Universal Disk Format (UDF) specification – Part 6 (Revision 1.50)
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1. Introduction
The Universal Disk Format (UDF) specification defines a subset of the standard ECMA 167 2nd edition. The primary goal of the UDF is to maximize data interchange and minimize the cost and complexity of implementing ECMA 167.

To accomplish this task this document defines a Domain. A domain defines rules and restrictions on the use of ECMA 167. The domain defined in this specification is known as the “OSTA UDF Compliant” domain.

This document attempts to answer the following questions for the structures of ECMA 167 on a per operating system basis:

Given some ECMA 167 structure X, for each field in structure X answer the following questions for a given operating system:

1) When reading this field: If the operating system supports the data in this field then what should it map to in the operating system?

2) When reading this field: If the operating system supports the data in this field with certain limitations then how should the field be interpreted under this operating system?

3) When reading this field: If the operating system does NOT support the data in this field then how should the field be interpreted under this operating system?

4) When writing this field: If the operating system supports the data for this field then what should it map from in the operating system?

5) When writing this field: If the operating system does NOT support the data for this field then to what value should the field be set?

For some structures of ECMA 167 the answers to the above questions were self explanatory and therefore those structures are not included in this document.

In some cases additional information is provided for each structure to help clarify the standard.

This document should help make the task of implementing the ECMA 167 standard easier.
1.1 Document Layout
This document presents information on the treatment of structures defined under standard ECMA 167.
This document is separated into the following 4 basic sections:

- **Basic Restrictions and Requirements** - defines the restrictions and requirements which are operating system independent.
- **System Dependent Requirements** - defines the restrictions and requirements which are operating system dependent.
- **User Interface Requirements** - defines the restrictions and requirements which are related to the user interface.
- **Informative Annex** - Additional useful information.

This document presents information on the treatment of structures defined under standard ECMA 167. The following areas are covered:

- Interpretation of a structure/field upon reading from media.
- Contents of a structure/field upon writing to media. Unless specified otherwise writing refers only to creating a new structure on the media. When it applies to updating an existing structure on the media it will be specifically noted as such.

The fields of each structure are listed first, followed by a description of each field with respect to the categories listed above. In certain cases, one or more fields of a structure are not described if the semantics associated with the field are obvious.

A word on terminology: in common with ECMA 167, this document will use *shall* to indicate a mandatory action or requirement, *may* to indicate an optional action or requirement, and *should* to indicate a preferred but still optional, action or requirement.

Also, special comments associated with fields and/or structures are prefaced by the notification: "**NOTE:**"
1.2 Compliance
This document requires conformance to parts 1, 2, 3 and 4 of ECMA 167. Compliance to part 5 of ECMA 167 is not supported by this document. Part 5 may be supported in a later revision of this document.

NOTE: Due to the nature of CD media, Partitions may contain volume structures. This violates ECMA 167 (3/8.5). Efforts are under way to revise ECMA 167 to allow volume structures within write-once partitions.

For an implementation to claim compliance to this document the implementation shall meet all the requirements (indicated by the word *shall*) specified in this document.

The following are a few points of clarification in regards to compliance:

- *Multi-Volume support is optional.* An implementation can claim compliance and only support single volumes.
- *Multi-Partition support is optional.* An implementation can claim compliance without supporting the special multi-partition case on a single volume defined in this specification.
- *Media support.* An implementation can claim compliance and support a single media type or any combination. All implementations should be able to read any media that is physically accessable.
- *File Name Translation* - Any time an implementation has the need to transform a filename to meet operating system restrictions it shall use the algorithms specified in this document.
- *Extended Attributes* - All compliant implementations shall preserve existing extended attributes encountered on the media. Implementations shall create and maintain the extended attributes for the operating systems they support. For example, an implementation that supports Macintosh shall preserve any OS/2 extended attributes encountered on the media. An implementation that supports Macintosh shall also create and maintain all Macintosh extended attributes specified in this document.

The full definition of compliance to this document is defined in a separate OSTA document.

1.3 General References

1.3.1 References


*IEC 908:1987* Compact disc digital audio system

*ISO/IEC 10149:1993* Information technology - Data Interchange on read-only 120mm optical data discs (CD-ROM based on the Philips/Sony “Yellow Book”)

*Orange Book part-II* Recordable Compact Disc System Part-II, N.V. Philips and Sony Corporation
ISO/IEC 13346:1995
Volume and file structure of write-once and rewritable media using non-sequential recording for information interchange. This ISO/IEC standard is equivalent to ECMA 167 2nd edition.

ECMA 167
European Computer Manufactures Association (ECMA) standard number 167. Revision 2, and is available from https://www.ecma-international.org/. References enclosed in [ ] in this document are references to ECMA 167. The references are in the form [x/a.b.c], where x is the section number and a.b.c is the paragraph or figure number.

1.3.2 Definitions

Audio session
Audio session contains one or more audio tracks, and no data track.

Audio track
Audio tracks are tracks that are designated to contain audio sectors specified in the ISO/IEC 908.

CD-R
CD-Recordable. A write once CD defined in Orange Book, part-II.

CD-RW
CD-Rewritable. An overwritable CD defined in Orange Book, part-III.

Clean File System
The file system on the media conforms to this specification.

Data track
Data tracks are tracks that are designated to contain data sectors specified in the ISO/IEC 10149.

Dirty File System
A file system that is not a clean file system.

Fixed Packet
An incremental recording method in which all packets in a given track are of a length specified in the Track Descriptor Block. Addresses presented to a CD drive are translated according to the Method 2 addressing specified in Orange Book parts-II and -III.

ICB
A control node in ECMA 167.

Logical Block Address
An address relative to the beginning of a partition, as defined in ECMA 167.

Media Block Address
The address of a sector as it appears on the medium, before any mapping performed by the device.

Packet
A recordable unit, which is an integer number of sectors.

Packet Size
The number of user data sectors in a Packet.

Physical Address
An address used when accessing the medium, as it would appear at the interface to the device.

Random Access File System
A file system for randomly writable media, either write once or rewritable.

Sequential File System
A file system for sequentially written media (e.g. CD-R)

Session
The tracks of a volume shall be organized into one or more sessions as specified by the Orange Book part-II. A session shall be a sequence of one or more tracks, the track numbers of which form a contiguous ascending sequence.

Track
The sectors of a volume shall be organized into one or more tracks. A track shall be a sequence of sectors, the sector numbers of which form a contiguous ascending sequence. No sector shall belong to more than one track.
Note: There may be gaps between tracks; that is, the last sector of a track need not be adjacent to the first sector of the next track.

**UDF**
OSTA Universal Disk Format

**Variable Packet**
An incremental recording method in which each packet in a given track is of a host determined length. Addresses presented to a CD drive are as specified in Method 1 addressing in Orange Book parts II and III.

**VAT ICB**
A File Entry ICB that describes a file containing a Virtual Allocation Table.

**Virtual Address**
An address described by a Virtual Allocation Table entry.

**VAT**
The Virtual Allocation Table (VAT) provides a Logical Block Address for each Virtual Address. The Virtual Allocation Table is used with sequential write once media.

### 1.3.3 Terms

**May**
Indicates an action or feature that is optional.

**Optional**
Describes a feature that may or may not be implemented. If implemented, the feature shall be implemented as described.

**Shall**
Indicates an action or feature that is mandatory and must be implemented to claim compliance to this standard.

**Should**
Indicates an action or feature that is optional, but its implementation is strongly recommended.

**Reserved**
A reserved field is reserved for future use and shall be set to zero. A reserved value is reserved for future use and shall not be used.
2. Basic Restrictions & Requirements

The following table summarizes several of the basic restrictions and requirements defined in this specification. These restrictions & requirements as well as additional ones are described in detail in the following sections of this specification.

<table>
<thead>
<tr>
<th>Item</th>
<th>Restrictions &amp; Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logical Sector Size</td>
<td>The <em>Logical Sector Size</em> for a specific volume shall be the same as the physical sector size of the specific volume.</td>
</tr>
<tr>
<td>Logical Block Size</td>
<td>The <em>Logical Block Size</em> for a Logical Volume shall be set to the logical sector size of the volume or volume set on which the specific logical volume resides.</td>
</tr>
<tr>
<td>Volume Sets</td>
<td>All media within the same Volume Set shall have the same physical sector size. Rewritable/Overwritable media and WORM media shall not be mixed in/ be present in the same volume set.</td>
</tr>
<tr>
<td>First 32K of Volume Space</td>
<td>The first 32768 bytes of the Volume space shall not be used for the recording of ECMA 167 structures. This area shall not be referenced by the Unallocated Space Descriptor or any other ECMA 167 descriptor. This is intended for use by the native operating system.</td>
</tr>
<tr>
<td>Volume Recognition Sequence</td>
<td>The Volume Recognition Sequence as described in part 2 of ECMA 167 shall be recorded.</td>
</tr>
<tr>
<td>Timestamp</td>
<td>All timestamps shall be recorded in local time. Time zones shall be recorded on operating systems that support the concept of a time zone.</td>
</tr>
<tr>
<td>Entity Identifiers</td>
<td>Entity Identifiers shall be recorded in accordance with this document. Unless otherwise specified in this specification the Entity Identifiers shall contain a value that uniquely identifies the implementation.</td>
</tr>
<tr>
<td>Descriptor CRCs</td>
<td>CRCs shall be supported and calculated for all Descriptors, except for the Space Bitmap Descriptor.</td>
</tr>
<tr>
<td>File Name Length</td>
<td>Maximum of 255 bytes</td>
</tr>
<tr>
<td>Maximum Pathsize</td>
<td>Maximum of 1023 bytes</td>
</tr>
<tr>
<td>Extent Length</td>
<td>Maximum Extent Length shall be $2^{30} - \text{Logical Block Size}$</td>
</tr>
<tr>
<td>Primary Volume Descriptor</td>
<td>There shall be exactly one prevailing Primary Volume Descriptor recorded per volume.</td>
</tr>
<tr>
<td>Anchor Volume Descriptor Pointer</td>
<td>Shall be recorded in at least 2 of the following 3 locations: 256, N-256, or N, where N is the last addressable sector of a volume.</td>
</tr>
<tr>
<td>Partition Descriptor</td>
<td>A Partition Access Type of Read-Only, Rewritable, Overwritable and WORM shall be supported. There shall be exactly one prevailing Partition Descriptor recorded per volume, with one exception. For Volume Sets that consist of single volume, the volume may contain 2 Partitions with 2 prevailing Partition Descriptors only if one has an access type of read only and the other has an access type of Rewritable or Overwritable. The Logical Volume for this volume would consist of the contents of both partitions.</td>
</tr>
<tr>
<td>Descriptor Type</td>
<td>Description</td>
</tr>
<tr>
<td>---------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Logical Volume Descriptor</td>
<td>There shall be exactly one prevailing Logical Volume Descriptor recorded per Volume Set. The LogicalVolumeIdentifier field shall not be null and should contain an identifier that aids in the identification of the logical volume. Specifically, software generating volumes conforming to this specification shall not set this field to a fixed or trivial value. Duplicate disks which are intended to be identical may contain the same value in this field. This field is extremely important in logical volume identification when multiple media are present within a jukebox. This name is typically what is displayed to the user.</td>
</tr>
<tr>
<td>Logical Volume Integrity Descriptor</td>
<td>Shall be recorded.</td>
</tr>
<tr>
<td>Unallocated Space Descriptor</td>
<td>A single prevailing Unallocated Space Descriptor shall be recorded per volume.</td>
</tr>
<tr>
<td>File Set Descriptor</td>
<td>There shall be exactly one File Set Descriptor recorded per Logical Volume on Rewritable/Overwritable media. For WORM media multiple File Set Descriptors may be recorded based upon certain restrictions defined in this document.</td>
</tr>
<tr>
<td>ICB Tag</td>
<td>Only strategy types 4 or 4096 shall be recorded.</td>
</tr>
<tr>
<td>File Identifier Descriptor</td>
<td>The total length of a File Identifier Descriptor shall not exceed the size of one Logical Block.</td>
</tr>
<tr>
<td>File Entry</td>
<td>The total length of a File Entry shall not exceed the size of one Logical Block.</td>
</tr>
<tr>
<td>Allocation Descriptors</td>
<td>Only Short and Long Allocation Descriptors shall be recorded.</td>
</tr>
<tr>
<td>Allocation Extent Descriptors</td>
<td>The length of any single Allocation Extent Descriptor shall not exceed the Logical Block Size.</td>
</tr>
<tr>
<td>Unallocated Space Entry</td>
<td>The total length of an Unallocated Space Entry shall not exceed the size of one Logical Block.</td>
</tr>
<tr>
<td>Space Bitmap Descriptor</td>
<td>CRC not required.</td>
</tr>
<tr>
<td>Partition Integrity Entry</td>
<td>Shall not be recorded.</td>
</tr>
<tr>
<td>Volume Descriptor Sequence Extent</td>
<td>Both the main and reserve volume descriptor sequence extents shall each have a minimum length of 16 logical sectors.</td>
</tr>
<tr>
<td>Record Structure</td>
<td>Record structure files, as defined in part 5 of ECMA 167, shall not be created.</td>
</tr>
</tbody>
</table>
2.1 Part 1 - General

2.1.1 Character Sets

The character set used by UDF for the structures defined in this document is the CS0 character set. The OSTA CS0 character set is defined as follows:

OSTA CS0 shall consist of the d-characters specified in the Unicode 1.1 standard (excluding #FEFF and FFFE) stored in the **OSTA Compressed Unicode** format which is defined as follows:

<table>
<thead>
<tr>
<th>RBP</th>
<th>Length</th>
<th>Name</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>Compression ID</td>
<td>Uint8</td>
</tr>
<tr>
<td>1</td>
<td>??</td>
<td>Compressed Bit Stream</td>
<td>byte</td>
</tr>
</tbody>
</table>

The CompressionID shall identify the compression algorithm used to compress the CompressedBitStream field. The following algorithms are currently supported:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 7</td>
<td>Reserved</td>
</tr>
<tr>
<td>8</td>
<td>Value indicates there are 8 bits per character in the CompressedBitStream.</td>
</tr>
<tr>
<td>9-15</td>
<td>Reserved</td>
</tr>
<tr>
<td>16</td>
<td>Value indicates there are 16 bits per character in the CompressedBitStream.</td>
</tr>
<tr>
<td>17-255</td>
<td>Reserved</td>
</tr>
</tbody>
</table>

For a CompressionID of 8 or 16, the value of the CompressionID shall specify the number of BitsPerCharacter for the d-characters defined in the CharacterBitStream field. Each sequence of CompressionID bits in the CharacterBitStream field shall represent an OSTA Compressed Unicode d-character. The bits of the character being encoded shall be added to the CharacterBitStream from most- to least-significant-bit. The bits shall be added to the CharacterBitStream starting from the most-significant-bit of the current byte being encoded into.

**NOTE:** This encoding causes characters written with a CompressionID of 16 to be effectively written in big endian format.

The value of the **OSTA Compressed Unicode** d-character interpreted as a Uint16 defines the value of the corresponding d-character in the Unicode 1.1 standard. Refer to appendix on **OSTA Compressed Unicode** for sample C source code to convert between **OSTA Compressed Unicode** and standard Unicode 1.1.
The Unicode byte-order marks, #FEFF and #FFFE, shall not be used.

2.1.2 OSTA CS0 Charspec

```c
struct Charspec {
    Uint8 CharacterSetType;
    byte CharacterSetInfo[63];
}
```

The `CharacterSetType` field shall have the value of 0 to indicate the CS0 coded character set.

The `CharacterSetInfo` field shall contain the following byte values with the remainder of the field set to a value of 0.

```plaintext
#4F, #53, #54, #41, #20, #43, #6F, #6D, #70, #72, #65, #73, #73, #65,
#64, #20, #55, #6E, #69, #63, #6F, #64, #65
```

The above byte values represent the following ASCII string: “OSTA Compressed Unicode”

2.1.3 Dstrings

The ECMA 167 standard, as well as this document, has normally defined byte positions relative to 0. In section 7.2.12 of ECMA 167, dstrings are defined in terms of being relative to 1. Since this offers an opportunity for confusion, the following shows what the definition would be if described relative to 0.

7.2.12 Fixed-length character fields

A dstring of length n is a field of n bytes where d-characters (1/7.2) are recorded. The number of bytes used to record the characters shall be recorded as a Uint8 (1/7.1.1) in byte n-1, where n is the length of the field. The characters shall be recorded starting with the first byte of the field, and any remaining byte positions after the characters up until byte n-2 inclusive shall be set to #00.

If the number of d-characters to be encoded is zero, the length of the dstring shall be zero. NOTE: The length of a dstring includes the compression code byte(2.1.1) except for the case of a zero length string. A zero length string shall be recorded by setting the entire dstring field to all zeros.
2.1.4 Timestamp

```c
struct timestamp {
    /* ECMA 167 1/7.3 */
    Uint16 TypeAndTimezone;
    Uint16 Year;
    Uint8  Month;
    Uint8  Day;
    Uint8  Hour;
    Uint8  Minute;
    Uint8  Second;
    Uint8  Centiseconds;
    Uint8  HundredsofMicroseconds;
    Uint8  Microseconds;
}
```

2.1.4.1 Uint16 TypeAndTimezone;

For the following descriptions *Type* refers to the most significant 4 bits of this field, and *TimeZone* refers to the least significant 12 bits of this field.

🔗 The time within the structure shall be interpreted as Local Time since *Type* shall be equal to ONE for OSTA UDF compliant media.

🔗 *Type* shall be set to ONE to indicate Local Time.

🔗 Shall be interpreted as specifying the time zone for the location when this field was last modified. If this field contains -2047 then the time zone has not been specified.

🔗 For operating systems that support the concept of a time zone, the offset of the time zone (in 1 minute increments), from Coordinated Universal Time, shall be inserted in this field. Otherwise the time zone portion of this field shall be set to -2047.

Note: Time zones West of Coordinated Universal Time have negative offsets. For example, Eastern Standard Time is -300 minutes; Eastern Daylight Time is -240 minutes.

2.1.5 Entity Identifier

```c
struct EntityID { /* ECMA 167 1/7.4 */
    Uint8 Flags;
    char  Identifier[23];
    char  IdentifierSuffix[8];
}
```
UDF classifies *Entity Identifiers* into 3 separate types as follows:

- *Domain Entity Identifiers*
- *UDF Entity Identifiers*
- *Implementation Entity Identifiers*

The following sections describes the format and use of *Entity Identifiers* based upon the different types mentioned above.

### 2.1.5.1 Uint8 Flags

- Self explanatory.
- Shall be set to ZERO.

### 2.1.5.2 char Identifier

Unless stated otherwise in this document this field shall be set to an identifier that uniquely identifies the implementation. This methodology will allow for identification of the implementation responsible for creating structures recorded on media interchanged between different implementations.

If an implementation updates existing structures on the media written by other implementations the updating implementation shall set the *Identifier* field to a value that uniquely identifies the updating implementation.

The following table summarizes the *Entity Identifier* fields defined in the ECMA 167 standard and this document and shows to what values they shall be set.

<table>
<thead>
<tr>
<th>Descriptor</th>
<th>Field</th>
<th>ID Value</th>
<th>Suffix Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Volume Descriptor</td>
<td>Implementation ID</td>
<td>&quot;<em>Developer ID</em>&quot;</td>
<td>Implementation Identifier Suffix</td>
</tr>
<tr>
<td>Implementation Use Volume Descriptor</td>
<td>Implementation ID</td>
<td>&quot;<em>Developer ID</em>&quot;</td>
<td>Implementation Identifier Suffix</td>
</tr>
<tr>
<td>Implementation Use Volume Descriptor</td>
<td>Implementation ID</td>
<td>&quot;<em>UDF LV Info</em>&quot;</td>
<td>UDF Identifier Suffix</td>
</tr>
<tr>
<td>Partition Descriptor</td>
<td>Implementation ID</td>
<td>&quot;<em>Developer ID</em>&quot;</td>
<td>Implementation Identifier Suffix</td>
</tr>
<tr>
<td>Logical Volume Descriptor</td>
<td>Implementation ID</td>
<td>&quot;<em>Developer ID</em>&quot;</td>
<td>Implementation Identifier Suffix</td>
</tr>
<tr>
<td>Logical Volume Descriptor</td>
<td>Domain ID</td>
<td>&quot;OSTA UDF Compliant&quot;</td>
<td>DOMAIN Identifier Suffix</td>
</tr>
<tr>
<td>File Set Descriptor</td>
<td>Domain ID</td>
<td>&quot;OSTA UDF Compliant&quot;</td>
<td>DOMAIN Identifier Suffix</td>
</tr>
<tr>
<td>File Identifier Descriptor</td>
<td>Implementation ID</td>
<td>&quot;<em>Developer ID</em>&quot;</td>
<td>Implementation Identifier Suffix (optional)</td>
</tr>
</tbody>
</table>
NOTE: The value of the Entity Identifier field is interpreted as a sequence of bytes, and not as a dstring specified in CS0. For ease of use the values used by UDF for this field are specified in terms of ASCII character strings. The actual sequence of bytes used for the Entity Identifiers defined by UDF are specified in the appendix.

In the ID Value column in the above table "*Developer ID" refers to a Entity Identifier that uniquely identifies the current implementation. The value specified should be used when a new descriptor is created. Also, the value specified should be used for an existing descriptor when anything within the scope of the specified EntityID field is modified.

NOTE: The value chosen for a "*Developer ID" should contain enough information to identify the company and product name for an implementation. For example, a company called XYZ with a UDF product called DataOne might choose "*XYZ DataOne" as their developer ID. Also in the suffix of their developer ID they may choose to record the current version number of their DataOne product. This information is extremely helpful when trying to determine which implementation wrote a bad structure on a piece of media when multiple products from different companies have been recording on the media.

The Suffix Type column in the above table defines the format of the suffix to be used with the corresponding Entity Identifier. These different suffix types are defined in the following paragraphs.
NOTE: All Identifiers defined in this document (appendix 6.1) shall be registered by OSTA as UDF Identifiers.

2.1.5.3 IdentifierSuffix

The format of the IdentifierSuffix field is dependent on the type of the Identifier.

In regard to OSTA Domain Entity Identifiers specified in this document (appendix 6.1) the IdentifierSuffix field shall be constructed as follows:

<table>
<thead>
<tr>
<th>RBP</th>
<th>Length</th>
<th>Name</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2</td>
<td>UDF Revision</td>
<td>Uint16 (= #0150)</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>Domain Flags</td>
<td>Uint8</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>Reserved</td>
<td>bytes (= #00)</td>
</tr>
</tbody>
</table>

The UDFRevision field shall contain #0150 to indicate revision 1.50 of this document. This field will allow an implementation to detect changes made in newer revisions of this document. The OSTA Domain Identifiers are only used in the Logical Volume Descriptor and the File Set Descriptor. The DomainFlags field defines the following bit flags:

<table>
<thead>
<tr>
<th>Bit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Hard Write-Protect</td>
</tr>
<tr>
<td>1</td>
<td>Soft Write-Protect</td>
</tr>
<tr>
<td>2-7</td>
<td>Reserved</td>
</tr>
</tbody>
</table>

The SoftWriteProtect flag is a user settable flag that indicates that the volume or file system structures within the scope of the descriptor in which it resides are write protected. A SoftWriteProtect flag value of ONE shall indicate user write protected structures. This flag may be set or reset by the user. The HardWriteProtect flag is an implementation settable flag that indicates that the scope of the descriptor in which it resides is permanently write protected. A HardWriteProtect flag value of ONE shall indicate a permanently write protected structure. Once set this flag shall not be reset. The HardWriteProtect flag overrides the SoftWriteProtect flag. These flags are only used in the Logical Volume Descriptor and the File Set Descriptor. The flags in the Logical Volume descriptor have precedence over the flags in the File Set Descriptors.

Implementation use Entity Identifiers defined by UDF (appendix 6.1) the IdentifierSuffix field shall be constructed as follows:

<table>
<thead>
<tr>
<th>RBP</th>
<th>Length</th>
<th>Name</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2</td>
<td>UDF Revision</td>
<td>Uint16 (= #0150)</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>OS Class</td>
<td>Uint8</td>
</tr>
</tbody>
</table>
The contents of the OS Class and OS Identifier fields are described in the Appendix on Operating System Identifiers.

