RECOMMENDATION ITU-R BR.1357

USE OF WRAPPERS AND METADATA IN TELEVISION PRODUCTION

(Questions ITU-R 238/11 and 239/11)

(1998)

The ITU Radiocommunication Assembly,

considering

a) that collections of audiovisual programme material and the related information (Wrappers) are exchanged within and between studios and other centres which process or store that information;

b) that programme elements and other data must be stored and retrieved as identifiable objects;

c) that access to and manipulation of these collections of information must be independent from the processing platform used;

d) that descriptive data (Metadata) will help in locating the material through various database entries;

e) that the use of Wrappers and Metadata can aid in the reuse of television programme material, thereby significantly increasing its value;

f) that the benefits listed above can only be obtained if the placing of information into the wrapper, the retrieval of information from the wrapper, and the management of transactions involving the collected information have been standardized to allow interoperability between systems of different vendors;

g) that the above studies on Wrappers and Metadata are deemed to be particularly important and urgent and will be beneficial to broadcasters, including those in developing countries, as it is demonstrated by contributions received from ITU-D, the WBU and some administrations,

recommends

1 that an extensible hierarchical classification of Metadata varieties, including the notion of Metadata Sets appropriate to particular television production uses should be developed;

2 that a single registry of Metadata identifiers and definitions should be established;

3 that a single generic Wrapper format for streaming of Metadata, which can be mapped onto existing and emerging signal transport layers should be standardized;

4 that a single generic Wrapper format for applications requiring arbitrary richness of Content of all types, including Metadata and Essence and highly compatible with the streaming format described above, should be standardized;

5 that a single format for a “unique identifier” would be of assistance.*

A general tutorial on Wrappers and Metadata suitable for use within television production as well as some application examples are given in the Appendices A, B and C to this draft Recommendation.

Appendix D contains a Glossary of some specialized terms frequently used in the context of innovative television production.

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* It is recognized that multiple formats are already in use. As a minimum therefore, it should be possible to register existing and new unique identifier formats within the Metadata registry above.

APPENDIX A

Wrappers and metadata in television production

Introduction

Wrappers form a collections of information which include both streams and files of programme material as well as related information in the form of Metadata, to be held in storage systems and manipulated by computer-based equipment. User requirements for the access to and manipulation of these collections of information are of great importance because these requirements may influence the characteristics of the Wrappers used to group and label the information.

To establish a maximum degree of interoperability independent of the encoding format for the audiovisual signal, the formatting of collections of audiovisual programme material and related information for exchange within and between studios and other centres which process or store that information is of pivotal importance.

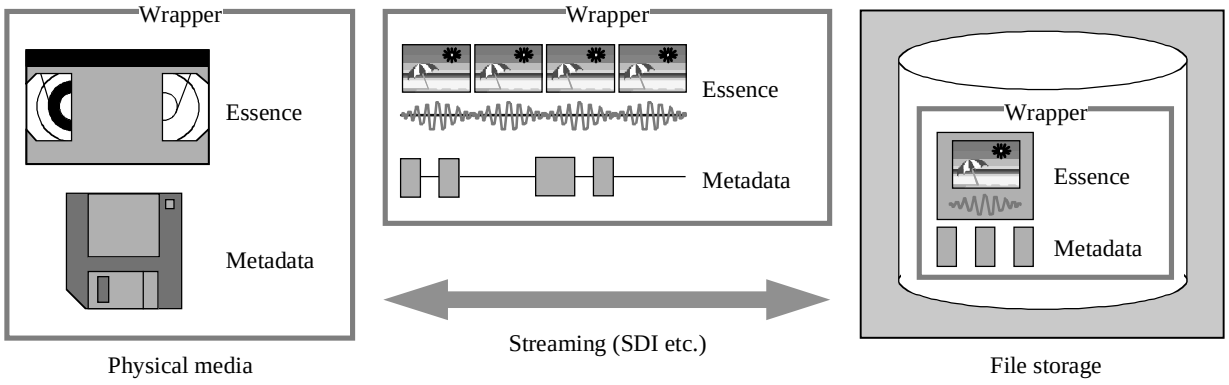
The deliberations below focus on user requirements for the related information within these collections, including the types of information appropriate for each application, its formatting, its relation to the programme material, and the relative importance of each type of information. These requirements may further influence the characteristics of the Wrappers used to group and label the information.

1 Wrappers and metadata

1.1 Purpose of wrappers

The fundamental purposes of a Wrapper are to gather programme material and related information together (both by inclusion and by reference to material stored elsewhere), identify the pieces of information and thus facilitate the placing of information into the wrapper, the retrieval of information from the wrapper, and the management of transactions involving the information.

