

Notes:
The Object ID field is the GUID for the File Properties Object (see Appendix A). The Object Size field is the size (in bytes) of the File Properties Object.

The value of the File ID field should be regenerated every time the file is edited. It provides a unique identification for this ASF file.

The Creation Date contains the date and time of the initial creation of the file.

Content Expiration Date indicates the date after which the author doesn't want the file to be used. This time can be „never" (value of zero).

Both the Last Send Time (formerly known as Send Duration) and the Play Duration fields have millisecond granularities. Both of these fields are invalid if the live Flag bit is set. Last Send Time is the send time of the last data unit within the file. Play Duration is the maximum End Time (of any of the SPOs) minus the minimum Start Time (of any of the SPOs).

The following are the meanings of the Flags:

- The Live Flag, if set, indicates that a file is in the process of being written (for example, for recording applications), and therefore various values stored in the header objects are invalid. It is highly recommended that post-processing be performed to remove this condition at the earliest opportunity.
- The Huge Data Units Flag determines whether the Data Unit Length field in the ASF Data Unit (Section 6.1) is 16 or 32 bits long (in other words, 0 signifies 16 bits, and 1 signifies 32 bits). The 32-bit Data Unit Length field should be used exclusively for local recording/editing at extremely high data rates. Any other use is strongly discouraged, since most networks will not be able to support such huge data units. Therefore, it is strongly recommended that the 16-bit Data Unit Length field alternative be used in the general case.

Minimum Bit Rate is in bits per second and indicates the total of the average bandwidth of all the mandatory streams.

Maximum Bit Rate is in bits per second and indicates the total of the maximum bandwidth of all of the non-excluded streams.

The Average Data Unit Size is in bytes. This field is invalid if the Live Flag is set.

The Maximum Data Unit Size is in bytes. This indicates the longest ASF Data Unit within the Data Object. This field is invalid if the Live Flag is set.

The Total Data Units field contains the number of ASF Data Unit entries that exist within the Data Object. This field is invalid if the Live Flag is set.

Stream Count field indicates the number of Stream Properties Objects (SPOs) that exist in this file. Each media stream is required to have its own SPO.

Invalid fields should have a value of zero for writing and should be ignored when reading.

5.3 Stream Properties Object

Mandatory:	Yes
Quantity:	1 per media stream

This object defines the specific properties and characteristics of a media stream. It defines how a multimedia stream within the Data Object is to be interpreted as well as the specific format (of elements) of the ASF Data Unit itself (see Section 6.1) for that media stream. One instance of this object is required for each media stream in the file, including each of the separate streams formed by a scalable media type.

Unlike most other ASF objects, the Stream Properties Object (SPO) is a "container object": it can optionally include additional ASF Objects (see Section 3.1) within itself in a manner similar to the Header Object. The size of these objects is included within the Object Size field and contained objects, if any, are appended after the Type-Specific

Data field within the object structure below. This provision dramatically enhances the scalability and expandability capabilities of ASF, since it permits the rapid introduction of innovations and support for technology evolution. Currently, only one ASF Object targeted to be optionally contained within the SPO has been defined within this specification: the Data Unit Extension Object (See Section 5.3.1). Other ASF objects (for example, alternative approaches to scalable media, a QoS (RSVP) information object, extra RTP information, or MPEG-4 enhancements) may subsequently be defined and included within the SPO as needed. In this way the SPO can be enhanced over time to embrace new technologies and innovations.

Object Structure:

Field Name	**Field Type**	**Size (bits)**
Object ID	GUID	128
Object Size	UINT	64
Stream Type	GUID	128
Start Time	UINT	64
End Time	UINT	64
Average Bit Rate	UINT	32
Maximum Bit Rate	UINT	32
Average Data Unit Size	UINT	32
Maximum Data Unit Size	UINT	32
Preroll	UINT	32
Flags	UINT	32
Reliable Flag		1 (LSB)
Recordable Flag		1
Seekable Flag		1
Presentation Time Flags		2
Reserved		27
Presentation Time Delta	UINT	0 or 32
Presentation Time Numerator	UINT	0 or 32
Presentation Time Denominator	UINT	0 or 32
Stream Number	UINT	16
Stream Language ID Index	UINT	16
Stream Name Count	UINT	16
Stream Names	See below	?
MIME Type Length	UINT	8
MIME Type	ASCII (UINT8)	?
Type-Specific Data Length	UINT	16
Type-Specific Data	UINT8	?

Stream Name:

Field Name	**Field Type**	**Size (bits)**
Language ID Index	UINT	16
Stream Name Length	UINT	16
Stream Name	Unicode (UINT16)	?

Notes:
The Object ID field is the GUID for the Stream Properties Object (see Appendix A). The Object Size field is the size (in bytes) of this Stream Properties Object instance (including the sizes of all contained objects).

Start Time and End Time are presentation times in millisecond granularities. Both fields are invalid if the Live Flag of the File Properties Object has been set. The Start Time is the presentation time of the first object. The End Time is the presentation time of the last object plus the duration of play. The time reference in both cases is relative to the the ASF file's timeline. These fields exist, therefore, to indicate where this media stream is located within the context of the timeline of the file as a whole.

Invalid fields should have a value of 0 (zero) for writing and should be ignored when reading.

The Average Bit Rate and the Maximum Bit Rates are in bits per second. Both fields solely refer to this media stream's Bit Rates. The Maximum Bit Rate is computed by identifying the maximum rate in any one-second period. The Maximum Bit Rate means that the Bit Rate for this stream must not ever exceed this value. This may be thought of as running a one second „sliding window“ over this media stream's contents and noting the specific one second interval in which the greatest number of bits-per-second occurred. This value must be non-zero. The Average Bit Rate is the approximation one would obtain by dividing the total bits sent within this media stream by the time (in seconds) during which those bits are being sent (i.e., one plus the send time of the last Data Unit of that stream minus the send time of first data unit of that stream).

The Average Data Unit Size and the Maximum Data Unit Size are in bytes and refer to the ASF Data Units for this media's data types within the Data Object. The Average Data Unit Size is computed by dividing the total size of all of the ASF Data Units of that stream by the number of ASF Data Units of that stream. The Maximum Data Unit Size is the size in bytes of the largest ASF-DU for this media stream. A value of zero means „unknown“. These values are aids to the server for making network fragmentation and packetization decisions.

Preroll is the minimum delay factor in milliseconds that a client should use between starting a particular stream and starting the clock for the client's timeline. It is used to compute the buffering requirements at the client in order to mitigate against network jitter. Specifically, when a data unit is received whose send time value is greater than the preroll value for that stream, the client's timeline clock is started. Rendering is subsequently determined by the Data Unit's presentation time for that (i.e., the client's) timeline. The default preroll value is zero.

The following is the significance of the various flags in the Flags field:

- Setting the Reliable Flag signifies that this media stream, if sent over a network, must be carried over a reliable data communications transport mechanism.
- Setting the Recordable Flag signifies that the content author has given permission for this media stream to be recorded. „Recorded,“ in this context, means that the client system can preserve the content for later end-user use by writing that content to a place (for example, a disk, CD-ROM, and DVD) where the end user can later access it. The Recordable Flag should be set unless the author explicitly does not want the material to be recorded.
- Setting the Seekable Flag means that this media stream may be presented starting at a non-zero time offset. This implies that this stream is a potential candidate to be included within an index since the media stream may be correctly understood – and potentially played -- from additional locations other than only the stream's beginning.
- The Presentation Time Flags are 2 bits long, signifying the following:

Value	Meaning	Explanation:
00	Not Used	The Presentation Time field is not used within the ASF Data Unit (see Section 6.1) for this media stream. The Presentation Time Delta, Presentation Time Numerator, and the Presentation Time Denominator fields are also not used within this object.
01	Fixed Delta	The Presentation Time field is not used within the ASF Data Unit (see Section 6.1) for this media stream. However, the presentation time is known to be a fixed delta (in Rational Units) off of the send time. This delta is established by the Presentation Time Delta field within this object (in other words, this is the only case in which the Presentation time Delta field is used within this object).
10	Delta in Data Units	A 16-bit Presentation Time field (in Rational Units) is used within the ASF Data Unit (see Section 6.1) for this media stream. That field identifies the presentation time as a delta off of the send time. The Presentation Time Delta field is not used within this object.
11	Full Data Unit Presentation Time	A 32-bit Presentation Time field (in Rational Units) is used within ASF Data Unit (see Section 6.1) for this media stream. That field identifies the actual presentation time for that data unit. The Presentation Time Delta field is not used within this object.

The Presentation Time Delta, Presentation Time Numerator, and Presentation Time Denominator fields do not exist if the Presentation Time Flags have a zero value. The Presentation Time Delta field also does not exist if the Presentation Time Flags have 10 or 11 values (in other words, it only exists if the flags have an 01 value; see above). Otherwise these fields are 32 bits long.

Presentation Time Delta is in Rational Time Units. It indicates that a fixed time delta (in Rational Units) between the presentation time and the send time should be applied to the entirety of this stream's data units (see the ASF Data Unit definition in Section 6.1). The Presentation Time flags determine whether or not this field is used.

Rational Time Units signify a media-stream specific time unit within the ASF file's intrinsic timeline. Rational Time Units are for Presentation Times only. They are determined by dividing the Presentation Time Numerator by the Presentation Time Denominator. The default Presentation Time Numerator value is 1 and the default Presentation Time Denominator value is 1000. Therefore, the default Rational Time Units are in milliseconds.

The Stream Number provides a reference to identify which media streams (in the ASF Data Unit's Stream Number field) are defined by a given Stream Properties Object instance. Zero is an invalid stream number (i.e., other Header Objects use stream number zero to refer to the entire file as a whole rather than to a specific media stream within the file).

The Stream Language ID Index field refers to the contents of the stream itself (in other words, the language, if any, which the stream uses/assumes).

Please see the Language List Object (Section 5.16) for the details concerning how the Stream Language ID Index and Language ID Index fields should be used.

The Stream Name Count field tells how many Stream Names are present. Each stream name instance is potentially a localization into a specific language. The Language ID Index field indicates the language in which the Stream Name has been written in Unicode values.

The Stream Name Length field indicates the number of Unicode „characters“ that are found within the Stream Name field. The MIME Type Length field indicates the number of bytes found within the MIME Type field.

The Stream Name, MIME Type, and Stream Type are each mechanisms to identify the Media Stream (in Unicode, MIME type, and GUID, respectively).

The structure for the Type Specific Data field varies by media type. The structure for this field for the Standard ASF Media Types is detailed in Section 8.

5.3.1 Data Unit Extension Object

Mandatory: No
Quantity: 0 - n

The Data Unit Extension Object is an optional provision to include application (or implementation)-specific data within each ASF Data Unit (see Section 6.1) instance of this media stream.

Object Structure:

Field Name	**Field Type**	**Size (bits)**
Object ID	GUID	128
Object Size	UINT	64
Extension System	GUID	128
Data Unit Extension Size	UINT	16
Extension System Info Size	UINT	32
Extension System Info	UINT8	??

Notes:
Extension System is a GUID identifier of the type of information being stored within the Extension Data field of the ASF Data Unit (see Section 6.1).

The Data Unit Extension Size field indicates the number of bytes of extension information that are present within the Extension Data field of the ASF Data Unit (see Section 6.1) for this media stream. If the Data Unit Extension Size field has a value of 0xFFFF (65535 decimal), then the Extension Data field is variable length and the first byte of the Extension Data field gives the length of the (following) extension data for that particular ASF Data Unit instance. For example, if the first byte of a variable sized entry has the value of „2,“ then two additional extension data bytes will be present in that instance of the Extension Data field.