For implementation use Entity Identifiers not defined by UDF the IdentifierSuffix field shall be constructed as follows:

<table>
<thead>
<tr>
<th>RBP</th>
<th>Length</th>
<th>Name</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>OS Class</td>
<td>Uint8</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>OS Identifier</td>
<td>Uint8</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>Implementation Use Area</td>
<td>bytes</td>
</tr>
</tbody>
</table>

NOTE: It is important to understand the intended use and importance of the OS Class and OS Identifier fields. The main purpose of these fields is to aid in debugging when problems are found on a UDF volume. The fields also provide useful information which could be provided to the end user. When set correctly these two fields provide an implementation with information such as the following:

- Identify under which operating system a particular structure was last modified.
- Identify under which operating system a specific file or directory was last modified.
- If a developer supports multiple operating systems with their implementation, it helps to determine under which operating system a problem may have occurred.
2.2 Part 3 - Volume Structure

2.2.1 Descriptor Tag

```c
struct tag {
    /* ECMA 167 3/7.2 */
    Uint16 TagIdentifier;
    Uint16 DescriptorVersion;
    Uint8  TagChecksum;
    byte   Reserved;
    Uint16 TagSerialNumber;
    Uint16 DescriptorCRC;
    Uint16 DescriptorCRCLength;
    Uint32 TagLocation;
}
```

2.2.1.1 Uint16 TagSerialNumber

Ignored. Intended for disaster recovery.

Reset to a unique value at volume initialization.

The TagSerialNumber shall be set to a value that differs from ones previously recorded, upon volume re-initialization. It is suggested that: TagSerialNumber = ((TagSerialNumber of the Primary Volume Descriptor) + 1).

2.2.1.2 Uint16 DescriptorCRCLength

CRCs shall be supported and calculated for each descriptor. The value of this field shall be set to (Size of the Descriptor) - (Length of Descriptor Tag). When reading a descriptor the CRC should be validated.

2.2.2 Primary Volume Descriptor

```c
struct PrimaryVolumeDescriptor {
    /* ECMA 167 3/10.1 */
    struct tag DescriptorTag;
    Uint32 VolumeDescriptorSequenceNumber;
    Uint32 PrimaryVolumeDescriptorNumber;
    dstring VolumeIdentifier[32];
    Uint16 VolumeSequenceNumber;
    Uint16 MaximumVolumeSequenceNumber;
    Uint16 InterchangeLevel;
    Uint16 MaximumInterchangeLevel;
    Uint32 CharSetList;
    Uint32 MaximumCharacterSetList;
    dstring VolumeSetIdentifier[128];
    struct charspec DescriptorCharacterSet;
    struct charspec ExplanatoryCharacterSet;
    struct extent_ad VolumeAbstract;
    struct extent_ad VolumeCopyrightNotice;
    struct EntityID ApplicationIdentifier;
}
```
struct timestamp          RecordingDateandTime;
struct EntityID           ImplementationIdentifier;
byte                       ImplementationUse[64];
Uint32                    PredecessorVolumeDescriptorSequenceLocation;
Uint16                    Flags;
byte                       Reserved[22];

2.2.2.1 Uint16 InterchangeLevel

Interpreted as specifying the current interchange level (as specified in ECMA 167 3/11), of the contents of the associated volume and the restrictions implied by the specified level.

If this volume is part of a multi-volume Volume Set then the level shall be set to 3, otherwise the level shall be set to 2.

ECMA 167 requires an implementation to enforce the restrictions associated with the specified current Interchange Level. The implementation may change the value of this field as long as it does not exceed the value of the Maximum Interchange Level field.

2.2.2.2 Uint16 MaximumInterchangeLevel

Interpreted as specifying the maximum interchange level (as specified in ECMA 167 3/11), of the contents of the associated volume.

This field shall be set to level 3 (No Restrictions Apply), unless specifically given a different value by the user.

NOTE: This field is used to determine the intent of the originator of the volume. If this field has been set to 2 then the originator does not wish the volume to be included in a multi-volume set (interchange level 3). The receiver may override this field and set it to a 3 but the implementation should give the receiver a strict warning explaining the intent of the originator of the volume.

2.2.2.3 Uint32 CharacterSetList

Interpreted as specifying the character set(s) in use by any of the structures defined in Part 3 of ECMA 167 (3/10.1.9).

Shall be set to indicate support for CS0 only as defined in 2.1.2.
2.2.2.4 Uint32 MaximumCharacterSetList

Interpreted as specifying the maximum supported character sets (as specified in ECMA 167) which may be specified in the CharacterSetList field.

Shall be set to indicate support for CS0 only as defined in 2.1.2.

2.2.2.5 dstring VolumeSetIdentifier

Interpreted as specifying the identifier for the volume set.

The first 16 characters of this field should be set to a unique value. The remainder of the field may be set to any allowed value. Specifically, software generating volumes conforming to this specification shall not set this field to a fixed or trivial value. Duplicate disks which are intended to be identical may contain the same value in this field.

NOTE: The intended purpose of this is to guarantee Volume Sets with unique identifiers. The first 8 characters of the unique part should come from a CS0 hexadecimal representation of a 32-bit time value. The remaining 8 characters are free for implementation use.

2.2.2.6 struct charspec DescriptorCharacterSet

Interpreted as specifying the character sets allowed in the Volume Identifier and Volume Set Identifier fields.

Shall be set to indicate support for CS0 as defined in 2.1.2.

2.2.2.7 struct charspec ExplanatoryCharacterSet

Interpreted as specifying the character sets used to interpret the contents of the VolumeAbstract and VolumeCopyrightNotice extents.

Shall be set to indicate support for CS0 as defined in 2.1.2.

2.2.2.8 struct EntityID ImplementationIdentifier;

For more information on the proper handling of this field see section 2.1.5.
2.2.3 Anchor Volume Descriptor Pointer

```c
struct AnchorVolumeDescriptorPointer {
    /* ECMA 167 3/10.2 */
    struct tag DescriptorTag;
    struct extent_ad MainVolumeDescriptorSequenceExtent;
    struct extent_ad ReserveVolumeDescriptorSequenceExtent;
    byte Reserved[480];
};
```

**NOTE:** An `AnchorVolumeDescriptorPointer` structure shall be recorded in at least 2 of the following 3 locations on the media:

- Logical Sector 256.
- Logical Sector (N - 256).
- N

**NOTE:** Unclosed CD-R media may have an `Anchor Volume Descriptor Pointer` recorded at only sector 512. Upon close, CD-R media will conform to the rules above.

2.2.3.1 struct MainVolumeDescriptorSequenceExtent

The main `VolumeDescriptorSequenceExtent` shall have a minimum length of 16 logical sectors.

2.2.3.2 struct ReserveVolumeDescriptorSequenceExtent

The reserve `VolumeDescriptorSequenceExtent` shall have a minimum length of 16 logical sectors.

2.2.4 Logical Volume Descriptor

```c
struct LogicalVolumeDescriptor {
    /* ECMA 167 3/10.6 */
    struct tag DescriptorTag;
    Uint32 VolumeDescriptorSequenceNumber;
    struct DescriptorCharacterSet;
    dstring LogicalVolumeIdentifier[128];
    Uint32 LogicalBlockSize,
    struct DomainIdentifier;
    byte LogicalVolumeContentsUse[16];
    Uint32 MapTableLength;
    Uint32 NumberOfPartitionMaps;
    struct ImplementationIdentifier;
    byte ImplementationUse[128];
    extent_ad IntegritySequenceExtent,
    PartitionMaps[??];
    byte
};
```
2.2.4.1 struct charspec DescriptorCharacterSet

Interpreted as specifying the character set allowed in the LogicalVolumeIdentifier field.

 Shall be set to indicate support for CS0 as defined in 2.1.2.

2.2.4.2 Uint32 LogicalBlockSize

Interpreted as specifying the Logical Block Size for the logical volume identified by this LogicalVolumeDescriptor.

This field shall be set to the largest logical sector size encountered amongst all the partitions on media that constitute the logical volume identified by this LogicalVolumeDescriptor. Since UDF requires that all Volumes within a VolumeSet have the same logical sector size, the Logical Block Size will be the same as the logical sector size of the Volume.

2.2.4.3 struct EntityID DomainIdentifier

Interpreted as specifying a domain specifying rules on the use of, and restrictions on, certain fields in the descriptors. If this field is all zero then it is ignored, otherwise the Entity Identifier rules are followed. NOTE: If the field does not contain “*OSTA UDF Compliant” then an implementation may deny the user access to the logical volume.

This field shall indicate that the contents of this logical volume conforms to the domain defined in this document, therefore the DomainIdentifier shall be set to:

"*OSTA UDF Compliant"

As described in the section on Entity Identifier the IdentifierSuffix field of this EntityID shall contain the revision of this document for which the contents of the Logical Volume is compatible. For more information on the proper handling of this field see section 2.1.5.

NOTE: The IdentifierSuffix field of this EntityID contains SoftWriteProtect and HardWriteProtect flags. Refer to 2.1.4.3.

2.2.4.4 struct EntityID ImplementationIdentifier;

For more information on the proper handling of this field see the section on Entity Identifier.

2.2.4.5 struct extent_ad IntegritySequenceExtent

A value in this field is required for the Logical Volume Integrity Descriptor. For Rewriteable or Overwriteable media this shall be set to a minimum of 8K bytes.
**WARNING:** For WORM media this field should be set to an extent of some substantial length. Once the WORM volume on which the Logical Volume Integrity Descriptor resides is full a new volume must be added to the volume set since the Logical Volume Integrity Descriptor must reside on the same volume as the prevailing Logical Volume Descriptor.

### 2.2.4.6 byte PartitionMaps

For the purpose of interchange partition maps shall be limited to Partition Map type 1, except type 2 maps as described in this document (2.2.8 and 2.2.9).

### 2.2.5 Unallocated Space Descriptor

```
struct UnallocatedSpaceDesc {
    /* ECMA 167 3/10.8 */
    struct tag DescriptorTag;
    Uint32 VolumeDescriptorSequenceNumber
    Uint32 NumberOfAllocationDescriptors;
    extent_ad AllocationDescriptors[];
}
```

This descriptor shall be recorded, even if there is no free volume space.

### 2.2.6 Logical Volume Integrity Descriptor

```
struct LogicalVolumeIntegrityDesc { /* ECMA 167 3/10.10 */
    struct tag DescriptorTag,
    Timestamp RecordingDateAndTime,
    Uint32 IntegrityType,
    struct extend_ad NextIntegrityExtent,
    byte LogicalVolumeContentsUse[32],
    Uint32 NumberOfPartitions,
    Uint32 LengthOfImplementationUse,
    Uint32 FreeSpaceTable[]?,
    Uint32 SizeTable[]?,
    byte ImplementationUse[]?
}
```

The Logical Volume Integrity Descriptor is a structure that shall be written any time the contents of the associated Logical Volume is modified. Through the contents of the Logical Volume Integrity Descriptor an implementation can easily answer the following useful questions:

1) Are the contents of the Logical Volume in a consistent state?

2) When was the last date and time that anything within the Logical Volume was modified?
3) What is the total Logical Volume free space in logical blocks?

4) What is the total size of the Logical Volume in logical blocks?

5) What is the next available UniqueID for use within the Logical Volume?

6) Has some other implementation modified the contents of the logical volume since the last time that the original implementation which created the logical volume accessed it.

2.2.6.1 byte LogicalVolumeContentsUse
See the section on Logical Volume Header Descriptor for information on the contents of this field.

2.2.6.2 Uint32 FreeSpaceTable
Since most operating systems require that an implementation provide the true free space of a Logical Volume at mount time it is important that these values be maintained. The optional value of #FFFFFFFF, which indicates that the amount of available free space is not known, shall not be used.

NOTE: The FreeSpaceTable is guaranteed to be correct only when the Logical Volume Integrity Descriptor is closed.

2.2.6.3 Uint32 SizeTable
Since most operating systems require that an implementation provide the total size of a Logical Volume at mount time it is important that these values be maintained. The optional value of #FFFFFFFF, which indicates that the partition size is not known, shall not be used.

2.2.6.4 byte ImplementationUse
The ImplementationUse area for the Logical Volume Integrity Descriptor shall be structured as follows:

<table>
<thead>
<tr>
<th>RBP</th>
<th>Length</th>
<th>Name</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>32</td>
<td>ImplementationID</td>
<td>EntityID</td>
</tr>
<tr>
<td>32</td>
<td>4</td>
<td>Number of Files</td>
<td>Uint32</td>
</tr>
<tr>
<td>36</td>
<td>4</td>
<td>Number of Directories</td>
<td>Uint32</td>
</tr>
<tr>
<td>40</td>
<td>2</td>
<td>Minimum UDF Read Revision</td>
<td>Uint16</td>
</tr>
<tr>
<td>42</td>
<td>2</td>
<td>Minimum UDF Write Revision</td>
<td>Uint16</td>
</tr>
<tr>
<td>44</td>
<td>2</td>
<td>Maximum UDF Write Revision</td>
<td>Uint16</td>
</tr>
<tr>
<td>46</td>
<td>??</td>
<td>Implementation Use</td>
<td>byte</td>
</tr>
</tbody>
</table>

Implementation ID - The implementation identifier EntityID of the implementation which last modified anything within the scope of this
**EntityID.** The scope of this EntityID is the Logical Volume Descriptor, and the contents of the associated Logical Volume. This field allows an implementation to identify which implementation last modified the contents of a Logical Volume.

**Number of Files** - The current number of files in the associated Logical Volume. This information is needed by the Macintosh OS. All implementations shall maintain this information. NOTE: This value does not include Extended Attributes as part of the file count.

**Number of Directories** - The current number of directories in the associated Logical Volume. This information is needed by the Macintosh OS. All implementations shall maintain this information. NOTE: The root directory shall be included in the directory count.

**Minimum UDF Read Revision** - Shall indicate the minimum recommended revision of the UDF specification that an implementation is required to support to successfully be able to read all potential structures on the media. This number shall be stored in binary coded decimal format, for example #0150 would indicate revision 1.50 of the UDF specification.

**Minimum UDF Write Revision** - Shall indicate the minimum revision of the UDF specification that an implementation is required to support to successfully be able to modify all structures on the media. This number shall be stored in binary coded decimal format, for example #0150 would indicate revision 1.50 of the UDF specification.

**Maximum UDF Write Revision** - Shall indicate the maximum revision of the UDF specification that an implementation which has modified the media has supported. An implementation shall update this field only if it has modified the media and the level of the UDF specification it supports is higher than the current value of this field. This number shall be stored in binary coded decimal format, for example #0150 would indicate revision 1.50 of the UDF specification.

**Implementation Use** - Contains implementation specific information unique to the implementation identified by the Implementation ID.
2.2.7 Implementation Use Volume Descriptor

```c
struct ImpUseVolumeDescriptor {
    struct DescriptorTag;
    Uint32 VolumeDescriptorSequenceNumber;
    struct EntityID ImplementationIdentifier;
    byte ImplementationUse[460];
};
```

This section defines an UDF Implementation Use Volume Descriptor. This descriptor shall be recorded on every Volume of a Volume Set. The Volume may also contain additional Implementation Use Volume Descriptors which are implementation specific. The intended purpose of this descriptor is to aid in the identification of a Volume within a Volume Set that belongs to a specific Logical Volume.

**NOTE:** An implementation may still record an additional Implementation Use Volume Descriptor in its own format on the media. The UDF Implementation Use Volume Descriptor does not preclude an additional descriptor.

2.2.7.1 EntityID Implementation Identifier

This field shall specify “*UDF LV Info*”.

2.2.7.2 bytes Implementation Use

The implementation use area shall contain the following structure:

```c
struct LVInformation {
    struct LVICharset,
    dstring LogicalVolumeIdentifier[128],
    dstring LVInfo1[36],
    dstring LVInfo2[36],
    dstring LVInfo3[36],
    struct EntityID ImplementationID,
    bytes ImplementationUse[128];
};
```

2.2.7.2.1 charspec LVICharset

- Interpreted as specifying the character sets allowed in the LogicalVolumeIdentifier and LVInfo fields.
- Shall be set to indicate support for CS0 only as defined in 2.1.2.

2.2.7.2.2 dstring LogicalVolumeIdentifier

Identifies the Logical Volume referenced by this descriptor.
2.2.7.2.3 **dstring LVInfo1**
The fields LVInfo1, LVInfo2 and LVInfo3 should contain additional information to aid in the identification of the media. For example the LVInfo fields could contain information such as *Owner Name*, *Organization Name*, and *Contact Information*.

2.2.7.2.4 **struct EntityID ImplementationID**
Refer to the section on Entity Identifier.

2.2.7.2.5 **bytes ImplementationUse[128]**
This area may be used by the implementation to store any additional implementation specific information.
2.2.8 Virtual Partition Map
This is an extension of ECMA 167 to expand its scope to include sequentially written media (eg. CD-R). This extension is for a partition map entry to describe a virtual space.

The Logical Volume Descriptor contains a list of partitions that make up a given volume. As the virtual partition cannot be described in the same manner as a physical partition, a Type 2 partition map defined below shall be used.
If a Virtual Partition Map is recorded, then the Logical Volume Descriptor shall contain at least two partition maps. One partition map, shall be recorded as a Type 1 partition map. One partition map, shall be recorded as a Type 2 partition map. The format of this Type 2 partition map shall be as specified in the following table.

<table>
<thead>
<tr>
<th>RBP</th>
<th>Length</th>
<th>Name</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>Partition Map Type</td>
<td>Uint8 = 2</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>Partition Map Length</td>
<td>Uint8 = 64</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>Reserved</td>
<td>#00 bytes</td>
</tr>
<tr>
<td>4</td>
<td>32</td>
<td>Partition Type Identifier</td>
<td>EntityID</td>
</tr>
<tr>
<td>36</td>
<td>2</td>
<td>Volume Sequence Number</td>
<td>Uint16</td>
</tr>
<tr>
<td>38</td>
<td>2</td>
<td>Partition Number</td>
<td>Uint16</td>
</tr>
<tr>
<td>40</td>
<td>24</td>
<td>Reserved</td>
<td>#00 bytes</td>
</tr>
</tbody>
</table>

- Partition Type Identifier:
  - Flags = 0
  - Identifier = *UDF Virtual Partition
  - IdentifierSuffix is recorded as in section 2.1.5.3
- Volume Sequence Number = volume upon which the VAT and Partition is recorded
- Partition Number = an identification of a partition within the volume identified by the volume sequence number

2.2.9 Sparsable Partition Map
Certain disk/drive systems do not perform defect management (eg. CD-RW). To provide an apparent defect-free space for these systems, a partition of type 2 is used. The partition map defines the partition number, packet size (see section 1.3.2), and size and locations of the sparing tables. This type 2 map is intended to replace the type 1 map normally found on the media. This map identifies not only the partition number and the volume sequence number, but also identifies the packet length and the sparing tables. A Sparsable Partition Map shall not be recorded on disk/drive systems that perform defect management.
### Layout of Type 2 partition map for separable partition

<table>
<thead>
<tr>
<th>RBP</th>
<th>Length</th>
<th>Name</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>Partition Map Type</td>
<td>Uint8 = 2</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>Partition Map Length</td>
<td>Uint8 = 64</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>Reserved</td>
<td>#00 bytes</td>
</tr>
<tr>
<td>4</td>
<td>32</td>
<td>Partition Type Identifier</td>
<td>EntityID</td>
</tr>
<tr>
<td>36</td>
<td>2</td>
<td>Volume Sequence Number</td>
<td>Uint16</td>
</tr>
<tr>
<td>38</td>
<td>2</td>
<td>Partition Number</td>
<td>Uint16</td>
</tr>
<tr>
<td>40</td>
<td>2</td>
<td>Packet Length</td>
<td>Uint16 = 32</td>
</tr>
<tr>
<td>42</td>
<td>1</td>
<td>Number of Sparing Tables (=N_ST)</td>
<td>Uint8</td>
</tr>
<tr>
<td>43</td>
<td>1</td>
<td>Reserved</td>
<td>#00 byte</td>
</tr>
<tr>
<td>44</td>
<td>4</td>
<td>Size of each sparing table</td>
<td>Uint32</td>
</tr>
<tr>
<td>48</td>
<td>4 * N_ST</td>
<td>Locations of sparing tables</td>
<td>Uint32</td>
</tr>
<tr>
<td>48 + 4 * N_ST</td>
<td>16 - 4 * N_ST</td>
<td>Pad</td>
<td>#00 bytes</td>
</tr>
</tbody>
</table>

- **Partition Type Identifier:**
  - Flags = 0
  - Identifier = *UDF Sparable Partition
  - IdentifierSuffix is recorded as in section 2.1.5.3.
- **Partition Number** = the number of this partition. Shall identify a Partition Descriptor associated with this partition.
- **Packet Length** = the number of user data blocks per fixed packet. Shall be set to 32.
- **Number of Sparing Tables** = the number of redundant tables recorded. This shall be a value in the range of 1 to 4.
- **Size of each sparing table** = Length, in bytes, allocated for each sparing table.
- **Locations of sparing tables** = the start locations of each sparing table specified as a media block address. Implementations should align the start of each sparing table with the beginning of a packet. Implementations should record at least two sparing tables in physically distant locations.

### 2.2.10 Virtual Allocation Table

The Virtual Allocation Table (VAT) is used on sequentially written media (eg. CD-R) to give the appearance of randomly writable media to the system. The existence of this partition is identified in the partition maps. The VAT shall only be recorded on sequentially written media (eg. CD-R).

The VAT is a map that translates Virtual Addresses to logical addresses. It shall be recorded as a file identified by a File Entry ICB (VAT ICB) which allows great flexibility in building the table. The VAT ICB is the last sector recorded in any transaction. The VAT itself may be recorded at any location.

The VAT shall be identified by a File Entry ICB with a file type of 0. This ICB shall be the last valid data sector recorded. Error recovery schemes can find the last valid VAT by finding ICBs with file type 0 and examining the contents for the EntityID at the end of the table.
This file, when small, can be embedded in the ICB that describes it. If it is larger, it can be recorded in a sector or sectors preceding the ICB. The sectors do not have to be contiguous, which allows writing only new parts of the table if desired. This allows small incremental updates, even on disks with many directories. Each sector can hold entries that represent up to 512 directories.

When the VAT is small (a small number of directories on the disk), the VAT is updated by writing a new file ICB with the VAT embedded. When the VAT becomes too large to fit in the ICB, writing a single sector with the VAT and a second sector with the ICB is required. Beyond this point, more than one sector is required for the VAT. However, as multiple extents are supported, updating the VAT may consist of writing only the sector or sectors that need updating and writing the ICB with pointers to all of the pieces of the VAT.

The Virtual Allocation Table is used to redirect requests for certain information to the proper logical location. The indirection provided by this table provides the appearance of direct overwrite capability. For example, the sector describing the root directory could be referenced as virtual sector 1. A virtual sector is contained in a partition identified by a virtual partition map entry. Over the course of updating the disk, the root directory may change. When it changes, a new sector describing the root directory is written, and its Logical Block Address is recorded as the Logical Block Address corresponding to virtual sector 1. Nothing that references virtual sector 1 needs to change, as it still points to the most current virtual sector 1 that exists, even though it exists at a new Logical Block Address.

The use of virtual addressing allows any desired structure to become effectively rewritable. The structure is rewritable when every pointer that references it does so only by its Virtual Address. When a replacement structure is written, the virtual reference does not need to change. The proper entry in the VAT is changed to reflect the new Logical Block Address of the corresponding Virtual Address and all virtual references then point to the new structure. All structures that require updating, such as directory ICBs, shall be referenced by a Virtual Address. As each structure is updated, its corresponding entry in the VAT ICB shall be updated.

The VAT shall be recorded as a sequence of Uint32 entries in a file. Each entry shall be the offset, in sectors, into the physical partition in which the VAT is located. The first entry shall be for the virtual partition sector 0, the second entry for virtual partition sector 1, etc. The Uint32 entries shall be followed by an EntityID and a Uint32 entry indicating the location of the previous VAT ICB.

The entry for the previous VAT ICB allows for viewing the file system as it appeared in an earlier state. If this field is #FFFFFFFF, then no such ICB is specified.
An entry of #FFFFFFFF indicates that the virtual sector is currently unused. The LBA specified is located in the partition identified by the partition map. The number of entries in the table can be determined from the VAT file size in the ICB:

\[
\text{Number of entries (N)} = \frac{\text{FileSize} - 36}{4}
\]

The EntityID shall contain:

- Flags = 0
- Identifier = *UDF Virtual Alloc Tbl
- IdentifierSuffix is recorded as in UDF 2.1.5.3

### 2.2.11 Sparing Table

Certain disk/drive systems do not perform defect management (eg. CD-RW). To provide an apparent defect-free space for these systems. Certain media can only be written in groups of sectors (“packets”), further complicating relocation: a whole packet must be relocated rather than only the sectors being written. To address this issue a sparable partition is identified in the partition map, which further identifies the location of the sparing tables. The sparing table identifies relocated areas on the media. Sparing tables are identified by a sparable partition map. Sparing tables shall not be recorded on disk/drive systems that perform defect management.

Sparing Tables point to space allocated for sparing and contains a list of mappings of defective sectors to their replacements. Separate copies of the sparing tables shall be recorded in separate packets. All instances of the sparing table shall be kept up to date.

