Cimarron Systems

Elements of the H.264 Video/AAC Audio MP4 Movie

Application Note: AN101

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Construction of the MP4 Movie Container

The present application note describes the core elements of a canonically constructed MPEG-4 movie using H.264 video and AAC-LC audio encapsulated in a media container commonly termed a MP4 movie. The MP4 movie elements described here were generated by the RTP A/V Streaming Client/Server Applications—available as part of the Cimarron Systems Digital Media Software Development Kits (DMSDK)—and, while the MP4 movie container complies with ISO/IEC 14496-12 *Information technology — Coding of audio-visual objects Part 12: ISO base media file format* and the *QuickTime Movie File Format Specification*, Apple, August, 2010, the discussion here focuses on a subset of the container elements defined in both specifications.

DMSDK Development Environment

Figure 1 shows a context diagram of the typical development environment in which the DMSDK operates, including: the TM320DM36x DVEVM running a number of the DMSDK components, a Ubuntu Linux Host computer, an audio/video source, and a video display/audio output device.

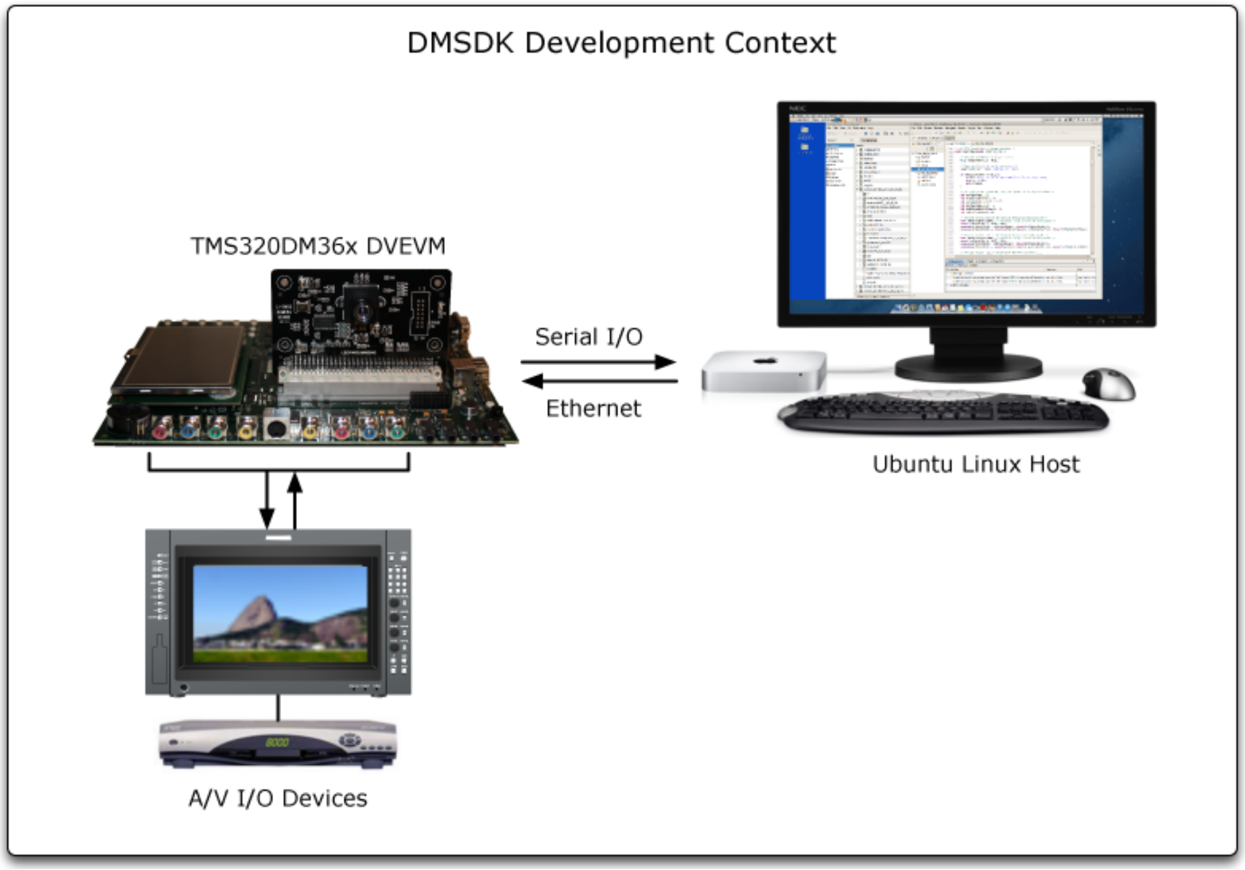
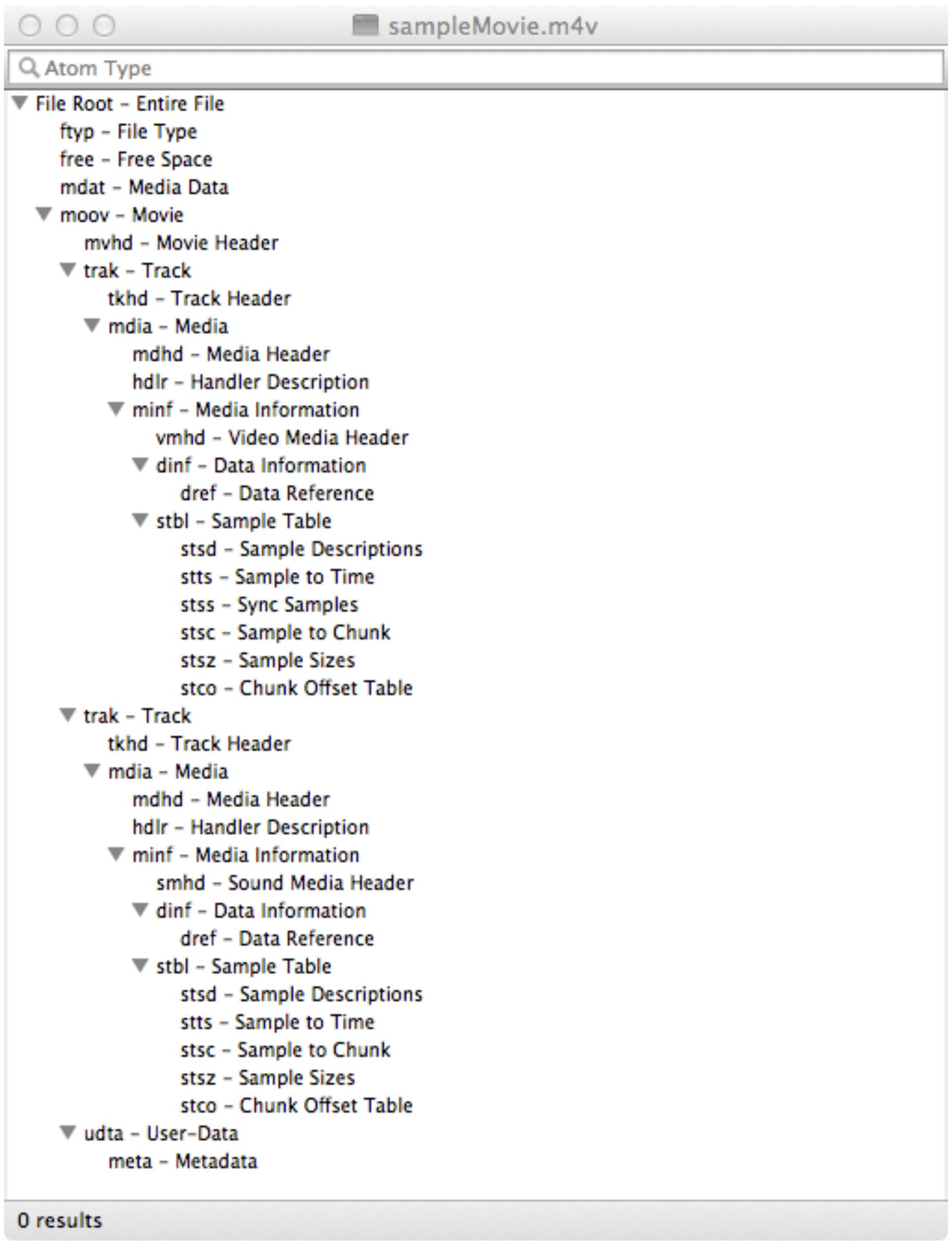


Figure 1: DMSDK Development Context Diagram.

MP4 Atom Descriptions

As illustrated in Figure 2, the MP4 movie container file format has a very specific hierarchy of elements called Atoms (in MPEG-4 terminology, they are called Boxes). Using Apple's naming convention, each of these movie container elements are described briefly below (Color Code for Atom Description Figures: blue represents the '`atom size`'; green represents the '`atom content`'; yellow represents the '`NAL Unit Size`'; and watermelon represents the NAL Unit Byte Sequence).



```
sampleMovie.m4v
Atom Type
▼ File Root - Entire File
    ftyp - File Type
    free - Free Space
    mdat - Media Data
  ▼ moov - Movie
      mvhd - Movie Header
    ▼ trak - Track
        tkhd - Track Header
      ▼ mdia - Media
          mdhd - Media Header
          hdlr - Handler Description
        ▼ minf - Media Information
            vmhd - Video Media Header
          ▼ dinf - Data Information
              dref - Data Reference
          ▼ stbl - Sample Table
              stsd - Sample Descriptions
              stts - Sample to Time
              stss - Sync Samples
              stsc - Sample to Chunk
              stsz - Sample Sizes
              stco - Chunk Offset Table
    ▼ trak - Track
        tkhd - Track Header
      ▼ mdia - Media
          mdhd - Media Header
          hdlr - Handler Description
        ▼ minf - Media Information
            smhd - Sound Media Header
          ▼ dinf - Data Information
              dref - Data Reference
          ▼ stbl - Sample Table
              stsd - Sample Descriptions
              stts - Sample to Time
              stsc - Sample to Chunk
              stsz - Sample Sizes
              stco - Chunk Offset Table
    ▼ udta - User-Data
        meta - Metadata
0 results
```

Figure 2: MP4 Movie Container Overview.