The number, order, and size of the data elements within the ASF Data Unit's Extension Data field directly correspond to the order in which the Data Unit Extension Objects occur within the SPO for this media stream. For example, assume that three Data Unit Extension Objects are included within a stream's SPO. Assume that the first specifies a fixed length of 4 bytes, the second specifies a variable length field, and the third specifies a fixed length of 2 bytes. Therefore, the Extension Data field of each ASF Data Unit for this stream will consist of 4 bytes (extension #1), followed by 1 length byte plus up to 255 data bytes (extension #2), and finally 2 bytes (extension #3).

The Extension System Information field is an optional field providing additional definitions or parameters (if any) of the Extension System.

5.4 Content Description Object

Mandatory:	No
Quantity:	0 or 1

This object permits authors to record human-readable, pertinent data about the file and its contents. This content is readily expandable to satisfy varying bibliographic needs. Authors can supplement (or ignore) the „standard“ bibliographic information (for example, title, author, copyright, and description) with content designations of their own choosing. Each individual field name and value can be stored in as many different languages as are preferred by the author, and can be stream-specific or pertinent to the whole file.

Object Structure:

Field Name	Field Type	Size (bits)
Object ID	GUID	128
Object Size	UINT	64
Description Record Count	UINT	16
Description Records	See below	?

Description Record:

Field Name	Field Type	Size (bits)
Field Type	UINT	8
Language ID Index	UINT (see S5.16)	16
Stream Number	UINT	16
Name Length	UINT	16
Value Length	UINT	16
Name	Unicode (UINT16)	?
Value	Unicode (UINT16)	?

Notes:
The Object ID field contains the GUID for the Stream Properties Object (see Appendix A). The Object Size is the length in bytes of this object.

Description Record Count indicates the number of Description Records.

The Field Type field contains unsigned integer values.

- ISRC is the International Standard Recording Code as described in ISO 3901.
- ISWC is the International Standard Work code.
- UPC/EAN is the Universal Product Code/European Article Number (in other words, the „Bar code").
- Values 13 through 49 of the Field Types were derived from Reference [5]. The number in parentheses is the MARC tag value for that item.
- Values 50 through 60 of the Field Types were derived from Reference [6] for those elements that were not already obviously included within 8 through 45.
- Values 61 through 68 are RTCP SDES values and value 69 is the RTCP APP value. RTCP is defined within Reference [7]. Values 70 through 73 are RTP header information that is also defined within Reference [7].

Please consult references [5], [6], and [7] for an interpretation of the meanings of their field types.
The values of the Field Type field are:

1 = Author	2 = Title	3 = Copyright	4 = Description	5 = Tool Name
6 = Tool Version	7 =Tool GUID	8 = Date of Last Modification	9 = Original Date Created	10 = ISRC
11 = ISWC	12 = UPC/EAN	13 = LCCN (10)	14 = ISBN (20)	15 = ISSN (22)
16 = Cataloging Source, Leader (40)	17 = Main Entry -- Personal Name (100)	18 = Main Entry – Corporate Name (110)	19 = Edition Statement (250)	20 = Main Uniform Title (130)
21 = Uniform Title (240)	22 = Title Statement (245)	23 = Varying Form Title (246)	24 = Publication, Distribution, and so on (260)	25 = Physical Description (300)
26 = Added Entry Title (440)	27 = Series Statement (490)	28 = General Note (500)	29 = Bibliography Note (504)	30 = Contents Note (505)
31 = Creation Credit (508)	32 = Citation (510)	33 = Participant (511)	34 = Summary (520)	35 = Target Audience (521)
36 = Added Form Available (530)	37 = System Details (538)	38 = Awards (586)	39 = Added Entry Personal Name (600)	40 = Added Entry Topical Term (650)
41 = Added Entry Geographic (651)	42 = Index Term, Genre (655)	43 = Tag Index Term, Curriculum (658)	44 = Added Entry Uniform Title (730)	45 = Added Entry Related (740)
46 = Series Statement Personal Name (800)	47 = Series Statement Uniform Title (830)	48 = Electronic Location and Access (856)	49 = Added Entry – Personal Name (700)	50 = Coverage
51 = Date	52 = Resource Type	53 = Format	54 = Resource Identifier	55 = Source
56 = Language	57 = Relation	58 = Coverage	59 = Subject	60 = Contributor
61 = CNAME	62 = NAME	63 = EMAIL	64 = PHONE	65 = LOC
66 = TOOL	67 = NOTE	68 = PRIV	69 = APP	70 = SSRC
71 = Initial RTP Timestamp value	72 = Initial RTP Sequence Number	73= RTP Version Number	Values between 74 and 99 (inclusive) are reserved. Values >= 100 are user-defined.	

The Stream Number indicates whether the entry applies to a specific media stream or whether it applies to the whole file. A value of zero in this field indicates that it applies to the whole file; otherwise, the entry applies only to the indicated stream number.

Name is in Unicode. This field may be blank if the Field Type value is less than 100, unless the author explicitly wants to localize the name of the field type.

The Name Length field indicates the number of Unicode „characters“ that are found within Name field. The Value Length field indicates the number of Unicode „characters“ that are found within Value field.

As a space optimization, a 16-bit Language ID Index field has been used. See the Language List Object (Section 5.16) for more details.

5.5 Script Command Object

Mandatory:	No
Quantity:	0 or 1

This object provides a list of Type/Parameter pairs of Unicode strings that are synchronized to the ASF file's timeline. Types can include „URL“ or „FILENAME.“ These semantics and use of types are identical to the Command Media Type (see Section 8.7). Other Type values may also be freely defined and used. The semantics and treatment of this latter set of Types are defined by the local implementations. The Parameter value (referred to as „Commands“ below) is specific to the type field. This Type/Parameter pairing can be used for many purposes, including sending URLs to be "launched" by a client into an HTML frame (in other words, the „URL“ type) or launching another ASF file for chained „continuous play“ audio or video presentations (in other words, the „FILENAME“ type). This object can also be used as an alternative method to stream text (in addition to the Text Media Type) as well as to provide „script commands“ that can be used to control elements within the client environment.

Object Structure:

Field Name	Field Type	Size (bits)
Object ID	GUID	128
Object Size	UINT	64
Type Count	UINT	16
Command Count	UINT	16
Types	See below	?
Commands	See below	?

Type:

Field Name	Field Type	Size (bits)
Type Name Length	UINT	16
Type Name	Unicode (UINT16)	?

Command:

Field Name	Field Type	Size (bits)
Presentation Time	UINT	32
Type Index	UINT	16
Command Name Length	UINT	16
Command Name	Unicode (UINT16)	?

Notes:
Presentation Time is given in millisecond granularities.

Types are stored as an array of Unicode strings, since they will typically be reused. Commands specify their type using a zero-based index into the array of Types.

The Type Name Length field indicates the number of Unicode „characters“ that are found within the Type Name field. The Command Name Length field indicates the number of Unicode „characters“ that are found within the Command Name field.

5.6 Marker Object

Mandatory: No
Quantity: 0 or 1

This object contains a small, specialized index which is used to provide named „jump points“ within a file. This allows a content author to divide a piece of content into logical sections such as song boundaries in an entire CD or topic changes during a long presentation, and to assign a human-readable name to each section of a file. This index information is then available to the client to permit the user to „jump“ directly to those points within the presentation.

Object Structure:

Field Name	**Field Type**	**Size (bits)**
Object ID	GUID	128
Object Size	UINT	64
Index Specifier Count	UINT	16
Marker Count	UINT	16
Index Specifiers	See Section 5.14	?
Markers	See below	?

Marker:

Field Name	**Field Type**	**Size (bits)**
Presentation Time	UINT	32
Offsets	UINT64	?
Marker Name Count	UINT	16
Marker Names	See below	?

Marker Name:

Field Name	**Field Type**	**Size (bits)**
Language ID Index	UINT	16
Marker Name Length	UINT	16
Marker Name	Unicode (UINT16)	?

Notes:
The Index Specifiers are defined within the Index Parameters Object (Section 5.14).

The Presentation Time is in millisecond granularities. This value does not wrap around, which means that markers can only refer to the first 49.7 days of information contained within an ASF file.

Potentially multiple Offsets entries are listed within the Marker structure. The number is determined by the requirement that there must be one Offsets entry in each Marker structure for each Index Specifier entry. Thus, the total size in bits of the Marker's Offsets field is 64 bits times the value of the Index Specifier Count field. An offset value of 0xFFFFFFFFFFFFFFFF signifies that the entry contains an invalid offset value.

As a space optimization, a 16-bit Language ID Index field has been used. See the Language List Object (Section 5.16) for more details.

The Marker Name Length field indicates the number of Unicode „characters“ which are found within Marker Name field.

5.7 Component Download Object

Mandatory: No
Quantity: 0 or 1

This object provides a list of components (including version information) required for the proper rendering of each stream in the file. Each listed component has a human-readable name, a category identifying the component type (which is usually either „codec“ or „renderer“), a component ID used to uniquely identify a specific component, and version information for that component.

This object presupposes that the Component ID will be the primary mechanism used to find the proper component to download. This object purposefully does not use URLs to find these objects, for the following reasons:

1. Embedded URLs become stale very quickly, and end up being just wasted header space.
2. Legacy files and current components such as codecs have no knowledge of source URLs. Either authoring/conversion tools need to have elaborate lookup tables so that they can embed the proper source URLs, or else the source URLs quickly become optional and, therefore, frequently omitted.
3. Embedded source URLs would quickly become implementation-specific. Product A's authoring tools would embed pointers to product A's playback components. When a Product B client got the source URL, it would have no way of knowing if it was talking to a general "component server" or a product-specific self-extracting download module.

Object Structure:

Field Name	**Field Type**	**Size (bits)**
Object ID	GUID	128
Object Size	UINT	64
Component Count	UINT	32
Component Records	See below	?

Component Record:

Field Name	**Field Type**	**Size (bits)**
Category	GUID	128
Component ID	GUID	128
Version	UINT	64
Stream Number	UINT	16
Component Name Length	UINT	16
Component Name	Unicode (UINT16)	?

Notes:
The Component ID is a GUID that can use mappings for ACM and VCM codecs, for example.

The Version field stores a „dotted quad“ version stamp using the highest 16 bits for the product version, the next 16 bits for the incremental version, the next 16 bits for the revision, and the lowest 16 bits for the build number. The value 0.0.0.0 should be used for the versions of ACM and VCM codecs. This value means „any version“ and is needed because there are no valid versioning numbers for ACM/VCM codecs, since the „versioning information“ is actually contained within the Component ID’s GUID value itself for these codec types. Other entities that do not have valid version numbers should also use 0.0.0.0 in this field.

Stream Number identifies the multimedia stream associated with this component. A 0 (zero) value means „all streams.“

The Component Name is a human-readable display name for this component.

5.8 Stream Group Object

Mandatory:	No
Quantity:	0 or 1

This object provides lists of „associated“ streams that are grouped into related presentation contexts. Each of these contexts contains a Group Name by which these contexts may be referenced. This permits the client to make implementation-specific composition and rendering decisions affecting those streams. For associated image/video streams, these decisions can include the number, size, and location of image/video rendering windows, and their relative positions in three-dimensional space. For audio streams, these decisions will impact the potential mixing of associated audio streams that occur simultaneously (stream start & end time can be determined using the Stream Properties Object).

The following are additional examples of potential uses of this object:

1. A file containing two video streams (such as a TV newscast with a large image of the anchorperson and a smaller image of the news story) would have each video stream in a separate group. A client implementation could then use external compositional information to decide that the video stream containing the news story (whose natural size is known in the Stream Properties Object's type-specific data field) should be superimposed in the top-right corner of the larger anchorperson video stream.
2. A file containing multi-track audio would group all of those audio streams together (perhaps along with associated video and lyrics for a karaoke effect). This might tell the client implementation that these streams should be mixed.
3. A file containing two separate image streams (for example, JPEGs, and GIFs) could group the streams together. This might tell the client to "mix" them, by logically rendering them into the same window. Another approach would be to make two different groups, which would imply that images from the two streams could be visible at the same time.

The default behavior if no Stream Group Object is present within the File Header (and therefore no stream groups are defined) is to assume that all streams are grouped together.