Partitions map logical space to physical space. Normally, this is a linear mapping where an offset and a length is specified. A sparable partition is based on this mapping, where the offset and length of a partition within physical space is specified by a partition descriptor. The sparing table further specifies an exception list of logical to physical
mappings. All mappings are one packet in length. The packet size is specified in the sparable partition map.

Available sparing areas may be anywhere on the media, either inside or outside of a partition. If located inside a partition, sparable space shall be marked as allocated and shall be included in the Non-Allocatable Space List. The mapped locations should be filled in at format time; the original locations are assigned dynamically as errors occur. Each sparing table shall be structured as shown below.

<table>
<thead>
<tr>
<th>BP</th>
<th>Length</th>
<th>Name</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>16</td>
<td>Descriptor Tag</td>
<td>tag = 0</td>
</tr>
<tr>
<td>16</td>
<td>32</td>
<td>Sparing Identifier</td>
<td>EntityID</td>
</tr>
<tr>
<td>48</td>
<td>2</td>
<td>Reallocation Table Length (=RT_L)</td>
<td>Uint16</td>
</tr>
<tr>
<td>50</td>
<td>2</td>
<td>Reserved</td>
<td>#00 bytes</td>
</tr>
<tr>
<td>52</td>
<td>4</td>
<td>Sequence Number</td>
<td>Uint32</td>
</tr>
<tr>
<td>56</td>
<td>8*RT_L</td>
<td>Map Entry</td>
<td>Map Entries</td>
</tr>
</tbody>
</table>

This structure may be larger than a single sector if necessary.

- **Descriptor Tag**
  
  Contains 0, indicating that the contents are not specified by ECMA 167.

- **Sparing Identifier**
  
  - Flags = 0
  
  - Identifier = "UDF Sparing Table"
  
  - IdentifierSuffix is recorded as in UDF 2.1.5.3

- **Reallocation Table Length**
  
  Indicates the number of entries in the Map Entry table.

- **Sequence Number**
  
  Contains a number that shall be incremented each time the sparing table is updated.

- **Map Entry**
  
  A map entry is described in the table below. Maps shall be sorted in ascending order by the Original Location field.

<table>
<thead>
<tr>
<th>RBP</th>
<th>Length</th>
<th>Name</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>4</td>
<td>Original Location</td>
<td>Uint32</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>Mapped Location</td>
<td>Uint32</td>
</tr>
</tbody>
</table>

- **Original Location**
  
  Logical Block Address of the packet to be spared. The address of a packet is the address of the first user data block of a packet. If this field is #FFFFFFFF, then this entry is available for sparing. If this field is #FFFFFFFF0, then the corresponding mapped location is marked as
defective and should not be used for mapping. Original Locations of #FFFFFFF1 through #FFFFFFFE are reserved.

- Mapped Location
  Physical Block Address of active data. Requests to the original packet location are redirected to the packet location identified here. All Mapped Location entries shall be valid, including those entries for which the Original Location is #FFFFFFF0, #FFFFFFF, or reserved. If the mapped location overlaps a partition, that partition shall have that space marked as allocated and that space shall be part of the Non-Allocatable Space list.
2.3 Part 4 - File System

2.3.1 Descriptor Tag

```
struct tag {
    /* ECMA 167 4/7.2 */
    Uint16 TagIdentifier;
    Uint16 DescriptorVersion;
    Uint8  TagChecksum;
    byte   Reserved;
    Uint16 TagSerialNumber;
    Uint16 DescriptorCRC;
    Uint16 DescriptorCRCLength;
    Uint32 TagLocation;
}
```

2.3.1.1 Uint16 TagSerialNumber

Ignored.

Reset to a unique value at volume initialization.

The `TagSerialNumber` shall be set to a value that differs from ones previously recorded, upon volume re-initialization. The intended use of this field is for disaster recovery. The `TagSerialNumber` for all descriptors in Part 4 should be the same as the serial number used in the associated File Set Descriptor.

2.3.1.2 Uint16 DescriptorCRCLength

CRCs shall be supported and calculated for each descriptor, unless otherwise noted. The value of this field shall be set to: (Size of the Descriptor) - (Length of Descriptor Tag). When reading a descriptor the CRC should be validated.

2.3.2 File Set Descriptor

```
struct FileSetDescriptor {
    /* ECMA 167 4/14.1 */
    struct tag DescriptorTag;
    struct timestamp RecordingDateandTime;
    Uint16 InterchangeLevel;
    Uint16 MaximumInterchangeLevel;
    Uint32 CharSetList;
    Uint32 MaximumCharacterSetList;
    Uint32 FileSetNumber;
    Uint32 FileSetDescriptorNumber;
    struct charspec LogicalVolumeIdentifierCharacterSet;
    dstring LogicalVolumeIdentifier[128];
    struct charspec FileSetCharacterSet;
    dstring FileSetIdentifier[32];
    dstring CopyrightFileIdentifier[32];
    dstring AbstractFileIdentifier[32];
```
struct long_ad RootDirectoryICB;
struct EntityID DomainIdentifier;
struct long_ad NextExtent;
byte Reserved[48];
}

Only one FileSet descriptor shall be recorded. On WORM media, multiple FileSets may be recorded.

The UDF provision for multiple File Sets is as follows:

- Multiple FileSets are only allowed on WORM media.
- The default FileSet shall be the one with the highest FileSetNumber.
- Only the default FileSet may be flagged as writable. All other FileSets in the sequence shall be flagged HardWriteProtect (see EntityID definition).
- No writable FileSet shall reference any metadata structures which are referenced (directly or indirectly) by any other FileSet.Writable FileSets may, however, reference the actual file data extents.

Within a FileSet on WORM, if all files and directories have been recorded with ICB strategy type 4, then the DomainID of the corresponding FileSet Descriptor shall be marked as HardWriteProtected.

The intended purpose of multiple FileSets on WORM is to support the ability to have multiple archive images on the media. For example one FileSet could represent a backup of a certain set of information made at a specific point in time. The next FileSet could represent another backup of the same set of information made at a later point in time.

### 2.3.2.1 Uint16 InterchangeLevel

Interpreted as specifying the current interchange level (as specified in ECMA 167 4/15), of the contents of the associated file set and the restrictions implied by the specified level.

Shall be set to a level of 3.

An implementation shall enforce the restrictions associated with the specified current Interchange Level.
2.3.2.2 **Uint16 MaximumInterchangeLevel**

Interpreted as specifying the maximum interchange level of the contents of the associated file set. This value restricts to what the current Interchange Level field may be set.

Shall be set to level 3.

2.3.2.3 **Uint32 CharacterSetList**

Interpreted as specifying the character set(s) specified by any field, whose contents are specified to be a charspec, of any descriptor specified in Part 4 of ECMA 167 and recorded in the file set described by this descriptor.

Shall be set to indicate support for CS0 only as defined in 2.1.2.

2.3.2.4 **Uint32 MaximumCharacterSetList**

Interpreted as specifying the maximum supported character set in the associated file set and the restrictions implied by the specified level.

Shall be set to indicate support for CS0 only as defined in 2.1.2.

2.3.2.5 **struct charspec LogicalVolumeIdentifierCharacterSet**

Interpreted as specifying the d-characters allowed in the Logical Volume Identifier field.

Shall be set to indicate support for CS0 as defined in 2.1.2.

2.3.2.6 **struct charspec FileSetCharacterSet**

Interpreted as specifying the d-characters allowed in dstring fields defined in Part 4 of ECMA 167 that are within the scope of the FileSetDescriptor.

Shall be set to indicate support for CS0 as defined in 2.1.2.

2.3.2.7 **struct EntityID DomainIdentifier**

Interpreted as specifying a domain specifying rules on the use of, and restrictions on, certain fields in the descriptors. If this field is NULL then it is ignored, otherwise the Entity Identifier rules are followed.

This field shall indicate that the scope of this File Set Descriptor conforms to the domain defined in this document, therefore the ImplementationIdentifier shall be set to:

"*OSTA UDF Compliant*"
As described in the section on *Entity Identifier* the *IdentifierSuffix* field of this *EntityID* shall contain the revision of this document for which the contents of the Logical Volume is compatible. For more information on the proper handling of this field see the section on *Entity Identifier*.

**NOTE:** The *IdentifierSuffix* field of this EntityID contains *SoftWriteProtect* and *HardWriteProtect* flags.

### 2.3.3 Partition Header Descriptor

```c
struct PartitionHeaderDescriptor { /* ECMA 167 4/14.3 */
    struct short_ad UnallocatedSpaceTable;
    struct short_ad UnallocatedSpaceBitmap;
    struct short_ad PartitionIntegrityTable;
    struct short_ad FreedSpaceTable;
    struct short_ad FreedSpaceBitmap;
    byte Reserved[88];
}
```

As a point of clarification the logical blocks represented as *Unallocated* are blocks that are ready to be written without any preprocessing. In the case of Rewritable media this would be a write without an erase pass. The logical blocks represented as *Freed* are blocks that are not ready to be written, and require some form of preprocessing. In the case of Rewritable media this would be a write with an erase pass.

**NOTE:** The use of Space Tables or Space Bitmaps shall be consistent across a Logical Volume. Space Tables and Space Bitmaps shall not both be used at the same time within a Logical Volume.

#### 2.3.3.1 struct short_ad PartitionIntegrityTable

Shall be set to all zeros since PartitionIntegrityEntries are not used.
2.3.4 File Identifier Descriptor

```c
struct FileIdentifierDescriptor { /* ECMA 167 4/14.4 */
    struct tag     DescriptorTag;
    Uint16          FileVersionNumber;
    Uint8           FileCharacteristics;
    Uint8           LengthOfFileIdentifier;
    struct long_ad ICB;
    Uint16          LengthOfImplementationUse;
    byte            ImplementationUse[??];
    char            FileIdentifier[??];
    byte            Padding[??];
};
```

The `File Identifier Descriptor` shall be restricted to the length of one Logical Block.

2.3.4.1 Uint16 FileVersionNumber

- There shall be only one version of a file as specified below with the value being set to 1.
- Shall be set to 1.

2.3.4.2 Uint16 Lengthof ImplementationUse

- Shall specify the length of the `ImplementationUse` field.
- Shall specify the length of the `ImplementationUse` field. This field may be ZERO, indicating that the `ImplementationUse` field has not been used.

2.3.4.3 byte ImplementationUse

- If the `LengthofImplementationUse` field is non ZERO then the first 32 bytes of this field shall be interpreted as specifying the implementation identifier `EntityID` of the implementation which last modified the `File Identifier Descriptor`.
- If the `LengthofImplementationUse` field is non ZERO then the first 32 bytes of this field shall be set to the implementation identifier `EntityID` of the current implementation.

**NOTE:** For additional information on the proper handling of this field refer to the section on `Entity Identifier`.

This field allows an implementation to identify which implementation last created and/or modified a specific `File Identifier Descriptor`.

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2.3.5 ICB Tag

```c
struct icbtag { /* ECMA 167 4/14.6 */
    Uint32 PriorRecordedNumberOfDirectEntries;
    Uint16 StrategyType;
    byte StrategyParameter[2];
    Uint16 NumberOfEntries;
    byte Reserved;
    Uint8 FileType;
    Lb_addr ParentICBLocation;
    Uint16 Flags;
}
```

2.3.5.1 Uint16 StrategyType

The contents of this field specifies the ICB strategy type used. For the purposes of read access an implementation shall support strategy types 4 and 4096.

Shall be set to 4 or 4096.

**NOTE**: Strategy type 4096, which is defined in the appendix, is intended for primary use on WORM media, but may also be used on rewritable and overwritable media.

2.3.5.2 Uint8 FileType

As a point of clarification a value of 5 shall be used for a standard byte addressable file, *not* 0.

2.3.5.3 ParentICBLocation

The use of this field by is optional.

**NOTE**: In ECMA 167-4/14.6.7 it states that “If this field contains 0, then no such ICB is specified.” This is a flaw in the ISO standard in that an implementation could store an ICB at logical block address 0. Therefore, if you decide to use this field, do not store an ICB at logical block address 0.

2.3.5.4 Uint16 Flags

**Bits 0-2**: These bits specify the type of allocation descriptors used. Refer to the section on *Allocation Descriptors* for the guidelines on choosing which type of allocation descriptor to use.
Bit 3 (Sorted):
☞ For OSTA UDF compliant media this bit shall indicate (ZERO) that directories may be unsorted.
☞ Shall be set to ZERO.

Bit 4 (Non-relocatable):
☞ For OSTA UDF compliant media this bit may indicate (ONE) that the file is non-relocatable. An implementation may reset this bit to ZERO to indicate that the file is relocatable if the implementation can not assure that the file will not be relocated.
☞ Should be set to ZERO.

Bit 9 (Contiguous):
☞ For OSTA UDF compliant media this bit may indicate (ONE) that the file is contiguous. An implementation may reset this bit to ZERO to indicate that the file may be non-contiguous if the implementation can not assure that the file is contiguous.
☞ Should be set to ZERO.

Bit 11 (Transformed):
☞ For OSTA UDF compliant media this bit shall indicate (ZERO) that no transformation has taken place.
☞ Shall be set to ZERO.

The methods used for data compression and other forms of data transformation might be addressed in a future OSTA document.

Bit 12 (Multi-versions):
☞ For OSTA UDF compliant media this bit shall indicate (ZERO) that multi-versioned files are not present.
☞ Shall be set to ZERO.
2.3.6 File Entry

```c
struct FileEntry {
    /* ECMA 167 4/14.9 */
    struct tag DescriptorTag;
    struct icbtag ICBTag;
    Uint32 Uid;
    Uint32 Gid;
    Uint32 Permissions;
    Uint16 FileLinkCount;
    Uint8 RecordFormat;
    Uint8 RecordDisplayAttributes;
    Uint32 RecordLength;
    Uint64 InformationLength;
    Uint64 LogicalBlocksRecorded;
    struct timestamp AccessTime;
    struct timestamp ModificationTime;
    struct timestamp AttributeTime;
    Uint32 Checkpoint;
    struct long_ad ExtendedAttributeICB;
    struct EntityID ImplementationIdentifier;
    Uint64 UniqueID;
    Uint32 LengthofExtendedAttributes;
    Uint32 LengthofAllocationDescriptors;
    byte ExtendedAttributes[??];
    byte AllocationDescriptors[??];
}
```

**NOTE:** The total length of a `FileEntry` shall not exceed the size of one logical block.

### 2.3.6.1 Uint8 RecordFormat;

For OSTA UDF compliant media this bit shall indicate (ZERO) that the structure of the information recorded in the file is not specified by this field.

_pembia Will be set to ZERO._

### 2.3.6.2 Uint8 RecordDisplayAttributes;

For OSTA UDF compliant media this bit shall indicate (ZERO) that the structure of the information recorded in the file is not specified by this field.

_pembia Will be set to ZERO._
2.3.6.3 **Uint8 RecordLength**;

- For OSTA UDF compliant media this bit shall indicate (ZERO) that the structure of the information recorded in the file is not specified by this field.
- Shall be set to ZERO.

2.3.6.4 **struct EntityID ImplementationIdentifier**;

Refer to the section on *Entity Identifier*.

2.3.6.5 **Uint64 UniqueID**

For the *root* directory of a file set this value shall be set to ZERO.

It is required that this value be maintained and unique for every file and directory in the LogicalVolume. This includes FileEntry descriptors defined for Extended Attribute spaces. The FileEntry for the Extended Attribute space shall contain the same *UniqueID* as the file to which it is attached.

**NOTE:** The *UniqueID* values 1-15 shall be reserved for the use of Macintosh implementations.

2.3.7 **Unallocated Space Entry**

```c
struct UnallocatedSpaceEntry {
    struct tag DescriptorTag;
    struct icbtag ICBTag;
    Uint32 LengthofAllocationDescriptors;
    byte AllocationDescriptors[??];
}
```

**NOTE:** The maximum length of an UnallocatedSpaceEntry shall be one Logical Block.

2.3.7.1 **byte AllocationDescriptors**

Only Short Allocation Descriptors shall be used.

**NOTE:** The upper 2 bits of the extent length field in allocation descriptors specify an extent type (ECMA 167 4/14.14.1.1). For the allocation descriptors specified for the UnallocatedSpaceEntry the type shall be set to a value of 1 to indicate *extent allocated but not recorded*, or shall be set to a value of 3 to indicate the *extent is the next extent of allocation descriptors*. This next extent of allocation descriptors shall be limited to the length of one Logical Block.

*AllocationDescriptors* shall be ordered sequentially in ascending location order. No overlapping *AllocationDescriptors* shall exist in the table. For example,
ad.location = 2, ad.length = 2048 (logical block size = 1024) then
nextad.location = 3 is not allowed. Adjacent AllocationDescriptors shall not be contiguous. For example ad.location = 2, ad.length = 1024 (logical block size = 1024), nextad.location = 3 is not allowed and would instead be a single AllocationDescriptor, ad.location = 2, ad.length = 2048. The only case where adjacent AllocationDescriptors may be contiguous is when the ad.length of one of the adjacent AllocationDescriptors is equal to the maximum AllocationDescriptors length.

2.3.8 Space Bitmap Descriptor
struct SpaceBitmap {}
  struct Tag
    DescriptorTag;
    Uint32 NumberOfBits;
    Uint32 NumberOfBytes;
    byte Bitmap[??];

2.3.8.1 struct Tag DescriptorTag
The calculation and maintenance of the DescriptorCRC field of the Descriptor Tag for the SpaceBitmap descriptor is optional. If the CRC is not maintained then both the DescriptorCRC and DescriptorCRCLength fields shall be ZERO.

2.3.9 Partition Integrity Entry
struct PartitionIntegrityEntry {}
  struct tag
    DescriptorTag;
  struct icbtag
    ICBTag;
  struct timestamp
    RecordingTime;
  Uint8 IntegrityType;
  byte Reserved[175];
  struct EntityID
    ImplementationIdentifier;
  byte ImplementationUse[256];

With the functionality of the Logical Volume Integrity Descriptor this descriptor is not needed, therefore this descriptor shall not be recorded.

2.3.10 Allocation Descriptors
When constructing the data area of a file an implementation has several types of allocation descriptors from which to choose. The following guidelines shall be followed in choosing the proper allocation descriptor to be used:
Short Allocation Descriptor - For a Logical Volume that resides on a single Volume with no intent to expand the Logical Volume beyond the single volume Short Allocation Descriptors should be used. For example a Logical Volume created for a stand alone drive.

NOTE: Refer to section 2.2.2.2 on the MaximumInterchangeLevel.

Long Allocation Descriptor - For a Logical Volume that resides on a single Logical Volume with intent to later expand the Logical Volume beyond the single volume, or a Logical Volume that resides on multiple Volumes Long Allocation Descriptors should be used. For example a Logical Volume created for a jukebox.

NOTE: There is a benefit of using Long Allocation Descriptors even on a single volume, which is the support of tracking erased extents on rewritable media. See section 2.3.10.1 for additional information.

For both Short and Long Allocation Descriptors, if the 30 least significant bits of the ExtentLength field is 0, then the 2 most significant bits shall be 0.

2.3.10.1 Long Allocation Descriptor

struct long_ad { /* ECMA 167 4/14.14.2 */
    Uint32 ExtentLength;
    Lb_addr ExtentLocation;
    byte ImplementationUse[6];
}

To allow use of the ImplementationUse field by UDF and also by implementations the following structure shall be recorded within the 6 byte Implementation Use field.

struct ADImpUse
{
    Uint16 flags;
    byte impUse[4];
}

/* ADImpUse Flags (NOTE: bits 1-15 reserved for future use by UDF)
 */
#define EXTENTErased (0x01)

In the interests of efficiency on Rewritable media that benefits from preprocessing, the EXTENTErased flag shall be set to ONE to indicate an erased extent. This applies only to extents of type not recorded but allocated.

2.3.11 Allocation Extent Descriptor

struct AllocationExtentDescriptor { /* ECMA 167 4/14.5 */
struct tag  DescriptorTag;
Uint32  PreviousAllocationExtentLocation;
Uint32  LengthOfAllocationDescriptors;
}

**NOTE:** *AllocationDescriptor* extents shall be a maximum of one logical block in length.

### 2.3.11.1 Uint12 PreviousAllocationExtentLocation

☑️ The previous allocation extent location shall not be used as specified below.

☑️ Shall be set to 0.

### 2.3.12 Pathname

#### 2.3.12.1 Path Component

```
struct PathComponent {
    /* ECMA 167 4/14.16.1 */
    Uint8  ComponentType;
    Uint8  LengthofComponentIdentifier;
    Uint16 ComponentFileVersionNumber;
    char   ComponentIdentifier[ ];
}
```

#### 2.3.12.1.1 Uint16 ComponentFileVersionNumber

☑️ There shall be only one version of a file as specified below with the value being set to ZERO.

☑️ Shall be set to ZERO.

### 2.3.13 Non-Allocatable Space List

ECMA 167 does not provide for a mechanism to describe defective areas on media or areas not usable due to allocation outside of the file system. The *Non-Allocatable Space List* provides a method to describe space not usable by the file system. The *Non-Allocatable Space List* shall be recorded only on media systems that do not do defect management (eg. CD-RW).

The *Non-Allocatable Space List* shall be generated at format time. All space indicated by the *Non-Allocatable Space List* shall also be marked as allocated in the free space map. The *Non-Allocatable Space List* shall be recorded as a file of the root directory. The file name “Non-Allocatable Space” (#4E, #6F, #6E, #2D, #41, #6C, #6C,#6F,#61,#74,#61,#62,#6C,#65, #20, #70, #61, #63, #65) shall be used. The file shall
be marked with the attributes Hidden (bit 0 of file characteristics set to ONE) and System (bit 10 of ICB flags field set to ONE). The name may be recorded in any legal word size. The information length of this file shall be zero. This file shall have all Non-Allocatable sectors identified by its allocation extents. The allocation extents shall indicate that each extent is allocated but not recorded. This list shall include both defective sectors found at format time and space allocated for sparing at format time.

2.4 Part 5 - Record Structure

*Record structure* files shall not be created. If they are encountered on the media and they are not supported by the implementation they shall be treated as an uninterpreted stream of bytes.
3. System Dependent Requirements

3.1 Part 1 - General

3.1.1 Timestamp

```c
struct timestamp { /* ECMA 167 1/7.3 */
    Uint16    TypeAndTimezone;
    Uint16    Year;
    Uint8     Month;
    Uint8     Day;
    Uint8     Hour;
    Uint8     Minute;
    Uint8     Second;
    Uint8     Centiseconds;
    Uint8     HundredsofMicroseconds;
    Uint8     Microseconds;
}
```

3.1.1.1 Uint8 Centiseconds;

For operating systems that do not support the concept of centiseconds the implementation shall ignore this field.

For operating systems that do not support the concept of centiseconds the implementation shall set this field to ZERO.

3.1.1.2 Uint8 HundredsofMicroseconds;

For operating systems that do not support the concept of hundreds of Microseconds the implementation shall ignore this field.

For operating systems that do not support the concept of a hundreds of Microseconds the implementation shall set this field to ZERO.

3.1.1.3 Uint8 Microseconds;

For operating systems that do not support the concept of microseconds the implementation shall ignore this field.

For operating systems that do not support the concept of microseconds the implementation shall set this field to ZERO.
3.2 Part 3 - Volume Structure

3.2.1 Logical Volume Header Descriptor

```c
struct LogicalVolumeHeaderDesc {
  /* ECMA 167 4/14.15 */
  Uint64 UniqueID,
  bytes reserved[24]
}
```

3.2.1.1 Uint64 UniqueID

This field contains the next *UniqueID* value which should be used.

**NOTE:** For compatibility with Macintosh systems implementations should keep this value less than the maximum value of a Int32 ($2^{31} - 1$).
3.3 Part 4 - File System

3.3.1 File Identifier Descriptor

```c
struct FileIdentifierDescriptor { /* ECMA 167 4/14.4 */
    struct tag     DescriptorTag;
    Uint16         FileVersionNumber;
    Uint8          FileCharacteristics;
    Uint8          LengthOfFileIdentifier;
    struct long_ad ICB;
    Uint16         LengthOfImplementationUse;
    byte           ImplementationUse[??];
    char           FileIdentifier[??];
    byte           Padding[??];
};
```

NOTE: All UDF directories shall include a File Identifier Descriptor that indicates the location of the parent directory. The File Identifier Descriptor describing the parent directory shall be the first File Identifier Descriptor recorded in the directory. The parent directory of the Root directory shall be Root, as stated in ECMA 167-4, section 8.6

### 3.3.1.1 Uint8 FileCharacteristics

The following sections describe the usage of the *FileCharacteristics* under various operating systems.