1.2 Terminology - What's in a wrapper



Temp 10-11/75-01

FIGURE 1

Schematic view of wrappers in use

Programme material and related information of any variety is called **Content**. The parts of Content which directly represent programme material (such as signal samples) are called **Essence** (see section 1.2.2 below); the parts which describe the Essence and other aspects of the material are called **Metadata** (see section 1.2.3 below).

Wrappers are intended to be used to link physical media together, for streaming of Content across interconnects, and to store Content in file systems and on servers.

This and other terminology is discussed in this section.

1.2.1 Content structure

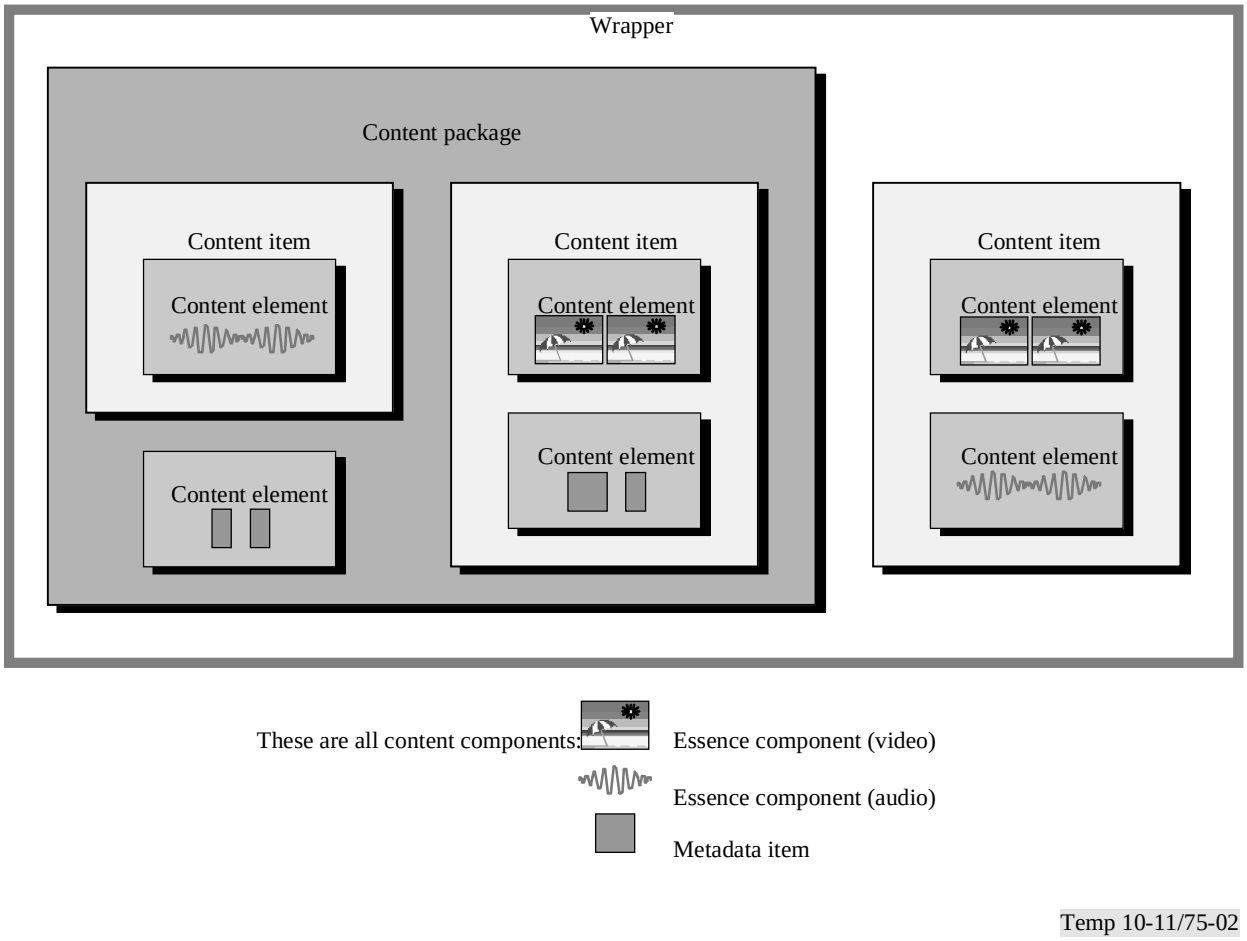


FIGURE 2

Content structure and content components

A Wrapper does more than just contain Content; it also defines and describes the structure of the Content. The microscopic structure of Content is inherent in the Essence itself; the macroscopic structure is built using Metadata and Overhead (see below), and is classified as described here.