Object Structure:
List of stream groupings, each of which contains a list of stream numbers for that grouping. Each stream grouping is optionally assigned a Group Name that can serve as a „handle“ by which the group as a whole may be referenced. This name may be localized into different languages.

Field Name	Field Type	Size (bits)
Object ID	GUID	128
Object Size	UINT	64
Stream Group Count	UINT	16
Stream Groups	See below	?

Stream Group:

Field Name	Field Type	Size (bits)
Group Name Count	UINT	16
Group Names	See below	?
Stream Count	UINT	16
Stream Numbers	UINT16	?

Group Name:

Field Name	Field Type	Size (bits)
Language ID Index	UINT	16
Group Name Length	UINT	16
Group Name	Unicode (UINT16)	?

Notes:
See the Language List Object (Section 5.16) for more details concerning how to use the Language ID Index field.

Media streams, which have been grouped into Group Names-named logical units, are grouped by enumerating their stream numbers in the Stream Numbers field. The Stream Count field identifies how many media streams are enumerated within the Stream Numbers field.

The Group Name Length field indicates the number of Unicode „characters“ that are found within Group Name field.

5.9 Scalable Object

Mandatory: No
Quantity: 0 - n

This object stores the dependency relationships between all of the media streams that comprise logical bands of the same scalable media. It can be used for scalable audio and video, as well as other types of scalable streams. Along with the dependency relationships among the streams, this object stores a default sequence in which the streams should be used when implementations are doing dynamic bandwidth scaling.

Object Structure:
The object consists of a list of Dependency Info „structures" for each stream that comprises a logical band of the same scalable stream.

A Dependency Info „structure“ (in other words, the Dependency Record) contains:
1. Stream Number.
2. List of stream numbers upon which this stream depends.

The object also contains an author-determined default sequence (in other words, the Default Sequence Record) that indicates the preferential order in which the streams should be used (in other words, items listed first should, by default, be used first). Each entry in this list consists of the following two fields:
1. Stream Number
2. Enhancement GUID.

Field Name	Field Type	Size (bits)
Object ID	GUID	128
Object Size	UINT	64
Record Count	UINT	16
Default Sequence Records	See below	?
Dependency Records	See below	?

Default Sequence Record:

Field Name	Field Type	Size (bits)
Stream Number	UINT	16
Enhancement Type	GUID	128

Dependency Record:

Field Name	Field Type	Size (bits)
Stream Number	UINT	16
Dependent Stream Count	UINT	16
Dependent Stream Numbers	UINT16	?

Notes:
The Record Count field stores both the number of Default Sequence Records and the number of Dependency Records (in other words, the same number of each). This number is equivalent to the number of streams involved in this scaleability relationship.

Possible Enhancement GUID Values are None, Unknown, Temporal, Spatial, Quality, Stereo (Audio), and Frequency Response (Audio).

5.10 Prioritization Object

Mandatory:	No
Quantity:	0 or 1

This object indicates the author's intentions as to which streams should or should not be dropped in response to varying network congestion situations. There may be special cases where this preferential order may be ignored (for example, the user hits the „mute“ button). However, generally it is expected that implementations will try to honor the author's preference.

Priority determinations are made solely with reference to base streams (in other words, this includes non-scalable streams and the base layer only of scalable streams). The author can indicate their preference as to what should happen to enhancement layer streams by means of the bandwidth restriction field.

The priority of each stream is indicated by how early in the list that stream's stream number is listed (in other words, the list is ordered in terms of decreasing priority). Two additional fields provide associated information:

1) The „Mandatory/Optional“ field identifies whether the author wants that stream kept „regardless“ (in other words, the Mandatory bit is set) or whether they are willing to have that stream dropped (in other words, an optional stream that is indicated by the Mandatory bit being cleared). Optional streams must never be assigned a higher priority than mandatory streams.
2) The Bandwidth Restriction field permits the author to indicate how much of the available bandwidth will be used. For example, if the stream is a base layer of a scalable codec, the bandwidth will determine how many enhancement layers may be selected. This number is determined by the dependency relationships and priority ordering information found within the Scalable Object combined with the bandwidth information contained within each stream's Stream Properties Object.

Streams in a mutual exclusion relationship with each other (for example, languages) should all be listed in adjacent order (in other words, priority n, n+1, n+2, and so on), sorted in decreasing order of maximum stream bandwidth. When bandwidth calculations are made, only the bandwidth used by the selected stream in a mutual exclusion relationship will be computed; each non-selected stream in such a relationship will be ignored. This combination of prioritization and mutual exclusion can be used to create scalable content even though scalable codecs have not been used by means of creating multiple distinct media stream instances of the „same content,“ each at different bandwidths.

Object Structure:

Field Name	Field Type	Size (bits)
Object ID	GUID	128
Object Size	UINT	64
Priority Record Count	UINT	16
Priority Records	See below	?

Priority Record:

Field Name		Field Type	Size (bits)
Stream Number		UINT	16
Priority Flags		UINT	16
	Mandatory		1 (LSB)
	Reserved		15
Bandwidth Restriction		UINT	32

Notes:
Priority Records are listed in order of decreasing priority.

The Stream Number should only specify the base stream (if it is scalable).

Bandwidth Restriction is in bits per second. A value of 0 (zero) indicates „no restriction."

5.11 Mutual Exclusion Object

Mandatory: No
Quantity: 0 - n

This object identifies streams that have a mutual exclusion relationship to each other (in other words, only one of the streams within such a relationship can be streamed – the rest are ignored). There should be one instance of this object for each set of objects that contain a mutual exclusion relationship. The exclusion type is used so that implementations can allow user selection of common choices, such as language.

Object Structure:

Field Name	Field Type	Size (bits)
Object ID	GUID	128
Object Size	UINT	64
Exclusion Type	GUID	128
Stream Number Count	UINT	16
Stream Numbers	UINT16	?

Notes:
The Exclusion Type identifies the nature of that mutual exclusion relationship (for example, language).

The Stream Number Count indicates how many Stream Numbers are in the Stream Numbers list. Each of the media streams in this list is in a mutual exclusion relationship with the others.

5.12 Inter-Media Dependency Object

Mandatory: No
Quantity: 0 or 1

This object provides the capability for an author to identify dependencies between different media types. An example of such a relationship would be to specify that a video effects stream will be presented only if a certain enhancement layer of a video codec is also currently being presented. Another example is binding a timecode media stream to another media stream to provide alternate timecodes for that other stream's data.

Object Structure:
List of Dependency Info „structures" for any stream involved in an inter-media dependency relationship.

Field Name	Field Type	Size (bits)
Object ID	GUID	128
Object Size	UINT	64
Dependency Record Count	UINT	16
Dependency Records	See Section 5.9	?

Notes:
The Dependency Record structure is given in Section 5.9.

The Dependency Record Count indicates the number of Dependency Records present.

Should multiple dependencies be listed within the Dependent Stream Numbers fields of a single Dependency Record, these dependencies are in a Boolean AND relationship to each other (in other words, the stream number is dependent upon x AND y). Boolean OR relationships (in other words, the stream number is dependent upon x OR y) are indicated by having multiple Dependency Record entries, each having the same Stream Number value in the Stream Number field of the Dependency Record. Streams that are dependent upon either one stream or another, or optionally both, are said to be in an OR dependency relationship.

5.13 Rating Object

Mandatory:	No
Quantity:	0 or 1

This object contains W3C-defined Platform for Internet Content Selection (PICS) information (see references [1] and [2]). PICS establishes Internet conventions for label formats. It thus provides a basis for specifying the rating of the multimedia content within an ASF file. This object does not specify the specific rating service that is to be used. The content creator is consequently able to use the rating service of their choice, as long as it is specified according to the PICS conventions.

Object Structure:

Field Name	Field Type	Size (bits)
Object ID	GUID	128
Object Size	UINT	64
PICS Data	UINT8	?

Note:
PICS information is stored as opaque data in an RFC 822-conformant format (see reference [3]).

5.14 Index Parameters Object

Mandatory:	Yes if index is present in file; Otherwise no.
Quantity:	0 or 1

This object supplies a sufficient amount of information to regenerate the index for an ASF file should the original index have been omitted or deleted. It includes only information about those streams that are actually indexed (there must be at least one stream in an index).

Object Structure:

Field Name	Field Type	Size (bits)
Object ID	GUID	128
Object Size	UINT	64
Index Entry Time Interval	UINT	32
Index Specifier Count	UINT	16
Index Specifiers	See below	?

Index Specifier:

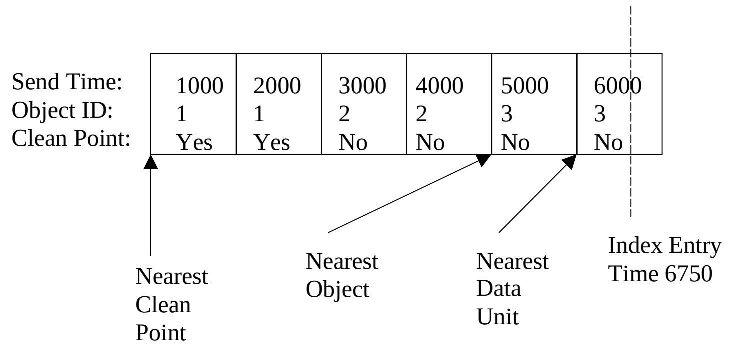
Field Name	Field Type	Size (bits)
Stream Number	UINT	16
Index Type	UINT	16

Notes:
The Index Entry Time Interval is in milliseconds.

The Index Specifier Count field identifies how many Index Specifier entries exist within the Index Specifiers field.

Every Index Type requires all index entry offsets to be to a data unit boundary of an ASF Data Unit containing data for the specified Stream Number. Also, the send time of that data unit must not exceed the time of the index entry, which is a presentation time.

Index Type values are as follows: 1 = Nearest Data Unit, 2 = Nearest Object, and 3 = Nearest Clean Point. The Nearest Data Unit indexes point to the data unit whose presentation time is closest to the index entry time. The Nearest Object indexes point to the closest data unit containing an entire object or first fragment of an object. The Nearest Clean Point indexes point to the closest data unit containing an entire object (or first fragment of an object) that has the Clean Point Flag set.



5.15 Color Table Object

Mandatory: No
Quantity: 0 to n

This object contains a color table that is used by one or more media streams. For purposes of reference, each color table is given a unique identifier for reference purposes.

Object Structure:

Field Name	Field Type	Size (bits)
Object ID	GUID	128
Object Size	UINT	64
Color Table ID	GUID	128
Color Table Record Count	UINT	16
Color Table Record	See below	?

Color Table Record:

Field Name	Field Type	Size (bits)
Red	UINT	8
Green	UINT	8
Blue	UINT	8

Note:
The structure consists of a list of Color Table Records, which contain RGB triplets.

5.16 Language List Object

Mandatory:	Yes
Quantity:	1

This object contains an array of ASCII-based Language IDs. All other header objects refer to languages through zero-based positions into this array.

Object Structure:

Field Name	Field Type	Size (bits)
Object ID	GUID	128
Object Size	UINT	64
Language ID Count	UINT	16
Language ID Records	See below	?

Language ID Record:

Field Name	Field Type	Size (bits)
Language ID Length	UINT	8
Language ID	ASCII (UINT8)	?

Notes:
Other objects refer to the Language List Object by means of their own Language List ID Index fields. The value within the Language ID Index field explicitly provides an index into the Language ID Record structure in order to identify a specific language. The first entry into this structure has an index value of 0 (zero). Index values that are greater than the number of entries within the Language ID Record structure are interpreted as signifying „American English.“

The Language ID Length field indicates the size in bytes of the Language ID field.

6 Data Object

Mandatory:	Yes
Quantity:	1

This object contains all of the ASF Data Units for a file. These data units are organized in terms of increasing send times. An ASF Data Unit contains data from only one media stream. This data may consist of an entire object from that stream. Alternatively, it can consist of a partial object of that stream (fragmentation) or several concatenated objects from that stream (grouping).