#### 3.3.1.1.1 MS-DOS, OS/2, Windows 95, Windows NT, Macintosh

- If Bit 0 is set to ONE, the file shall be considered a "hidden" file.
- If Bit 1 is set to ONE, the file shall be considered a "directory."
- If Bit 2 is set to ONE, the file shall be considered "deleted."
- If Bit 3 is set to ONE, the ICB field within the associated *FileIdentifier* structure shall be considered as identifying the "parent" directory of the directory that this descriptor is recorded in

#### 3.3.1.1.2 UNIX

Under UNIX these bits shall be processed the same as specified in 3.3.1.1.1., except for hidden files which will be processed as normal non-hidden files.
3.3.2 ICB Tag

```c
struct icbtag { /* ECMA 167 4/14.6 */
    Uint32 PriorRecordedNumberofDirectEntries;
    Uint16 StrategyType;
    byte StrategyParameter[2];
    Uint16 NumberofEntries;
    byte Reserved;
    Uint8 FileType;
    Lb_addr ParentICBLocation;
    Uint16 Flags;
}
```

3.3.2.1 Uint16 Flags

3.3.2.1.1 MS-DOS, OS/2, Windows 95, Windows NT

**Bits 6 & 7 (Setuid & Setgid):**

- Ignored.

- In the interests of maintaining security under environments which do support these bits; bits 6 and 7 shall be set to ZERO if any one of the following conditions are true:
  - A file is created.
  - The attributes/permissions associated with a file, are modified.
  - A file is written to (the contents of the data associated with a file are modified).

**Bit 8 (Sticky):**

- Ignored.

- Shall be set to ZERO.

**Bit 10 (System):**

- Mapped to the MS-DOS / OS/2 system bit.

- Mapped from the MS-DOS / OS/2 system bit.
3.3.2.1.2 Macintosh

Bits 6 & 7 (Setuid & Setgid):

Ignored.

In the interests of maintaining security under environments which do support these bits; bits 6 and 7 shall be set to ZERO if any one of the following conditions are true:

- A file is created.
- The attributes/permissions associated with a file, are modified.
- A file is written to (the contents of the data associated with a file are modified).

Bit 8 (Sticky):

Ignored.

 Shall be set to ZERO.

Bit 10 (System):

Ignored.

 Shall be set to ZERO.

3.3.2.1.3 UNIX

Bits 6, 7 & 8 (Setuid, Setgid, Sticky):

These bits are mapped to/from the corresponding standard UNIX file system bits.

Bit 10 (System):

Ignored.

 Shall be set to ZERO upon file creation only, otherwise maintained.
3.3.3 File Entry

```c
struct FileEntry {
    /* ECMA 167 4/14.9 */
    struct tag
        DescriptorTag;
    struct icbtag
        Uid;
        Gid;
    Uint32
        Permissions;
    Uint16
        FileLinkCount;
    Uint8
        RecordFormat;
    Uint8
        RecordDisplayAttributes;
    Uint32
        RecordLength;
    Uint64
        InformationLength;
    Uint64
        LogicalBlocksRecorded;
    struct timestamp
        AccessTime;
    struct timestamp
        ModificationTime;
    struct timestamp
        AttributeTime;
    Uint32
        Checkpoint;
    struct long_ad
        ExtendedAttributeICB;
    struct EntityID
        ImplementationIdentifier;
    Uint64
        UniqueID,
        LengthofExtendedAttributes;
    Uint32
        LengthofAllocationDescriptors;
    byte
        ExtendedAttributes[??];
    byte
        AllocationDescriptors[??];
}
```

**NOTE:** The total length of a `FileEntry` shall not exceed the size of one logical block.

3.3.3.1 Uint32 Uid

- For operating systems that do not support the concept of a **user identifier** the implementation shall ignore this field. For operating systems that do support this field a value of $2^w - 1$ shall indicate an invalid UID, otherwise the field contains a valid **user identifier**.

- For operating systems that do not support the concept of a **user identifier** the implementation shall set this field to $2^w - 1$ to indicate an invalid UID, unless otherwise specified by the user.

3.3.3.2 Uint32 Gid

- For operating systems that do not support the concept of a **group identifier** the implementation shall ignore this field. For operating systems that do support this field a value of $2^w - 1$ shall indicate an invalid GID, otherwise the field contains a valid **group identifier**.
For operating systems that do not support the concept of a *group identifier* the implementation shall set this field to $2^n - 1$ to indicate an invalid GID, unless otherwise specified by the user.

### 3.3.3.3 Uint32 Permissions;

```c
#define OTHER_Execute 0x00000001
#define OTHER_Write 0x00000002
#define OTHER_Read 0x00000004
#define OTHER_ChAttr 0x00000008
#define OTHER_Delete 0x00000010

#define GROUP_Execute 0x00000020
#define GROUP_Write 0x00000040
#define GROUP_Read 0x00000080
#define GROUP_ChAttr 0x00000100
#define GROUP_Delete 0x00000200

#define OWNER_Execute 0x00000400
#define OWNER_Write 0x00000800
#define OWNER_Read 0x00001000
#define OWNER_ChAttr 0x00002000
#define OWNER_Delete 0x00004000
```

The concept of permissions which deals with security is not completely portable between operating systems. This document attempts to maintain consistency among implementations in processing the permission bits by addressing the following basic issues:

1. How should an implementation handle Owner, Group and Other permissions when the operating system has no concept of User and Group Ids?
2. How should an implementation process permission bits when encountered, specifically permission bits that do not directly map to an operating system supported permission bit?
3. What default values should be used for permission bits that do not directly map to an operating system supported permission bit when creating a new file?

**User, Group and Other**

In general, for operating systems that do not support User and Group Ids the following algorithm should be used when processing permission bits:

When reading a specific permission, the logical OR of all three (owner, group, other) permissions should be the value checked. For example a file would be
considered writable if the logical OR of OWNER_Write, GROUP_Write and OTHER_Write was equal to one.

When setting a specific permission the implementation should set all three (owner, group, other) sets of permission bits. For example to mark a file as writable the OWNER_Write, GROUP_Write and OTHER_Write should all be set to one.

Processing Permissions
Implementation shall process the permission bits according to the following table which describes how to process the permission bits under the operating systems covered by this document. The table addresses the issues associated with permission bits that do not directly map to an operating system supported permission bit.

<table>
<thead>
<tr>
<th>Permission</th>
<th>File/Directory</th>
<th>Description</th>
<th>DOS</th>
<th>OS/2</th>
<th>Win 95</th>
<th>Win NT</th>
<th>Mac OS</th>
<th>UNIX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Read</td>
<td>file</td>
<td>The file may be read</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
</tr>
<tr>
<td>Read</td>
<td>directory</td>
<td>The directory may be read</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
</tr>
<tr>
<td>Write</td>
<td>file</td>
<td>The file's contents may be modified</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
</tr>
<tr>
<td>Write</td>
<td>directory</td>
<td>Files or subdirectories may be created, deleted or renamed</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
</tr>
<tr>
<td>Execute</td>
<td>file</td>
<td>The file by be executed.</td>
<td>I</td>
<td>I</td>
<td>I</td>
<td>I</td>
<td>I</td>
<td>E</td>
</tr>
<tr>
<td>Execute</td>
<td>directory</td>
<td>The directory may be searched for a specific file or subdirectory.</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
</tr>
<tr>
<td>Attribute</td>
<td>file</td>
<td>The file's permissions may be changed.</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
</tr>
<tr>
<td>Attribute</td>
<td>directory</td>
<td>The directory's permissions may be changed.</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
</tr>
<tr>
<td>Delete</td>
<td>file</td>
<td>The file may be deleted.</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
</tr>
<tr>
<td>Delete</td>
<td>directory</td>
<td>The directory may be deleted.</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
</tr>
</tbody>
</table>

E - Enforce, I - Ignore

The Execute bit for a directory, sometimes referred to as the search bit, has special meaning. This bit enables a directory to be searched, but not have its contents listed. For example assume a directory called PRIVATE exists which only has the Execute permission and does not have the Read permission bit set. The contents of the directory PRIVATE can not be listed. Assume there is a file within the PRIVATE directory called README. The user can get access to the README file since the PRIVATE directory is searchable.

To be able to list the contents of a directory both the Read and Execute permission bits must be set for the directory. To be able to create, delete and rename a file or subdirectory both the Write and Execute permission bits must be set for the directory. To get a better understanding of the Execute bit for a directory reference any UNIX book that covers file and directory permissions. The rules defined by the Execute bit for a directory shall be enforced by all implementations.

NOTE: To be able to delete a file or subdirectory the Delete permission bit for the file or subdirectory must be set, and both the Write and Execute permission bits must be set for the directory it occupies.
Default Permission Values

For the operating systems covered by this document the following table describes what default values should be used for permission bits that do not directly map to an operating system supported permission bit when creating a new file.

<table>
<thead>
<tr>
<th>Permission</th>
<th>File/Directory</th>
<th>Description</th>
<th>DOS</th>
<th>OS/2</th>
<th>Win 95</th>
<th>Win NT</th>
<th>Mac OS</th>
<th>UNIX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Read</td>
<td>file</td>
<td>The file may be read</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>U</td>
</tr>
<tr>
<td>Read</td>
<td>directory</td>
<td>The directory may be read, only if the directory is also marked as Execute.</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>U</td>
</tr>
<tr>
<td>Write</td>
<td>file</td>
<td>The file’s contents may be modified</td>
<td>U</td>
<td>U</td>
<td>U</td>
<td>U</td>
<td>U</td>
<td>U</td>
</tr>
<tr>
<td>Write</td>
<td>directory</td>
<td>Files or subdirectories may be renamed, added, or deleted, only if the directory is also marked as Execute.</td>
<td>U</td>
<td>U</td>
<td>U</td>
<td>U</td>
<td>U</td>
<td>U</td>
</tr>
<tr>
<td>Execute</td>
<td>file</td>
<td>The file may be executed.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>U</td>
</tr>
<tr>
<td>Execute</td>
<td>directory</td>
<td>The directory may be searched for a specific file or subdirectory.</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>U</td>
</tr>
<tr>
<td>Attribute</td>
<td>file</td>
<td>The file’s permissions may be changed.</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>Note 1</td>
</tr>
<tr>
<td>Attribute</td>
<td>directory</td>
<td>The directory’s permissions may be changed.</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>Note 1</td>
</tr>
<tr>
<td>Delete</td>
<td>file</td>
<td>The file may be deleted.</td>
<td>Note 2</td>
<td>Note 2</td>
<td>Note 2</td>
<td>Note 2</td>
<td>Note 2</td>
<td>Note 2</td>
</tr>
<tr>
<td>Delete</td>
<td>directory</td>
<td>The directory may be deleted.</td>
<td>Note 2</td>
<td>Note 2</td>
<td>Note 2</td>
<td>Note 2</td>
<td>Note 2</td>
<td>Note 2</td>
</tr>
</tbody>
</table>

Note: Under UNIX only the owner of a file/directory may change its attributes.

Note 2: The Delete permission bit should be set based upon the status of the Write permission bit. Under DOS, OS/2 and Macintosh, if a file or directory is marked as writable (Write permission set) then the file is considered deletable and the Delete permission bit should be set. If a file is read only then the Delete permission bit should not be set. This applies to file create as well as changing attributes of a file.

3.3.3.4 Uint64 UniqueID

Note: For some operating systems (i.e. Macintosh) this value needs to be less than the max value of a Int32 (2^31 - 1). Under the Macintosh operating system this value is used to represent the Macintosh directory/file ID. Therefore an implementation should attempt to keep this value less than the max value of a Int32 (2^31 - 1). The values 1-15 shall be reserved for the use of Macintosh implementations.

3.3.3.5 byte Extended Attributes

Certain extended attributes should be recorded in this field of the FileEntry for performance reasons. Other extended attributes should be recorded in an ICB pointed to by the field ExtendedAttributeICB. In the section on Extended Attributes it will be specified which extended attributes should be recorded in this field.
3.3.4 Extended Attributes

In order to handle some of the longer Extended Attributes (EAs) which may vary in length, the following rules apply to the EA space.

1. *All* EAs with an attribute length greater than or equal to a logical block shall be block aligned by starting and ending on a logical block boundary.
2. Smaller EAs shall be constrained to an attribute length which is a multiple of 4 bytes.
3. The Extended Attribute space shall appear as a single contiguous logical space constructed as follows:

<table>
<thead>
<tr>
<th>ECMA 167 EAs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non block aligned Implementation Use EAs</td>
</tr>
<tr>
<td>Block aligned Implementation Use EAs</td>
</tr>
<tr>
<td>Application Use EAs</td>
</tr>
</tbody>
</table>

3.3.4.1 Extended Attribute Header Descriptor

```c
struct ExtendedAttributeHeaderDescriptor { /* ECMA 167 4/14.10.1 */
  struct tag DescriptorTag;
  Uint32 ImplementationAttributesLocation;
  Uint32 ApplicationAttributesLocation;
};
```

If the attributes associated with the *location* fields highlighted above do not exist, then the value of the *location* field shall point to the byte after the extended attribute space.

3.3.4.2 Alternate Permissions

```c
struct AlternatePermissionsExtendedAttribute { /* ECMA 167 4/14.10.4 */
  Uint32 AttributeType;
  Uint8 AttributeSubtype;
  byte Reserved[3];
  Uint32 AttributeLength;
  Uint16 OwnerIdentification;
  Uint16 GroupIdentification;
  Uint16 Permission;
};
```

This structure shall not be recorded.
3.3.4.3 File Times Extended Attribute

struct FileTimesExtendedAttribute { /* ECMA 167 4/14.10.5 */
    Uint32 AttributeType;
    Uint8 AttributeSubtype;
    byte Reserved[3];
    Uint32 AttributeLength;
    Uint32 DataLength;
    Uint32 FileTimeExistence;
    byte FileTimes;
}

3.3.4.3.1 Uint32 FileTimeExistence

3.3.4.3.1.1 Macintosh OS

This field shall be set to indicate that only the file creation time has been recorded.

3.3.4.3.1.2 Other OS

This structure need not be recorded.

3.3.4.3.2 byte FileTimes

3.3.4.3.2.1 Macintosh OS

\(\) Shall be interpreted as the creation time of the associated file.

\(\) Shall be set to creation time of the associated file.

If the File Times Extended Attribute does not exist then a Macintosh implementation shall use the ModificationTime field of the File Entry to represent the file creation time.

3.3.4.3.2.2 Other OS

This structure need not be recorded.

3.3.4.4 Device Specification Extended Attribute

struct DeviceSpecificationExtendedAttribute { /* ECMA 167 4/14.10.7 */
    Uint32 AttributeType;
    Uint8 AttributeSubtype;
    byte Reserved[3];
    Uint32 AttributeLength;
    Uint32 ImplementationUseLength; /* (=IU_L) */
    Uint32 MajorDeviceIdentification;
    Uint32 MinorDeviceIdentification;
    byte ImplementationUse[IU_L];
}

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The following paradigm shall be followed by an implementation that creates a Device Specification Extended Attribute associated with a file:

If and only if a file has a DeviceSpecificationExtendedAttribute associated with it, the contents of the FileType field in the icbtag structure be set to 6 (indicating a block special device file), OR 7 (indicating a character special device file).

If the contents of the FileType field in the icbtag structure do not equal 6 or 7, the DeviceSpecificationExtendedAttribute associated with a file shall be ignored.

In the event that the contents of the FileType field in the icbtag structure equal 6 or 7, and the file does not have a DeviceSpecificationExtendedAttribute associated with it, access to the file shall be denied.

For operating system environments that do not provide for the semantics associated with a block special device file, requests to open/read/write/close a file that has the DeviceSpecificationExtendedAttribute associated with it shall be denied.

All implementations shall record a developer ID in the ImplementationUse field that uniquely identifies the current implementation.

### 3.3.4.5 Implementation Use Extended Attribute

```c
struct ImplementationUseExtendedAttribute { /* ECMA 167 4/14.10.8 */
    Uint32     AttributeType;
    Uint8     AttributeSubtype;
    byte       Reserved[3];
    Uint32     AttributeLength;
    Uint32     ImplementationUseLength; /* (=IU_L) */
    struct EntityID ImplementationIdentifier;
    byte       ImplementationUse[IU_L];
};
```

The AttributeLength field specifies the length of the entire extended attribute. For variable length extended attributes defined using the Implementation Use Extended Attribute the Attribute Length field should be large enough to leave padding space between the end of the Implementation Use field and the end of the Implementation Use Extended Attribute.

The following sections describe how the Implementation Use Extended Attribute is used under various operating systems to store operating system specific extended attributes.
The structures defined in the following sections contain a header checksum field. This field represents a 16-bit checksum of the Implementation Use Extended Attribute header. The fields AttributeType through ImplementationIdentifier inclusively represent the data covered by the checksum. The header checksum field is used to aid in disaster recovery of the extended attribute space. C source code for the header checksum may be found in the appendix.

NOTE: All compliant implementations shall preserve existing extended attributes encountered on the media. Implementations shall create and support the extended attributes for the operating system they currently support. For example, a Macintosh implementation shall preserve any OS/2 extended attributes encountered on the media. It shall also create and support all Macintosh extended attributes specified in this document.

3.3.4.5.1 All Operating Systems
3.3.4.5.1.1 FreeEASpace
This extended attribute shall be used to indicate unused space within the extended attribute space. This extended attributes shall be stored as an Implementation Use Extended Attribute whose ImplementationIdentifier shall be set to:

"*UDF FreeEASpace"

The ImplementationUse area for this extended attribute shall be structured as follows:

<table>
<thead>
<tr>
<th>RBP</th>
<th>Length</th>
<th>Name</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2</td>
<td>Header Checksum</td>
<td>Uint16</td>
</tr>
<tr>
<td>2</td>
<td>IU_L-1</td>
<td>Free EA Space</td>
<td>bytes</td>
</tr>
</tbody>
</table>

This extended attribute allows an implementation to shrink/grow the total size of other extended attributes without rewriting the complete extended attribute space. The FreeEASpace extended attribute may be overwritten and the space re-used by any implementation who sees a need to overwrite it.

3.3.4.5.1.2 DVD Copyright Management Information
This extended attribute shall be used to store DVD Copyright Management Information. This extended attribute shall be stored as an Implementation Use Extended Attribute whose ImplementationIdentifier shall be set to:

"*UDF DVD CGMS Info"
The *ImplementationUse* area for this extended attribute shall be structured as follows:

**DVD CGMS Info format**

<table>
<thead>
<tr>
<th>RBP</th>
<th>Length</th>
<th>Name</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2</td>
<td>Header Checksum</td>
<td>Uint16</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>CGMS Information</td>
<td>byte</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>Data Structure Type</td>
<td>Uint8</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>Protection System Information</td>
<td>bytes</td>
</tr>
</tbody>
</table>

This extended attribute allows DVD Copyright Management Information to be stored. The interpretation of this format shall be defined in the DVD specification published by the DVD Consortium (see 6.9.3). Support for this extended attribute is optional.

3.3.4.5.2 MS-DOS, Windows 95, Windows NT

Ignored.

Not supported. Extended attributes for existing files on the media shall be preserved.

3.3.4.5.3 OS/2

OS/2 supports an unlimited number of extended attributes which shall be supported through the use of the following two *Implementation Use Extended Attributes*.

3.3.4.5.3.1 OS2EA

This extended attribute contains all OS/2 definable extended attributes which shall be stored as an *Implementation Use Extended Attribute* whose *ImplementationIdentifier* shall be set to:

"*UDF OS/2 EA*"

The *ImplementationUse* area for this extended attribute shall be structured as follows:

**OS2EA format**

<table>
<thead>
<tr>
<th>RBP</th>
<th>Length</th>
<th>Name</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2</td>
<td>Header Checksum</td>
<td>Uint16</td>
</tr>
<tr>
<td>2</td>
<td>IU_L-2</td>
<td>OS/2 Extended Attributes</td>
<td>FEA</td>
</tr>
</tbody>
</table>
The OS2ExtendedAttributes field contains a table of OS/2 Full EAs (FEA) as shown below.

**FEA format**

<table>
<thead>
<tr>
<th>RBP</th>
<th>Length</th>
<th>Name</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>Flags</td>
<td>Uint8</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>Length of Name (=L_N)</td>
<td>Uint8</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>Length of Value (=L_V)</td>
<td>Uint16</td>
</tr>
<tr>
<td>4+L_N</td>
<td></td>
<td>Name</td>
<td>bytes</td>
</tr>
<tr>
<td>4+L_V</td>
<td></td>
<td>Value</td>
<td>bytes</td>
</tr>
</tbody>
</table>

For a complete description of Full EAs (FEA) please reference the following IBM document:

"Installable File System for OS/2 Version 2.0"
OS/2 File Systems Department
PSPC Boca Raton, Florida
February 17, 1992

3.3.4.5.3.2 OS2EALength
This attribute specifies the OS/2 Extended Attribute information length. Since this value needs to be reported back to OS/2 under certain directory operations, for performance reasons it should be recorded in the ExtendedAttributes field of the FileEntry. This extended attribute shall be stored as an Implementation Use Extended Attribute whose ImplementationIdentifier shall be set to:

"*UDF OS/2 EALength"

The ImplementationUse area for this extended attribute shall be structured as follows:

**OS2EALength format**

<table>
<thead>
<tr>
<th>RBP</th>
<th>Length</th>
<th>Name</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2</td>
<td>Header Checksum</td>
<td>Uint16</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>OS/2 Extended Attribute Length</td>
<td>Uint32</td>
</tr>
</tbody>
</table>

The value recorded in the OS2ExtendedAttributeLength field shall be equal to the ImplementationUseLength field of the OS2EA extended attribute - 2.

3.3.4.5.4 Macintosh OS
The Macintosh OS requires the use of the following four extended attributes.
3.3.4.5.4.1 MacVolumeInfo

This extended attribute contains Macintosh volume information which shall be stored as an Implementation Use Extended Attribute whose ImplementationIdentifier shall be set to:
"*UDF Mac VolumeInfo"

The ImplementationUse area for this extended attribute shall be structured as follows:

<table>
<thead>
<tr>
<th>RBP</th>
<th>Length</th>
<th>Name</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2</td>
<td>Header Checksum</td>
<td>Uint16</td>
</tr>
<tr>
<td>2</td>
<td>12</td>
<td>Last Modification Date</td>
<td>timestamp</td>
</tr>
<tr>
<td>14</td>
<td>12</td>
<td>Last Backup Date</td>
<td>timestamp</td>
</tr>
<tr>
<td>26</td>
<td>32</td>
<td>Volume Finder Information</td>
<td>Uint32</td>
</tr>
</tbody>
</table>

The MacVolumeInfo extended attribute shall be recorded as an extended attribute of the root directory FileEntry.

3.3.4.5.4.2 MacFinderInfo

This extended attribute contains Macintosh Finder information for the associated file or directory. Since this information is accessed frequently, for performance reasons it should be recorded in the ExtendedAttributes field of the FileEntry.

The MacFinderInfo extended attribute shall be stored as an Implementation Use Extended Attribute whose ImplementationIdentifier shall be set to:
"*UDF Mac FinderInfo"

The ImplementationUse area for this extended attribute shall be structured as follows:

<table>
<thead>
<tr>
<th>RBP</th>
<th>Length</th>
<th>Name</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2</td>
<td>Header Checksum</td>
<td>Uint16</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>Reserved for padding (=0)</td>
<td>Uint16</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>Parent Directory ID</td>
<td>Uint32</td>
</tr>
<tr>
<td>8</td>
<td>16</td>
<td>Directory Information</td>
<td>UDFDInfo</td>
</tr>
<tr>
<td>24</td>
<td>16</td>
<td>Directory Extended Information</td>
<td>UDFDXInfo</td>
</tr>
</tbody>
</table>
The `MacFinderInfo` extended attribute shall be recorded as an extended attribute of every file and directory within the Logical Volume.

The following structures used within the `MacFinderInfo` structure are listed below for clarity. For complete information on these structures refer to the Macintosh books called "Inside Macintosh". The volume and page number listed with each structure correspond to a specific "Inside Macintosh" volume and page.

