Action Plan Background: AVI

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Preface:
The AVI file format is based on the RIFF (resource interchange file format) document format. It is a proprietary format jointly developed by Microsoft and IBM.

1 General Description

1.1 Format Name:
Audio/Video Interleaved (AVI) File

1.2 Version:
1.0

1.3 MIME media type name:
video

1.4 MIME subtype:
AVI has never been officially registered with IANA. In practice, there are many MIME types used for AVI, including video/avi, video/msvideo, video/x-msvideo and many others. RFC 2361 (WAVE and AVI codec registries) indicates the applications could use "video/vnd.avi; codec=XXX" to refer to a specific codec, but it does not recommend any MIME subtype to be used for general AVI file.

Following the MIME subtype naming rules [RFC4288], formats without registered MIME types should use an "x-" prefix for their MIME subtype. Therefore video/x-avi should be used for AVI files.

1.5 Short Description:
AVI is a wrapper file format that may contain multiple streams of different types of data, such as video or audio streams.

1.6 Common Extensions:
.avi

1.7 Color depth:
1,4, 8, 16, 24 and 32 bits per pixel

1.8 Color Space:
AVI files may be saved in many different color spaces [McGowan 2000] , they include:

15-bit RGB (16 bits with most significant bit zero, 5 bits each for red, green and blue)
16-bit RGB (16 bits with 5 bits each for red, 6 bits for green and 5 bits for blue)
24-bit RGB (one byte each for red, green and blue color component)
32-bit RGB (most significant byte is set zero, 8 bits each for red, green and blue)
8-bit grayscale (Y8)

9-bit YUV9
12-bit BTYUV (4:1:1)
12-bit YUV12
16 bit YUV2 (4:2:2)
The 24-bit RGB is the most well supported color format. However, some of the less popular color formats such as 8-bit grayscale, may not be supported in some AVI playback drivers.

1.9 Compression:
Various compressors can be used in compressing the video stream in an AVI file. The most popular video codecs (compressor/decompressor) used in AVI file are Cinpak, MJPEG, Indeo 3, Indeo 5 and DivX 5. An AVI video stream can contain uncompressed frames where no codec is used.

1.9.1 Video Codec
Cinepak:
Cinepak codec is perhaps one of the oldest and most popular codec used in AVI [McGowan 2000] . It was originally developed for Macintosh and then distributed with Microsoft Video for Windows, QuickTime and DirectX SDK. Cinepak supports both 24-bits color and grayscale formats.

Indeo 3.2:
Indeo codec was originally developed by Intel in the 80's and then sold to Ligos Technology Inc [McGowan 2000] . It is also a very old and popular codec for AVI. Compared to Cinepak, Indeo is more CPU intensive and provides faster compression time. It is also built into QuickTime, Video for Windows and DirectX SDK. Indeo 3.2 supports 16-bits color format. Both Cinepak and Indeo 3.0 uses vector quantization algorithm for image compression and motion estimation [Ferguson 2001].

Indeo 5:
Indeo 5 is a much high quality codec developed by Intel. However, it requires more powerful processors for playback and has longer compression time. It is built into DirectX API and QuickTime. Both 16-bits and 24-bits color format are supported in Indeo 5 [LIGO 2003]. Indeo5 does not use vector quantization algorithm for compression. Instead, it uses wavelet compression algorithm.

DivX:
DivX is a video codec based on the international MPEG-4 video standard [DIVX 2004]. It was originally developed by a French engineer, Jérôme Rota, in 1999 to store MPEG-4 video stream in AVI files as Microsoft only allow writing MPEG-4 video stream in ASF format at that time. DivX codec uses I (Intra-frame), P (Predicted-frame) and B (Bi-directional frames) as defined in the MPEG-4 standard to provide better compression ratio. Both simple profile and advanced simple profile are supported in DivX 5.0. DivX codec is also supported in Microsoft Video for Windows and Apple QuickTime.

Motion JPEG:
Motion JPEG is essentially storing video as a sequence of JPEG images. It does not provide temporal compression and thus, it is a possible candidate for archiving quality video. However, there is currently no standard for motion JPEG. It is possible that video encoded with one specific Motion JPEG codec may not be able decoded with another Motion JPEG codec.