File Type, Free, and Media Data Atoms

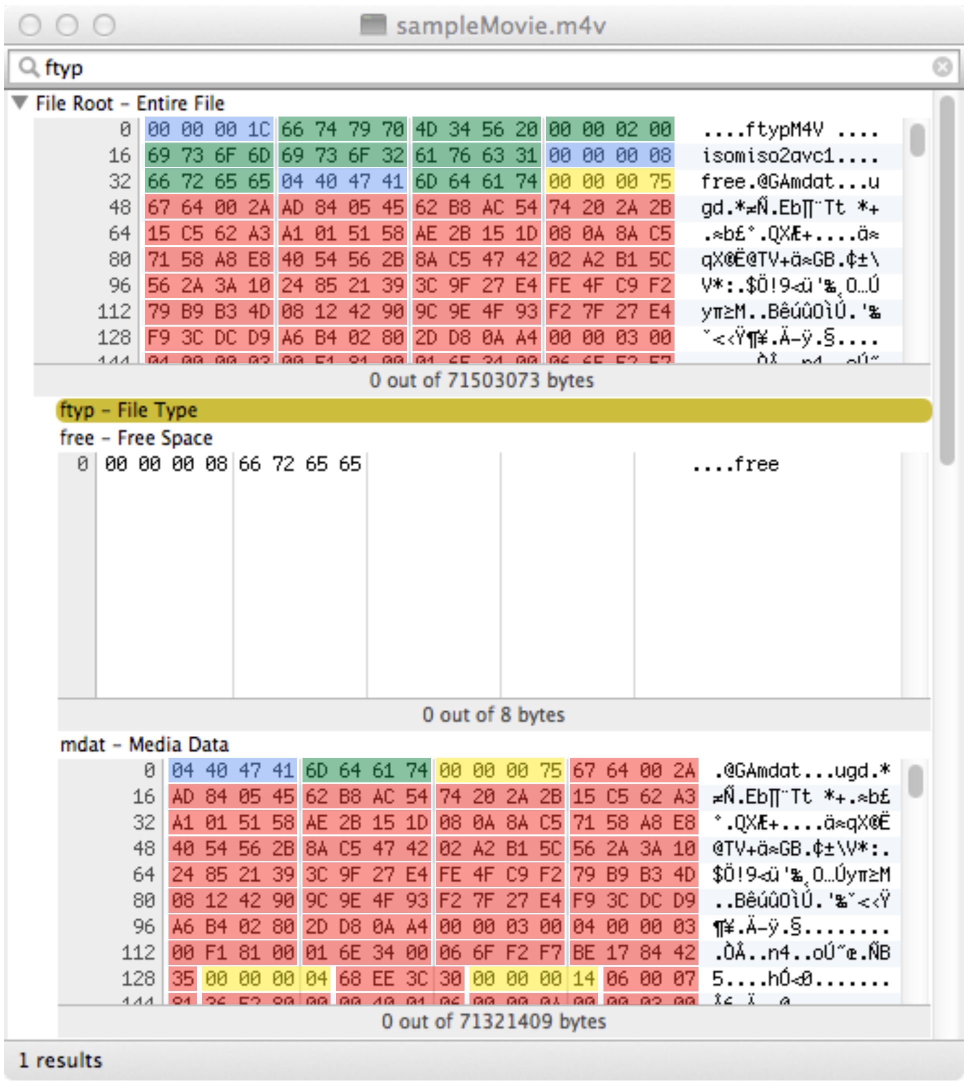
Figure 3 illustrates the general structure of the MP4 movie container file structure, specifically the: 'ftyp' atom; free' atom; 'mdat' A/V media data block; and two full (plus one partial) H.264 NAL Units .

- **ftyp** contains the following fields:
  - Size—A 32-bit unsigned integer that specifies the number of bytes in this File Type atom; set here to '0x0000001C'.
  - Type—A 32-bit unsigned integer that identifies the atom type, represented as a four-character code; this field must be set to 'ftyp'.
  - Major Brand—A 32-bit unsigned integer that identifies the movie file type, represented as a four-character code; is set to 'm4v ' (note the trailing ASCII space character).

- Minor Version— A 32-bit unsigned integer that identifies the movie file type Minor Version, represented as a four-byte number represented in binary coded decimal (BCD) form; is set to '0x00000200'.
- Compatible Brands— A series of unsigned 32-bit integers listing compatible file formats; set here to 'isom', 'iso2', and 'avc1'.

▪ **free** contains the following fields:

- Size—A 32-bit unsigned integer that specifies the number of bytes in this Free atom; set here to '0x00000008'.
- Type—A 32-bit unsigned integer that identifies the atom type, represented as a four-character code; this field must be set to 'free'.
- Free Space—The number of bytes of Free Space; a place holder not allocated here.



```
sampleMovie.m4v
ftyp
▼ File Root - Entire File
    0 00 00 00 1C 66 74 79 70 4D 34 56 20 00 00 02 00  ....ftypM4V ....
   16 69 73 6F 6D 69 73 6F 32 61 76 63 31 00 00 00 08  isomiso2avc1....
   32 66 72 65 65 04 40 47 41 6D 64 61 74 00 00 00 75  free.@GAmdat...u
   48 67 64 00 2A AD 84 05 45 62 B8 AC 54 74 20 2A 2B  gd.*≠Ñ.Eb∏¨Tt *+
   64 15 C5 62 A3 A1 01 51 58 AE 2B 15 1D 08 0A 8A C5  .≈b£°.QXÆ+....ä≈
   80 71 58 A8 E8 40 54 56 2B 8A C5 47 42 02 A2 B1 5C  qX®Ë@TV+ä≈GB.¢±\
   96 56 2A 3A 10 24 85 21 39 3C 9F 27 E4 FE 4F C9 F2  V*:.$Ö!9<ü'‰˛O…Ú
  112 79 B9 B3 4D 08 12 42 90 9C 9E 4F 93 F2 7F 27 E4  yπ≥M..BêúûOìÚ.'‰
  128 F9 3C DC D9 A6 B4 02 80 2D D8 0A A4 00 00 03 00  ˘<‹Ÿ¶¥.Ä-ÿ.§....
0 out of 71503073 bytes
ftyp - File Type
free - Free Space
    0 00 00 00 08 66 72 65 65                          ....free
0 out of 8 bytes
mdat - Media Data
    0 04 40 47 41 6D 64 61 74 00 00 00 75 67 64 00 2A  .@GAmdat...ugd.*
   16 AD 84 05 45 62 B8 AC 54 74 20 2A 2B 15 C5 62 A3  ≠Ñ.Eb∏¨Tt *+.≈b£
   32 A1 01 51 58 AE 2B 15 1D 08 0A 8A C5 71 58 A8 E8  °.QXÆ+....ä≈qX®Ë
   48 40 54 56 2B 8A C5 47 42 02 A2 B1 5C 56 2A 3A 10  @TV+ä≈GB.¢±\V*:.
   64 24 85 21 39 3C 9F 27 E4 FE 4F C9 F2 79 B9 B3 4D  $Ö!9<ü'‰˛O…Úyπ≥M
   80 08 12 42 90 9C 9E 4F 93 F2 7F 27 E4 F9 3C DC D9  ..BêúûOìÚ.'‰˘<‹Ÿ
   96 A6 B4 02 80 2D D8 0A A4 00 00 03 00 04 00 00 03  ¶¥.Ä-ÿ.§........
  112 00 F1 81 00 01 6E 34 00 06 6F F2 F7 BE 17 84 42  .ÒÅ..n4..oÚ˜æ.ÑB
  128 35 00 00 00 04 68 EE 3C 30 00 00 00 14 06 00 07  5....hÓ<0.......
0 out of 71321409 bytes
1 results
```

Figure 3: MP4 Movie Container 'ftyp', 'free', and 'mdat' Structures.