### `MacFinderInfo` format for a file

<table>
<thead>
<tr>
<th>RBP</th>
<th>Length</th>
<th>Name</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2</td>
<td>Header Checksum</td>
<td>UInt16</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>Reserved for padding (=0)</td>
<td>UInt16</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>Parent Directory ID</td>
<td>UInt32</td>
</tr>
<tr>
<td>8</td>
<td>16</td>
<td>File Information</td>
<td>UDFFInfo</td>
</tr>
<tr>
<td>24</td>
<td>16</td>
<td>File Extended Information</td>
<td>UDFFXInfo</td>
</tr>
<tr>
<td>40</td>
<td>4</td>
<td>Resource Fork Data Length</td>
<td>UInt32</td>
</tr>
<tr>
<td>44</td>
<td>4</td>
<td>Resource Fork Allocated Length</td>
<td>UInt32</td>
</tr>
</tbody>
</table>

### `UDFPoint` format (Volume I, page 139)

<table>
<thead>
<tr>
<th>RBP</th>
<th>Length</th>
<th>Name</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2</td>
<td>v</td>
<td>Int16</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>h</td>
<td>Int16</td>
</tr>
</tbody>
</table>

### `UDFRect` format (Volume I, page 141)

<table>
<thead>
<tr>
<th>RBP</th>
<th>Length</th>
<th>Name</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2</td>
<td>top</td>
<td>Int16</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>left</td>
<td>Int16</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>bottom</td>
<td>Int16</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
<td>right</td>
<td>Int16</td>
</tr>
</tbody>
</table>

### `UDFDInfo` format (Volume IV, page 105)

<table>
<thead>
<tr>
<th>RBP</th>
<th>Length</th>
<th>Name</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>8</td>
<td>frRect</td>
<td>UDFRect</td>
</tr>
<tr>
<td>8</td>
<td>2</td>
<td>frFlags</td>
<td>Int16</td>
</tr>
<tr>
<td>10</td>
<td>4</td>
<td>frLocation</td>
<td>UDFPoint</td>
</tr>
<tr>
<td>14</td>
<td>2</td>
<td>frView</td>
<td>Int16</td>
</tr>
</tbody>
</table>

### `UDFDXInfo` format (Volume IV, page 106)

<table>
<thead>
<tr>
<th>RBP</th>
<th>Length</th>
<th>Name</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>4</td>
<td>frScroll</td>
<td>UDFPoint</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>frOpenChain</td>
<td>Int32</td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td>frScript</td>
<td>Uint8</td>
</tr>
<tr>
<td>9</td>
<td>1</td>
<td>frXflags</td>
<td>Uint8</td>
</tr>
<tr>
<td>10</td>
<td>2</td>
<td>frComment</td>
<td>Int16</td>
</tr>
<tr>
<td>12</td>
<td>4</td>
<td>frPutAway</td>
<td>Int32</td>
</tr>
</tbody>
</table>
### UDFInfo format (Volume II, page 84)

<table>
<thead>
<tr>
<th>RBP</th>
<th>Length</th>
<th>Name</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>4</td>
<td>fdType</td>
<td>Uint32</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>fdCreator</td>
<td>Uint32</td>
</tr>
<tr>
<td>8</td>
<td>2</td>
<td>fdFlags</td>
<td>Uint16</td>
</tr>
<tr>
<td>10</td>
<td>4</td>
<td>fdLocation</td>
<td>UDFPoint</td>
</tr>
<tr>
<td>14</td>
<td>2</td>
<td>fdFlr</td>
<td>Int16</td>
</tr>
</tbody>
</table>

### UDFXInfo format (Volume IV, page 105)

<table>
<thead>
<tr>
<th>RBP</th>
<th>Length</th>
<th>Name</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2</td>
<td>fdIconID</td>
<td>Int16</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>fdUnused</td>
<td>bytes</td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td>fdScript</td>
<td>Int8</td>
</tr>
<tr>
<td>9</td>
<td>1</td>
<td>fdXFlags</td>
<td>Int8</td>
</tr>
<tr>
<td>10</td>
<td>2</td>
<td>fdComment</td>
<td>Int16</td>
</tr>
<tr>
<td>12</td>
<td>4</td>
<td>fdPutAway</td>
<td>Int32</td>
</tr>
</tbody>
</table>

**NOTE:** The above mentioned structures have their original Macintosh names preceded by "UDF" to indicate that they are actually different from the original Macintosh structures. On the media the UDF structures are stored *little endian* as opposed to the original Macintosh structures which are in *big endian* format.

#### 3.3.4.5.4.3 MacUniqueIDTable

This extended attribute contains a table used to look up the FileEntry for a specified UniqueID. This table shall be stored as an Implementation Use Extended Attribute whose ImplementationIdentifier shall be set to: "*UDF Mac UniqueIDTable"

The ImplementationUse area for this extended attribute shall be structured as follows:

### MacUniqueIDTable format

<table>
<thead>
<tr>
<th>RBP</th>
<th>Length</th>
<th>Name</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2</td>
<td>Header Checksum</td>
<td>Uint16</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>Reserved for padding (=0)</td>
<td>Uint16</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>Number of Unique ID Maps (=N_DID)</td>
<td>Uint32</td>
</tr>
<tr>
<td>8</td>
<td>N_DID x 8</td>
<td>Unique ID Maps</td>
<td>UniqueIDMap</td>
</tr>
</tbody>
</table>

### UniqueIDMap format

<table>
<thead>
<tr>
<th>RBP</th>
<th>Length</th>
<th>Name</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>8</td>
<td>File Entry Location</td>
<td>small_ad</td>
</tr>
</tbody>
</table>
This **UniqueIDTable** is used to look up the corresponding **FileEntry** for a specified Macintosh directory/file ID (**UniqueID**). For example, given some Macintosh directory/file ID \( i \) the corresponding **FileEntry** location may be found in the \((i-2)\) **UniqueIDMap** in the **UniqueIDTable**. The correspondence of directory/file ID to **UniqueID** is \((\text{Directory/file ID} - 2)\) because Macintosh directory/file IDs start at 2 while **UniqueIDs** start at 0. In the Macintosh the root directory always has a directory ID of 2, which corresponds to the requirement of having the **UniqueID** of the root **FileEntry** have the value of 0.

If the value of the **Extent Length** field of the **File Entry Location** is 0 then the corresponding **UniqueID** is free.

The **MacUniqueIDTable** extended attribute shall be recorded as an extended attribute of the root directory.

The **MacUniqueIDTable** is created and updated only by implementations that support the Macintosh. When the Logical Volume is modified by implementations that do not support the **MacUniqueIDTable** can become out of date in the following ways:

- Files can exist on the media which are not referenced in the **MacUniqueIDTable**. This can result from a non-Macintosh implementation creating a new file on the media.
- Files in the **UniqueID** table may no longer exist on the media. This can result from a non-Macintosh implementation deleting a file on the media.

The Macintosh uses the **UniqueID** to directly address a file on the media without reference to its file name. This will only happen if the file was originally created by an implementation that supports the Macintosh. Therefore any new files added to the logical volume by non-Macintosh implementations will always be referenced by file name first, never by **UniqueID**. At the first access of the file by file name, the Macintosh implementation can detect that this **UniqueID** is not in the **MacUniqueIDTable** and update the table appropriately.

The second problem is a little more difficult to address. The problem occurs when a Macintosh implementation gets a reference to a file on the media given a **UniqueID**. The Macintosh implementation needs to make sure that the file the **UniqueID** references still exists. The following things can be done:

---

### small_ad format

<table>
<thead>
<tr>
<th>RBP</th>
<th>Length</th>
<th>Name</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2</td>
<td>Extent Length</td>
<td>Uint16</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>Extent Location</td>
<td>lb_addr (4/7.1)</td>
</tr>
</tbody>
</table>
Verify that the File Entry (FE) pointed to by the UniqueID contains the same UniqueID.

AND Verify that the block that contains the FE is not on the free list. This could occur when the file is deleted by a non-Macintosh implementation, and the FE has not been overwritten.

The only case that these two tests do not catch is when a file has been deleted by a non-Macintosh implementation, and the logical block associated with the FE has been reassigned to a new file, and the new file has used the block in an extent of \textit{Allocated but not recorded}.

3.3.4.5.4 MacResourceFork

This extended attribute contains the Macintosh resource fork data for the associated file. The resource fork data shall be stored as an Implementation Use Extended Attribute whose ImplementationIdentifier shall be set to:

"*UDF Mac ResourceFork"

The ImplementationUse area for this extended attribute shall be structured as follows:

\begin{center}
\begin{tabular}{|c|c|c|}
\hline
RBP & Length & Name & Contents \\
\hline
0 & 2 & HeaderChecksum & Uint16 \\
1 & IU L-2 & Resource Fork Data & bytes \\
\hline
\end{tabular}
\end{center}

The MacResourceFork extended attribute shall be recorded as an extended attribute of all files, with > 0 bytes in the resource fork, within the Logical Volume.

The two fields of the MacFinderInfo extended attribute the reference the MacResourceFork extended attributes are defined as follows:

\textit{Resource Fork Data Length} - Shall be set to the length of the actual data considered to be part of the resource fork.

\textit{Resource Fork Allocated Length} - Shall be set to the total amount of space in bytes allocated to the resource fork.

3.3.4.5.5 UNIX

\begin{itemize}
\item Ignored.
\item Not supported. Extended attributes for existing files on the media shall be preserved.
\end{itemize}
3.3.4.6  Application Use Extended Attribute

```c
struct ApplicationUseExtendedAttribute { /* ECMA 167 4/14.10.9 */
    Uint32  AttributeType; /* = 65536 */
    Uint8   AttributeSubtype;
    byte    Reserved[3];
    Uint32  AttributeLength;
    Uint32  ApplicationUseLength; /* (=AU_L) */
    struct EntityID ApplicationIdentifier;
    byte    ApplicationUse[AU_L];

};
```

The `AttributeLength` field specifies the length of the entire extended attribute. For variable length extended attributes defined using the `Application Use Extended Attribute` the `Attribute Length` field should be large enough to leave padding space between the end of the `ApplicationUse` field and the end of the `Application Use Extended Attribute`.

The structures defined in the following section contains a `header checksum` field. This field represents a 16-bit checksum of the Application Use Extended Attribute header. The fields `AttributeType` through `ApplicationIdentifier` inclusively represent the data covered by the `checksum`. The header `checksum` field is used to aid in disaster recovery of the extended attribute space. C source code for the header checksum may be found in the appendix.

**NOTE:** All compliant implementations shall preserve existing extended attributes encountered on the media. Implementations shall create and support the extended attributes for the operating system they currently support. For example, a Macintosh implementation shall preserve any OS/2 extended attributes encountered on the media. It shall also create and support all Macintosh extended attributes specified in this document.

3.3.4.6.1  All Operating Systems

This extended attribute shall be used to indicate unused space within the extended attribute space reserved for Application Use Extended Attributes. This extended attribute shall be stored as an `Application Use Extended Attribute` whose `ApplicationIdentifier` shall be set to:

```
"*UDF FreeAppEASpace"
```
The *ApplicationUse* area for this extended attribute shall be structured as follows:

**FreeAppEASpace format**

<table>
<thead>
<tr>
<th>RBP</th>
<th>Length</th>
<th>Name</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2</td>
<td>Header Checksum</td>
<td>Uint16</td>
</tr>
<tr>
<td>2</td>
<td>IU_L-1</td>
<td>Free EA Space</td>
<td>bytes</td>
</tr>
</tbody>
</table>

This extended attribute allows an implementation to shrink/grow the total size of other extended attributes without rewriting the complete extended attribute space. The *FreeAppEASpace* extended attribute may be overwritten and the space reused by any implementation who sees a need to overwrite it.
4. User Interface Requirements

4.1 Part 3 - Volume Structure

Part 3 of ECMA 167 contains various Identifiers which, depending upon the implementation, may have to be presented to the user.

- **VolumeIdentifier**
- **VolumeSetIdentifier**
- **LogicalVolumeID**

These identifiers, which are stored in CS0, may have to go through some form of translation to be displayable to the user. Therefore when an implementation must perform an OS specific translation on the above listed identifiers the implementation shall use the algorithms described in section 4.1.2.1.

C source code for the translation algorithms may be found in the appendices of this document.

4.2 Part 4 - File System

4.2.1 ICB Tag

```c
struct icbtag { /* ECMA 167 4/14.6 */
    Uint32 PriorRecordedNumberOfDirectEntries;
    Uint16 StrategyType;
    byte StrategyParameter[2];
    Uint16 NumberOfEntries;
    byte Reserved; /* == #00 */
    Uint8 FileType;
    Lb_addr ParentICBLocation;
    Uint16 Flags;
}
```

4.2.1.1 FileType

Any open/close/read/write requests for file(s) that have any of the following values in this field shall result in an *Access Denied* error condition under non-UNIX operating system environments:

*FileType* values - 0 (Unknown), 6 (block device), 7 (character device), 9 (FIFO), and 10 (C_ISSOCK).

Any open/close/read/write requests to a file of type 12 (*SymbolicLink*) shall access the file/directory to which the symbolic link is pointing.
4.2.2 File Identifier Descriptor

```c
struct FileIdentifierDescriptor {
    struct tag    DescriptorTag;
    Uint16        FileVersionNumber;
    Uint8         FileCharacteristics;
    Uint8         LengthOfFileIdentifier;
    struct long _ad ICB;
    Uint16        LengthOfImplementationUse;
    byte          ImplementationUse[??];
    char          FileIdentifier[??];
    byte          Padding[??];
}
```

4.2.2.1 char FileIdentifier

Since most operating systems have their own specifications as to characteristics of a legal FileIdentifier, this becomes a problem with interchange. Therefore since all implementations must perform some form of FileIdentifier translation it would be to the users advantage if all implementations used the same algorithm.

The problems with FileIdentifier translations fall within one or more of the following categories:

- **Name Length** - Most operating systems have some fixed limit for the length of a file identifier.

- **Invalid Characters** - Most operating systems have certain characters considered as being illegal within a file identifier name.

- **Displayable Characters** - Since UDF supports the Unicode character set standard characters within a file identifier may be encountered which are not displayable on the receiving system.

- **Case Insensitive** - Some operating systems are case insensitive in regards to file identifiers. For example OS/2 preserves the original case of the file identifier when the file is created, but uses a case insensitive operations when accessing the file identifier. In OS/2 “Abc” and “ABC” would be the same file name.

- **Reserved Names** - Some operating systems have certain names that cannot be used for a file identifier name.

The following sections outline the FileIdentifier translation algorithm for each specific operating system covered by this document. This algorithm shall be used by all OSTA UDF compliant implementations. The algorithm only applies when
reading an illegal FileIdentifier. The original FileIdentifier name on the media should not be modified. This algorithm shall be applied by any implementation which performs some form of FileIdentifier translation to meet operating system file identifier restrictions.

All OSTA UDF compliant implementations shall support the UDF translation algorithms, but may support additional algorithms. If multiple algorithms are supported the user of the implementation shall be provided with a method to select the UDF translation algorithms. It is recommended that the default displayable algorithm be the UDF defined algorithm.

The primary goal of these algorithms is to produce a unique file name that meets the specific operating system restrictions without having to scan the entire directory in which the file resides.

C source code for the following algorithms may be found in the appendices of this document.

NOTE: In the definition of the following algorithms anytime a d-character is specified in quotes, the Unicode hexadecimal value will also be specified. In addition the following algorithms reference “CS0 Hex representation”, which corresponds to using the Unicode values #0030 - #0039, and #0041 - #0046 to represent a value in hex.

The following algorithms could still result in name-collisions being reported to the user of an implementation. However, the rationale includes the need for efficient access to the contents of a directory and consistent name translations across logical volume mounts and file system driver implementations, while allowing the user to obtain access to any file within the directory (through possibly renaming a file).

Definitions:
A FileIdentifier shall be considered as being composed of two parts, a file name and file extension.

The character '.' (#002E) shall be considered as the separator for the FileIdentifier of a file; characters appearing subsequent to the last '.' (#002E) shall be considered as constituting the file extension if and only if it is less than or equal to 5 characters in length, otherwise the file extension shall not exist. Characters appearing prior to the file extension, excluding the last '.' (#002E), shall be considered as constituting the file name.

NOTE: Even though OS/2, Macintosh, and UNIX do not have an official concept of a filename extension it is common file naming conventions to end a file with “.” followed by a 1 to 5 character extension. Therefore the
following algorithms attempt to preserve the file extension up to a maximum of 5 characters.

4.2.2.1.1 MS-DOS

Due to the restrictions imposed by the MS DOS operating system environments on the FileIdentifier associated with a file the following methodology shall be employed to handle FileIdentifier(s) under the above-mentioned operating system environments:

Restrictions: The file name component of the FileIdentifier shall not exceed 8 characters. The file extension component of the FileIdentifier shall not exceed 3 characters.

1. **FileIdentifier Lookup:** Upon request for a "lookUp" of a FileIdentifier, a case-insensitive comparison shall be performed.
2. **Validate FileIdentifier:** If the FileIdentifier is a valid MS-DOS file identifier then do not apply the following steps.
3. **Remove Spaces:** All embedded spaces within the identifier shall be removed.
4. **Invalid Characters:** A FileIdentifier that contains characters considered invalid within a file name or file extension (as defined above), or not displayable in the current environment, shall have them translated into "_" (#005F). (the file identifier on the media is NOT modified). Multiple sequential invalid or non-displayable characters shall be translated into a single "_" (#005F) character. Reference the appendix on invalid characters for a complete list.
5. **Leading Periods:** In the event that there do not exist any characters prior to the first "." (#002E) character, leading "." (#002E) characters shall be disregarded up to the first non "." (#002E) character, in the application of this heuristic.
6. **Multiple Periods:** In the event that the FileIdentifier contains multiple "." (#002E) characters, all characters appearing subsequent to the last "." (#002E) shall be considered as constituting the file extension if and only if it is less than or equal to 5 characters in length, otherwise the file extension shall not exist. Characters appearing prior to the file extension, excluding the last "." (#002E), shall be considered as constituting the file name. All embedded "." (#002E) characters within the file name shall be removed.
7. **Long Extension:** In the event that the number of characters constituting the file extension at this step in the process is greater than 3, the file extension shall be regarded as having been composed of the first 3 characters amongst the characters constituting the file extension at this step in the process.
8. **Long Filename:** In the event that the number of characters constituting the file name at this step in the process is greater than 8, the file name shall be truncated to 4 characters.
9. **FileIdentifier CRC:** Since through the above process character information from the original `FileIdentifier` is lost the chance of creating a duplicate `FileIdentifier` in the same directory increases. To greatly reduce the chance of having a duplicate `FileIdentifier` the file name shall be modified to contain a CRC of the original `FileIdentifier`. The file name shall be composed of the first 4 characters constituting the file name at this step in the process; followed by a 4 digit CS0 Hex representation of the 16-bit CRC of the original CS0 `FileIdentifier`.

**NOTE:** All other algorithms except DOS precede the CRC by a separator ' #' (#0023). Due to the limited number of characters in a DOS file name a separator for the CRC is not used.

10. The new file identifier shall be translated to all upper case.

### 4.2.2.1.2 OS/2

Due to the restrictions imposed by the OS/2 operating system environment, on the `FileIdentifier` associated with a file the following methodology shall be employed to handle `FileIdentifier(s)` under the above-mentioned operating system environment:

1. **FileIdentifier Lookup:** Upon request for a "lookUp" of a `FileIdentifier`, a case-insensitive comparison shall be performed.
2. **Validate FileIdentifier:** If the `FileIdentifier` is a valid OS/2 file identifier then do not apply the following steps.
3. **Invalid Characters:** A `FileIdentifier` that contains characters considered invalid within an OS/2 file name, or not displayable in the current environment shall have them translated into "_" (#005F). Multiple sequential invalid or non-displayable characters shall be translated into a single "_" (#005F) character. Reference the appendix on invalid characters for a complete list.
4. **Trailing Periods and Spaces:** All trailing "." (#002E) and " " (#0020) shall be removed.
5. **FileIdentifier CRC:** Since through the above process character information from the original `FileIdentifier` is lost the chance of creating a duplicate `FileIdentifier` in the same directory increases. To greatly reduce the chance of having a duplicate `FileIdentifier` the file name shall be modified to contain a CRC of the original `FileIdentifier`. The file name shall be composed of up to the first (254 - (length of (new file extension)) + 1 (for the ")). - 5 (for the #CRC)) characters constituting the file name at this step in the process, followed by the separator '#' (#0023); followed by a 4 digit CS0 Hex representation of the 16-bit CRC of the original CS0 `FileIdentifier`, followed by '.' (#002E) and the file extension at this step in the process.
Otherwise if there is no file extension the new FileIdentifier shall be composed of up to the first (254 - 5 (for the #CRC)) characters constituting the file name at this step in the process. Followed by the separator '#' (#0023); followed by a 4 digit CS0 Hex representation of the 16-bit CRC of the original CS0 FileIdentifier.

4.2.2.1.3 Macintosh

Due to the restrictions imposed by the Macintosh operating system environment, on the FileIdentifier associated with a file the following methodology shall be employed to handle FileIdentifier(s) under the above-mentioned operating system environment:

1. FileIdentifier Lookup: Upon request for a "lookUp" of a FileIdentifier, a case-insensitive comparison shall be performed.
2. Validate FileIdentifier: If the FileIdentifier is a valid Macintosh file identifier then do not apply the following steps.
3. Invalid Characters: A FileIdentifier that contains characters considered invalid within a Macintosh file name, or not displayable in the current environment, shall have them translated into "_" (#005F). Multiple sequential invalid or non-displayable characters shall be translated into a single "_" (#005F) character. Reference the appendix on invalid characters for a complete list.
4. Long FileIdentifier - In the event that the number of characters constituting the FileIdentifier at this step in the process is greater than 31 (maximum name length for the Macintosh operating system), the new FileIdentifier will consist of the first 26 characters of the FileIdentifier at this step in the process.
5. FileIdentifier CRC Since through the above process character information from the original FileIdentifier is lost the chance of creating a duplicate FileIdentifier in the same directory increases. To greatly reduce the chance of having a duplicate FileIdentifier the file name shall be modified to contain a CRC of the original FileIdentifier.

If there is a file extension then the new FileIdentifier shall be composed of up to the first (31 - (length of (new file extension) + 1 (for the '.').)) - 5 (for the #CRC)) characters constituting the file name at this step in the process, followed by the separator '#' (#0023); followed by a 4 digit CS0 Hex representation of the 16-bit CRC of the original CS0 FileIdentifier, followed by '.' (#002E) and the file extension at this step in the process.

Otherwise if there is no file extension the new FileIdentifier shall be composed of up to the first (31 - 5(for the #CRC)) characters constituting the file name at this step in the process. Followed by the separator '#' (#0023); followed by a 4 digit CS0 Hex representation of the 16-bit CRC of the original CS0 FileIdentifier.
4.2.2.1.4 Windows 95 & Windows NT

Due to the restrictions imposed by the Windows 95 and Windows NT operating system environments, on the FileIdentifier associated with a file the following methodology shall be employed to handle FileIdentifier(s) under the above-mentioned operating system environment:

1. **FileIdentifier Lookup**: Upon request for a "lookUp" of a FileIdentifier, a case-insensitive comparison shall be performed.
2. **Validate FileIdentifier**: If the FileIdentifier is a valid file identifier for Windows 95 or Windows NT then do not apply the following steps.
3. **Invalid Characters**: A FileIdentifier that contains characters considered invalid within a file name of the supported operating system, or not displayable in the current environment shall have them translated into "_" (#005F). Multiple sequential invalid or non-displayable characters shall be translated into a single “_” (#005F) character. Reference the appendix on invalid characters for a complete list.
4. **Trailing Periods and Spaces**: All trailing “.” (#002E) and “ “ (#0020) shall be removed.
5. **FileIdentifier CRC**: Since through the above process character information from the original FileIdentifier is lost the chance of creating a duplicate FileIdentifier in the same directory increases. To greatly reduce the chance of having a duplicate FileIdentifier the file name shall be modified to contain a CRC of the original FileIdentifier.

If there is a file extension then the new FileIdentifier shall be composed of up to the first (255 - (length of (new file extension) + 1) (for the ’.’)) - 5 (for the #CRC) characters constituting the file name at this step in the process, followed by the separator '#' (#0023); followed by a 4 digit CS0 Hex representation of the 16-bit CRC of the original CS0 FileIdentifier, followed by '.' (#002E) and the file extension at this step in the process.

Otherwise if there is no file extension the new FileIdentifier shall be composed of up to the first (255 - 5 (for the #CRC)) characters constituting the file name at this step in the process. Followed by the separator '#' (#0023); followed by a 4 digit CS0 Hex representation of the 16-bit CRC of the original CS0 FileIdentifier.

4.2.2.1.5 UNIX

Due to the restrictions imposed by UNIX operating system environments, on the FileIdentifier associated with a file the following methodology shall be employed to handle FileIdentifier(s) under the above-mentioned operating system environment:
1. **FileIdentifier Lookup**: Upon request for a "lookUp" of a FileIdentifier, a case-sensitive comparison shall be performed.

2. **Validate FileIdentifier**: If the FileIdentifier is a valid UNIX file identifier for the current system environment then do not apply the following steps.

3. **Invalid Characters**: A FileIdentifier that contains characters considered invalid within a UNIX file name for the current system environment, or not displayable in the current environment shall have them translated into "_" (#005E). Multiple sequential invalid or non-displayable characters shall be translated into a single “_” (#005E) character. Reference the appendix on invalid characters for a complete list.

4. **Long FileIdentifier** - In the event that the number of characters constituting the FileIdentifier at this step in the process is greater than MAXNameLength (maximum name length for the specific UNIX operating system), the new FileIdentifier will consist of the first MAXNameLength-5 characters of the FileIdentifier at this step in the process.