The structure of the data object contains the following two fields, which are immediately followed by one or more instances of ASF Data Units.

Field Name	Field Type	Size (bits)
Object ID	GUID	128
Object Size	UINT	64

6.1 ASF Data Unit Definition

In general, ASF media types logically consist of sub-elements that are referred to as objects. What an object happens to be in a given media stream is entirely media stream-dependent (for example, it is a specific image within an image media stream, a frame within a (non-scalable) video stream, etc). It is efficient to try to fit a media stream's object into a single ASF Data Unit whenever possible. When that is not possible, we can fragment the object (if it is too big) or group the object (if it is too little) with other objects within that same media stream when forming a data unit. In any case, each ASF Data Unit is a conveniently sized grouping of data from a single media type.

ASF data units have the following format:

Field Name	Field Type	Size (bits)
Data Unit Length	UINT	16 or 32
Stream Number	UINT	16
Send Time	UINT	32
Data Unit Flags	UINT	8 or 32
Extended Flags		1 (LSB)
Clean Point		1
Fragment		1
Fragment Size		1
Grouped Data		1
Reserved		3
Object Number	UINT	8
Presentation Time	UINT	0, 16, 32
Offset Into Object	UINT	0, 16, 32
Object Size	UINT	0, 16, 32
Extension Data	UINT8	?
Data Unit Data	UINT8	?

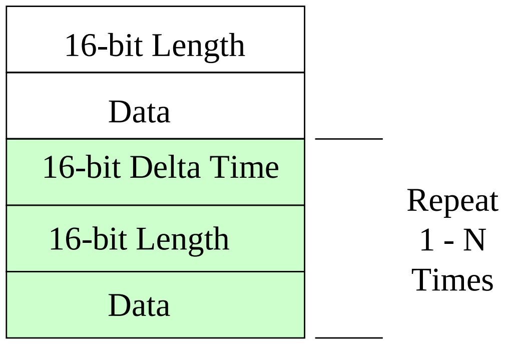
Notes:
The Data Unit Length Field specifies the length in bytes of that ASF Data Unit. The Huge Data Units Flag (in the Flags field of the File Properties Object) determines the size of the Data Unit Length field. In general, it is strongly recommended that the 16-bit size alternative of the Data Unit Length field should be used and that the maximum size value for this field should not exceed 65,000. All ASF Data Units must be smaller (in bytes) than the value indicated by the Maximum Data Unit Size field within the File Properties Object. Thus, the value of the Data Unit Length field can never exceed the Maximum Data Unit Size value.

The Stream Number identifies the media stream data of which is contained within the Data Unit Data field of this ASF Data Unit. The value of the Stream Number field corresponds to the Stream Number value within this media stream's Stream Properties Object.

The Send Time is in milliseconds and refers to the intrinsic timeline of the ASF file (which begins at value 0). The value of this field „wraps around" to zero every 2**32 milliseconds (which is roughly every 49.7 days).

The following give the significance of the Data Unit Flags:

- The size of the Data Unit Flags field is determined by whether the Extended Flags flag is set or cleared. If it is cleared, then there are only 8 bits of flags present. If it is set, then there are 32 bits of flags with the value of the highest order 3 bytes being reserved.
- The Clean Point Flag identifies whether this data unit is a „clean point" (for example, video key frame) or not.
- The Fragment Flag indicates whether this data unit contains a fragment of an object or not. If the Fragment Flag is set, then the Offset Into Object and Object Size fields exist within this ASF Data Unit instance. These fields are used to indicate the breakup of large object across data unit boundaries. If this flag is cleared, then these two fields do not exist within this ASF Data Unit instance. If the Fragment Flag is set, then the Grouped Data Flag must be cleared. If an object containing a clean point is fragmented, the Clean Point Flag is set all of the fragments of that object.
- The Fragment Size flag is valid only if the Fragment Flag has been set. If the Fragment Size Flag is cleared, then the Offset Into Object and Object Size fields are 16 bits long. If it is set, then these fields are 32-bits long.
- The Grouped Data Flag indicates whether or not multiple objects from the same stream are grouped together into a single data unit. The Grouped Data flag must be cleared (in other words, indicating no grouped data) if the Fragment Flag is set. Grouping consists of prefixing a 16-bit length field to the object data. A 16-bit delta time (in milliseconds) is inserted between each length-object pairing. For example:



The 16-bit Delta Time field is always included within Grouped Data as shown above. This field indicates a presentation time for the following grouped object. If the Presentation Time flags within the Stream Properties Object are configured to state that presentation times are not used (value of 00), then the value of the 16-bit Delta Time field of the Grouped Data indicates the difference in send times between the two objects. In this case, the delta time effectively indicates a presentation time difference for the grouped objects only.

Should an object containing a clean point be grouped, the object containing the clean point must be the first object in the grouping. All other objects in a grouping are interpreted as not being clean points.

The Object Number field identifies which object within the data stream is being sent. (The first object is Object Number 0.) The value of this field „wraps" around to 0 every 2**8 objects. It should be explicitly noted that the term „object" within the context of ASF media types (and hence the Object Number field of the ASF Data Unit) is entirely unrelated to the ASF Object definition, which was given in Section 3.1.

The Presentation Time Flags within the Stream Properties Object determine whether the Presentation Time field exists or not. Those flags also determine whether the Presentation time is full presentation time (in other words, full 32-bit reference to the timeline) or whether the presentation time is a 16-bit delta off of the send time. All presentation times are in terms of the Rational Unit values established for that media stream within the Stream Properties Object.

The Offset Into Object and Object Size fields are used exclusively for fragmentation. The former identifies the offset into the object (identified by the Object Number field) where the current fragment begins, and the Object Size identifies the total size of that object. These fields provide the information needed to reconstruct the object when it is received at the client.

The Extension Data field is optional and its existence and size is determined by the optional presence of one or more Data Unit Extension Object(s) (see Section 5.3.1) within the Stream Properties Object (see Section 5.3). The Extension System (GUID) field within the Data Unit Extension Object(s) establishes the semantics of the Extension Data.

6.2 ASF Data Unit Examples

The following examples are provided to help explain how the data unit format may appear in various usage scenarios. In each case excerpts from the example Stream Properties Object must be included, since they determine the actual data unit composition. Also, it is assumed in all examples that the Huge Data Units Flag within the File Properties Object has been cleared.

6.2.1 Complete Key Frame Example:

The Presentation Time Flags in the Stream Properties Object specify that the Presentation Delta is in the data units (in other words, value „10“). The Extension Data Size value (of the Data Unit Extension Object) is 2.

The following is an example data unit for the case where the Object Number is 5, the Send Time is 5000, and the Presentation Time is 5750:

Field Name	Field Size (bytes)	Field Value
Data Unit Length	2	1014
Stream Number	2	1
Send Time	4	5000
Data Unit Flags	1	0x02
Object Number	1	5
Presentation Time	2	750
Extension Data	2	Opaque
Data Unit Data	1000	Opaque

6.2.2 Partial JPEG Example:

The Presentation Time Flags in the Stream Properties Object specify that presentation times are not used (value „00“). The Extension Data Size value (of the Data Unit Extension Object) is 0.

The following is an example data unit for the case where bytes 1000 through 1799 are being sent for a 4000-byte-long JPEG image at a Send Time of 7000. The Object Number of this JPEG image is 17.

Field Name	Field Size (bytes)	Field Value
Data Unit Length	2	814
Stream Number	2	2
Send Time	4	7000
Data Unit Flags	1	0x06
Object Number	1	17
Offset Into Object	2	1000
Object Size	2	4000
Data Unit Data	800	Opaque

6.2.3 Three Delta Frames Example

The Presentation Time Flags in the Stream Properties Object specifies that the Presentation Time Delta is carried in the data units (value „10“). The Extension Data Size value (of the Data Unit Extension Object) is 0.

The following is an example of a data unit containing three delta video frames. The first is 20 bytes long, and presents at 8500, the second is 30 bytes long and presents at 8533, and the third is 40 bytes long and presents at 8575.

Field Name			**Field Size (bytes)**	**Field Value**
Data Unit Length			2	112
Stream Number			2	1
Send Time			4	8000
Data Unit Flags			1	0x10
Object Number			1	97
Presentation Time			2	500
Data Unit Data			100	See below
	[Object Number #97]	Data Length	2	20
		Data	20	Opaque
	[Object Number #98]	Pres. Time Delta	2	33 [in other words,8533 – 8500]
		Data Length	2	30
		Data	30	Opaque
	[Object Number #99]	Pres. Time Delta	2	42 [in other words, 8575 – 8533]
		Data Length	2	40
		Data	40	Opaque

7 Index Object

Mandatory: No, but strongly recommended
Quantity: 0 or 1

This top-level ASF object supplies the necessary indexing information for an ASF file. It includes stream-specific indexing information based on an adjustable index entry time interval. The index is designed to be broken into blocks to facilitate storage that is more space-efficient by using 32-bit offsets relative to a 64-bit base. That is, each index block has a full 64-bit offset in the block header, which is added to the 32-bit offsets found in each index entry. If a file is larger than 2^32 bytes, then multiple index blocks can be used to fully index the entire large file while still keeping index entry offsets at 32 bits.

Indices into the Index Object are in terms of Presentation Times. The corresponding Offset field values (of the Index Entry, see below) are byte offsets that, when combined with the Index Block's Block Position value, indicate the starting location of an ASF Data Unit.

The Index Object is not recommended to be used for files where the Send Time of the first Data Unit within the Data Object has a Send Time value significantly greater than zero (otherwise the index itself will be sparse and inefficient). In such cases, an offset value of 0xFFFFFFFF is used to indicate an invalid offset value. Invalid offsets signify that this particular index entry does not identify a valid indexable point. Invalid offsets may occur for the initial index entries of a media stream whose first ASF Data Unit has a non-zero send time.

Object Structure:

Field Name	Field Type	Size (bits)
Object ID	GUID	128
Object Size	UINT	64
Index Entry Time Interval	UINT	32
Index Specifier Count	UINT	16
Index Specifiers	See Section 5.14	?
Index Block Count	UINT	32
Index Blocks	See below	?

Index Block:

Field Name	Field Type	Size (bits)
Block Position	UINT	64
Index Entry Count	UINT	32
Index Entries	See below	?

Index Entry:

Field Name	Field Type	Size (bits)
Offsets	UINT32	?

Notes:
Block Position is the byte offset of the beginning of this block relative to the beginning of the first Data Unit (i.e., the beginning of the Data Object + 24 bytes).

Index Entry Count is the number of Index Entries in the block.

The size of the Offsets field within each Index Entry structure is 32 bits multiplied by the value of the Index Specifier Count field. For example, if the Index Specifier Count is 3, then there are three 32-bit offsets in each Index Entry. Index Entry offsets are ordered according to the ordering specified by the Index Parameters Object, thereby permitting the same stream to be potentially indexed by multiple Index Types (e.g., Nearest Clean Point, Nearest Object, Nearest Data Unit).

The Index Entry Time Interval has a millisecond granularity.

8 Standard ASF Media Types

ASF files store a wide variety of multimedia content. It is natural to expect implementations to make use of this content to produce rich multimedia experiences. It is anticipated that implementations will flexibly produce unique media types of their own creation. It is highly desirable, however, that a rich set of standard media types be commonly supported to permit content compatibility between diverse implementations.

The purpose of this section is to define a set of Standard ASF Media Types.[1] The explicit intention of this section is that if an implementation supports a media type defined within this section (in other words, audio, video, image, timecode, text, MIDI, command, Media Object), that media type must be supported in the manner described within this section if the implementation is to be considered to be „content-compliant“ with the ASF specification. This commonality will hopefully define a minimum subset of media within which multi-vendor interoperability will be possible. This, in turn, will simplify media exchange between companies, developers, and individuals. No restrictions are placed upon how implementations support non-standard media types (in other words, media types other than those covered in this section).