▪ **mdat** contains the following fields:

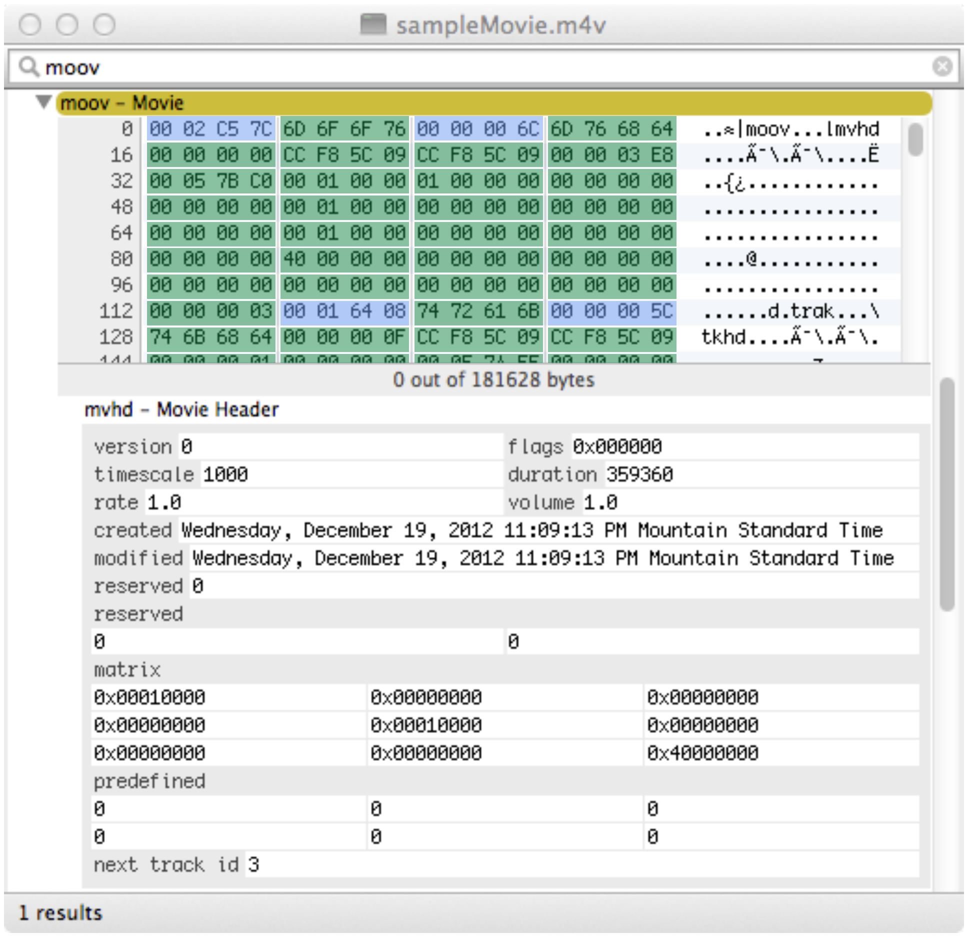
- Size—A 32-bit unsigned integer that specifies the number of bytes in this Media Data portion of the MP4 movie file; set here to '0x04404741'.

- Type—A 32-bit unsigned integer that identifies the type, represented as a four-character code; this field must be set to 'mdat'. Note: 'mdat' is technically not an atom rather it is the actual A/V Media Data that other atoms may reference via a byte offset into the data block.

Movie and Movie Header Atoms

Figure 4 shows the structure of the 'moov' and 'mvhd' atoms:

- **moov** contains the following fields:
  - Size—A 32-bit unsigned integer that specifies the number of bytes in this Movie atom; set here to '0x0002C57C'.
  - Type—A 32-bit unsigned integer that identifies the type, represented as a four-character code; this field must be set to 'moov'.



```
sampleMovie.m4v
moov
moov – Movie
  0  00 02 C5 7C 6D 6F 6F 76 00 00 00 6C 6D 76 68 64   ..≈|moov...lmvhd
 16  00 00 00 00 CC F8 5C 09 CC F8 5C 09 00 00 03 E8   ....Ã¯\.Ã¯\....Ë
 32  00 05 7B C0 00 01 00 00 01 00 00 00 00 00 00 00   ..{¿............
 48  00 00 00 00 00 01 00 00 00 00 00 00 00 00 00 00   ................
 64  00 00 00 00 00 01 00 00 00 00 00 00 00 00 00 00   ................
 80  00 00 00 00 40 00 00 00 00 00 00 00 00 00 00 00   ....@...........
 96  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
112  00 00 00 03 00 01 64 08 74 72 61 6B 00 00 00 5C   ......d.trak...\
128  74 6B 68 64 00 00 00 0F CC F8 5C 09 CC F8 5C 09   tkhd....Ã¯\.Ã¯\.
0 out of 181628 bytes
mvhd – Movie Header
version 0                          flags 0x000000
timescale 1000                     duration 359360
rate 1.0                           volume 1.0
created Wednesday, December 19, 2012 11:09:13 PM Mountain Standard Time
modified Wednesday, December 19, 2012 11:09:13 PM Mountain Standard Time
reserved 0
reserved
0                                  0
matrix
0x00010000          0x00000000          0x00000000
0x00000000          0x00010000          0x00000000
0x00000000          0x00000000          0x40000000
predefined
0                   0                   0
0                   0                   0
next track id 3
1 results
```

Figure 4: MP4 Movie Container 'moov' and 'mvhd' Structures.

- **mvhd** contains the following fields:
  - Size—A 32-bit unsigned integer that specifies the number of bytes in this Movie Header atom; set here to '0x0000006C'.
  - Type—A 32-bit unsigned integer that identifies the type, represented as a four-character code; this field must be set to 'mvhd'.
  - Version—A 1-byte specification of the version of this Movie Header atom; set here to '0x00'.
  - Flags—Three bytes of space for future movie header flags; set here to '0x000000'.
  - Creation Time—A 32-bit integer that specifies the calendar date and time (in seconds since

midnight, January 1, 1904) when the movie atom was created in coordinated universal time (UTC); set here to '0xCCF85C09'.

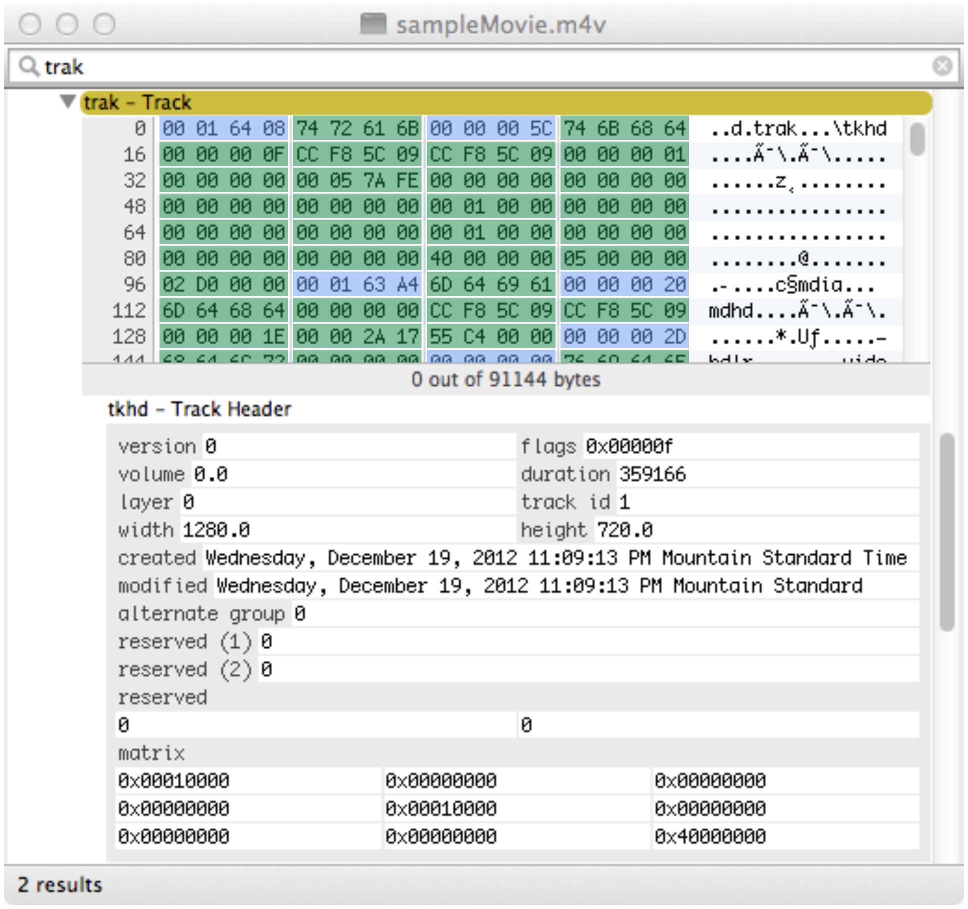
- Modification Time—A 32-bit integer that specifies the calendar date and time (in seconds since midnight, January 1, 1904) when the movie atom was created in coordinated universal time (UTC); set here to '0xCCF85C09'.
- Time Scale—A time value that indicates the time scale for this movie—that is, the number of time units that pass per second in its time coordinate system; set here to '0x000003E8'.
- Duration—A time value that indicates the duration of the movie in time scale units, derived from the movie's tracks, corresponding to the duration of the longest track in the movie; set here to '0x00057BC0'.
- Preferred Rate— A 32-bit fixed-point number that specifies the rate at which to play this movie (a value of 1.0 indicates normal rate); set here to '0x00010000'.
- Preferred Volume—A 16-bit fixed-point number that specifies how loud to play this movie's sound (a value of 1.0 indicates full volume); set here to '0x0100'.
- Reserved—Ten reserved bytes set to zero.
- Matrix—A transformation matrix that defines how to map points from one coordinate space into another coordinate space (please reference to the *QuickTime File Format Specification* for details).
- Predefines—Media Header predefines; set to zero (please refer to the *QuickTime File Format Specification* for details).
- Next Track ID—The number of the Next Track ID; set here to **'3'**.