The audio stream in AVI files can be either stored as uncompressed PCM (Pulse Code Modulated) audio stream or compressed with many different audio codecs such as MP3.

1.9.2 Audio Codec

MP3

MP3 (MPEG 1/LAYER 3) is a perceptual audio encoding and lossy compression format devised by Fraunhofer IIS in 1987 as part of EUREKA project EU147, Digital Audio Broadcasting (DAB)[1]. The MP3 compression uses various techniques, including psychoacoustics, to discard portions of audio that are insensible to human ears. It can achieve up to 1/12 of compression rate without reducing the sampling rate or sample resolution. In 1993, MP3 is standardized as ISO-MPEG Audio Layer-3 (IS 11172-3 and IS 13818-3).

1.10 Magic number(s):

HEX: 52 49 46 46 xx xx xx xx 41 56 49 20 4C 49 53 54
ASCII: RIFF....AVILIST

1.11 Byte Order:

Big-endian or Little-endian

1.12 Specification Requirements:

AVI file format is a specialization of the RIFF file format [MSFT 1993]. The RIFF file format consists of a series of chunks, each prefixed by a four-character ID (FOURCC) and a four-byte length. Each chunk may in turn be nested to form a structured file.

An AVI file starts with a RIFF header followed by *chunks*. The RIFF header for an AVI file is "AVI ". The AVI file format uses FOURCC to identify stream types, data chunks, index entries, and other information. All AVI files must include two mandatory chunks to define the format of the streams and stream data.