5. **FileIdentifier CRC**: Since through the above process character information from the original FileIdentifier is lost the chance of creating a duplicate FileIdentifier in the same directory increases. To greatly reduce the chance of having a duplicate FileIdentifier the file name shall be modified to contain a CRC of the original FileIdentifier.

   If there is a file extension then the new FileIdentifier shall be composed of up to the first (MAXNameLength - (length of (new file extension) + 1 (for the ‘.’)) - 5 (for the #CRC)) characters constituting the file name at this step in the process, followed by the separator ‘#’ (#0023); followed by a 4 digit CS0 Hex representation of the 16-bit CRC of the original CS0 FileIdentifier, followed by ‘.’ (#002E) and the file extension at this step in the process.

   Otherwise if there is no file extension the new FileIdentifier shall be composed of up to the first (MAXNameLength - 5 (for the #CRC)) characters constituting the file name at this step in the process. Followed by the separator ‘#’ (#0023); followed by a 4 digit CS0 Hex representation of of the 16-bit CRC of the original CS0 FileIdentifier.
5. Informative

5.1 Descriptor Lengths

The following table summarizes the UDF limitations on the lengths of the Descriptors described in ECMA 167.

<table>
<thead>
<tr>
<th>Descriptor</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anchor Volume Descriptor Pointer</td>
<td>512</td>
</tr>
<tr>
<td>Volume Descriptor Pointer</td>
<td>512</td>
</tr>
<tr>
<td>Implementation Use Volume Descriptor</td>
<td>512</td>
</tr>
<tr>
<td>Partition Descriptor</td>
<td>512</td>
</tr>
<tr>
<td>Logical Volume Descriptor</td>
<td>no max</td>
</tr>
<tr>
<td>Unallocated Space Descriptor</td>
<td>no max</td>
</tr>
<tr>
<td>Terminating Descriptor</td>
<td>512</td>
</tr>
<tr>
<td>Logical Volume Integrity Descriptor</td>
<td>no max</td>
</tr>
<tr>
<td>File Set Descriptor</td>
<td>512</td>
</tr>
<tr>
<td>File Identifier Descriptor</td>
<td>Maximum of a Logical Block Size</td>
</tr>
<tr>
<td>Allocation Extent Descriptor</td>
<td>24</td>
</tr>
<tr>
<td>Indirect Entry</td>
<td>52</td>
</tr>
<tr>
<td>Terminal Entry</td>
<td>36</td>
</tr>
<tr>
<td>File Entry</td>
<td>Maximum of a Logical Block Size</td>
</tr>
<tr>
<td>Unallocated Space Entry</td>
<td>Maximum of a Logical Block Size</td>
</tr>
<tr>
<td>Space Bit Map Descriptor</td>
<td>no max</td>
</tr>
<tr>
<td>Partition Integrity Entry</td>
<td>N/A</td>
</tr>
</tbody>
</table>

5.2 Using Implementation Use Areas

5.2.1 Entity Identifiers

Refer to the section on Entity Identifiers defined earlier in this document.

5.2.2 Orphan Space

Orphan space may exist within a logical volume, but it is not recommended since it may be reallocated by some type of logical volume repair facility. Orphan space is defined as space that is not directly or indirectly referenced by any of the non-implementation use descriptors defined in ECMA 167.

NOTE: Any allocated extent for which the only reference resides within an implementation use field is considered orphan space.
5.3 Boot Descriptor

Please refer to the "OSTA Native Implementation Specification" document for information on the Boot Descriptor.
6. Appendices

6.1 UDF Entity Identifier Definitions

<table>
<thead>
<tr>
<th>Entity Identifier</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;OSTA UDF Compliant&quot;</td>
<td>Indicates the contents of the specified logical volume or file set is compliant with the domain defined by this document.</td>
</tr>
<tr>
<td>&quot;UDF LV Info&quot;</td>
<td>Contains additional Logical Volume identification information.</td>
</tr>
<tr>
<td>&quot;UDF FreeEASpace&quot;</td>
<td>Contains free unused space within the implementation extended attribute space.</td>
</tr>
<tr>
<td>&quot;UDF FreeAppEASpace&quot;</td>
<td>Contains free unused space within the application extended attribute space.</td>
</tr>
<tr>
<td>&quot;UDF DVD CGMS Info&quot;</td>
<td>Contains DVD Copyright Management Information</td>
</tr>
<tr>
<td>&quot;UDF OS/2 EA&quot;</td>
<td>Contains OS/2 extended attribute data.</td>
</tr>
<tr>
<td>&quot;UDF OS/2 EALength&quot;</td>
<td>Contains OS/2 extended attribute length.</td>
</tr>
<tr>
<td>&quot;UDF Mac VolumeInfo&quot;</td>
<td>Contains Macintosh volume information.</td>
</tr>
<tr>
<td>&quot;UDF Mac FinderInfo&quot;</td>
<td>Contains Macintosh finder information.</td>
</tr>
<tr>
<td>&quot;UDF Mac UniqueIDTable&quot;</td>
<td>Contains Macintosh UniqueID Table which is used to map a Unique ID to a File Entry.</td>
</tr>
<tr>
<td>&quot;UDF Mac ResourceFork&quot;</td>
<td>Contains Macintosh resource fork information.</td>
</tr>
<tr>
<td>&quot;UDF Virtual Partition&quot;</td>
<td>Describes UDF Virtual Partition</td>
</tr>
<tr>
<td>&quot;UDF Sparable Partition&quot;</td>
<td>Describes UDF Sparable Partition</td>
</tr>
<tr>
<td>&quot;UDF Virtual Alloc Tbl&quot;</td>
<td>Contains information for handling rewriting to sequentially written media.</td>
</tr>
<tr>
<td>&quot;UDF Sparing Table&quot;</td>
<td>Contains information for handling defective areas on the media</td>
</tr>
</tbody>
</table>
### 6.2 UDF Entity Identifier Values

<table>
<thead>
<tr>
<th>Entity Identifier</th>
<th>Byte Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;*OSTA UDF Compliant&quot;</td>
<td>#2A, #4F, #53, #54, #41, #20, #55, #44, #46, #20, #43, #6F, #6D, #70, #6C, #69, #61, #6E, #74</td>
</tr>
<tr>
<td>&quot;*UDF LV Info&quot;</td>
<td>#2A, #55, #44, #46, #20, #4C, #56, #20, #49, #6E, #66, #6F</td>
</tr>
<tr>
<td>&quot;*UDF FreeEASpace&quot;</td>
<td>#2A, #55, #44, #46, #20, #46, #72, #65, #65, #45, #41, #53, #70, #61, #63, #65</td>
</tr>
<tr>
<td>&quot;*UDF FreeAppEASpace&quot;</td>
<td>#2A, #55, #44, #46, #20, #46, #72, #65, #44, #46, #20, #43, #47, #4D, #53, #20, #49, #6E, #66, #6F</td>
</tr>
<tr>
<td>&quot;*UDF DVD CGMS Info&quot;</td>
<td>#2A, #55, #44, #46, #20, #44, #56, #44, #20, #43, #47, #4D, #53, #20, #49, #6E, #66, #6F</td>
</tr>
<tr>
<td>&quot;*UDF OS/2 EA&quot;</td>
<td>#2A, #55, #44, #46, #20, #45, #41, #4C, #65, #6E, #67, #74, #68</td>
</tr>
<tr>
<td>&quot;*UDF OS/2 EALength&quot;</td>
<td>#2A, #55, #44, #46, #20, #45, #41, #4C, #65, #6E, #66, #6F</td>
</tr>
<tr>
<td>&quot;*UDF Mac VolumeInfo&quot;</td>
<td>#2A, #55, #44, #46, #20, #4D, #61, #63, #20, #56, #6F, #6C, #75, #6D, #65, #49, #6E, #66, #6F</td>
</tr>
<tr>
<td>&quot;*UDF Mac FinderInfo&quot;</td>
<td>#2A, #55, #44, #46, #20, #4D, #61, #63, #20, #49, #69, #6E, #64, #65, #72, #49, #6E, #66, #6F</td>
</tr>
<tr>
<td>&quot;*UDF Mac UniqueIDTable&quot;</td>
<td>#2A, #55, #44, #46, #20, #4D, #61, #63, #20, #55, #6E, #69, #71, #75, #65, #49, #44, #54, #61, #62, #6C, #65</td>
</tr>
<tr>
<td>&quot;*UDF Mac ResourceFork&quot;</td>
<td>#2A, #55, #44, #46, #20, #4D, #61, #63, #20, #52, #65, #73, #6F, #75, #72, #63, #65, #46, #6F, #72, #6B</td>
</tr>
<tr>
<td>&quot;*UDF Virtual Partition&quot;</td>
<td>#2A, #55, #44, #46, #20, #56, #69, #72, #74, #75, #61, #6C, #20, #50, #61, #72, #74, #69, #74, #6F, #6E</td>
</tr>
<tr>
<td>&quot;*UDF Sparable Partition&quot;</td>
<td>#2A, #55, #44, #46, #20, #55, #70, #61, #72, #61, #62, #6C, #65, #20, #50, #61, #72, #74, #69, #74, #6F, #6E</td>
</tr>
<tr>
<td>&quot;*UDF Virtual Alloc Tbl&quot;</td>
<td>#2A, #55, #44, #46, #20, #56, #69, #72, #74, #75, #61, #6C, #20, #41, #6C, #6C, #6F, #63, #20, #54, #62, #6C</td>
</tr>
<tr>
<td>&quot;*UDF Sparing Table&quot;</td>
<td>#2A, #55, #44, #46, #20, #53, #70, #61, #72, #69, #6E, #67, #20, #54, #61, #62, #6C, #65</td>
</tr>
</tbody>
</table>
6.3 Operating System Identifiers
The following tables define the current allowable values for the *OS Class* and *OS Identifier* fields in the *IdentifierSuffix* of Entity Identifiers.

The *OS Class* field will identify under which class of operating system the specified descriptor was recorded. The valid values for this field are as follows:

<table>
<thead>
<tr>
<th>Value</th>
<th>Operating System Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Undefined</td>
</tr>
<tr>
<td>1</td>
<td>DOS</td>
</tr>
<tr>
<td>2</td>
<td>OS/2</td>
</tr>
<tr>
<td>3</td>
<td>Macintosh OS</td>
</tr>
<tr>
<td>4</td>
<td>UNIX</td>
</tr>
<tr>
<td>5</td>
<td>Windows 9x</td>
</tr>
<tr>
<td>6</td>
<td>Windows NT</td>
</tr>
<tr>
<td>7-255</td>
<td>Reserved</td>
</tr>
</tbody>
</table>

The *OS Identifier* field will identify under which operating system the specified descriptor was recorded. The valid values for this field are as follows:

<table>
<thead>
<tr>
<th>OS Class</th>
<th>OS Identifier</th>
<th>Operating System Identified</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Any Value</td>
<td>Undefined</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>DOS/Windows 3.x</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>OS/2</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>Macintosh OS System 7</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>UNIX - Generic</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>UNIX - IBM AIX</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>UNIX - SUN OS / Solaris</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>UNIX - HP/UX</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>UNIX - Silicon Graphics Irix</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>UNIX - Linux</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
<td>UNIX - MKLinux</td>
</tr>
<tr>
<td>4</td>
<td>7</td>
<td>UNIX - FreeBSD</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>Windows 95</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>Windows NT</td>
</tr>
</tbody>
</table>

For the most update list of values for OS Class and OS Identifier please contact OSTA and request a copy of the *UDF Entity Identifier Directory*. This directory will also contain Implementation Identifiers of ISVs who have provided the necessary information to OSTA.
6.4 OSTA Compressed Unicode Algorithm

OSTA compliant Unicode compression, uncompression routines.
Written by Jason M. Rinn.
Micro Design International gives permission for the free use of the
following source code.

```
#include <stddef.h>

typedef unsigned short unicode_t;
typedef unsigned char byte;

int UncompressUnicode(
    int numberOfBytes, /* (Input) number of bytes read from media. */
    byte *UDFCompressed, /* (Input) bytes read from media. */
    unicode_t *unicode) /* (Output) uncompressed unicode characters. */
{
    unsigned int compID;
    int returnValue, unicodeIndex, byteIndex;

    // Use UDFCompressed to store current byte being read.
    compID = UDFCompressed[0];

    // First check for valid compID.
    if (compID != 8 && compID != 16)
    {
        returnValue = -1;
    }
    else
    {
        unicodeIndex = 0;
        byteIndex = 1;

        // Loop through all the bytes.
        while (byteIndex < numberOfBytes)
        {
            if (compID == 16)
            {
                // Move the first byte to the high bits of the unicode char.
                unicode[unicodeIndex] = UDFCompressed[byteIndex++] << 8;
            }
            else
            {
                unicode[unicodeIndex] = 0;
            }
            if (byteIndex < numberOfBytes)
            {
```
/* Then the next byte to the low bits. */
unicode[unicodeIndex] |= UDFCompressed[byteIndex++];
unicodeIndex++;
returnValue = unicodeIndex;
return(returnValue);

int CompressUnicode(int numberOfChars, /* (Input) number of unicode characters. */
int compID, /* (Input) compression ID to be used. */
unicode_t *unicode, /* (Input) unicode characters to compress. */
byte *UDFCompressed) /* (Output) compressed string, as bytes. */
{
int byteIndex, unicodeIndex;
if (compID != 8 && compID != 16)
{
    byteIndex = -1; /* Unsupported compression ID ! */
} else
{
    /* Place compression code in first byte. */
    UDFCompressed[0] = compID;
    byteIndex = 1;
    unicodeIndex = 0;
    while (unicodeIndex < numberOfChars)
    {
        if (compID == 16)
        {
            /* First, place the high bits of the char * into the byte stream. */
            UDFCompressed[byteIndex++] = (unicode[unicodeIndex] & 0xFF00) >> 8;
        }
        /* Then place the low bits into the stream. */
        UDFCompressed[byteIndex++] = unicode[unicodeIndex] & 0xFF;
        unicodeIndex++;
    }
    return(byteIndex);
}

******************************************************************************
* DESCRIPTION: *
* Takes a string of unicode wide characters and returns an OSTA CS0*
* compressed unicode string. The unicode MUST be in the byte order of*
* the compiler in order to obtain correct results. Returns an error*
* if the compression ID is invalid. *
* NOTE: This routine assumes the implementation already knows, by*
* the local environment, how many bits are appropriate and*
* therefore does no checking to test if the input characters fit*
* into that number of bits or not. *
* RETURN VALUE*
* The total number of bytes in the compressed OSTA CS0 string,*
* including the compression ID. *
* A -1 is returned if the compression ID is invalid. */
int CompressUnicode
int numberOfChars, /* (Input) number of unicode characters. */
int compID, /* (Input) compression ID to be used. */
unicode_t *unicode, /* (Input) unicode characters to compress. */
byte *UDFCompressed) /* (Output) compressed string, as bytes. */
{
6.5 CRC Calculation

The following C program may be used to calculate the CRC-CCITT checksum used in the TAG descriptors of ECMA 167.

```c
/* CRC Calculation */

static unsigned short crc_table[256] = {
  0x0000, 0x1021, 0x2042, 0x3063, 0x4084, 0x50a5, 0x60c6, 0x70e7,
  0x8108, 0x9129, 0xa14a, 0xb16b, 0xc18c, 0xd1ad, 0xe1ce, 0xf1ef,
  0x02b2, 0x1293, 0x22f4, 0x32d5, 0x4236, 0x5217, 0x61f8, 0x71d9,
  0x833a, 0x931b, 0xa2f2, 0xb273, 0xc2d4, 0xd295, 0xe2f6, 0xf2d7,
  0x0498, 0x1479, 0x24d0, 0x3431, 0x44d2, 0x5433, 0x65f4, 0x7575,
  0x8656, 0x9677, 0xa5d8, 0xb539, 0xc59a, 0xd5fb, 0xe57c, 0xf55d,
  0x074e, 0x172f, 0x2760, 0x3701, 0x4762, 0x5743, 0x66a4, 0x76c5,
  0x8706, 0x9727, 0xa6a8, 0xb6e9, 0xc68a, 0xd6ca, 0xe6e2, 0xf663,
  0x0884, 0x1865, 0x28c6, 0x3827, 0x48c8, 0x58a9, 0x67e0, 0x7761,
  0x86c2, 0x96e3, 0xa5a4, 0xb5e5, 0xc5c6, 0xd507, 0xe468, 0xf429,
  0x042a, 0x140b, 0x24c2, 0x34e3, 0x44f4, 0x54d5, 0x6536, 0x7517,
  0x86f8, 0x9679, 0xa5d10, 0xb5921, 0xc5f32, 0xd5743, 0xe4d54, 0xf4965,
  0x05a7, 0x1588, 0x25e9, 0x35c0, 0x45e1, 0x5582, 0x65c3, 0x75e4,
  0x8705, 0x9726, 0xa6a7, 0xb6eb, 0xc68a, 0xd6ca, 0xe6e2, 0xf663,
  0x0744, 0x1725, 0x2766, 0x3707, 0x4768, 0x5749, 0x66a0, 0x76c1,
  0x8762, 0x9743, 0xa6c4, 0xb685, 0xc646, 0xd607, 0xe5c8, 0xf5a9,
  0x030a, 0x138b, 0x23e2, 0x33c3, 0x43e4, 0x53c5, 0x63e6, 0x73c7,
  0x84a8, 0x94c9, 0xa58a, 0xb5eb, 0xc5c2, 0xd503, 0xe464, 0xf425,
  0x0526, 0x1547, 0x25a8, 0x35c9, 0x45a0, 0x5541, 0x6582, 0x75c3,
  0x86e4, 0x9665, 0xa5c6, 0xb587, 0xc5a8, 0xd5c9, 0xe4e0, 0xf4c1,
  0x01a2, 0x1183, 0x21c4, 0x31e5, 0x41c6, 0x51e7, 0x6188, 0x71c9,
  0x83e0, 0x9381, 0xa2e2, 0xb263, 0xc204, 0xd2c5, 0xe2a6, 0xf2c7,
  0x06fa, 0x167e, 0x26df, 0x363f, 0x46f0, 0x5671, 0x66d2, 0x76f3,
  0x85f4, 0x9575, 0xa4d6, 0xb4b7, 0xc438, 0xd4f9, 0xe45a, 0xf43b,
  0x07b8, 0x1799, 0x27df, 0x373e, 0x47f0, 0x57b1, 0x67d2, 0x77f3,
  0x8634, 0x9615, 0xa576, 0xb557, 0xc518, 0xd579, 0xe53a, 0xf5b1,
  0x0000, 0x1021, 0x2042, 0x3063, 0x4084, 0x50a5, 0x60c6, 0x70e7,
  0x8108, 0x9129, 0xa14a, 0xb16b, 0xc18c, 0xd1ad, 0xe1ce, 0xf1ef,
  0x02b2, 0x1293, 0x22f4, 0x32d5, 0x4236, 0x5217, 0x61f8, 0x71d9,
  0x833a, 0x931b, 0xa2f2, 0xb273, 0xc2d4, 0xd295, 0xe2f6, 0xf2d7,
  0x0498, 0x1479, 0x24d0, 0x3431, 0x44d2, 0x5433, 0x65f4, 0x7575,
  0x8656, 0x9677, 0xa5d8, 0xb539, 0xc59a, 0xd5fb, 0xe57c, 0xf55d,
};

unsigned short cksum(s, n)
    register unsigned char *s;
    register int n;
{
    register unsigned short crc=0;
    while (n-- > 0)
        crc = crc_table[(crc>>8 ^ *s++) & 0xff] ^ (crc << 8);
    return crc;
}

#ifdef MAIN
unsigned char bytes[] = { 0x70, 0x6A, 0x77 };

main()
{
    unsigned short x;
    x = cksum(bytes, sizeof(bytes));
    printf("checksum: calculated=%4.4x, correct=%4.4x\n", x, 0x3299);
}
#endif
```

82
exit(0);
}
#endif
The CRC table in the previous listing was generated by the following program:

```c
#include <stdio.h>

/*
a.out 010041 for CRC-CCITT
*/
main(argc, argv)
int argc; char *argv[];
{
    unsigned long crc, poly;
    int n, i;
    sscanf(argv[1], "%lo", &poly);
    if(poly & 0xffff0000)
        fprintf(stderr, "polynomial is too large\n");
    printf("\n/*\n crc 0%o
 */\n", poly);
    printf("static unsigned short crc_table[256] = {\n\n");
    for(n = 0; n < 256; n++)
    {
        if(n % 8 == 0)
            printf("\n");
        crc = n << 8;
        for(i = 0; i < 8; i++)
            if(crc & 0x8000)
                crc = (crc << 1) ^ poly;
        else
            crc <<= 1;
        crc &= 0xFFFF;
    }
    printf("0x%04X\n", crc);
    else
        printf("0x%04X\n", crc);
    if(n % 8 == 7)
        printf("\n");
}
```


AT&T gives permission for the free use of the above source code.
6.6 Algorithm for Strategy Type 4096

This section describes a strategy for constructing an ICB hierarchy. For strategy type 4096 the root ICB hierarchy shall contain 1 direct entry and 1 indirect entry. To indicate that there is 1 direct entry a 1 shall be recorded as a Uint16 in the StrategyParameter field of the ICB Tag field. A value of 2 shall be recorded in the MaximumNumberOfEntries field of the ICB Tag field.

The indirect entry shall specify the address of another ICB which shall also contain 1 direct entry and 1 indirect entry, where the indirect entry specifies the address of another ICB of the same type. See the figure below:

```
NOTE: This strategy builds an ICB hierarchy that is a simple linked list of direct entries.
```
6.7 Identifier Translation Algorithms
The following sample source code examples implement the file identifier translation algorithms described in this document.

The following basic algorithms may also be used to handle OS specific translations of the VolumeIdentifier, VolumeSetIdentifier, LogicalVolumeID and FileSetID.