Track and Track Header Atoms

Figure 5 shows the structure of the 'trak' and 'tkhd' atoms:

- **trak** contains the following fields:
  - Size—A 32-bit unsigned integer that specifies the number of bytes in this first Movie Track atom; set here to '0x00016408'.
  - Type—A 32-bit unsigned integer that identifies the type, represented as a four-character code; this field must be set to 'trak'.
- **tkhd** contains the following fields:
  - Size—A 32-bit unsigned integer that specifies the number of bytes in this first Movie Track Header atom; set here to '0x0000005C'.
  - Type—A 32-bit unsigned integer that identifies the type, represented as a four-character code; this field must be set to 'tkhd'.
  - Version—A 1-byte specification of the version of this first Movie Track Header atom; set here to **'0x00'**.
  - Flags—Three bytes specification of the version of this first Movie Track Header atom; set here to 0x00000F (please refer to the *QuickTime File Format Specification* for details).
  - Creation Time—A 32-bit integer that specifies the calendar date and time (in seconds since midnight, January 1, 1904) when the movie atom was created in coordinated universal time (UTC); set here to '0xCCF85C09'.
  - Modification Time—A 32-bit integer that specifies the calendar date and time (in seconds since midnight, January 1, 1904) when the movie atom was created in coordinated universal time (UTC); set here to '0xCCF85C09'.
  - Track ID—A 32-bit integer that uniquely identifies the track; the value 0 cannot be used.
  - Reserved—A 32-bit integer that is reserved; this field is set to '0x00000000'.
  - Duration—A time value that indicates the duration of this track (in the movie's time coordinate system). Note that this property is derived from the track's edits: the value of this field is equal to the sum of the durations of all of the track's edits and that if there is no edit list, the duration is the

sum of the sample durations, converted into the movie timescale; set here to '0x00057AFE'.



sampleMovie.m4v

trak

trak – Track

```
  0  00 01 64 08  74 72 61 6B  00 00 00 5C  74 6B 68 64   ..d.trak...\tkhd
 16  00 00 00 0F  CC F8 5C 09  CC F8 5C 09  00 00 00 01   ....Ã¯\.Ã¯\.....
 32  00 00 00 00  00 05 7A FE  00 00 00 00  00 00 00 00   ......z¸........
 48  00 00 00 00  00 00 00 00  00 01 00 00  00 00 00 00   ................
 64  00 00 00 00  00 00 00 00  00 01 00 00  00 00 00 00   ................
 80  00 00 00 00  00 00 00 00  40 00 00 00  05 00 00 00   ........@.......
 96  02 D0 00 00  00 01 63 A4  6D 64 69 61  00 00 00 20   .-....c§mdia...
112  6D 64 68 64  00 00 00 00  CC F8 5C 09  CC F8 5C 09   mdhd....Ã¯\.Ã¯\.
128  00 00 00 1E  00 00 2A 17  55 C4 00 00  00 00 00 2D   ......*.Uƒ.....-
```

0 out of 91144 bytes

tkhd – Track Header

version 0	flags 0x00000f
volume 0.0	duration 359166
layer 0	track id 1
width 1280.0	height 720.0
created Wednesday, December 19, 2012 11:09:13 PM Mountain Standard Time	
modified Wednesday, December 19, 2012 11:09:13 PM Mountain Standard	
alternate group 0	
reserved (1) 0	
reserved (2) 0	
reserved	
0	0

matrix

0x00010000	0x00000000	0x00000000
0x00000000	0x00010000	0x00000000
0x00000000	0x00000000	0x40000000

2 results

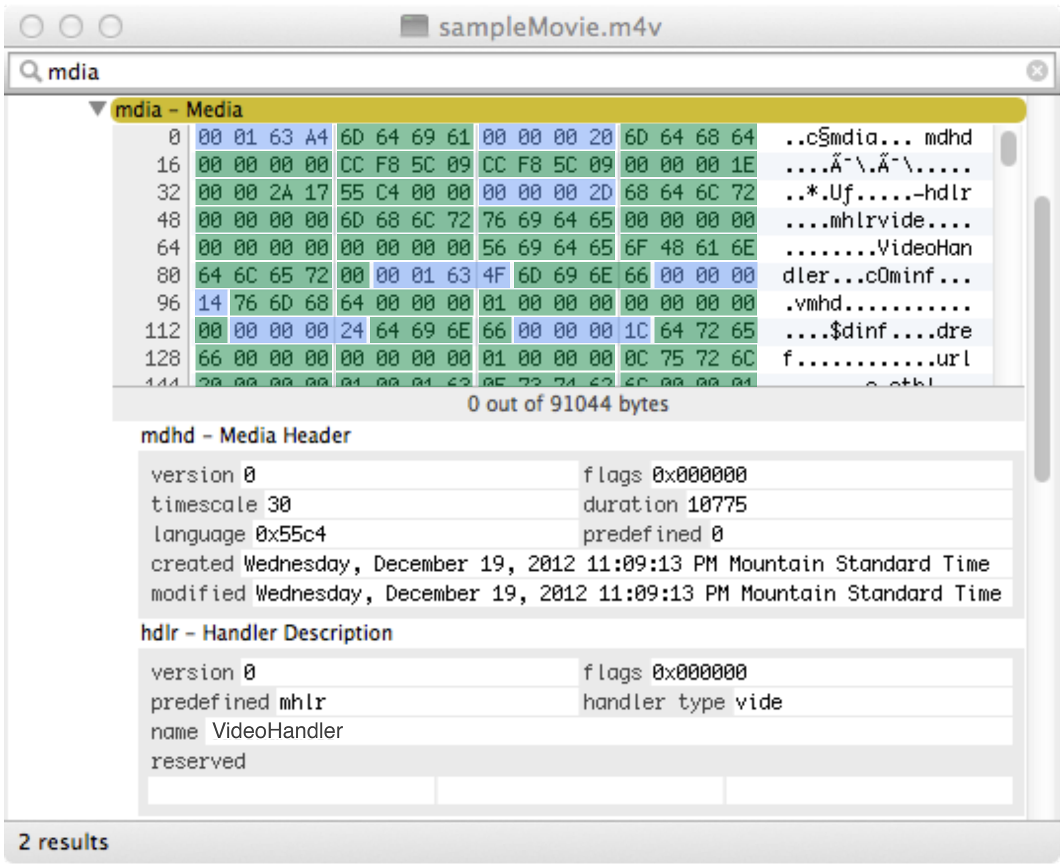
Figure 5: MP4 Movie Container 'trak' and 'tkhd' Structures.

- Reserved—An 8-byte value that is reserved; this field is set to 0.
- Layer—A 16-bit integer that indicates this track's spatial priority in its movie (the QuickTime Movie Toolbox uses this value to determine how tracks overlay one another). Tracks with lower layer values are displayed in front of tracks with higher layer values.
- Alternative Group— A 16-bit integer that specifies a collection of movie tracks that contain alternate data for one another; set here to **'0x0000'**.
- Volume—A 16-bit fixed-point value that indicates how loudly this track's audio is to be played; a value of 1.0 indicates normal volume.
- Reserved—A 16-bit integer that is reserved; this field is set to **'0x0000'**.
- Matrix Structure—The matrix structure associated with this track (please refer to the *QuickTime File Format Specification* for details).
- Track Width—A 32-bit fixed-point number that specifies the width of this track in pixels; set here to '0x05000000'.
- Track Height—A 32-bit fixed-point number that specifies the height of this track in pixels; set here to '0x02D00000'.

Movie Media, Movie Media Header, and Media Handler Reference Atoms

Figure 6 shows the structure of the 'mdia', 'mdhd', and 'hdlr' atoms:

- **mdia** contains the following fields:
  - Size—A 32-bit unsigned integer that specifies the number of bytes in this first Movie Media atom; set here to '0x000163A4'.
  - Type—A 32-bit unsigned integer that identifies the type, represented as a four-character code; this field must be set to 'mdia'.



sampleMovie.m4v

mdia

mdia - Media

```
  0  00 01 63 A4 6D 64 69 61 00 00 00 20 6D 64 68 64   ..c§mdia... mdhd
 16  00 00 00 00 CC F8 5C 09 CC F8 5C 09 00 00 00 1E   ....Ã¯\.Ã¯\.....
 32  00 00 2A 17 55 C4 00 00 00 00 00 2D 68 64 6C 72   ..*.Uf.....-hdlr
 48  00 00 00 00 6D 68 6C 72 76 69 64 65 00 00 00 00   ....mhlrvide....
 64  00 00 00 00 00 00 00 00 56 69 64 65 6F 48 61 6E   ........VideoHan
 80  64 6C 65 72 00 00 01 63 4F 6D 69 6E 66 00 00 00   dler...cOminf...
 96  14 76 6D 68 64 00 00 00 01 00 00 00 00 00 00 00   .vmhd...........
112  00 00 00 00 24 64 69 6E 66 00 00 00 1C 64 72 65   ....$dinf....dre
128  66 00 00 00 00 00 00 00 01 00 00 00 0C 75 72 6C   f...........url
```

0 out of 91044 bytes

mdhd - Media Header

version 0	flags 0x000000
timescale 30	duration 10775
language 0x55c4	predefined 0
created Wednesday, December 19, 2012 11:09:13 PM Mountain Standard Time	
modified Wednesday, December 19, 2012 11:09:13 PM Mountain Standard Time	

hdlr - Handler Description

version 0	flags 0x000000
predefined mhlr	handler type vide
name VideoHandler	
reserved	

2 results

Figure 6: MP4 Movie Container 'mdia', 'mdhd', and 'hdlr' Structures.