There are two elements to each Media Type definition:
1. Identification of the information that will populate the *Type-Specific Data* field of the Stream Properties Object. This provides media-specific information needed to interpret the data in the media stream.
2. Description of the media stream data itself.

Each of the following sub-sections will define the core media types in terms of these two elements.

8.1 Audio Media Type

Type-Specific Data:

Field Name	Field Type	Size (bits)
Codec ID	GUID	128
Error Concealment Type	GUID	128
Bits per Sample	UINT	32
Samples per Second	UINT	32
Average Frame Size	UINT	32
Maximum Frame Size	UINT	32
Samples per Frame	UINT	32
Flags	UNIT	16
Reserved		16
Number of Channels	UINT	16
Error Concealment Data Size	UINT	16
Codec Specific Data Size	UINT	16
Error Concealment Data	UINT8	?
Codec Specific Data	UINT8	?

Media Stream Format:
Output of a codec or sampling device.

Notes:
The Bits per Sample field should have a value of 0 (zero) if a variable bit-rate compression scheme is used.

The term „frame“ in this context refers to the compressed chunk of data produced by an audio codec.

[1] „Media types“, as used in this document, is roughly equivalent to the IETF RFC 1590 term „content type.“

8.1.1 Scrambled Audio

One Error Concealment Type is so-called „scrambled audio.“ This refers to an error concealment approach that mitigates the impact of lost audio data units by rearranging the order in which audio data is sent. The Scrambled Audio concealment scheme stores audio data in a rearranged fashion on disk. This disk order is maintained as the data is streamed over a network. The client must correctly unscramble the audio data before submitting it to the codec to decompress. This approach works well for fixed bit-rate audio codecs that have no inter-frame dependencies.

The Error Concealment Data field has the following structure for this approach:

Field Name	Field Type	Size (bits)
Audio Object Size	UINT	32
Rearranged Chunk Size	UINT	32
Chunks per Data Unit	UINT	32
Chunk Distance	UINT	32

Notes:
The Audio Object Size refers to the size in bytes of all rearranged audio objects in this stream. Other object sizes are possible but will not use this concealment scheme.

Rearranged Chunk Size refers to the size in bytes of audio blocks that are rearranged within each object. This value should be a multiple of the Average Frame Size.

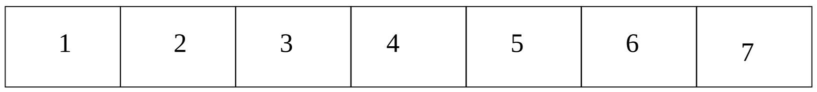
Chunks per Data Unit refers to the number of Rearranged Chunk Size audio blocks that are contained in each ASF data unit for this stream.

Chunk Distance refers to the number of audio chunks to skip when filling data units.

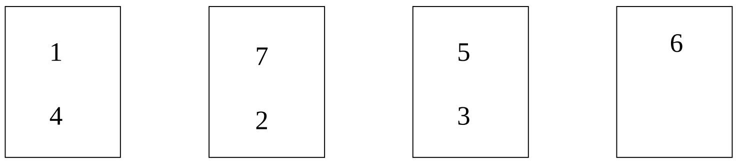
Every data unit except for the one containing the „end“ of each audio object will always contain (Chunks per Data Unit) * (Rearranged Chunk Size) bytes of audio.

The following diagram illustrates how audio scrambling will be done.

Original Audio Media “chunks” before scrambling.



Each rectangle represents the Rearranged Chunk Size.
The size of all rectangles added together represents the Audio Object Size.
If the Chunk Distance = 3 and the Chunks per Packet = 2, the following would be the resulting packet order stored on the disk (and streamed across the network):



8.2 Video Media Type

Type-Specific Data:

Field Name	Field Type	Size (bits)
Codec ID	GUID	128
Color Table ID	GUID	128
Average Frame Rate	FLOAT	64
Average Key Frame Rate	FLOAT	64
Maximum Key Frame Rate	FLOAT	64
Average Frame Size	UINT	32
Maximum Frame Size	UINT	32
Flags	UINT	16
Reserved		16
Encoded Image Width	UINT	16
Encoded Image Height	UINT	16
Display Image Width	UINT	16
Display Image Height	UNIT	16
Color Depth	UINT	16
Codec Specific Data Size	UINT	16
Codec Specific Data	UINT8	?

Media Stream Format:
Output of a codec or sampling device.

Notes:

The Encoded/Display Image Width/Height is in pixels.

The Average Key Frame Rate and the Maximum Key Frame Rate are able to indicate very slow rates as a fractional value. For example, a frame rate of one frame every 8 seconds would be shown as 0.125.

Key Frames are also known as Clean Points within the ASF Data Unit (see Section 6.1). Key Frames are known as I-Frames in MPEG terminology.

8.3 Image Media Type

Type-Specific Data:

Field Name	Field Type	Size (bits)
Codec ID	GUID	128
Color Table ID	GUID	128
Maximum Image Size	UINT	32
Encoded Image Width	UINT	16
Encoded Image Height	UINT	16
Display Image Width	UINT	16
Display Image Height	UINT	16
Flags	UINT	16
Reserved		16
Color Depth	UINT	16
Codec Specific Data Size	UINT	16
Codec Specific Data	UINT8	?

Media Stream Format:
The data contents of one or more logical Image files.

Notes:
The following Image Types must be supported on all ASF clients: Loss-Tolerant JPEG and JPEG. Other Image Types may also be optionally supported. [Note: Loss-Tolerant JPEG is a Microsoft-defined JPEG variant that will be described in a future version of this document.]

The Codec ID will include GUIDs for many image formats, including Loss-Tolerant JPEG, GIF, and JPEG.

The Color Table ID is used to indicate the palette when Color Depth is 8 bpp.

The Encoded/Display Image Width/Height is in pixels.

The Maximum Image Size is specified in bytes.

The existence, content, and size of Codec Specific Data is keyed off of the Codec ID.

8.4 Timecode Media Type

Type-Specific Data:

Field Name	Field Type	Size (bits)
Timecode ID	GUID	128

Media Stream Format:
Timecodes of the type indicated by the Timecode ID.

Notes:
The Timecode ID will contain GUIDs for SMPTE.

It is expected that a timecode media stream will be bound to specific other media streams by means of the Inter-Media Dependency object. This will provide a basis for establishing (non-mathematic) SMPTE timecode for that media stream (in other words, Rational Presentation Times solely are able to establish mathematically based timecodes). For example, if an SMPTE timecode is bound to a video stream, entries with the same send times in the two streams are paired, thereby permitting SMPTE timecodes to be given to that video stream.

8.5 Text Media Type

Type-Specific Data:

Field Name	Field Type	Size (bits)
Text Encoding System	GUID	128
Encoding Specific Data	??	??

Media Stream Format:
Text Media shall be streamed as NULL-terminated streams.

Notes:
The following Text Types must be supported on all ASF clients: ASCII, Unicode, and HTML. Other Text Types may also be optionally supported.

The Encoding Specific Data field will have a different meaning depending on the Text type identified within the Text ID field:

- If ASCII or Unicode is the Text Encoding System, then the Encoding Specific Data field will not exist.
- If HTML, then this may optionally contain a Cascading Style Sheet (CSS) that will be in common across each of the HTML objects within this media stream.

All ASF implementations are required to support ASCII and are strongly encouraged to support Unicode and HTML.

As is the case with the other media types, all rendering and composition decisions for Text Media (for example, overlays, Z-ordering, positioning, marquis, and so on) are made by out-of-band techniques alluded to in Section 5.8.

Should „text files“ be streamed, each „file“ is considered to be an object within this data stream (in other words, it will have a distinct Object ID value within the ASF Data Unit (see Section 6.1)).

8.6 MIDI Media Type

The goals for the definition of the MIDI media type were to incur minimal overhead for MIDI data while maintaining extensibility for future enhancements. Also, it was desirable to enable reasonable granularity seeking operations within MIDI streams. We believe that this proposal meets the stated objectives.

Minimal overhead is present in the definition of the MIDI event structure (see the Media Stream Format section below). Usually, only two bytes more than MIDI’s standard overhead is required, while maintaining a more accurate timing model.

Extensibility is built in through an event class system, which permits the mapping and assignment of globally unique identifiers (GUIDs) to the integer-based event classes contained in a MIDI stream.

Seeking operations are supported through an expanded use of the Clean Point concept. On some interval throughout a seekable MIDI stream, objects will need to begin with what is termed „Clean Point Info“ events. These events will serve to re-establish the state of patch changes and controllers at that point in the MIDI stream. Those objects that contain this Clean Point Info can then be marked using the Clean Point Flag in the ASF data unit definition, and indexed using the normal ASF Index. During the course of normal streaming playback, these redundant Clean Point Info events are ignored. When seeking, the client uses these events to re-establish the current state of patches and controllers. An exact list of which controllers’ state should be preserved is TBD.

Type-Specific Data:

Field Name		Field Type	Size (bits)
Flags		UINT	16
	Extended Classes		1 (LSB)
	Extended Channels		1
	Reserved		14
Event Class Count		UINT	16
Event Classes		GUID	?

Notes:
The Extended Classes Flag means that every MIDI event in this stream uses the 8 bit Extended Event Class field (see below) to extend the number of possible event classes from 63 to 16383 (by extending the event class space from 6 bits to 14 bits).

The Extended Channels Flag means that every MIDI event in this stream is followed by a byte that contains an additional 8 bits of MIDI channel information, permitting the use of 4096 channels instead of just the traditional 16 channels.

The Event Classes list of GUIDs contains the mapping used for this particular stream from the GUID identifiers for MIDI event classes to the integers used in this stream. The first entry in this list is given the integer value 1 (one), since 0 (zero) is reserved to indicate a standard MIDI event.

It is expected that MIDI streams will have the Reliable Flag set in their Stream Properties Object, as the loss of MIDI data generally leads to undesirable and unpredictable results.

Media Stream Format:
Each object within a MIDI stream will contain an array of the following MIDI Event structures:

Field Name		Field Type	Size (bits)
Presentation Time Delta		UINT	16
		UINT	8
	Event Size Present		1 (LSB)
	Clean Point Event		1
	Event Class		6
Extended Event Class		UINT	0 or 8
Event Size		UINT	0 or 32
MIDI Event		UINT8	?
Extended Channel Info		UINT	0 or 8

Notes:
The Presentation Time Delta field is stored in units of 100 microseconds (tenths of milliseconds). The 16-bit size of the field, when combined with the chosen time units, permits ASF MIDI objects to contain up to 6.5535 seconds worth of MIDI data in a single object. The delta is based on the explicit or implicit Presentation Time value of the object in the ASF MIDI stream. Each event stores an individual time delta from the base presentation time of the object (for ease of manipulation), so the resulting presentation time for every single MIDI event in the same object can be computed as object presentation time + presentation time delta. All MIDI events in a single object must be stored in sorted order of increasing presentation time deltas.

The Event Size Present field is used to indicate that an explicit 32-bit event size field is being used in this particular event. This will typically be useful for SYSEX events whose lengths can not be predicted. If not present, the size of the MIDI Event field must be implicitly determined based on the event's contents. In the case of a standard MIDI event (with Event Class == 0), a simple table can be used to map from MIDI status byte values to the overall size of the MIDI event data. Recall that if the stream's Extended Channels flag is set, then an Extended Channel Info byte follows the standard MIDI event.

The Clean Point Event field indicates that this particular MIDI event should only be processed if received immediately following a seek operation. Otherwise, client implementations should skip this event.

The Event Class field is used as a 1-based index into the Event Classes list of GUIDs stored in the stream header. Event Class 0 (zero) is reserved to indicate a Standard MIDI event. The Extended Event Class field is used to expand the number of simultaneously permissible event classes for a particular stream from 63 to 16383 by extending the number of event class bits from 6 to 14. It occurs only if the Extended Classes flag is set in the stream header.