1 Please refer to http://www.iis.fraunhofer.de/amm/techinf/layer3/

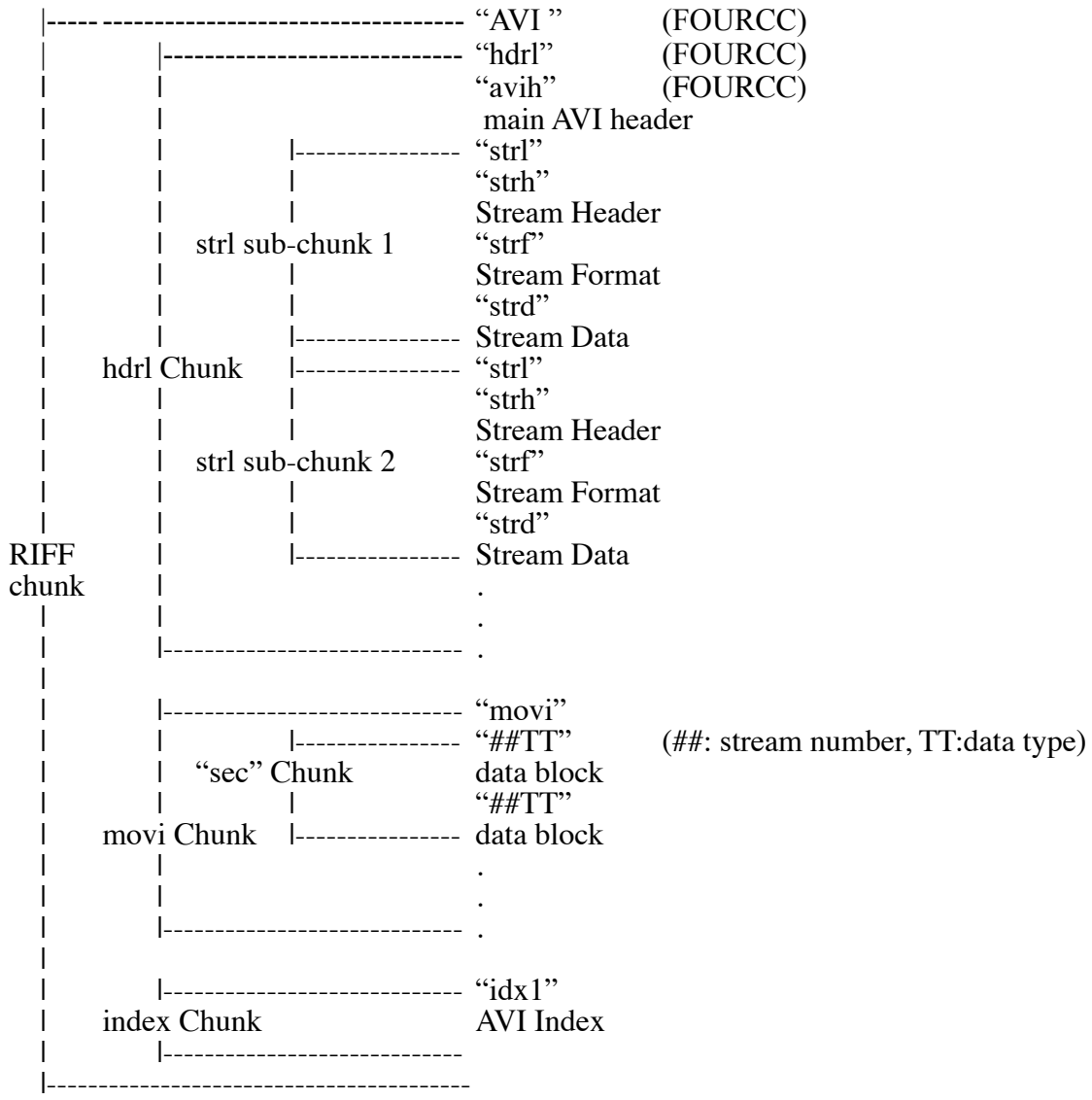

Figure 1. AVI File Structure

The first required chunk, identified by 'hdrl' FOURCC, defines the data format. It contains the main AVI header plus additional "strl" sub-chunks to specify the information about the streams in the AVI file. The main AVI header contains general information about the AVI file such as the number of streams, total number of frames and the dimension of the video frame in the AVI file. Each "strl" sub-chunk must contain a stream header and stream format chunk. The stream header, identified by "strh", specifies the type of data the stream contains, such as audio or video, and the codec used with the data. The stream format ("strf") chunk describes the data format in the stream. For video data, the stream format contains a structure that could include palette

information. The stream format chunk may be followed by a stream data chunk ("strd"). The stream data chunk is defined and used by each codec.

The second chunk, "movi", contains the actual data for the AVI sequence. It contains chunks of the actual data in the streams; that is, the actual sound or movie data. The data chunk begins with a FOURCC. The first two characters in the FOURCC is the stream number in the "hdrl" chunk. It associates the data chunk with the stream chunk in the "hdrl" chunk. The last two characters in the FOURCC identify the data type such as "wb" for waveform audio, "db" for uncompressed video frames and "dc" for compressed video frames.

Audio and video data are typically stored in the 'movi' chunk in chronological order unless it specifically requires the use of index chunk to determine the order of presentation (defined in the AVI header). Video data are separated into frames where each chunk contains only one frame. Audio data are broken into blocks to be contained in chunks. These audio and video chunks are then regrouped together (interleaved) into "rec" chunks. This allows players to read the AVI file sequentially and pick up the audio and video it needs without seeking all over the place.

AVI files may also include an optional index chunk after the "movi" chunk to specify the location of the data chunks within the file. The index chunk lists all the chunks in the "movi" chunk and their location in the file (relative offsets within the "movi" chunk). This provides random access to the data within the file. For multimedia applications, this means that applications can locate a particular video frame or audio sequence without scanning through the entire file.

2 Essential and Distinguishing Characteristics

2.1 AVI File Technical Metadata

Metadata Element (G = general file metadata, GM = general media metadata, F = Format Specific Medatadata)	***Obligation (R = Required by spec., S= Defined in spec., D = Derived from spec., O = Optional)***	***Location***
Micro seconds per frame [GM]	R	defined in main AVI Header
Max. bytes per second [GM]	R	defined in main AVI Header
Total number of frames of data in the AVI file [GM]	R	defined in main AVI Header
The number of frames in the AVI file prior to the initial frame of the AVI sequence. Used for interleaved files [GM]	R	defined in main AVI Header
Number of streams [GM]	R	defined in main AVI Header
Duration (seconds) [GM]	D	derived from main AVI Header
Whether or not the AVI file contains an index chunk [F]	R	defined in main AVI Header
Whether the order of presentation of data is determined by the index [F]	R	defined in main AVI Header