- **mdhd** contains the following fields:
  - Size—A 32-bit unsigned integer that specifies the number of bytes in this first Movie Media Header atom; set here to '0x00000020'.
  - Type—A 32-bit unsigned integer that identifies the type, represented as a four-character code; this field must be set to 'mdhd'.
  - Version—A 1-byte specification of the version of this first Movie Track Header atom; set here to **'**0x00**'**.
  - Flags—Three bytes specification of the version of this first Movie Media Header atom; set here to 0x000000 (please refer to the *QuickTime File Format Specification* for details).
  - Creation Time—A 32-bit integer that specifies the calendar date and time (in seconds since midnight, January 1, 1904) when the movie atom was created in coordinated universal time (UTC); set here to '0xCCF85C09'.
  - Modification Time—A 32-bit integer that specifies the calendar date and time (in seconds since

midnight, January 1, 1904) when the movie atom was created in coordinated universal time (UTC); set here to '0xCCF85C09'.

- Time Scale—A time value that indicates the time scale for this media—that is, the number of time units that pass per second in its time coordinate system; set here to '0x0000001E' which represents 30 fps.
- Duration—Duration of the media in Time Scale units; set here to '0x00002A17' which represents 10,775 frames (or 323,250 seconds).
- Language— A 16-bit integer that specifies the language code for this media; set here to '0x55C4'.
- Predefined—Set here to **'0x0000'**.

▪ **hdlr** contains the following fields:

- Size—A 32-bit unsigned integer that specifies the number of bytes in this first Movie Media Handler Reference atom; set here to '0x0000002D'.
- Type—A 32-bit unsigned integer that identifies the type, represented as a four-character code; this field must be set to 'hdlr'.
- Version—A 1-byte specification of the version of this first Movie Track Header atom; set here to **'0x00'**.
- Flags—Three bytes specification of the version of this first Movie Media Header atom; set here to **'0x000000'** (please refer to the *QuickTime File Format Specification* for details).
- Component Type—A four-character code that identifies the type of the handler (normally only two values are valid for this field: 'mhlr' for media handlers and 'dhlr' for data handlers); set here to **'0x6D686C72'**.
- Component Subtype—A four-character code that identifies the type of the media handler or data handler. For media handlers, this field defines the type of data—for example, **'vide'** for video data or **'soun'** for sound data.; set here to **'0x76696465'**.
- Component Name— A (counted) string that specifies the name of the component; set here to **'VideoHandler'**.

Media Information, Media Information Header, Media Data Information, and Media Data Reference Atoms

Figure 7 shows the structure of the 'minf', 'vmhd', 'dinf', and 'dref' atoms:

▪ **minf** contains the following fields:

- Size—A 32-bit unsigned integer that specifies the number of bytes in this Video Media Information atom; set here to '0x0001634F'.
- Type—A 32-bit unsigned integer that identifies the type, represented as a four-character code; this field must be set to 'minf'.

▪ **vmhd** contains the following fields:

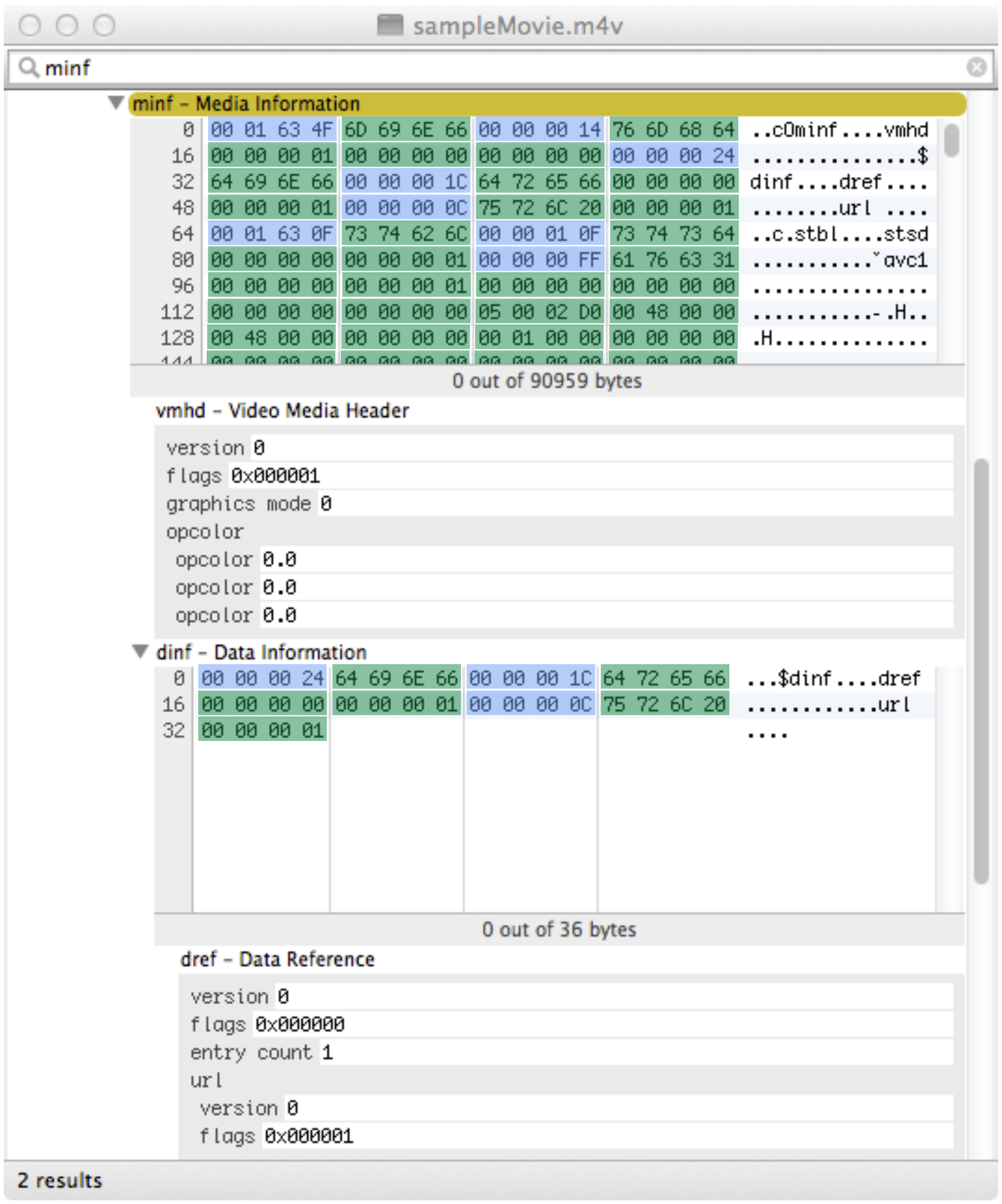
- Size—A 32-bit unsigned integer that specifies the number of bytes in this Video Media Information Header atom; set here to '0x00000014'.
- Type—A 32-bit unsigned integer that identifies the type, represented as a four-character code; this field must be set to 'vmhd'.
- Version—A 1-byte specification of the version of this Video Media Information Header; set here to '0x00'.
- Flags—A 3-byte space for video media information flags; set here to '0x000001'.
- Graphics Mode—A 16-bit integer that specifies the transfer mode; set here to '0x0000'.
- Opcolor—Three 16-bit values that specify the red, green, and blue colors for the transfer mode operation indicated in the graphics mode field; all set here to '0x0000'.

▪ **dinf** contains the following fields:

- Size—A 32-bit unsigned integer that specifies the number of bytes in this Video Media Data

Information atom; set here to '0x00000024'.
- Type—A 32-bit unsigned integer that identifies the type, represented as a four-character code; this field must be set to 'dinf'.

- **dref** contains the following fields:
  - Size—A 32-bit unsigned integer that specifies the number of bytes in this Media Data Reference atom; set here to '0x0000001C'.
  - Type—A 32-bit unsigned integer that identifies the type, represented as a four-character code; this field must be set to 'dref'.
  - Version—A 1-byte specification of the version of this Data Reference; set here to '0x00'.


sampleMovie.m4v

minf

minf – Media Information

```
  0  00 01 63 4F 6D 69 6E 66 00 00 00 14 76 6D 68 64  ..cOminf....vmhd
 16  00 00 00 01 00 00 00 00 00 00 00 00 00 00 00 24  ...............$
 32  64 69 6E 66 00 00 00 1C 64 72 65 66 00 00 00 00  dinf....dref....
 48  00 00 00 01 00 00 00 0C 75 72 6C 20 00 00 00 01  ........url ....
 64  00 01 63 0F 73 74 62 6C 00 00 01 0F 73 74 73 64  ..c.stbl....stsd
 80  00 00 00 00 00 00 00 01 00 00 00 FF 61 76 63 31  ...........˘avc1
 96  00 00 00 00 00 00 00 01 00 00 00 00 00 00 00 00  ................
112  00 00 00 00 00 00 00 00 05 00 02 D0 00 48 00 00  ..........-.H..
128  00 48 00 00 00 00 00 00 00 01 00 00 00 00 00 00  .H..............
```

0 out of 90959 bytes

vmhd – Video Media Header

```
version 0
flags 0x000001
graphics mode 0
opcolor
 opcolor 0.0
 opcolor 0.0
 opcolor 0.0
```

dinf – Data Information

```
  0  00 00 00 24 64 69 6E 66 00 00 00 1C 64 72 65 66  ...$dinf....dref
 16  00 00 00 00 00 00 00 01 00 00 00 0C 75 72 6C 20  ............url
 32  00 00 00 01                                      ....
```

0 out of 36 bytes

dref – Data Reference

```
version 0
flags 0x000000
entry count 1
url
 version 0
 flags 0x000001
```