The Event Size field is used only if the Event Size Present field is set, as was previously mentioned.

MIDI running status can be used between the events contained within one individual ASF object (or buffer), but should not cross object boundaries. This recommendation is designed to simplify client playback resource requirements and implementations.

8.7 Command Media Type

Type-Specific Data:

Field Name	Field Type	Size (bits)
Command Type	GUID	128

Media Stream Format:
The data of URL Command Types complies with the URL format strings as defined in RFC 1738 and RFC 2017. These strings shall be NULL terminated ASCII strings. Frame values are indicated by a „&" delimiter according to the following syntax: „& frame & URL \0".

The data of the FILENAME Command Type either complies with the URL Command Type format or else the format used on the local operating system to indicate ASCII filenames.

Notes:
There are two standard Command Type GUIDs: URL and FILENAME. The URL command indicates that the URL is to be „launched“ by a client into an HTML window or frame. The FILENAME command indicates the ASF file indicated is to be played immediately (for example, for „continuous play“ environments).

It is required that all ASF implementations support fully specified URLs for both URL and FILENAME uses. Relative path URLs may be optionally supported. The use of Local URLs (in other words, those containing O/S dependent references such as drive letters) is discouraged but not prohibited.

8.8 Media-Objects (Hotspot) Media Type

The goal of the Media-Objects stream is to encode an object representation of a related visual media stream (for example, video, image, slideshow, animation, and so on) and the interactive features associated with these objects. This is accomplished by „binding“ the media object stream to the related visual media stream by means of the Inter-Media Dependency Object.

Theoretically, the Media Object stream will enable elements within the visual media stream to be referred to in an object-oriented fashion (in addition to the traditional image-oriented fashion). This approach enhances the information level embedded in a visual media stream, providing both the developer and the viewer with a new, more natural method of referencing the logical objects in the media. For example, derived applications may include object-based interactivity, object-based storage and retrieval and object-based statistics.

Type-Specific Data:

Field Name	**Field Type**	**Size (bits)**	**Description**
Horizontal Resolution	UINT	16	The horizontal resolution of frame. This parameter is used to interpret the objects' geometry parameters.
Vertical Resolution	UINT	16	The vertical resolution of frame. This parameter is used to interpret the objects' geometry parameters.
Number of Commands	UINT	16	Total number of Command Entries.
Command Entry Array	Command Entry Structure	??	

Command Entry Structure:

Field Name	**Field Type**	**Size (bits)**	**Description**
Link Type	OBLinkType	8	The command type that will be activated when actuating the object.
Link Command:			
For URL command:			
URL	ASCII String	??	The full URL address. Identical to the URL Command type (see Section 8.7).
Seek to Time command:			
Time	Timestamp	32	The point in time within the stream to seek to. This value is in millisecond granularity.
Seek to Marker command:			
Marker	UINT	32	The point in the stream to seek to (in reference to locations indicated by an index value into the Markers field of the Marker Object (see Section 5.6)). Values exceeding the number of Markers field entries will be ignored.
For Filename commands:			
Filename	ASCII String	??	Identical to the Filename Command type

			(see Section 8.7).
For Script command:			
Type Field Size	UINT	8	Number of Unicode characters in the Type Field.
Value Field Size	UINT	16	Number of Unicode characters in the Value Field.
Type Field	Unicode	??	The Type field (for example, Script Name).
Value Field	Unicode	??	The Value field (for example, Script contents).
For Pause, Resume, Exit, and Same-Value commands, no Link Command field is present			

Notes:

The Horizontal and Vertical Resolution parameters determine the units by which the objects' geometry will be defined. These parameters describe the number of "logical units" in each frame width and height. This relative representation provides easy interface for objects' re-sizing and media scaling.

The Link Type defines the command that is linked to the object. This command is activated by a mouse-click upon the object. OBLinkType defines one of the following commands:
0 = NO_LINK (nothing happens upon mouse click)
1 = URL (flip a URL page)
2 = SeekToTime
3 = SeekToMarker
4 = Filename (jump to another ASF file)
5 = Script (Type/Value pair whose actual meaning (semantics) is locally defined. For example, the Type may indicate a script name and the Value may indicate the contents of the script body.)
6 = Pause
7 = Resume (ignore if pause had not previously been hit)
8 = Exit
9 = Same-Value: Continue to use the command which had been previously specified for this Object ID. [Note: if there was not a previously specified command for this Object ID, then the command for this Object ID will default to NO_LINK. This command type should not be used for instances in which the Command Entry Structure has been appended to the Object Structure of the Media Object Stream.]
Values greater than 9 are Reserved

Media Stream Format:
Following is the structure of each object instance. Multiple object instances can optionally be directly concatenated together as an array of structures in one ASF Data Unit. Every instance encodes the object description and/or interactive features for a given duration. Each description is valid from its Start Time until its End Time.

Field Name	Field Type	Size (bits)	Description
Object ID	UINT	16	A unique identifier of the object.
Start Time	UINT	32	The starting time of this instance of the object (presentation time value).
End Time	UINT	32	The ending time of this instance of the object (presentation time value).
Object Shape	OBShape	4	The primitive shape of the hot spot.
Object Flags	OBFlags	4 (low-order nibble)	Different flags assigned to the object. (could be used by any external application).
Object Geometry		(4*16) or (N*2*16)	
For primitive shape objects (Rectangle, Triangle, Ellipse, and so on.)			
Left	UINT	16	X coordinate of the top-left corner of the bounding rectangle.
Top	UINT	16	Y coordinate of the top-left corner of the

			bounding rectangle.
Right	UINT	16	X coordinate of the bottom-right corner of the bounding rectangle.
Bottom	UINT	16	Y coordinate of the bottom-right corner of the bounding rectangle.
For Polygon shape object			
X1	UINT	16	X coordinate of the first vertex of the polygon.
Y1	UINT	16	Y coordinate of the first vertex of the polygon.
Xn…	UINT	16	X coordinate of the nth vertex of the polygon.
Yn…	UINT	16	Y coordinate of the nth vertex of the polygon.
XN	UINT	16	X coordinate of the last vertex of the polygon.
YN	UINT	16	Y coordinate of the last vertex of the polygon.
Effects Field	UINT	8	Cursor and visual effects.
Cursor Type	OBCursor	4	Cursor effects.
Marking Type	OBMark	4 (low-order nibble)	Marking effects.
Index	UINT	16	The command that will be activated when actuating this object.

Notes:

Object ID is a unique identifier of the object, throughout its life span.

The Start Time and End Time parameters are interpreted according the presentation time granularities of the visual media stream to which this particular Media Object stream was bound by means of the Inter-media Dependency Object.

Object Shape selects one of the pre-defined shapes: 0 = Rectangle, 1 = Triangle, 2 = Ellipse, and 4 = Polygon.

Object Flags field is defined in an implementation-specific manner. The default value of this field is zero. Clients may optionally ignore this field.

The object geometry parameters are all represented in the Horizontal/Vertical Resolution units, which are defined in the stream header.

For all primitive shapes (in other words Rectangle, Ellipse, Triangle), defining the bounding rectangle of the shape is sufficient to fully describe the shape. (That is also true, for an isosceles triangle with a horizontal base. For any other type of triangle, the polygon shape can be used.)

The Cursor Type specifies the author's preference for cursor shape. OBCursor values are:
0 = arrow
1 = hand
2 = hide cursor
3 – 10 Implementation Specific
11 – 15 Reserved
Implementations may use the Implementation specific values in an implementation-specific manner. Clients may also optionally ignore interpreting the Cursor Type field altogether at their own discretion.

The Marker Type visual effects associated with a hot spot. OBMark values are:
0 = none
1 = invert
2 = darken
3 = outline

4 – 10 Implementation Specific
11 – 15 Reserved
Implementations may use the Implementation specific values in an implementation-specific manner. Clients may also optionally ignore interpreting the Cursor Type field altogether at their own discretion.

The Index value refers to which entry in the Command List Array (within the Stream Properties Object) is being activated. Index values exceeding the number of entries within the Command List Array will be ignored unless it is 0xFFFF (in other words, 65535 decimal). A value of 0xFFFF signifies that a Command Entry Structure is appended to this object structure instance (for example, to support Real-Time Editing).

9 Bibliography

[1] T. Krauskopf, J. Miller, P. Resnick, and G. W. Treese, „Label Syntax and Communication Protocols,“ World Wide Web Consortium http://www.w3.org/PICS/labels.html, May 5 1996.

[2] J. Miller, P. Resnick, and D. Singer, „Rating Services and Rating Systems (and Their Machine Readable Descriptions),“ World Wide Web Consortium http://www.w3.org/PICS/services.html, May 5 1996.

[3] D. Crocker, „RFC 822: Standard for the Format of ARPA Internet Text Messages,“ ftp://ds.internic.net/rfc/rfc822.txt, August 1982.

[4] H. Alvestrand, „RFC 1766: Tags for the Identification of Languages,“ ftp://ds.internic.net/rfc/rfc1766.txt, March 2, 1995.

[5] „MARC Bibliographic Formats,“ http://www.fsc.follett.com/data/marctags/.

[6] „Dublin Core Elements,“ ftp://ds.internic.net/internet-drafts/draft-kunze-dc-01.txt or http://purl.org/metadata/dublin_core_elements/.

[7] H. Schulzrinne, S. Casner, R. Frederick, V. Jacobson, „RFC 1889: RTP: A Transport Protocol for Real-Time Applications,“ January 1996; ftp://ds.internic.net/rfc/rfc1889.txt.

Appendix A: ASF GUIDs

Use of GUIDs within ASF

GUIDs are used to uniquely identify all objects and entities within ASF files. This provides the foundation for the extensibility and flexibility that characterizes ASF. For example, versioning is transparently supported within ASF by this mechanism. That is, since each version of an ASF object has its own unique GUID, the ASF library knows how to interpret the semantics and syntax of any given version of that object based upon the GUID that is used.

Similarly, each ASF multimedia object type is uniquely identified by a GUID. New media types can be created, identified by their own GUID, and inserted into ASF data streams.

Similarly, new codec types, new error correction approaches, and novel innovations of all types can be readily invented, identified by GUIDs and used within ASF.

New ASF object types (for example, see *Other Objects* as is shown in Figure 2 of Section 3.2 as well as explicit text within Sections 5.1 and 5.3) may be defined. This forms a chief „extensibility feature" of ASF to support new innovations and inventions as they arise. Each new ASF object type needs its own unique GUID identification.

ASF GUIDs

The following are standard GUIDs that have been defined for all ASF objects and GUID-based fields within this specification. This list is not exhaustive. Implementations may supplement this list with additional GUIDs when necessary to identify entities/elements/ideas that have not yet been enumerated by this appendix.

Microsoft will endeavor to maintain a list of the additional GUID definitions (about which it has been informed) at a public Web site. The initial location of this web site will be http://www.microsoft.com/asf/ Companies desiring to register additional GUID definitions should send an email message to ASF@microsoft.com.