6.7.1 DOS Algorithm

/***********************************************
* OSTA UDF compliant file name translation routine for DOS.
* Copyright 1995 Micro Design International, Inc.
* Written by Jason M. Rinn.
* Micro Design International gives permission for the free use of the
* following source code.
*/
#include <stddef.h>
#define DOS_NAME_LEN 8
#define DOS_EXT_LEN 3
#define ILLEGAL_CHAR_MARK 0x005F
#define TRUE 1
#define FALSE 0
#define PERIOD 0x002E
#define SPACE 0x0020
/***********************************************
* The following two typedef's are to remove compiler dependancies.
* byte needs to be unsigned 8-bit, and unicode_t needs to
* be unsigned 16-bit.
*/
typedef unsigned short unicode_t;
typedef unsigned char byte;
/** *
** PROTOTYPES **/
unsigned short cksum(register unsigned char *s, register int n);
int IsIllegal(unicode_t current);
/* Define functions or macros to both determine if a character
* is printable and compute the uppercase version of a character
* under your implementation.
*/
int UnicodeIsPrint(unicode_t);
unicode_t UnicodeToUpper(unicode_t);
/***********************************************
* Translate udfName to dosName using OSTA compliant.
* dosName must be a unicode string with min length of 12.
* 
* RETURN VALUE
* Number of unicode characters in dosName.
*/
int UDFDOSName(unicode_t *dosName, /* (Output)DOS compatible name. */
    unicode_t *udfName, /* (Input) Name from UDF volume. */
    int udfLen, /* (Input) Length of UDF Name. */
    byte *fidName, /* (Input) Bytes as read from media */
    int fidNameLen)/* (Input) Number of bytes in fidName.*/
{
    int index, dosIndex = 0, extIndex = 0, lastPeriodIndex;
int needsCRC = FALSE, hasExt = FALSE, writingExt = FALSE;
unsigned short valueCRC;
unicode_t ext[DOS_EXT_LEN], current;

/* Used to convert hex digits. Used ASCII for readability. */
const char hexChar[] = "0123456789ABCDEF";

for (index = 0; index < udfLen; index++)
{
    current = udfName[index];
    current = UnicodeToUpper(current);
    if (current == PERIOD)
    {
        if (dosIndex==0 || hasExt)
        {
            /* Ignore leading periods or any other than *
             * used for extension. */
            needsCRC = TRUE;
        }
        else
        {
            /* First, find last character which is NOT a period *
             * or space. */
            lastPeriodIndex = udfLen - 1;
            while(lastPeriodIndex >= 0 &&
                  (udfName[lastPeriodIndex] == PERIOD ||
                   udfName[lastPeriodIndex] == SPACE))
            {
                lastPeriodIndex--;
            }
            /* Now search for last remaining period. */
            while(lastPeriodIndex >= 0 &&
                  udfName[lastPeriodIndex] != PERIOD)
            {
                lastPeriodIndex--;
            }
            /* See if the period we found was the last or not. */
            if (lastPeriodIndex != index)
            {
                needsCRC = TRUE; /* If not, name needs translation. */
            }
            /* As long as the period was not trailing, *
             * the file name has an extension. */
            if (lastPeriodIndex >= 0)
            {
                hasExt = TRUE;
            }
        }
    }
    else
    {
        if ((!hasExt && dosIndex == DOS_NAME_LEN) ||
            extIndex == DOS_EXT_LEN)
        {
            /* File name or extension is too long for DOS. */
            needsCRC = TRUE;
        }
        else
        {
            if (current == SPACE) /* Ignore spaces. */
needsCRC = TRUE;
}
else
{
  /* Look for illegal or unprintable characters. */
  if (IsIllegal(current) || !UnicodeIsPrint(current))
  {
    needsCRC = TRUE;
    current = ILLEGAL_CHAR_MARK;
    /* Skip illegal characters (even spaces),
    * but not periods.
    */
    while(index+1 < udfLen
      && (IsIllegal(udfName[index+1])
        || !UnicodeIsPrint(udfName[index+1]))
      && udfName[index+1] != PERIOD)
    {
      index++;
    }
  }

  /* Add current char to either file name or ext. */
  if (writingExt)
  {
    ext[extIndex++] = current;
  }
  else
  {
    dosName[dosIndex++] = current;
  }
}
/* See if we are done with file name, either because we reached
 * the end of the file name length, or the final period.
 */
if (!writingExt && hasExt && (dosIndex == DOS_NAME_LEN ||
  index == lastPeriodIndex))
{
  /* If so, and the name has an extension, start reading it. */
  writingExt = TRUE;
  /* Extension starts after last period. */
  index = lastPeriodIndex;
}
/* Now handle CRC if needed. */
if (needsCRC)
{
  /* Add CRC to end of file name or at position 4. */
  if (dosIndex >4)
  {
    dosIndex = 4;
  }
  valueCRC = cksum(fidName, fidNameLen);
  /* Convert 16-bit CRC to hex characters. */
  dosName[dosIndex++] = hexChar[(valueCRC & 0xf000) >> 12];
  dosName[dosIndex++] = hexChar[(valueCRC & 0x0f00) >> 8];
  dosName[dosIndex++] = hexChar[(valueCRC & 0x00f0) >> 4];
  dosName[dosIndex++] = hexChar[(valueCRC & 0x000f)];
}
/* Add extension, if any. */
if (extIndex != 0)
{
dosName[dosIndex++] = PERIOD;
for (index = 0; index < extIndex; index++)
{
    dosName[dosIndex++] = ext[index];
}

return(dosIndex);

/**************************************************************************/
* Decides if a Unicode character matches one of a list
* of ASCII characters.
* Used by DOS version of IsIllegal for readability, since all of the
* illegal characters above 0x0020 are in the ASCII subset of Unicode.
* Works very similarly to the standard C function strchr().
* 
* RETURN VALUE
* 
* Non-zero if the Unicode character is in the given ASCII string.
* */
int UnicodeInString(
    unsigned char *string, /* (Input) String to search through. */
    unicode_t ch) /* (Input) Unicode char to search for. */
{
    int found = FALSE;
    while (*string != '\0' && found == FALSE)
    {
        /* These types should compare, since both are unsigned numbers. */
        if (*string == ch)
        {
            found = TRUE;
        }
        string++;
    }
    return(found);
}

/**************************************************************************/
* Decides whether character passed is an illegal character for a
* DOS file name.
* 
* RETURN VALUE
* 
* Non-zero if file character is illegal.
* */
int Is Illegal(
    unicode_t ch) /* (Input) character to test. */
{
    /* Genuine illegal char's for DOS. */
    if (ch < 0x20 || UnicodeInString("\/:*?<>|", ch))
    {
        return(1);
    }
    else
    {
        return(0);
    }
}
6.7.2 OS/2, Macintosh, Windows 95, Windows NT and UNIX Algorithm

OSTA UDF compliant file name translation routine for OS/2, Windows 95, Windows NT, Macintosh and UNIX.
Copyright 1995 Micro Design International, Inc.
Written by Jason M. Rinn.
Micro Design International gives permission for the free use of the following source code.

To use these routines with different operating systems.

OS/2
Define OS2
Define MAXLEN = 254

Windows 95
Define WIN_95
Define MAXLEN = 255

Windows NT
Define WIN_NT
Define MAXLEN = 255

Macintosh:
Define MAC.
Define MAXLEN = 31.

UNIX
Define UNIX.
Define MAXLEN as specified by unix version.

#define ILLEGAL_CHAR_MARK 0x005F
#define CRC_MARK 0x0023
#define EXT_SIZE 5
#define TRUE 1
#define FALSE 0
#define PERIOD 0x002E
#define SPACE 0x0020

The following two typedef's are to remove compiler dependencies.
byte needs to be unsigned 8-bit, and unicode_t needs to be unsigned 16-bit.

typedef unsigned int unicode_t;
typedef unsigned char byte;

/** PROTOTYPES **/
int IsIllegal(unicode_t ch);
unsigned short cksum(unsigned char *s, int n);

Define a function or macro which determines if a Unicode character is printable under your implementation.

int UnicodeIsPrint(unicode_t);

Translates a long file name to one using a MAXLEN and an illegal char set in accord with the OSTA requirements. Assumes the name has already been translated to Unicode.

* RETURN VALUE
int UDFTransName(unicode_t *newName, /*(Output) Translated name. Must be of length MAXLEN*/
unicode_t *udfName, /* (Input) Name from UDF volume. */
int udfLen, /* (Input) Length of UDF Name. */
byte *fidName, /* (Input) Bytes as read from media. */
int fidNameLen) /* (Input) Number of bytes in fidName. */
{
    int index, newIndex = 0, needsCRC = FALSE;
    int extIndex, newExtIndex = 0, hasExt = FALSE;
    #ifdef (OS2 | WIN_95 | WIN_NT)
    int trailIndex = 0;
    #endif
    unsigned short valueCRC;
    unicode_t current;
    const char hexChar[] = "0123456789ABCDEF";
    for (index = 0; index < udfLen; index++)
    {
        current = udfName[index];
        if (IsIllegal(current) || !UnicodeIsPrint(current))
        {
            needsCRC = TRUE;
            /* Replace Illegal and non-displayable chars with underscore. */
            /* current = ILLEGAL_CHAR_MARK;
            /* Skip any other illegal or non-displayable characters. */
            while(index+1 < udfLen && (IsIllegal(udfName[index+1])
                || !UnicodeIsPrint(udfName[index+1])))
                index++;
        }
        /* Record position of extension, if one is found. */
        if (current == PERIOD && (udfLen - index - 1) <= EXT_SIZE)
        {
            if (udfLen == index + 1)
            {
                /* A trailing period is NOT an extension. */
                hasExt = FALSE;
            }
            else
            {
                hasExt = TRUE;
                extIndex = index;
                newExtIndex = newIndex;
            }
        }
        #ifdef (OS2 | WIN_95 | WIN_NT)
        /* Record position of last char which is NOT period or space. */
        else if (current != PERIOD && current != SPACE)
        {
            trailIndex = newIndex;
        }
        #endif
        if (newIndex < MAXLEN)
        {
            newName[newIndex++] = current;
        }
        else
        {
            needsCRC = TRUE;
        }
    }
    return needsCRC;
}
#ifdef (OS2 | WIN_95 | WIN_NT)
	/* For OS2, 95 & NT, truncate any trailing periods and\or spaces. */
	if (trailIndex != newIndex - 1)
	{
		newIndex = trailIndex + 1;
		needsCRC = TRUE;
		hasExt = FALSE; /* Trailing period does not make an extension. */
	}
#endif

if (needsCRC)
{
	unicode_t ext[EXT_SIZE];
	int localExtIndex = 0;
	if (hasExt)
	{
		int maxFilenameLen;
		/* Translate extension, and store it in ext. */
		for(index = 0; index<EXT_SIZE && extIndex + index +1 < udfLen;
	index++)
	{
		current = udfName[extIndex + index + 1];
		if (IsIllegal(current) || !isprint(current))
		{
		needsCRC = 1;
		/* Replace Illegal and non-displayable chars
		* with underscore.
		*/
		current = ILLEGAL_CHAR_MARK;
		/* Skip any other illegal or non-displayable
		* characters.
		*/
		while(index + 1 < EXT_SIZE
		&& (IsIllegal(udfName[extIndex + index + 2]))
		|| !isprint(udfName[extIndex + index + 2])))
		{
		index++;
		}
		}
		ext[localExtIndex++] = current;
	}
	/* Truncate filename to leave room for extension and CRC. */
	maxFilenameLen = ((MAXLEN - 4) - localExtIndex - 1);
	if (newIndex > maxFilenameLen)
	{
		newIndex = maxFilenameLen;
	}
	else
	{
		newIndex = newExtIndex;
	}
	else if (newIndex > MAXLEN - 5)
	{
	/*If no extension, make sure to leave room for CRC. */
		newIndex = MAXLEN - 5;
	}
	newName[newIndex++] = CRC_MARK; /* Add mark for CRC. */
	/*Calculate CRC from original filename from FileIdentifier. */
	valueCRC = cksum(fidName, fidNameLen);
	/* Convert 16-bits of CRC to hex characters. */
	newName[newIndex++] = hexChar[(valueCRC & 0xf000) >> 12];
	newName[newIndex++] = hexChar[(valueCRC & 0x0f00) >> 8];
	newName[newIndex++] = hexChar[(valueCRC & 0x00f0) >> 4];
newName[newIndex++] = hexChar[(valueCRC & 0x000f)];

/* Place a translated extension at end, if found. */
if (hasExt)
{
    newName[newIndex++] = PERIOD;
    for (index = 0; index < localExtIndex; index++)
    {
        newName[newIndex++] = ext[index];
    }
}
return(newIndex);

#ifdef (OS2 | WIN_95 | WIN_NT)
/***************************************************************/
/* Decides if a Unicode character matches one of a list */
/* of ASCII characters. */
/* Used by OS2 version of IsIllegal for readability, since all of the */
/* illegal characters above 0x0020 are in the ASCII subset of Unicode. */
/* Works very similarly to the standard C function strchr(). */
/* */
/* RETURN VALUE */
/* Non-zero if the Unicode character is in the given ASCII string. */

int UnicodeInString(
    unsigned char *string,    /* (Input) String to search through. */
    unicode_t ch)             /* (Input) Unicode char to search for. */
{
    int found = FALSE;
    while (*string != '\0' && found == FALSE)
    {
        /* These types should compare, since both are unsigned numbers. */
        if (*string == ch)
        {
            found = TRUE;
        }
        string++;
    }
    return(found);
}
#endif /* OS2 */
/***************************************************************/
/* Decides whether the given character is illegal for a given OS. */
/* */
/* RETURN VALUE */
/* Non-zero if char is illegal. */

int IsIllegal(unicode_t ch)
{
#ifdef MAC
    /* Only illegal character on the MAC is the colon. */
    if (ch == 0x003A)
    {
        return(1);
    }
    else
    {
        return(0);
    }
#else defined UNIX
    /* Illegal UNIX characters are NULL and slash. */
    if (ch == 0x0000 || ch == 0x002F)
    {  

93
{  
    return(1);
}
else
{
    return(0);
}

#elif defined (OS2 | WIN_95 | WIN_NT)
/* Illegal char's for OS/2 according to WARP toolkit. */
if (ch < 0x0020 || UnicodeInString("\":?<>|", ch))
{  
    return(1);
}
else
{
    return(0);
}
#endif
6.8 Extended Attribute Checksum Algorithm

/*
 * Calculates a 16-bit checksum of the Implementation Use
 * Extended Attribute header. The fields AttributeType
 * through ImplementationIdentifier inclusively represent the
 * data covered by the checksum (48 bytes).
 */

Uint16 ComputeEAChecksum(byte *data)
{
    Uint16 checksum = 0;
    Uint count;

    for( count = 0; count < 48; count++)
    {
        checksum += *data++;
    }

    return(checksum);
}
6.9 Requirements for DVD-ROM
This appendix defines the requirements and restrictions for UDF formatted DVD-ROM discs.

- DVD-ROM discs shall be mastered with the UDF file system
- DVD-ROM discs shall consist of a single volume and a single partition.

**NOTE:** The disc may also include the ISO 9660 file system. If the disc contains both UDF and ISO 9660 file systems it shall be known as a *UDF Bridge* disc. This *UDF Bridge* disc will allow playing DVD-ROM media in computers which may only support ISO 9660. As UDF computer implementations are provided, the need for ISO 9660 will disappear, and future discs should contain only UDF.

6.9.1 Constraints imposed by UDF for DVD-Video
This section describes the restrictions and requirements for UDF formatted DVD-Video discs for dedicated DVD content players. DVD-Video is one specific application of DVD-ROM using the UDF format for the home consumer market. Due to limited computing resources within a DVD player, restrictions and requirements were created so that a DVD player would not have to support every feature of the UDF specification.

All DVD-Video discs shall be mastered to contain all required data as specified by ECMA 167 and UDF. This will ease playing of DVD-Video in computer systems. Examples of such data include the time, date, permission bits, and a free space map (indicating no free space). While DVD player implementations may ignore these fields, a UDF computer system implementation will not. Both entertainment-based and computer-based content can reside on the same disc.

In an attempt to reduce code size and improve performance, all division described is integer arithmetic; all denominators shall be $2^n$, such that all divisions may be carried out via logical shift operations.

- A DVD player shall only support UDF and not ISO 9660.
- Originating systems shall constrain individual files to be less than or equal to $2^{30} - \text{Logical Block Size}$ bytes in length.
- The data of each file shall be recorded as a single extent. Each File Entry shall be recorded using the ICB Strategy Type 4.
- File and directory names shall be compressed as 8 bits per character using OSTA Compressed Unicode format.
• A DVD player shall not be required to follow symbolic links to any files.

• The DVD-Video files shall be stored in a subdirectory named "VIDEO_TS" directly under the root directory. Directory names are standardized in the DVD Specifications for Read-Only Disc document.

  **NOTE:** The DVD Specifications for Read-Only Disc is a document, developed by the DVD Consortium, that describes the names of all DVD-Video files and a DVD-Video directory which will be stored on the media, and additionally describes the contents of the DVD-Video files.

• The file named "VIDEO_TS.IFO" in the VIDEO_TS subdirectory shall be read first.

All the above constraints apply only to the directory and files which the DVD player needs to access. There may be other files and directories on the media which are not intended for the DVD player and do not meet the above listed constraints. These other files and directories are ignored by the DVD player. This is what enables the ability to have both entertainment-based and computer-based content on the same disc.

6.9.2 How to read a UDF disc
This section describes the basic procedures that a DVD player would go through to read a UDF formatted DVD-Video disc.

6.9.2.1 Step 1. Volume Recognition Sequence
Find an ECMA 167 Descriptor in a volume recognition area which shall start at logical sector 16.

6.9.2.2 Step 2. Anchor Volume Descriptor Pointer
The Anchor Volume Descriptor Pointer which is located at an anchor point must be found. Duplicate anchor points shall be recorded at logical sector 256 and logical sector n, where n is the highest numbered logical sector on the disc.

A DVD player only needs to look at logical sector 256; the copy at logical sector n is redundant and only needed for defect tolerance. The Anchor Volume Descriptor Pointer contains three things of interest:

1. Static structures that may be used to identify and verify integrity of the disc.
2. Location of the Main Volume Descriptor Sequence (absolute logical sector number)
3. Length of the Main Volume Descriptor Sequence (bytes)

The data located in bytes 0-3 and 5 of the Anchor Volume Descriptor Pointer may be used for format verification if desired. Verifying the checksum in byte 4 and CRC in bytes 8-11 are good additional verifications to perform. MVDS_Location and MVDS_Length are read from this structure.
6.9.2.3 Step 3. Volume Descriptor Sequence

Read logical sectors:

\[
\text{MVDS\_Location through MVDS\_Location + (MVDS\_Length - 1) / SectorSize}
\]

The logical sector size shall be 2048 bytes for DVD media. If this sequence can not be read, a Reserve Volume Descriptor Sequence should be read.

The Partition Descriptor shall be a descriptor with a tag identifier of 5. The partition number and partition location shall be recorded in logical sector number.

Partition\_Location and Partition\_Length are obtained from this structure.

The Logical Volume Descriptor shall be a descriptor with a tag identifier of 6. The location and length of the File Set Descriptor shall be recorded in logical block number.

FSD\_Location, and FSD\_Length are returned from this structure.

6.9.2.4 Step 4. File Set Descriptor

The File Set Descriptor is located at logical sector numbers:

\[
\text{Partition\_Location + FSD\_Location through Partition\_Location + FSD\_Location + (FSD\_Length - 1) / BlockSize}
\]

RootDir\_Location and RootDir\_Length shall be read from the File Set Descriptor in logical block number.

6.9.2.5 Step 5. Root Directory File Entry

RootDir\_Location and RootDir\_Length define the location of a File Entry. The File Entry describes the data space and permissions of the root directory.

The location and length of the Root Directory is returned.

6.9.2.6 Step 6. Root Directory

Parse the data in the root directory extent to find the VIDEO_TS subdirectory.

Find the VIDEO_TS File Identifier Descriptor. The name shall be in 8 bit compressed UDF format. Verify that VIDEO_TS is a directory.

Read the File Identifier Descriptor and find the location and length of a File Entry describing the VIDEO_TS directory.

6.9.2.7 Step 7. File Entry of VIDEO_TS

The File Entry found in the step above describes the data space and permissions of the VIDEO_TS directory.
The location and length of the VIDEO_TS directory is returned.

6.9.2.8 Step 8. VIDEO_TS directory
The extent found in the step above contains sets of File Identifier Descriptors. In this pass, verify that the entry points to a file and is named VIDEO_TS.IFO.

6.9.2.9 Step 9. File Entry of VIDEO_TS.IFO
The File Entry found in the step above describes the data space and permissions of the VIDEO_TS.IFO file.

The location and length of the VIDEO_TS.IFO file is returned.

Further files can be found in the same manner as the VIDEO_TS.IFO file when needed.
6.10 Recommendations for CD Media
CD Media (CD-R and CD-RW) requires special consideration due to its nature. CD was originally designed for read-only applications which affects the way in which it is written. The following guidelines are established to ensure interchange.

The VAT may be located by using READ TRACK INFORMATION (for unfinished media) or READ TOC or READ CD RECORDED CAPACITY for finished media. See X3T10-1048D (SCSI-3 Multi Media Commands).

Each file and directory shall be described by a single direct ICB. The ICB should be written after the file data to allow for data underruns during writing, which will cause logical gaps in the file data. The ICB can be written afterward which will correctly identify all extents of the file data. The ICB shall be written in the data track, the file system track (if it exists), or both.

6.10.1 Use of UDF on CD-R media
ECMA 167 requires an Anchor Volume Descriptor Pointer (AVDP) at sector 256 and either $N$ or $(N - 256)$, where $n$ is the last recorded Physical Address on the media. UDF requires that the AVDP be recorded at both sector 256 and sector $(N - 256)$ when each session is closed. The file system may be in an intermediate state before closing and still be interchangeable, but not strictly in compliance with ECMA 167. In the intermediate state, only one AVDP exists. It should exist at sector 256, but if this is not possible due to a track reservation, it shall exist at sector 512.

Implementations should place file system control structures into virtual space and file data into real space. Reader implementations may cache the entire VAT; the size of the VAT should be considered by any UDF originating software. Computer based implementations are expected to handle VAT sizes of at least 64K bytes; dedicated player implementations may handle only smaller sizes.

6.10.1.1 Requirements
- Writing shall use Mode 1 or Mode 2 Form 1 sectors. On one disc, either Mode 1 or Mode 2 Form 1 shall be used; a mixture of Mode 1 and Mode 2 Form 1 sectors on one disc is not allowed.
- If Mode 2 Form 1 is used, then the subheader bytes of all sectors used by the user data files and by the UDF structures shall have the following value:

  - File number = 0
  - Channel number = 0
  - Submode = 08h
  - Coding information = 0
• An intermediate state is allowed on CD-R media in which only one AVDP is recorded; this single AVDP shall be at sector 256 or sector 512 and according to the multisession rules below.

• Sequential file system writing shall be performed with variable packet writing. This allows maximum space efficiency for large and small updates. Variable packet writing is more compatible with CD-ROM drives as current models do not support method 2 addressing required by fixed packets.

• The Logical Volume Integrity descriptor shall be recorded and the volume marked as open. Logical volume integrity can be verified by finding the VAT ICB at the last recorded Physical Address. If the VAT ICB is present, the volume is clean; otherwise it is dirty.

• The Partition Header descriptor, if recorded, shall specify no Unallocated Space Table, no Unallocated Space Bitmap, no Partition Integrity Table, no Freed Space Table, and no Freed Space Bitmap. The drive is capable of reporting free space directly, eliminating the need for a separate descriptor.

• Each surface shall contain 0 or 1 read only partitions, 0 or 1 write once partitions, and 0 or 1 virtual partitions. CD media should contain 1 write once partition and 1 virtual partition.

6.10.1.2 “Bridge” formats
ISO 9660 requires a Primary Volume Descriptor (PVD) at sector 16. If an ISO 9660 file system is desired, it may contain references to the same files as those referenced by ECMA 167 structures, or reference a different set of files, or a combination of the two.

It is assumed that early implementations will record some ISO 9660 structures but that as implementations of UDF become available, the need for ISO 9660 structures will decrease.

If an ISO 9660 bridge disc contains Mode 2 Form 1 sectors, then the CD-ROM XA extensions of ISO 9660 must be used.

6.10.1.3 End of session data
A session is closed to enable reading by CD-ROM drives. The last complete session on the disc shall conform completely to ECMA 167 and have two AVDPs recorded. This shall be accomplished by writing data according to End of session data table below. Although not shown in the following example, the data may be written in multiple packets.
<table>
<thead>
<tr>
<th>Count</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Anchor Volume Descriptor Pointer</td>
</tr>
<tr>
<td>255</td>
<td>Implementation specific. May contain user data, file system structures, and/or link areas.</td>
</tr>
<tr>
<td>1</td>
<td>VAT ICB.</td>
</tr>
</tbody>
</table>

The implementation specific data may contain repeated copies of the VAT and VAT ICB. Compatibility with drives that do not accurately report the location of the last sector will be enhanced. Implementations shall ensure that enough space is available to record the end of session data. Recording the end of session data brings a volume into compliance with ECMA 167.

### 6.10.2 Use of UDF on CD-RW media

CD-RW media is randomly readable and block writable. This means that while any individual sector may be read, writing must occur in blocks containing multiple sectors. CD-RW systems do not provide for sparing of bad areas. Writing rules and sparing mechanisms have been defined.

#### 6.10.2.1 Requirements

- Writing which conforms to this section of the standard shall be performed using fixed length packets.

- Writing shall be performed using Mode 1 or Mode 2, Form 1 sectors. On one disc, either Mode 1 or Mode 2 Form 1 shall be used.

- If Mode 2 Form 1 is used, then the subheader bytes of all sectors used by the user data files and by the UDF structures shall have the following value:

  File number = 0  
  Channel number = 0  
  Submode = 08h  
  Coding information = 0
• The host shall perform read/modify/write to enable the apparent writing of single 2K sectors.

• The packet length shall be set when the disc is formatted. The packet length shall be 32 sectors (64 KB).

• The host shall maintain a list of defects on the disc using a Non-Allocatable Space List (see 2.3.13).

• Sparing shall be managed by the host via the sparable partition and a sparing table.

• Discs shall be formatted prior to use.

6.10.2.2 Formatting
Formatting shall consist of writing a lead-in, user data area, and lead-out. These areas may be written in any order. This physical format may be followed by a verification pass. Defects found during the verification pass shall be enumerated in the Non-Allocatable Space list (2.3.13). Finally, file system root structures shall be recorded. These mandatory file system and root structures include the Volume Recognition Sequence, Anchor Volume Descriptor Pointers, a Volume Descriptor Sequence, a File Set Descriptor and a Root Directory.

The Anchor Volume Descriptor Pointers shall be recorded at sectors 256 and N - 256, where N is the Physical Address of the last addressable sector.

Allocation for sparing shall occur during the format process. The sparing allocation may be zero in length.

The free space descriptors shall be recorded and shall reflect space allocated to defective areas and sector sparing areas.

The format may include all available space on the medium. However, if requested by the user, a subset may be formatted to save formatting time. That smaller format may be later “grown” to the full available space.
6.10.2.3 Growing the Format
If the medium is partially formatted, it may be later grown to a larger size. This operation consists of:

- Optionally erase the lead-in of the last session.
- Optionally erase the lead-out of the last session.
- Write packets beginning immediately after the last previously recorded packet.
- Update the sparing table to reflect any new spare areas
- Adjust the partition map as appropriate
- Update the free space map to show new available area
- Move the last AVDP to the new N - 256
- Write the lead-in (which reflects the new track size)
- Write the lead-out

6.10.2.4 Host Based Defect Management
The host shall perform defect management operations. The CD format was defined without any defect management; to be compatible with existing technology and components, the host must manage defects. There are two levels of defect management: Marking bad sectors at format time and on-line sparing. The host shall keep the tables on the media current.