Metadata Element (G = general file metadata, GM = general media metadata, F = Format Specific Medatadata)	*Obligation (R = Required by spec., S= Defined in spec., D = Derived from spec., O = Optional)*	*Location*
Whether the AVI file is interleaved [F]	R	defined in main AVI Header
Whether the AVI file contains copyrighted data [F]	R	defined in main AVI Header
If the AVI file is a specially allocated file used for capturing real-time video [F]	R	defined in main AVI Header

2.2 Video Steam Technical Metadata

Metadata Element (GS = general stream metadata, GV = general video metadata)	*Obligation (R = required by spec., S= Defined in spec., D = given by spec., O = Optional)*	*Location*
Stream Data Type (video) [GS]	R	defined in Stream Header
Encoding [GS]	R	defined in Stream Header
Frame Rate (frames/s) [GV]	D	derived from Stream Header
Bits Per Pixel [GV]	R	defined in Stream Format
Frame Height (pixels) [GV]	R	defined in Stream Format
Frame Width (pixels) [GV]	R	defined in Stream Format
Length (frames) [GV]	D	derived from Stream Header
Data Quality (0 – 10000), used by codec [GV]	R	defined in Stream Header
Whether the stream data is enabled by default [GS]	R	defined in Stream Header
Whether the palette changes are embedded in the files [GS]	R	defined in Stream Header

2.3 Audio Stream Technical Metadata

Metadata Element (GS = general stream metadata, *GA = general audio metadata)*	***Obligation (R = required by spec., S= Defined in spec., D = derived from spec., O = Optional)***	***Location***
Stream Data Type (audio) [GS]	R	defined in Stream Header
Encoding [GS]	R	defined in Stream Header
Sample Rate (samples/s) [GA]	D	derived from Stream Header
Sample Size (bits) [GA]	R	defined in Stream Format
Number of Channels [GA]	R	defined in Stream Format
Length (samples) [GA]	D	derived from Stream Header
Data Quality (0 – 10000), used by codec [GV]	R	defined in Stream Header
Whether the stream data is enabled by default [GS]	R	defined in Stream Header

3 Usefulness

3.1 Version Duration:
14 years.

3.2 History of Prior Versions Duration:
N/A

3.3 Expected Newer Versions:
N/A

3.4 Existence of Publicly Available Complete Specifications:
The original AVI file format specification, Multimedia Programming Interface and Data Specifications 1.0, is freely available on many web sites. Microsoft also publishes AVI file format specification as part of their Video for Windows and DirectX documents. Those documents are also available on Microsoft's website.

John F. McGowan, wrote an overview for AVI file format in 2000 [McGowan 2000]. It was widely referenced in many articles describing AVI file format.

However, many of the codecs used in encoding/decoding multimedia data in AVI files are proprietary. Public documentation for each installable AVI codec is limited.

3.5 Specifications-controlling Body:
Microsoft Corporation.

3.6 Related Legal Issues:
Microsoft owns the copyright of AVI file format. Currently, there appears to be no known licensing issue associated with AVI file format. However, some proprietary codecs encoded in AVI files may require licenses from vendors.

3.7 Application and Platform Support:
Most video players support playback of AVI files, including Microsoft Media Player, QuickTime player, Mplayer, Real Player and Helix player. Even though Real Player and Helix player for Linux currently do not support AVI file format, support is expected in the future.

There are many tools available to write AVI files. Adobe Premier, QuickTime Pro and many other video editing software all support writing multimedia data in AVI format. There are also many software conversion programs to convert multimedia files from AVI to other formats and vice versa. Windows developers can use Microsoft Video for Windows (VFW) or Microsoft DirectShow to create AVI files.

3.8 Limitations:
The RIFF chunk in AVI files uses a 32-bit integer to describe its size. This inherently limits the size of any chunk to 4GB (4,294,967,295 bytes). Since the original AVI file specification only allow one RIFF chunk per AVI file, this limits the size of standard AVI files to 4GB.