Standard Base ASF Objects GUIDs

ASF Header Object	{D6E229D1-35DA-11d1-9034-00A0C90349BE}
ASF Data Object	{D6E229D2-35DA-11d1-9034-00A0C90349BE}
ASF Index Object	{D6E229D3-35DA-11d1-9034-00A0C90349BE}

Standard ASF Header Object GUIDs

File Properties Object	{D6E229D0-35DA-11d1-9034-00A0C90349BE}
Stream Properties Object	{D6E229D4-35DA-11d1-9034-00A0C90349BE}
Data Unit Extension Object	{D6E22A0F-35DA-11d1-9034-00A0C90349BE}
Content Description Object	{D6E229D5-35DA-11d1-9034-00A0C90349BE}
Script Command Object	{D6E229D6-35DA-11d1-9034-00A0C90349BE}
Marker Object	{D6E229D7-35DA-11d1-9034-00A0C90349BE}
Component Download Object	{D6E229D8-35DA-11d1-9034-00A0C90349BE}
Stream Group Object	{D6E229D9-35DA-11d1-9034-00A0C90349BE}
Scalable Object	{D6E229DA-35DA-11d1-9034-00A0C90349BE}
Prioritization Object	{D6E229DB-35DA-11d1-9034-00A0C90349BE}
Mutual Exclusion Object	{D6E229DC-35DA-11d1-9034-00A0C90349BE}
Inter-Media Dependency Object	{D6E229DD-35DA-11d1-9034-00A0C90349BE}
Rating Object	{D6E229DE-35DA-11d1-9034-00A0C90349BE}
Index Parameters Object	{D6E229DF-35DA-11d1-9034-00A0C90349BE}
Color Table Object	{D6E229E0-35DA-11d1-9034-00A0C90349BE}
Language List Object	{D6E229E1-35DA-11d1-9034-00A0C90349BE}

Other ASF Header Object GUIDs

ASF Placeholder Object	{D6E22A0E-35DA-11d1-9034-00A0C90349BE}

Standard GUIDs for the Stream Type Field of the Stream Properties Object

Audio Media	{D6E229E2-35DA-11d1-9034-00A0C90349BE}

Video Media	{D6E229E3-35DA-11d1-9034-00A0C90349BE}
Image Media	{D6E229E4-35DA-11d1-9034-00A0C90349BE}
Timecode Media	{D6E229E5-35DA-11d1-9034-00A0C90349BE}
Text Media	{D6E229E6-35DA-11d1-9034-00A0C90349BE}
MIDI Media	{D6E229E7-35DA-11d1-9034-00A0C90349BE}
Command Media	{D6E229E8-35DA-11d1-9034-00A0C90349BE}
Media-Object (Hotspot)	{D6E229FF-35DA-11d1-9034-00A0C90349BE}

Codecs for Audio and Video Media Types

A GUID is needed for each version of a codec implementation that produces dissimilar encodings of the same input. Microsoft will maintain a list of GUIDs according to their Codec/version number at a Microsoft Web site. The initial location of this site is http://www.microsoft.com/asf/ Companies that want to register the GUIDs of additional Codec/version numbers should send their registrations to ASF@microsoft.com.

GUIDs for the Error Concealment Type Field of the Audio Media Type

No Error Concealment	{D6E229EA-35DA-11d1-9034-00A0C90349BE}
Scrambled Audio (see Section 8.1.1)	{D6E229EB-35DA-11d1-9034-00A0C90349BE}

GUIDs for the Color Table ID field of the Video and Image Media Types

No Color Table	{D6E229EC-35DA-11d1-9034-00A0C90349BE}

GUIDs for the Timecode ID of the Timecode Media Type

SMPTE Time	{D6E229ED-35DA-11d1-9034-00A0C90349BE}

GUIDs for the Text Encoding System Field of the Text Media Type

ASCII Text	{D6E229EE-35DA-11d1-9034-00A0C90349BE}
Unicode Text	{D6E229EF-35DA-11d1-9034-00A0C90349BE}
HTML Text	{D6E229F0-35DA-11d1-9034-00A0C90349BE}

GUIDs for the Extension System Field of the Data Unit Extension Object

RTP Extension Data	{96800c63-4c94-11d1-837b-0080c7a37f95}

GUIDs for the Command Type Field of the Command Media Type

URL Command	{D6E229F1-35DA-11d1-9034-00A0C90349BE}
Filename Command	{D6E229F2-35DA-11d1-9034-00A0C90349BE}

GUIDs for the Category Field of the Component Download Object

ACM Codec	{D6E229F3-35DA-11d1-9034-00A0C90349BE}
VCM Codec	{D6E229F4-35DA-11d1-9034-00A0C90349BE}
QuickTime Codec	{D6E229F5-35DA-11d1-9034-00A0C90349BE}
DirectShow Transform Filter	{D6E229F6-35DA-11d1-9034-00A0C90349BE}
DirectShow Rendering Filter	{D6E229F7-35DA-11d1-9034-00A0C90349BE}

Enhancement GUIDs for the Scalable Object

No Enhancement	{D6E229F8-35DA-11d1-9034-00A0C90349BE}
Unknown Enhancement Type	{D6E229F9-35DA-11d1-9034-00A0C90349BE}
Temporal Enhancement	{D6E229FA-35DA-11d1-9034-00A0C90349BE}
Spatial Enhancement	{D6E229FB-35DA-11d1-9034-00A0C90349BE}
Quality Enhancement	{D6E229FC-35DA-11d1-9034-00A0C90349BE}
Number of Channels Enhancement (for example, Stereo)	{D6E229FD-35DA-11d1-9034-00A0C90349BE}
Frequency Response Enhancement	{D6E229FE-35DA-11d1-9034-00A0C90349BE}

GUIDs for the Exclusion Type Field of the Mutual Exclusion Object

Language	{D6E22A00-35DA-11d1-9034-00A0C90349BE}
Same Content at Different Bit Rates	{D6E22A01-35DA-11d1-9034-00A0C90349BE}
Unknown Reason	{D6E22A02-35DA-11d1-9034-00A0C90349BE}

Appendix B: Bit Stream Types

The bit stream type describes the target data type and the order of transmission of bits in the coded bit stream. The bit stream types are ASCII, GUID, FILETIME, UINT, and Unicode.

ASCII

A UINT8 (see UINT below) value containing ASCII data. ASCII data is defined in RFC 1766.

FILETIME

A 64-bit integer that contains a time stamp corresponding to the number of 100 nanosecond ticks since January 1, 1601. The following diagram demonstrates the filetime format:

```
(MSB)                                                  (LSB)
+--------+--------+--------+--------+--------+--------+--------+--------+
|byte 0 |byte 1 |byte 2 |byte 3 |byte 4 |byte 5 |byte 6 |byte 7 |
+--------+--------+--------+--------+--------+--------+--------+--------+
<-------------------------------- 64 bits ------------------------------->
```

The GMT time zone is used for all filetime entries.

GUID

The terms GUID (globally unique identifier) and UUID (universally unique identifier) are identical. GUIDs are a 128-bit (16 octet) data structure composed of a 32-bit unsigned integer, two 16-bit unsigned integers, and an array of eight octets. The constituent parts are shown in the following diagrams:

```
(MSB)                       (LSB)
+-------+-------+-------+-------+
|byte 0 |byte 1 |byte 2 |byte 3 |
+-------+-------+-------+-------+
<------------32 bits------------>
UNSIGNED INTEGER

(MSB)       (LSB)
+-------+-------+
|byte 0 |byte 1 |
+-------+-------+
<----16 bits---->
UNSIGNED INTEGER

(MSB)       (LSB)
+-------+-------+
|byte 0 |byte 1 |
+-------+-------+
<----16 bits---->
UNSIGNED INTEGER

(MSB)                           (LSB)
+-------+-------+...+-------+-------+
|byte 0 |byte 1 |...|byte 7 |byte 8 |
+-------+-------+...+-------+-------+
<--------------64 bits------------->|
FIXED-LENGTH ARRAY

These components are concatenated to form the UUID:
```

```
(MSB)                                                         (LSB)
+-------+-------+-------+-------+-------+-------+...+-------+-------+
|byte 0 |byte 1 |byte 2 |byte 3 |byte 4 |byte 5 |...|byte 14|byte 15|
+-------+-------+-------+-------+-------+-------+...+-------+-------+
<------------------------------128 bits---------------------------->
UNIVERSALLY UNIQUE IDENTIFIER (UUID)
```

UINT

Unsigned integer in Little-Endian byte and Little-Endian bit order. When a number is appended to UINT, the number refers to the number of bits contained within this unsigned integer value. For example:

- UINT64 is an unsigned integer value that is 64 bits long
- UINT32 is an unsigned integer value that is 32 bits long
- UINT16 is an unsigned integer value that is 16 bits long
- UINT8 is an unsigned integer value that is 8 bits long.

UNICODE

A UINT16 (see UINT above) value containing Unicode data.

Appendix C: GUIDs and UUIDs

ABSTRACT

This appendix describes the format of UUIDs (Universally Unique IDentifier), which are also known as GUIDs (Globally Unique IDentifier). A GUID is 128 bits long, and if generated according to the one of the mechanisms in this document, is either guaranteed to be different from all other UUIDs/GUIDs generated until 3400 A.D. or extremely likely to be different (depending on the mechanism chosen). GUIDs were originally used in the Network Computing System (NCS) [1] and later in the Open Software Foundation's (OSF) Distributed Computing Environment [2].

This specification is derived from the latter specification with the kind permission of the OSF.

Introduction

This specification defines the format of UUIDs (Universally Unique IDentifiers), also known as GUIDs (Globally Unique IDentifiers). A GUID is 128 bits long, and if generated according to the one of the mechanisms in this document, is either guaranteed to be different from all other UUIDs/GUIDs generated until 3400 A.D. or extremely likely to be different (depending on the mechanism chosen).

Motivation

One of the main reasons for using GUIDs is that no centralized authority is required to administer them (beyond the one that allocates IEEE 802.1 node identifiers). As a result, generation on demand can be completely automated, and they can be used for a wide variety of purposes. The GUID generation algorithm described here supports very high allocation rates: 10 million per second per machine if you need it, so that they could even be used as transaction IDs. GUIDs are fixed-size (128 bits), which is reasonably small relative to other alternatives. This fixed, relatively small size lends itself well to sorting, ordering, hashing of all sorts, storing in databases, simple allocation, and ease of programming in general.

Specification

A GUID is an identifier that is unique across both space and time, with respect to the space of all GUIDs. To be precise, the GUID consists of a finite bit space. Thus the time value used for constructing a GUID is limited and will roll over in the future (at approximately A.D. 3400, based on the specified algorithm). A GUID can be used for multiple purposes, from tagging objects with an extremely short lifetime, to reliably identifying very persistent objects across a network.

The generation of GUIDs does not require that a registration authority be contacted for each identifier. Instead, it requires a unique value over space for each GUID generator. This spatially unique value is specified as an IEEE 802 address, which is usually already available to network-connected systems. This 48-bit address can be assigned based on an address block obtained through the IEEE registration authority. This section of the GUID specification assumes the availability of an IEEE 802 address to a system desiring to generate a GUID, but if one is not available, Section 4 specifies a way to generate a probabilistically unique one that can not conflict with any properly assigned IEEE 802 address.

C.1 Format

The following table gives the format of a GUID.

Field	Data Type	Octet #	Note
time_low	unsigned 32-bit integer	0-3	The low field of the timestamp.
time_mid	unsigned 16-bit integer	4-5	The middle field of the timestamp.
time_hi_and_version	unsigned 16-bit integer	6-7	The high field of the timestamp multiplexed with the version number.
clock_seq_hi_and_reserved	unsigned 8-bit integer	8	The high field of the clock sequence multiplexed with the variant.
clock_seq_low	unsigned 8-bit integer	9	The low field of the clock sequence.

node	character	10-15	The spatially unique node identifier.

The GUID consists of a record of 16 octets and must not contain padding between fields. The total size is 128 bits.

To minimize confusion about bit assignments within octets, the GUID record definition is defined only in terms of fields that are integral numbers of octets. The version number is multiplexed with the timestamp (*time_high*), and the variant field is multiplexed with the clock sequence (*clock_seq_high*).

The timestamp is a 60-bit value. For GUID version 1, this is represented by Coordinated Universal Time (UTC) as a count of 100-nanosecond intervals since 00:00:00.00, 15 October 1582 (the date of Gregorian reform to the Christian calendar).

The version number is multiplexed in the 4 most significant bits of the *time_hi_and_version* field.

The following table lists currently defined versions of the GUID.

msb1	msb2	msb3	msb4	Version	Description
0	0	0	1	1	DCE version, as specified herein.
0	0	1	0	2	DCE Security version, with embedded POSIX UIDs.