6.10.2.5 Read Modify Write Operation
CD-RW media requires large writable units, as each unit incurs a 14KB overhead. The file system requires a 2KB writable unit. The difference in write sizes is handled by a read-modify-write operation by the host. An entire packet is read, the appropriate portions are modified, and the entire packet written to the CD. Note that packets may not be aligned to 32 sector boundaries.

6.10.2.6 Levels of Compliance
6.10.2.6.1 Level 1
The disc shall be formatted with exactly one lead-in, program area, and lead-out. The program area shall contain exactly one track. The start of the partition shall be on a packet boundary. The partition length shall be an integral multiple of the packet size.

6.10.2.6.2 Level 2
The last session shall contain the UDF file system. All prior sessions shall be contained in one read-only partition.
6.10.2.6.3 Level 3
No restrictions shall apply.

6.10.3 Multisession and Mixed Mode
The Volume Recognition Sequence and Anchor Volume Descriptor Pointer locations are specified by ECMA 167 to be at a location relative to the beginning of the disc. The beginning of a disc shall be determined from a base address $S$ for the purposes of finding the VRS and AVDP.

‘$S$’ is the Physical Address of the first data sector in the first recorded data track in the last existent session of the volume. ‘$S$’ is the same value currently used in multisession ISO 9660 recording. The first track in the session shall be a data track.

‘$N$’ is the physical sector number of the last recorded data sector on a disc. If random write mode is used, the media may be formatted with zero or one audio sessions followed by exactly one writable data session containing one track. Other session configurations are possible but not described here. There shall be no more than one writable partition or session at one time, and this session shall be the last session on the disc.

6.10.3.1 Volume Recognition Sequence
The following descriptions are added to UDF (see also ECMA 167 Part 2) in order to handle a multisession disc.

- The volume recognition area of the UDF Bridge format shall be the part of the volume space starting at sector $S + 16$.
- The volume recognition space shall end in the track in which it begins. As a result of this definition, the volume recognition area always exists in the last session of a disc.
- When recorded in Random Access mode, a duplicate Volume Recognition Sequence shall be recorded beginning at sector $N - 256$.

6.10.3.2 Anchor Volume Descriptor Pointer
Anchor Volume Descriptor Pointers (AVDP) shall be recorded at the following logical sector numbers: $S + 256$ and $N - 256$. The AVDP at sector $N - 256$ shall be recorded before closing a session; it may not be recorded while a session is open.

6.10.3.3 UDF Bridge format
The UDF Bridge format allows UDF to be added to a disc that may contain another file system. A UDF Bridge disc shall contain a UDF file system in its last session. The last session shall follow the rules described in “Multisession and Mixed Mode” section above. The disc may contain sessions that are based on ISO 9660, audio, vendor unique, or a combination of file systems. The UDF Bridge format allows CD enhanced discs to be created.
The UDF session may contain pointers to data in other sessions, pointers to data only within the UDF session, or a combination of both. Some examples of UDF Bridge discs are shown below.

**Multisession UDF disc**

Access to LSN=16+x Access to LSN=256

First Session

Access to LSN=256 Access to LSN=16+x

1st Recorded Track in the last session

: Volume recognition area

: Anchor point

**CD enhanced disc**

1st session 2nd session

UDF Session

Playable by conventional CD-Player Used by UDF
ISO 9660 converted to UDF

1st session | 2nd session | 3rd session
---|---|---
9660 Session | 9660 Session | UDF Session

Written by conventional 9660 formatter software

Managed by UDF

Foreign format converted to UDF

1st session | 2nd session | 3rd session
---|---|---
Data Session | Data Session | UDF Session

Written by another file system

Managed by UDF
7. UDF 1.50 ERRATA

7.1 Addition to sequentially written file systems

Description:
Sequential File Systems in UDF 1.5 are missing some information that Random-Access File Systems provide: the current volume name and the number of files & directories on the volume. This information is added to the VAT File Entry in an optional Extended Attribute.

Change:
Add the following paragraph:

3.3.4.5.1.3 Logical Volume Extended Information

The LVExtensionEA is stored only in VAT File Entries. It is optional. It shall only be used on UDF 1.5 compliant media, not on UDF 2.0 or later (UDF 2.0 provides already a different solution).

This extended attribute shall be stored as an Implementation Use Extended Attribute whose ImplementationIdentifier shall be set to:

\[**UDF VAT LVExtension**\]

<table>
<thead>
<tr>
<th>RBP</th>
<th>Length</th>
<th>Name</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2</td>
<td>Header Checksum</td>
<td>Uint16</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>Verification ID</td>
<td>Uint64</td>
</tr>
<tr>
<td>10</td>
<td>4</td>
<td>Number Of Files</td>
<td>Uint32</td>
</tr>
<tr>
<td>14</td>
<td>4</td>
<td>Number Of Directories</td>
<td>Uint32</td>
</tr>
<tr>
<td>18</td>
<td>128</td>
<td>Logical Volume Identifier</td>
<td>dstring</td>
</tr>
</tbody>
</table>

*Verification ID* – When writing this EA, a copy of the Unique ID field in the VAT ICB’s File Entry shall be stored here. When reading, this value helps identifying whether the values in Number Of Files & Directories are accurate: Only when this field is identical to the Unique ID field, those values are valid, otherwise the reader shall assume that the fields are invalid. The values shall only be updated when the Number of Files & Directories is known, otherwise these values shall not be modified or all filled with zero bytes.

*Number Of Files* – Same as in 2.2.6.4

*Number Of Directories* – Same as in 2.2.6.4

*Logical Volume Identifier* – Specifies the current logical volume name as assigned by the user. This name can be different from the L.V.I. in both the LVD and the FSD. When it is different, this value precedes the other values.
7.2 Correction for “Non-Allocatable Space” file

Description:
Name for sparing file “Non-Allocatable Space” has wrong translation in representation (In 2.3.13 in UDF 1.5)

Change:
In 2.3.13, replace the text
(#4E,#6F,#6E,#2D,#41,#6C,#6F,#61,#74,#61,#62,#6C,#65,#20,#70,#61,#63,#65)
with
(#4E,#6F,#6E,#2D,#41,#6C,#6F,#61,#74,#61,#62,#6C,#65,#20,#53,#70,#61,#63,#65)
7.3 Correction for processing permissions

Description:
The Attribute and Delete permissions should be changed from Enforce to Ignore for UNIX.

Change:
In section 3.3.3.3, replace

<table>
<thead>
<tr>
<th>Attribute</th>
<th>directory</th>
<th>The file's permissions may be changed.</th>
<th>E</th>
<th>E</th>
<th>E</th>
<th>E</th>
<th>E</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attribute</td>
<td>directory</td>
<td>The directory's permissions may be changed.</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
</tr>
<tr>
<td>Delete</td>
<td>file</td>
<td>The file may be deleted.</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
</tr>
<tr>
<td>Delete</td>
<td>directory</td>
<td>The directory may be deleted.</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
</tr>
</tbody>
</table>

With

<table>
<thead>
<tr>
<th>Attribute</th>
<th>directory</th>
<th>The file's permissions may be changed.</th>
<th>E</th>
<th>E</th>
<th>E</th>
<th>E</th>
<th>E</th>
<th>I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attribute</td>
<td>directory</td>
<td>The directory's permissions may be changed.</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>I</td>
</tr>
<tr>
<td>Delete</td>
<td>file</td>
<td>The file may be deleted.</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>I</td>
</tr>
<tr>
<td>Delete</td>
<td>directory</td>
<td>The directory may be deleted.</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>I</td>
</tr>
</tbody>
</table>
7.4 Sparing Packet Length errata

Description:
The Sparing Packet Length is equal to a fixed value being 32, see 2.2.9. The value of 32
must be allowed for all media in order to avoid that existing UDF implementations are
broken while they are according to the current UDF 1.50 and 2.00 specification.

Changes:
In 2.2.9, table "Layout of Type 2 partition map for separable partition"
replace:

<table>
<thead>
<tr>
<th>Packet Length</th>
<th>Uint16 = 32</th>
</tr>
</thead>
</table>

by:

<table>
<thead>
<tr>
<th>Packet Length</th>
<th>Uint16</th>
</tr>
</thead>
</table>

and below the table replace:

- Packet Length = the number of user data blocks per fixed packet. Shall be set
to 32.

by:

Packet Length = the number of user data blocks per sparing packet. Shall be
set to 32. The sole exception is that some implementations may use
16 for DVD media but this may reduce compatibility. When 32 is
used for DVD, then 2 ECC blocks are spared together using one
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<table>
<thead>
<tr>
<th>Filename</th>
<th>Description</th>
<th>Num. of Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>UNICODE.C</td>
<td>Unicode sample source code</td>
<td>2</td>
</tr>
<tr>
<td>DOSNAME.C</td>
<td>UDF DOS filename translation</td>
<td>4</td>
</tr>
<tr>
<td>UDFTRANS.C</td>
<td>UDF OS/2, Macintosh and UNIX filename translation</td>
<td>5</td>
</tr>
<tr>
<td>FILE_ID.DIZ</td>
<td>BBS Description file</td>
<td>1</td>
</tr>
</tbody>
</table>
#include <stddef.h>

typedef unsigned short unicode_t;
typedef unsigned char byte;

int UncompressUnicode(
    int numberOfBytes, /* (Input) number of bytes read from media. */
    byte *UDFCompressed, /* (Input) bytes read from media. */
    unicode_t *unicode) /* (Output) uncompressed unicode characters. */
{
    unsigned int compID;
    int returnValue, unicodeIndex, byteIndex;

    /* Use UDFCompressed to store current byte being read. */
    compID = UDFCompressed[0];

    /* First check for valid compID. */
    if (compID != 8 && compID != 16)
    {
        returnValue = -1;
    }
    else
    {
        unicodeIndex = 0;
        byteIndex = 1;

        /* Loop through all the bytes. */
        while (byteIndex < numberOfBytes)
        {
            if (compID == 16)
            {
                /*Move the first byte to the high bits of the unicode char. */
                unicode[unicodeIndex] = UDFCompressed[byteIndex++] << 8;
            }
            else
            {
                /*Then the next byte to the low bits. */
                unicode[unicodeIndex] |= UDFCompressed[byteIndex++];
            }
        }
    }

    return returnValue;
}
extern

int CompressUnicode(
    int numberOfChars, /* (Input) number of unicode characters. */
    int compID, /* (Input) compression ID to be used. */
    unicode_t *unicode, /* (Input) unicode characters to compress. */
    byte *UDFCompressed) /* (Output) compressed string, as bytes. */
{
    int byteIndex, unicodeIndex;
    if (compID != 8 && compID != 16)
    {
        byteIndex = -1; /* Unsupported compression ID ! */
    } else
    {
        /* Place compression code in first byte. */
        UDFCompressed[0] = compID;

        byteIndex = 1;
        unicodeIndex = 0;
        while (unicodeIndex < numberOfChars)
        {
            if (compID == 16)
            {
                /*First, place the high bits of the char into the byte stream. */
                UDFCompressed[byteIndex++] = (unicode[unicodeIndex] & 0xFF00) >> 8;
            }
            /*Then place the low bits into the stream. */
            UDFCompressed[byteIndex++] = unicode[unicodeIndex] & 0x00FF;
            unicodeIndex++;
        }
    }
    return(byteIndex);
}
#include <stddef.h>
#define DOS_NAME_LEN 8
#define DOS_EXT_LEN 3
#define ILLEGAL_CHAR_MARK 0x005F
#define CRC_MARK 0x0023
#define TRUE 1
#define FALSE 0
#define PERIOD 0x002E
#define SPACE 0x0020

/* The following two typedef's are to remove compiler dependencies.
 * byte needs to be unsigned 8-bit, and unicode_t needs to be unsigned 16-bit.
 */
typedef unsigned short unicode_t;
typedef unsigned char byte;

/** PROTOTYPES **/
unsigned short cksum(register unsigned char *s, register int n);
int IsIllegal(unicode_t current);

// Define functions or macros to both determine if a character is printable
// and compute the uppercase version of a character under your implementation.
int UnicodeIsPrint(unicode_t);
unicode_t UnicodeToUpper(unicode_t);

/*/ OSTA UDF compliant file name translation routine for DOS.
* Copyright 1995 Micro Design International, Inc.
* Written by Jason M. Rinn.
* Micro Design International gives permission for the free use of the
* following source code.
*/

int UDFDOSName(
    unicode_t *dosName, /* (Output) DOS compatible name. */
    unicode_t *udfName, /* (Input) Name from UDF volume. */
    int udfLen, /* (Input) Length of UDF Name. */
    byte *fidName, /* (Input) Bytes as read from media. */
    int fidNameLen) /* (Input) Number of bytes in fidName. */
{
    int index, dosIndex = 0, extIndex = 0, lastPeriodIndex;
    int needsCRC = FALSE, hasExt = FALSE, writingExt = FALSE;
    unsigned short valueCRC;
    unicode_t ext[DOS_EXT_LEN], current;

    /* Used to convert hex digits. Used ASCII for readability. */
    const char hexChar[] = "0123456789ABCDEF";

    for (index = 0; index < udfLen; index++)
    {
        current = udfName[index];
        current = UnicodeToUpper(current);
        if (current == ILLEGAL_CHAR_MARK)
            needsCRC = TRUE;
        else if (current == PERIOD)
if (current == PERIOD) {
  if (dosIndex==0 || hasExt) {
    /* Ignore leading periods or any other than used for extension. */
    needsCRC = TRUE;
  } else {
    /* First, find last character which is NOT a period or space. */
    lastPeriodIndex = udfLen - 1;
    while (lastPeriodIndex >= 0 && (udfName[lastPeriodIndex] == PERIOD || udfName[lastPeriodIndex] == SPACE)) {
      lastPeriodIndex--;
    }
    /* Now search for last remaining period. */
    while (lastPeriodIndex >= 0 && udfName[lastPeriodIndex] != PERIOD) {
      lastPeriodIndex--;
    }
    /* See if the period we found was the last or not. */
    if (lastPeriodIndex != index) {
      needsCRC = TRUE; /* If not, name needs translation. */
    }
    /* As long as the period was not trailing, */
    /* the file name has an extension. */
    if (lastPeriodIndex >= 0) {
      hasExt = TRUE;
    }
  }
} else {
  if ((!hasExt && dosIndex == DOS_NAME_LEN) || extIndex == DOS_EXT_LEN) {
    /* File name or extension is too long for DOS. */
    needsCRC = TRUE;
  } else {
    if (current == SPACE) /* Ignore spaces. */ {
      needsCRC = TRUE;
    } else {
      /* Look for illegal or unprintable characters. */
      if (IsIllegal(current) || !UnicodeIsPrint(current)) {
        needsCRC = TRUE;
        current = ILLEGAL_CHAR_MARK;
        /* Skip Illegal characters(even spaces), but not periods. */
        while(index+1 < udfLen
&& (IsIllegal(udfName[index+1])
    || !UnicodeIsPrint(udfName[index+1]))
    && udfName[index+1] != PERIOD)
{
    index++;}

/* Add current char to either file name or ext. */
if (writingExt)
{
    ext[extIndex++] = current;
}
else
{
    dosName[dosIndex++] = current;
}
}

/* See if we are done with file name, either because we reached *
* the end of the file name length, or the final period. */
if (!writingExt && hasExt && (dosIndex == DOS_NAME_LEN ||
    index == lastPeriodIndex))
{
    /* If so, and the name has an extension, start reading it. */
    writingExt = TRUE;
    /* Extension starts after last period. */
    index = lastPeriodIndex;
}

/*Now handle CRC if needed. */
if (needsCRC)
{
    /* Add CRC to end of file name or at position 4. */
    if (dosIndex > 4)
    {
        dosIndex = 4;
    }

    dosName[dosIndex++] = CRC_MARK;

    valueCRC = cksum(fidName, fidNameLen);

    /* Convert lower 12-bits of CRC to hex characters. */
    dosName[dosIndex++] = hexChar[(valueCRC & 0x0f00) >> 8];
    dosName[dosIndex++] = hexChar[(valueCRC & 0x00f0) >> 4];
    dosName[dosIndex++] = hexChar[(valueCRC & 0x000f)];
}

/* Add extension, if any. */
if (extIndex != 0)
{
    dosName[dosIndex++] = PERIOD;
    for (index = 0; index < extIndex; index++)
    {
        dosName[dosIndex++] = ext[index];
    }
}

return(dosIndex);
int UnicodeInString(  unsigned char *string, /* (Input) String to search through. */  unicode_t ch) /* (Input) Unicode char to search for. */  
{ 
    int found = FALSE; 
    while (*string != '\0' && found == FALSE) 
    { 
        /* These types should compare, since both are unsigned numbers. */ 
        if (*string == ch) 
        { 
            found = TRUE; 
        } 
        string++; 
    } 
    return(found); 
} 

int IsIllegal(  unicode_t ch) /* (Input) character to test. */  
{ 
    /* Genuine illegal char's for DOS. */ 
    if (ch < 0x20 || UnicodeInString("\/:*?"<>", ch)) 
    { 
        return(1); 
    } 
    else 
    { 
        return(0); 
    } 
}
OSTA UDF compliant file name translation routine for OS/2,
Windows 95, Windows NT, Macintosh and UNIX.
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Written by Jason M. Rinn.
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following source code.

To use these routines with different operating systems.

OS/2
Define OS2
Define MAXLEN = 254

Windows 95
Define WIN 95
Define MAXLEN = 255

Windows NT
Define WIN_NT
Define MAXLEN = 255

Macintosh:
Define MAC.
Define MAXLEN = 31.

UNIX
Define UNIX.
Define MAXLEN as specified by unix version.

#define ILLEGAL_CHAR_MARK 0x005F
#define CRC_MARK 0x0023
#define EXT_SIZE 5
#define TRUE 1
#define FALSE 0
#define PERIOD 0x002E
#define SPACE 0x0020

The following two typedef's are to remove compiler dependancies.
byte needs to be unsigned 8-bit, and unicode_t needs to
be unsigned 16-bit.

typedef unsigned int unicode_t;
typedef unsigned char byte;

int IsIllegal(unicode_t ch);
unsigned short cksum(unsigned char *s, int n);

Define a function or macro which determines if a Unicode character is
printable under your implementation.

int UnicodeIsPrint(unicode_t);

Translates a long file name to one using a MAXLEN and an illegal
char set in accord with the OSTA requirements. Assumes the name has
* already been translated to Unicode.
* *
* RETURN VALUE
* *
* Number of unicode characters in translated name.
*/
int UDFTransName(
    unicode_t *newName, /* (Output) Translated name. Must be of length MAXLEN */
    unicode_t *udfName, /* (Input) Name from UDF volume. */
    int udfLen, /* (Input) Length of UDF Name. */
    byte *fidName, /* (Input) Bytes as read from media. */
    int fidNameLen) /* (Input) Number of bytes in fidName. */
{
    int index, newIndex = 0, needsCRC = FALSE;
    int extIndex, newExtIndex = 0, hasExt = FALSE;
    #ifdef (OS2 | WIN_95 | WIN_NT)
    int trailIndex = 0;
    #endif
    unsigned short valueCRC;
    unicode_t current;
    const char hexChar[] = "0123456789ABCDEF";

    for (index = 0; index < udfLen; index++)
    {
        current = udfName[index];

        if (IsIllegal(current) || !UnicodeIsPrint(current))
        {
            needsCRC = TRUE;
            /* Replace Illegal and non-displayable chars with underscore. */
            current = ILLEGAL_CHAR_MARK;
            /* Skip any other illegal or non-displayable characters. */
            while(index+1 < udfLen && (IsIllegal(udfName[index+1])
                    || !UnicodeIsPrint(udfName[index+1])))
            {
                index++;
            }
        }
        /* Record position of extension, if one is found. */
        if (current == PERIOD && (udfLen - index -1) <= EXT_SIZE)
        {
            if (udfLen == index + 1)
            {
                /* A trailing period is NOT an extension. */
                hasExt = FALSE;
            }
            else
            {
                hasExt = TRUE;
                extIndex = index;
                newExtIndex = newIndex;
            }
        }
    #ifdef (OS2 | WIN_95 | WIN_NT)
        /* Record position of last char which is NOT period or space. */
        else if (current != PERIOD && current != SPACE)
        {
            trailIndex = newIndex;
        }
    #endif
    }
if (newIndex < MAXLEN)
{
    newName[newIndex++] = current;
}
else
{
    needsCRC = TRUE;
}

#ifdef (OS2 | WIN_95 | WIN_NT)
/* For OS2, 95 & NT, truncate any trailing periods and/or spaces. */
if (trailIndex != newIndex - 1)
{
    newIndex = trailIndex + 1;
    needsCRC = TRUE;
    hasExt = FALSE; /* Trailing period does not make an extension. */
}
#endif

if (needsCRC)
{
    unicode_t ext[EXT_SIZE];
    int localExtIndex = 0;
    if (hasExt)
    {
        int maxFilenameLen;
        /* Translate extension, and store it in ext. */
        for(index = 0; index<EXT_SIZE && extIndex + index + 1 < udfLen;
            index++ )
        {
            current = udfName[extIndex + index + 1];
            if (IsIllegal(current) || !isprint(current))
            {
                needsCRC = 1;
                /* Replace Illegal and non-displayable chars
                 * with underscore.
                 */
                current = ILLEGAL_CHAR_MARK;
                /* Skip any other illegal or non-displayable
                 * characters.
                 */
                while(index + 1 < EXT_SIZE
                    && (IsIllegal(udfName[extIndex + index + 2])
                        || !isprint(udfName[extIndex + index + 2])))
                {
                    index++;
                }
            }
            ext[localExtIndex++] = current;
        }
        /* Truncate filename to leave room for extension and CRC. */
        maxFilenameLen = ((MAXLEN - 4) - localExtIndex - 1);
        if (newIndex > maxFilenameLen)
        {
            newIndex = maxFilenameLen;
        }
        else
        {
newIndex = newExtIndex;

else if (newIndex > MAXLEN - 5)
{
    /*If no extension, make sure to leave room for CRC. */
    newIndex = MAXLEN - 5;
}
newName[newIndex++] = CRC_MARK; /* Add mark for CRC. */

/*Calculate CRC from original filename from FileIdentifier. */
valueCRC = cksum(fidName, fidNameLen);
newName[newIndex++] = hexChar[(valueCRC & 0xf000) >> 12];
newName[newIndex++] = hexChar[(valueCRC & 0x0f00) >> 8];
newName[newIndex++] = hexChar[(valueCRC & 0x00f0) >> 4];
newName[newIndex++] = hexChar[(valueCRC & 0x000f)];

/* Place a translated extension at end, if found. */
if (hasExt)
{
    newName[newIndex++] = PERIOD;
    for (index = 0;index < localExtIndex ;index++ )
    {
        newName[newIndex++] = ext[index];
    }
}
return(newIndex);

#ifdef (OS2 | WIN_95 | WIN_NT)
/**************************************************************
* Decides if a Unicode character matches one of a list
* of ASCII characters.
* Used by OS2 version of IsIllegal for readability, since all of the
* illegal characters above 0x0020 are in the ASCII subset of Unicode.
* Works very similarly to the standard C function strchr().
* *
* RETURN VALUE
* *
* Non-zero if the Unicode character is in the given ASCII string.
*/
int UnicodeInString(
    unsigned char *string, /* (Input) String to search through. */
    unicode_t ch) /* (Input) Unicode char to search for. */
{
    int found = FALSE;
    while (*string != '\0' && found == FALSE)
    {
        /* These types should compare, since both are unsigned numbers. */
        if (*string == ch)
        {
            found = TRUE;
        }
        string++;
    }
    return(found);
} #endif /* OS2 */
/**************************************************************
* Decides whether the given character is illegal for a given OS.
  *
  * RETURN VALUE
  *
  * Non-zero if char is illegal.
  */
int IsIllegal(unicode_t ch)
{
  #ifdef MAC
    /* Only illegal character on the MAC is the colon. */
    if (ch == 0x003A)
    {
      return(1);
    }
    else
    {
      return(0);
    }
  #elif defined UNIX
    /* Illegal UNIX characters are NULL and slash. */
    if (ch == 0x0000 || ch == 0x002F)
    {
      return(1);
    }
    else
    {
      return(0);
    }
  #elif defined (OS2 | WIN_95 | WIN_NT)
    /* Illegal char's for OS/2 according to WARP toolkit. */
    if (ch < 0x0020 || UnicodeInString("/:*?"">|", ch))
    {
      return(1);
    }
    else
    {
      return(0);
    }
  #endif
}
UDF Specification v1.02 - A specification describing the Universal Disk Format developed by the Optical Storage Technology Association (OSTA). This specification is for developers who plan to implement UDF which is based upon the ISO 13346 standard. UDF is a file system format standard that enables file interchange among different operating systems.