2 results

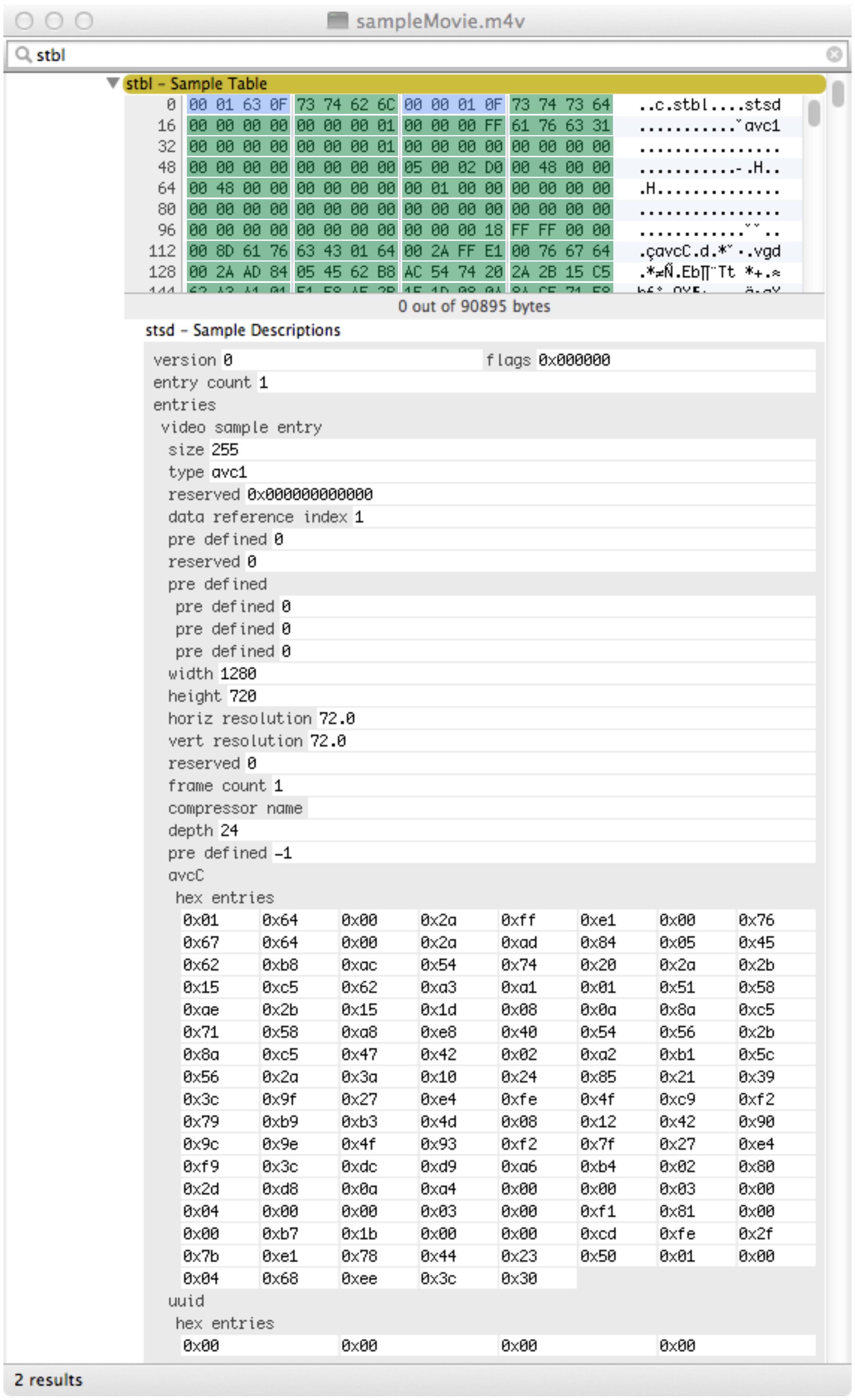
Figure 7: MP4 Movie Container 'minf', 'vmhd', 'dinf', and 'dref' Structures.

- Number of Entries—A 32-bit integer containing the count of data references that follow; set here to '0x000001'.
- Data References— An array of data references: Each data reference is formatted like an atom and contains the following data elements.
- **url** referenced data item:
- Size—A 32-bit unsigned integer that specifies the number of bytes in this Data atom; set here to '0x0000000C'.
- Type—A 32-bit unsigned integer that identifies the type, represented as a four-character code; this field is set to 'url '.
- Version—A 1-byte specification of the version of this Data atom; set here to '0x00'.
- Flags—A 3-byte space for Data flags; set here to '0x000001'.

Sample Table and Sample Description Atoms

Figure 8 shows the structure of the 'stbl' and 'stsd' atoms:

- **stbl** contains the following fields:
  - Size—A 32-bit unsigned integer that specifies the number of bytes in this Sample Table atom; set here to '0x0001630F'.
  - Type—A 32-bit unsigned integer that identifies the type, represented as a four-character code; this field must be set to 'stbl'.
- **stsd** contains the following fields:
  - Size—A 32-bit unsigned integer that specifies the number of bytes in this Sample Description atom; set here to '0x0000010F'.
  - Type—A 32-bit unsigned integer that identifies the type, represented as a four-character code; this field must be set to 'stsd'.
  - Version—A 1-byte specification of the version of this Sample Description; set here to '0x00'.
  - Flags—A 3-byte space for Data Reference flags; set here to '0x000000'.
  - Number of Entries—A 32-bit integer containing the count of data references that follow; set here to '0x000001'.
  - Sample Description Size—A 32-bit integer indicating the number of bytes in the sample description; set here to '0x0000FF'.
  - Data Format/Type— A 32-bit value indicating the format of the stored data: this depends on the media type, but is usually either the compression format or the media type; set here to 'avc1'.
  - Reserved—Six bytes that must be set to '0x00000000'.
  - Data Reference Index— A 16-bit integer that contains the index of the data reference to use to retrieve data associated with samples that use this sample description (data references are stored in data reference atoms); set here to '0x0001'.
  - Predefines—Values set here to 0.
  - Reserved—Values set here to 0.
  - Media Width—Video Width is 1280 pixels.
  - Media Height—Video Height is 720 pixels.
  - Horizontal Resolution—Horizontal Video Resolution is 72 pixels/inch.
  - Vertical Resolution—Vertical Video Resolution is 72 pixels/inch.
  - Reserved—Values set here to 0.
  - Frame Count— A 16-bit integer that indicates how many frames of compressed data are stored in each sample; set here to 1.



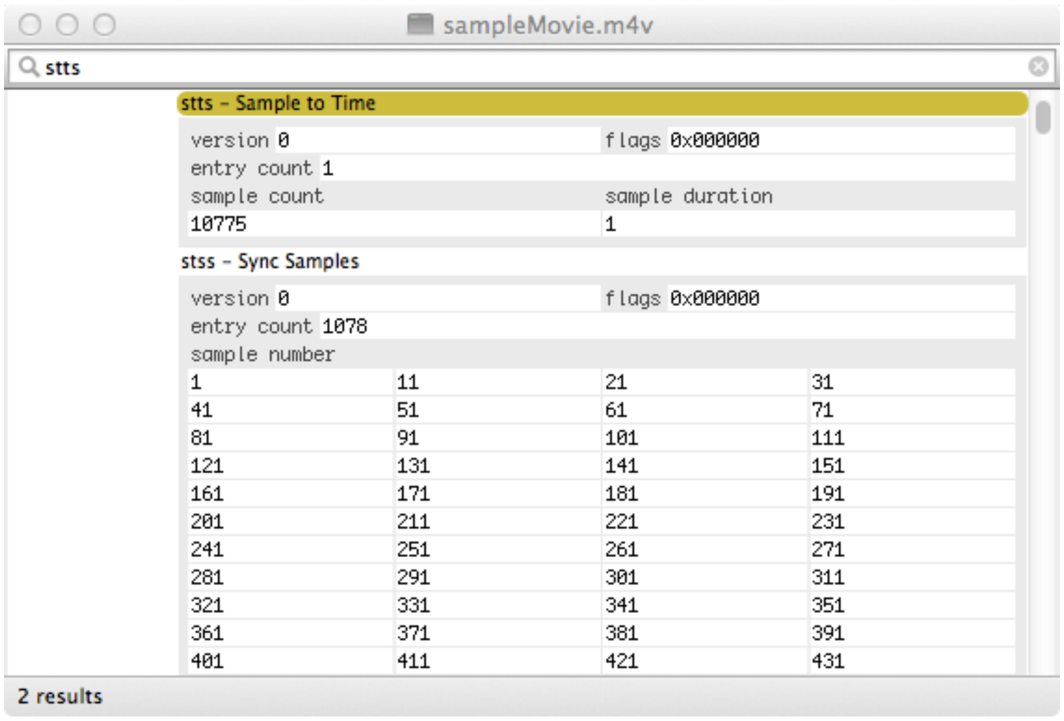
```
sampleMovie.m4v
stbl

▼ stbl – Sample Table
  0  00 01 63 0F  73 74 62 6C  00 00 01 0F  73 74 73 64   ..c.stbl....stsd
 16  00 00 00 00  00 00 00 01  00 00 00 FF  61 76 63 31   ...........˘avc1
 32  00 00 00 00  00 00 00 01  00 00 00 00  00 00 00 00   ................
 48  00 00 00 00  00 00 00 00  05 00 02 D0  00 48 00 00   ...........-.H..
 64  00 48 00 00  00 00 00 00  00 01 00 00  00 00 00 00   .H..............
 80  00 00 00 00  00 00 00 00  00 00 00 00  00 00 00 00   ................
 96  00 00 00 00  00 00 00 00  00 00 00 18  FF FF 00 00   ............˘˘..
112  00 8D 61 76  63 43 01 64  00 2A FF E1  00 76 67 64   .çavcC.d.*˘•.vgd
128  00 2A AD 84  05 45 62 B8  AC 54 74 20  2A 2B 15 C5   .*≠Ñ.Eb∏¨Tt *+.≈
                    0 out of 90895 bytes

stsd – Sample Descriptions
  version 0                               flags 0x000000
  entry count 1
  entries
   video sample entry
    size 255
    type avc1
    reserved 0x000000000000
    data reference index 1
    pre defined 0
    reserved 0
    pre defined
     pre defined 0
     pre defined 0
     pre defined 0
    width 1280
    height 720
    horiz resolution 72.0
    vert resolution 72.0
    reserved 0
    frame count 1
    compressor name
    depth 24
    pre defined -1
    avcC
     hex entries
      0x01   0x64   0x00   0x2a   0xff   0xe1   0x00   0x76
      0x67   0x64   0x00   0x2a   0xad   0x84   0x05   0x45
      0x62   0xb8   0xac   0x54   0x74   0x20   0x2a   0x2b
      0x15   0xc5   0x62   0xa3   0xa1   0x01   0x51   0x58
      0xae   0x2b   0x15   0x1d   0x08   0x0a   0x8a   0xc5
      0x71   0x58   0xa8   0xe8   0x40   0x54   0x56   0x2b
      0x8a   0xc5   0x47   0x42   0x02   0xa2   0xb1   0x5c
      0x56   0x2a   0x3a   0x10   0x24   0x85   0x21   0x39
      0x3c   0x9f   0x27   0xe4   0xfe   0x4f   0xc9   0xf2
      0x79   0xb9   0xb3   0x4d   0x08   0x12   0x42   0x90
      0x9c   0x9e   0x4f   0x93   0xf2   0x7f   0x27   0xe4
      0xf9   0x3c   0xdc   0xd9   0xa6   0xb4   0x02   0x80
      0x2d   0xd8   0x0a   0xa4   0x00   0x00   0x03   0x00
      0x04   0x00   0x00   0x03   0x00   0xf1   0x81   0x00
      0x00   0xb7   0x1b   0x00   0x00   0xcd   0xfe   0x2f
      0x7b   0xe1   0x78   0x44   0x23   0x50   0x01   0x00
      0x04   0x68   0xee   0x3c   0x30
    uuid
     hex entries
      0x00          0x00          0x00          0x00

2 results
```