The variant field determines the layout of the GUID. The structure of DCE GUIDs is fixed across different versions. Other GUID variants may not interoperate with DCE GUIDs. Interoperability of GUIDs is defined as the applicability of operations such as string conversion, comparison, and lexical ordering across different systems. The *variant* field consists of a variable number of the MSBS of the *clock_seq_hi_and_reserved* field.

The following table lists the contents of the DCE variant field.

msb1	msb2	msb3	Description
0	-	-	Reserved, NCS backward compatibility.
1	0	-	DCE variant.
1	1	0	Reserved, Microsoft Corporation GUID.
1	1	1	Reserved for future definition.

The clock sequence is required to detect potential losses of monotonicity of the clock. Thus, this value marks discontinuities and prevents duplicates. An algorithm for generating this value is outlined in the „Clock Sequence“ section below.

The clock sequence is encoded in the 6 least significant bits of the *clock_seq_hi_and_reserved* field and in the *clock_seq_low* field.

The *node* field consists of the IEEE address, which is usually the host address. For systems with multiple IEEE 802 nodes, any available node address can be used. The lowest addressed octet (octet number 10) contains the global/local bit and the unicast/multicast bit, and is the first octet of the address transmitted on an 802.3 LAN.

Depending on the network data representation, the multi-octet unsigned integer fields are subject to byte swapping when communicated between different endian machines.

The nil GUID is special form of GUID that is specified to have all 128 bits set to 0 (zero).

C.2 Algorithms for Creating a GUID

Various aspects of the algorithm for creating a GUID are discussed in the following sections. GUID generation requires a guarantee of uniqueness within the node ID for a given variant and version. Interoperability is provided by complying with the specified data structure. To prevent possible GUID collisions, which could be caused by different implementations on the same node, compliance with the algorithms specified here is required.

C.2.1 Clock Sequence

The clock sequence value must be changed whenever:

- The GUID generator detects that the local value of UTC has gone backward; this may be due to normal functioning of the DCE Time Service.

- The GUID generator has lost its state of the last value of UTC used, indicating that time \f2 may have gone backward; this is typically the case on reboot.

While a node is operational, the GUID service always saves the last UTC used to create a GUID. Each time a new GUID is created, the current *UTC* is compared to the saved value and if either the current value is less (the non-monotonic clock case) or the saved value was lost, then the *clock sequence* is incremented modulo 16,384, thus avoiding production of duplicate GUIDs.

The *clock sequence* must be initialized to a random number to minimize the correlation across systems. This provides maximum protection against *node* identifiers that may move or switch from system to system rapidly. The initial value MUST NOT be correlated to the node identifier.

The rule of initializing the *clock sequence* to a random value is waived if, and only if, all of the following are true:
- The *clock sequence* value is stored in a form of non-volatile storage.
- The system is manufactured such that the IEEE address ROM is designed to be inseparable from the system by either the user or field service, so that it cannot be moved to another system.
- The manufacturing process guarantees that only new IEEE address ROMs are used.
- Any field service, remanufacturing or rebuilding process that could change the value of the clock sequence must reinitialise it to a random value.

In other words, the system constraints prevent duplicates caused by possible migration of the IEEE address, while the operational system itself can protect against non-monotonic clocks, except in the case of field service intervention. At manufacturing time, such a system may initialise the clock sequence to any convenient value.

C.2.2 System Reboot

There are two possibilities when rebooting a system:
- The GUID generator states that the last UTC, adjustment, and clock sequence of the GUID service has been restored from non-volatile store.
- The state of the last UTC or adjustment has been lost.

If the state variables have been restored, the GUID generator just continues as normal. Alternatively, if the state variables cannot be restored, they are reinitialized, and the clock sequence is changed.
If the clock sequence is stored in non-volatile store, it is incremented; otherwise, it is reinitialized to a new random value.

C.2.3 Clock Adjustment

GUIDs may be created at a rate greater than the system clock resolution. Therefore, the system must also maintain an adjustment value to be added to the lower-order bits of the time. Logically, each time the system clock ticks, the adjustment value is cleared. Every time a GUID is generated, the current adjustment value is read and incremented atomically, and then added to the UTC time field of the GUID.

C.2.4 Clock Overrun

The 100-nanosecond granularity of time should prove sufficient even for bursts of GUID creation in the next generation of high-performance multiprocessors. If a system overruns the clock adjustment by requesting too many GUIDs within a single system clock tick, the GUID service may raise an exception, handled in a system or process-dependent manner either by:
- Terminating the requester.
- Reissuing the request until it succeeds.
- Stalling the GUID generator until the system clock catches up.

If the processors overrun the GUID generation frequently, additional node identifiers and clocks may need to be added.

C.2.5 GUID Generation

GUIDs are generated according to the following algorithm:
- Determine the values for the UTC-based timestamp and clock sequence to be used in the GUID.
- Sections format and clock_seq define how to determine these values. For the purposes of this algorithm, consider the timestamp to be a 60-bit unsigned integer and the clock sequence to be a 14-bit unsigned integer. Sequentially number the bits in a field, starting from 0 (zero) for the least significant bit.

- Set the *time_low* field equal to the least significant 32 bits (bits numbered 0 to 31 inclusive) of the time stamp in the same order of significance. If a DCE Security version GUID is being created, then replace the *time_low* field with the local user security attribute as defined by the *(ZB.
- Set the *time_mid* field equal to the bits numbered 32 to 47 inclusive of the timestamp in the same order of significance.
- Set the 12 least significant bits (bits numbered 0 to 11 inclusive) of the *time_hi_and_version* field equal to the bits numbered 48 to 59 inclusive of the time stamp in the same order of significance.
- Set the 4 most significant bits (bits numbered 12 to 15 inclusive) of the *time_hi_and_version* field to the 4-bit version number corresponding to the GUID version being created, as shown in the table above.
- Set the *clock_seq_low* field to the 8 least significant bits (bits numbered 0 to 7 inclusive) of the *clock sequence* in the same order of significance.
- Set the 6 least significant bits (bits numbered 0 to 5 inclusive) of the *clock_seq_hi_and_reserved* field to the 6 most significant bits (bits numbered 8 to 13 inclusive) of the *clock sequence* in the same order of significance.
- Set the 2 most significant bits (bits numbered 6 and 7) of the *clock_seq_hi_and_reserved* to 0 and 1, respectively.
- Set the *node* field to the 48-bit IEEE address in the same order of significance as the address.

C.3 String Representation of GUIDs

For use in human-readable text, a GUID string representation is specified as a sequence of fields, some of which are separated by single dashes.

Each field is treated as an integer and has its value printed as a zero-filled hexadecimal digit string with the most significant digit first. The hexadecimal values a to f inclusive are output as lowercase characters, and are case-insensitive on input. The sequence is the same as the GUID constructed type.

The formal definition of the GUID string representation is provided by the following extended BNF:

```
GUID                   = <time_low> <hyphen> <time_mid> <hyphen>
                         <time_high_and_version> <hyphen>
                         <clock_seq_and_reserved>
                         <clock_seq_low> <hyphen> <node>
time_low               = <hexOctet> <hexOctet> <hexOctet> <hexOctet>
time_mid               = <hexOctet> <hexOctet>
time_high_and_version  = <hexOctet> <hexOctet>
clock_seq_and_reserved = <hexOctet>
clock_seq_low          = <hexOctet>
node                   = <hexOctet><hexOctet><hexOctet>
                         <hexOctet><hexOctet><hexOctet>
hexOctet               = <hexDigit> <hexDigit>
hexDigit               = <digit> | <a> | <b> | <c> | <d> | <e> | <f>
digit                  = "0" | "1" | "2" | "3" | "4" | "5" | "6" | "7" |
                         "8" | "9"
hyphen                 = "-"
a                      = "a" | "A"
b                      = "b" | "B"
c                      = "c" | "C"
d                      = "d" | "D"
e                      = "e" | "E"
f                      = "f" | "F"
```

The following is an example of the string representation of a GUID:

```
            2fac1234-31f8-11b4-a222-08002b34c003
```

C.4 Comparing GUIDs

The following table lists the GUID fields in order of significance, from most significant to least significant, for purposes of GUID comparison. The table also shows the data types applicable to the fields.

Field	Type
time_low	Unsigned 32-bit integer

time_mid	Unsigned 16-bit integer
time_hi_and_version	Unsigned 16-bit integer
clock_seq_hi_and_reserved	Unsigned 8-bit integer
clock_seq_low	Unsigned 8-bit integer
node	Unsigned 48-bit integer

Consider each field to be an unsigned integer as shown above. Then, to compare a pair of GUIDs, arithmetically compare the corresponding fields from each GUID in order of significance and according to their data type. Two GUIDs are equal if and only if all the corresponding fields are equal. The first of two GUIDs follows the second if the most significant field in which the GUIDs differ is greater for the first GUID. The first of a pair of GUIDs precedes the second if the most significant field in which the GUIDs differ is greater for the second GUID.

C.5 Node IDs when no IEEE 802 network card is available

If a system wants to generate GUIDs but has no IEE 802-compliant network card or other source of IEEE 802 addresses, then this section describes how to generate one.

The ideal solution is to obtain a 47-bit cryptographic quality random number, and use it as the low 47 bits of the node ID, with the high-order bit of the node ID set to 1. (The high-order bit is the unicast/multicast bit, which will never be set in IEEE 802 addresses obtained from network cards.)

If a system does not have a primitive to generate cryptographic quality random numbers, then in most systems there are usually a fairly large number of sources of randomness available from which one can be generated. Such sources are system-specific, but often include:

- the percent of memory in use
- the size of main memory in bytes
- the amount of free main memory in bytes
- the size of the paging or swap file in bytes
- free bytes of paging or swap file
- the total size of user virtual address space in bytes
- the total available user address space bytes
- the size of boot disk drive in bytes
- the free disk space on boot drive in bytes
- the current time
- the amount of time since the system booted
- the individual sizes of files in various system directories
- the creation, last read, and modification times of files in various system directories
- the utilization factors of various system resources (heap, and so on.)
- current mouse cursor position
- current caret position
- current number of running processes, threads
- handles or IDs of the desktop window and the active window
- the value of stack pointer of the caller
- the process and thread ID of caller
- various processor architecture specific performance counters (instructions executed, cache misses, TLB misses)

In addition, items such as the computer's name and the name of the operating system, while not strictly speaking random, will differentiate the results from those obtained by other systems.

The exact algorithm to generate a node ID using this data is system-specific, because both the data available and the functions to obtain them are often very system-specific. However, assuming that one can concatenate all the values from the randomness sources into a buffer, and that a cryptographic hash function such as MD5 [3] is available, the following code will compute a node ID:

```
#include <md5.h>
#define HASHLEN 16
```

```
void GenNodeID(
      unsigned char * pDataBuf,     // concatenated "randomness values"
      long cData,             // size of randomness values
      unsigned char NodeID[6]       // node ID
) {
      int i, j, k;
      unsigned char Hash[HASHLEN];
  MD_CTX context;

  MDInit (&context);
  MDUpdate (&context, pDataBuf, cData);
  MDFinal (Hash, &context);

      for (i,j = 0; i < HASHLEN; i++) {
            NodeID[j] ^= Hash[i];
            if (j == 6) j = 0;
      };
      NodeID[0] |= 0x80;            // set the multicast bit
};
```

Other hash functions, such as SHA-1 [4], can also be used (in which case HASHLEN will be 20). The only requirement is that the result be suitably random – in the sense that the outputs from a set uniformly distributed inputs are themselves uniformly distributed, and that a single bit change in the input can be expected to cause half of the output bits to change.

C.6 References

[1] Lisa Zahn, et.al. *Network Computing Architecture*. Englewood Cliffs, NJ: Prentice Hall, 1990

[2] OSF DCE Spec

[3] R. Rivest, RFC 1321, "The MD5 Message-Digest Algorithm," 04/16/1992.

[4] SHA Spec