There is a bug in the early Microsoft Video for Windows code which limits AVI file size to 2GB. This is the reason that AVI files are widely perceived to be not larger than 2 GB.

3.9 Perceived Popularity:
AVI file format has been around for over a decade. It is one of the first video file formats developed for video playback and storage. It has a simple architecture built from RIFF blocks. In particular, it is very easy to write AVI files. Thus, many multimedia programs support AVI format. Because of its simplicity, AVI has become one of the most popular file formats for audio/video data on personal computers. In fact, AVI format is still one of the most commonly found video file formats available today.

After defining the OPEN DML AVI and DV data in AVI file format specifications, Microsoft has since not actively maintaining AVI file format but instead focus on developing its own file format: Advanced System Format (ASF)[2]. The ASF file format can contain various types of data including audio, video, metadata, index and script command. Theoretically, the ASF file wrapper can support files up to 17 million terabytes.

4 Related Formats

4.1 Specification Variations:
OpenDML AVI
To support larger file size and provide backward compatibility with legacy applications, the Open Digital Media (OpenDML) AVI M-JPEG File Format Subcommittee released the OpenDML File Format Extensions in November 1995. It explains extensions to the AVI file format and Motion-JPEG DIB definition in order to improve the file format for playback

2 Please refer to http://www.microsoft.com/windows/windowsmedia/format/robust.aspx

purposes. The latest version of the OpenDML File Format Extensions, version 1.02, was published in 1996 by the OpenDML File Format Subcommittee [OpenDML 1996]. OpenDML File Format Extensions is sometimes referred as AVI 2.0.

DV-AVI
Many Digital Video (DV) consumer electronics such as digital camcorders, store audio and video data in AVI file. To ensure compatibility among multimedia applications developed using DirectShow (now DirectX), Microsoft developed the DV Data in the AVI File Format Specification [MSFT 1997].

5 Summary and Conclusions

AVI file format is a relatively simple multimedia file format compared to other media file formats such as QuickTime, ASF, RM (Real Media), and MPEG. Its simplicity has made it one of the most popular multimedia file formats, especially on the Windows platform.

Besides its simplicity, AVI format is also openly documented and are well supported in most multimedia applications and computer platforms. It is a stable file format that has not been modified since its original deployment except specification variations like OpenDML AVI and DV-AVI.

However, AVI format does not provide some newer video storage functionalities such as timestamps, subtitles, etc. Perhaps the biggest drawback of AVI file format is that it was not designed for streaming. AVI and Video for Window were originally developed for playing back video and audio on hard disks and CD-ROMs. They are not well suited for real-time steaming or video playback over networks. This means that AVI files usually have to be fully downloaded and then played back locally rather than streaming the content over the networks[3].

The newer format developed by Microsoft, Advanced System Format (ASF), improves support for video streaming over networks. However, Microsoft has patented the ASF media file format (US Patent No. 6,041,345) [4]which prevents third parties from developing their own tools to import ASF files or convert ASF to other formats [Rowe 2001]. Even though Microsoft has strongly encouraged the use of ASF file format instead of AVI file format, its popularity is still limited to Microsoft software or tools that are developed using Microsoft Software Development Toolkits.

6 References

[IBM 1991] Multimedia Programming Interface and Data Specifications 1.0, IBM Corporation and Microsoft Corporation, August 1991

[Ferguson 2001] Cinepak (CVID) stream format for AVI and QT, Dr. Time Ferguson, 2001

[DIVX 2004] The Official DivX 5.2 Guide, DivX Networks, 2004 (http://www.divx.com/divx/create/divxpro/guides/).

3 Some applications allow streaming AVI files across a network. However, they usually do not playback very well (see http://www.virtualdub.org/).
4 See http://www.cptech.org/ip/business/software/audio.html

[LIGO 2003] Indeo Video and Audio Codecs Technical Documentation, Ligos Corporation, January 3, 2003 (http://ligos.com/pdf_docs/Indeo_doc.pdf).

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[Zimmermann 2003] Multimedia and visualization: Streaming of DivX AVI movie, Roger Zimmermann, ACM symposium on Applied computing, March 2003