Figure 8: MP4 Movie Container ‘stbl’ and ‘stsd’ Structures.

Sample-to-Time Table and Sync Sample Atoms

Figure 9 shows the structure of the 'stts' and 'stss' atoms:

- **stts** contains the following fields:
  - Size—A 32-bit unsigned integer that specifies the number of bytes in this Sample-to Time Table atom; set here to '0x00000018'.
  - Type—A 32-bit unsigned integer that identifies the type, represented as a four-character code; this field must be set to 'stts'.
  - Version—A 1-byte specification of the version of this Sample-to-Time Table; set here to '0x00'.
  - Flags—A 3-byte space for Sample-to-Time Table flags; set here to '0x000000'.
  - Number of Entries—A 32-bit integer containing the count of the Sample-to-Time Table entries that follow; set here to '1078'.
  - Sample Duration—A 32-bit integer that specifies the duration of each sample; set here to '1'.
  - Sample Count—A 32-bit integer that specifies the number of consecutive samples that have the same duration; set here to '10775'.



stts – Sample to Time

version 0	flags 0x000000
entry count 1	
sample count	sample duration
10775	1

stss – Sync Samples

version 0		flags 0x000000	
entry count 1078			
sample number			
1	11	21	31
41	51	61	71
81	91	101	111
121	131	141	151
161	171	181	191
201	211	221	231
241	251	261	271
281	291	301	311
321	331	341	351
361	371	381	391
401	411	421	431

Figure 9: MP4 Movie Container 'stts' and 'stss' Structures.

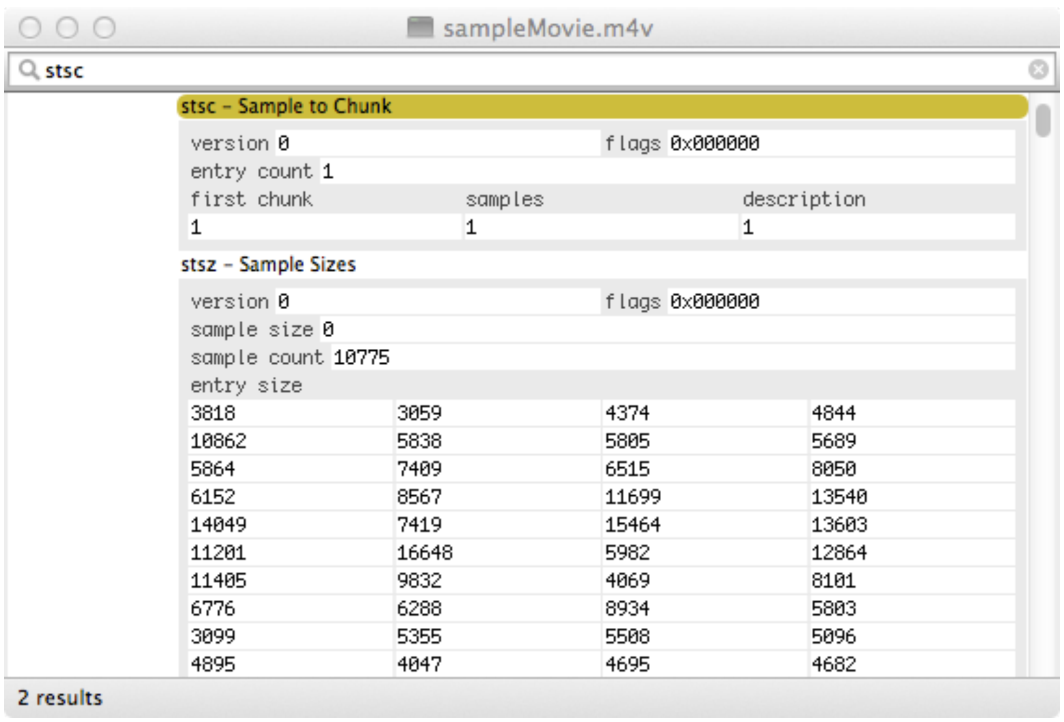
- **stss** contains the following fields:
  - Size—A 32-bit unsigned integer that specifies the number of bytes in this Sync Sample atom; set here to '0x00000018'.
  - Type—A 32-bit unsigned integer that identifies the type, represented as a four-character code; this field must be set to 'stts'.
  - Version—A 1-byte specification of the version of this Sync Sample atom; set here to '0x00'.
  - Flags—A 3-byte space for Sync Sample atom flags; set here to '0x000000'.
  - Number of Entries—A 32-bit integer containing the count of the Sync Sample Table entries that follow; set here to '1078'.

- Sample Duration—A 32-bit integer that specifies the duration of each sample; set here to '1'.

Sample-to-Chunk and Sample Sizes Atoms

Figure 10 shows the structure of the 'stsc' and 'stsz' atoms:

- **stsc** contains the following fields:
  - Size—A 32-bit unsigned integer that specifies the number of bytes in this Sample-to-Chuck atom; set here to '0x0000001C'.
  - Type—A 32-bit unsigned integer that identifies the type, represented as a four-character code; this field must be set to 'stsc'.
  - Version—A 1-byte specification of the version of this Sample-to-Chunk atom; set here to '0x00'.
  - Flags—A 3-byte space for Sample-to-Chunk atom flags; set here to '0x000000'.
  - Number of Entries—A 32-bit integer containing the count of the Time-to-Chunk Table entries that follow; set here to '1078'.
  - Sample-to-Chunk Table—The table that maps samples to chunks. Each sample-to-chunk atom contains such a table, which identifies the chunk for each sample in a media. Each entry in the table contains a first chunk field, a samples per chunk field, and a sample description ID field. From this information, you can ascertain where samples reside in the media data.



stsc – Sample to Chunk

version 0 flags 0x000000
entry count 1

first chunk	samples	description
1	1	1

stsz – Sample Sizes

version 0 flags 0x000000
sample size 0
sample count 10775
entry size

3818	3059	4374	4844
10862	5838	5805	5689
5864	7409	6515	8050
6152	8567	11699	13540
14049	7419	15464	13603
11201	16648	5982	12864
11405	9832	4069	8101
6776	6288	8934	5803
3099	5355	5508	5096
4895	4047	4695	4682

Figure 10: MP4 Movie Container 'stsc' and 'stsz' Structures.

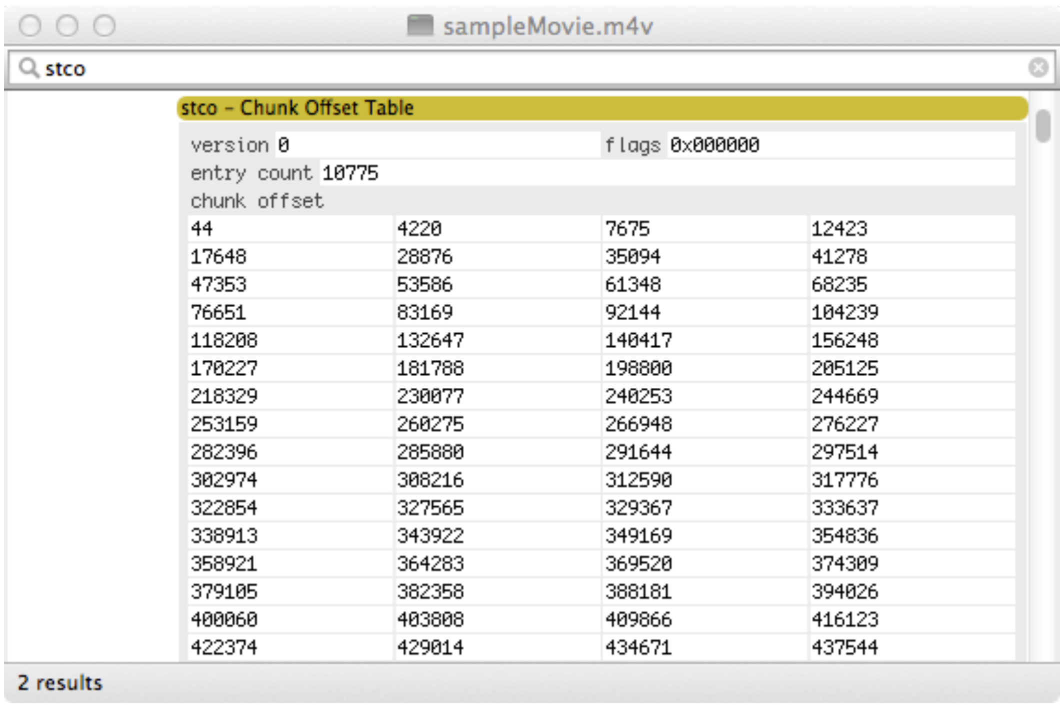
- **stsz** contains the following fields:
  - Size—A 32-bit unsigned integer that specifies the number of bytes in this Sample Size atom; set here to '0x0000A870'.
  - Type—A 32-bit unsigned integer that identifies the type, represented as a four-character code; this field must be set to 'stsz'.
  - Version—A 1-byte specification of the version of this Sample Sizes atom; set here to '0x00'.
  - Flags—A 3-byte space for Sample Sizes atom flags; set here to '0x000000'.

- Sample Size— A 32-bit integer specifying the sample size: if all the samples are the same size, this field contains that size value. If this field is set to 0, then the samples have different sizes, and those sizes are stored in the sample size table.
- Number of Entries—A 32-bit integer containing the count of the Time-to-Chunk Table entries that follow; set here to '10775'.
- Sample-to-Chunk Table—The table that maps samples to chunks. Each Sample-to-Chunk atom contains such a table, which identifies the chunk for each sample in a media. Each entry in the table contains a first chunk field, a samples per chunk field, and a sample description ID field. From this information, you can ascertain where samples reside in the media data.

Chunk Offset Atom

Figure 11 shows the structure of the 'stco' atom:

- **stco** contains the following fields:
  - Size—A 32-bit unsigned integer that specifies the number of bytes in this Sample Offset Table atom; set here to '0x0000A86C'.
  - Type—A 32-bit unsigned integer that identifies the type, represented as a four-character code; this field must be set to 'stsc'.
  - Version—A 1-byte specification of the version of this Sample Offset Table atom; set here to '0x00'.
  - Flags—A 3-byte space for Sample Offset Table atom flags; set here to '0x000000'.
  - Number of Entries—A 32-bit integer containing the count of the Sample Offset Table entries that follow; set here to '10775'.



stco – Chunk Offset Table

version 0 flags 0x000000

entry count 10775

chunk offset

44	4220	7675	12423
17648	28876	35094	41278
47353	53586	61348	68235
76651	83169	92144	104239
118208	132647	140417	156248
170227	181788	198800	205125
218329	230077	240253	244669
253159	260275	266948	276227
282396	285880	291644	297514
302974	308216	312590	317776
322854	327565	329367	333637
338913	343922	349169	354836
358921	364283	369520	374309
379105	382358	388181	394026
400060	403808	409866	416123
422374	429014	434671	437544

Figure 11: MP4 Movie Container 'stco' Structure.

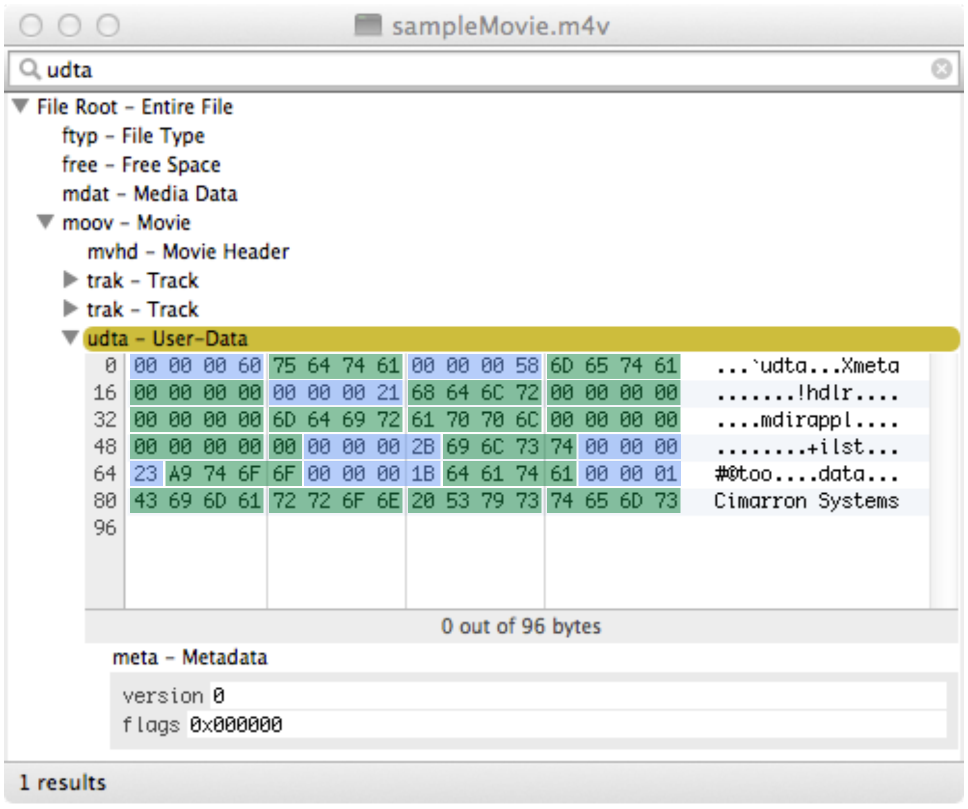
User Data Atom

Figure 12 shows the structure of the 'udta' atom:

- **udta** contains the following fields:
  - Size—A 32-bit unsigned integer that specifies the number of bytes in this User Data atom; set here

to '0x00000060'.

- Type—A 32-bit unsigned integer that identifies the type, represented as a four-character code; this field must be set to 'udta'.
- Version—A 1-byte specification of the version of this Sample Offset Table atom; set here to '0x00'.
- Flags—A 3-byte space for Sample Offset Table atom flags; set here to '0x000000'.
- User Data List—A user data list that is formatted as a series of atoms. Each data element in the user data list contains size and type information along with its data. For historical reasons, the data list is optionally terminated by a 32-bit integer set to 0. If you are writing a program to read user data atoms, you should allow for the terminating 0. However, if you are writing a program to create user data atoms, you can safely leave out the trailing 0.



```
▼ File Root - Entire File
    ftyp - File Type
    free - Free Space
    mdat - Media Data
  ▼ moov - Movie
      mvhd - Movie Header
    ▶ trak - Track
    ▶ trak - Track
    ▼ udta - User-Data
       0  00 00 00 60  75 64 74 61  00 00 00 58  6D 65 74 61   ...`udta...Xmeta
      16  00 00 00 00  00 00 00 21  68 64 6C 72  00 00 00 00   .......!hdlr....
      32  00 00 00 00  6D 64 69 72  61 70 70 6C  00 00 00 00   ....mdirappl....
      48  00 00 00 00  00 00 00 00  2B 69 6C 73  74 00 00 00   ........+ilst...
      64  23 A9 74 6F  6F 00 00 00  1B 64 61 74  61 00 00 01   #©too....data...
      80  43 69 6D 61  72 72 6F 6E  20 53 79 73  74 65 6D 73   Cimarron Systems
      96
                          0 out of 96 bytes
        meta - Metadata
          version 0
          flags 0x000000
```

Figure 12: MP4 Movie Container 'udta' Structure.

In this Application Note 101, we have presented an overview of the elements of a canonically constructed MP4 Movie Container encapsulate H.264 Video and AAC-LC Audio. Although we have not presented the MP4 atoms used to encapsulate the AAC-LC Audio, the hierarchy and structure of these atoms are very similar to the video atoms.

Additional Resources

In addition to those already described, listed below are a number of resources that may be helpful:

1. QuickTime File Format
2. M4V File Format
3. MPEG-4 Part 14

For more information regarding this and other Cimarron Systems products, please contact us using the contact information below.

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Revision History:

Date	Version	Notes
10/15/2012	version 1.0	Initial version
4/28/2014	version 2.0	Minor editorial updates