Each individual item, either Essence or Metadata, is called a **Content Component** - for example, a block of audio samples, or a timecode word. A Wrapper contains some number of Content Components, built into a logical structure.

A **Content Element** (CE) consists only of Essence of a single type, plus any Metadata directly related only to that Essence - for example, the blocks of samples of a video signal plus the Format Metadata describing the sample structure plus the Descriptive Metadata identifying the origin of the signal.

An exception to this definition is when a Content Element can be generated entirely from Metadata, without the need for Essence - for example, an encoded subtitle.

Types of Essence include Video, Audio, Graphics, Still Images, Text, and other sensor data as needed by each application.

A **Content Item** (CI) consists of a collection of one or more Content Elements, plus any Metadata directly related to the Content Item itself or required to associate the component parts (Content Elements) together - for example, a video clip.

A **Content Package** (CP) consists of a collection of one or more Content Items or Content Elements, plus any Metadata directly related to the Content Package itself or required to associate the component parts (Content Items and Content Elements) together - for example, a programme composed of video plus audio plus subtitles plus description.

Although these terms describe larger and larger structures of Content, the smaller structures do not have to be fully contained within bigger ones. For example, a single Wrapper could contain Content Elements equal to a full hour of programme source material, and Content Packages describing only a couple of five minute segments within the material.

Thus, a Wrapper is not restricted to contain any specific quantity or portion of any of these constructs - it may contain only a few Content Components, or as much as several Content Packages.

Besides using a single Wrapper, two or more Wrappers may be used to transport components of a single Content Item or Content Package where separate transport mechanisms are used. In this case each of the Wrappers will contain a partial common set of Metadata to allow the wrappers to be cross referenced. This is the mechanism used where not all of the Metadata can be accommodated in the transport used for the Essence.

1.2.2 Essence

Programme material itself is referred to as **Essence**. Essence includes all data that represents pictures, sound and text; types of Essence include Video, Audio, Graphics, Still Images, Text, and other sensor data as needed by each application. Essence may be encoded or compressed in whatever way is appropriate. and is typically structured in packets, blocks, frames or other groups, which are collectively called **Essence Components**. The microscopic structure of Essence Components depends on the particular encoding scheme used, which in turn is identified by Format Metadata (see below).

Essence typically has the characteristic of a stream, with sequential access whether stored on a file device or streaming device. Stream data will normally be presented in a sequential time dependent manner. Essence stored on a file storage device can be randomly accessible. Essence not having the characteristic of a stream (e.g. graphics, captions, text) may still be presented in a sequential time dependent manner.

1.2.3 Metadata

Other information is referred to as **Metadata**. Metadata is broadly defined as “data about data”.

The number of distinct varieties of Metadata is potentially limitless. To assist with describing requirements and behavior, Metadata is divided into several **categories**, depending upon its purpose, including at least the following:

– **Format** – any information necessary to decode the Essence.

  Examples: video formats, audio formats, numbers of audio channels, aspect ratio, pan and scan etc.

– **Descriptive** – all information used in the cataloguing, search & retrieval, and administration of Content.

  Examples: unique material identifiers (UIDs), labels, author, location, date & time, geospatial (information related to the position of the source), copyright information, access rights information, modification time stamps, version information, transaction records, etc.

– **Association** – any information necessary to achieve synchronization between different Content Components, and to achieve appropriate interleaving of the components.

– **Composition** – information required on how to combine a number of other components (e.g. video clips) into a sequence or structure (Content Element, Content Item, or Content Package) This may equally be regarded as information recording the derivation of the Content.

  Examples: edit decision list, titling information, zoom lens positioning (for virtual studio use), color correction parameters, etc.

– **Other** – anything not included above.

  Examples: Scripts. Definitions of the names and formats of other Metadata.

  Within each category, Metadata may be further divided into sub-categories.

1.2.4 Metadata characteristics

Metadata which is related to the whole of a subsection of the Content (for example a Content Item or Content Package) is referred to as **Static Metadata**.

Metadata which is related to a subsection of the Content (e.g. a single Content Component, a Content Element, or a frame or scene) is referred to as **Variant Metadata.** The variation will frequently be connected to the timing of the Content, but may also be associated with other indexing of the Content. Most categories of Metadata may be Variant.

Other such **characteristics** of items of Metadata may be identified.

1.2.5 Overhead

In addition, the construction of the Wrappers themselves will require some additional items of data. This data is referred to as **Overhead**. Overhead includes such things as Flags, Headers, Separators, Byte Counts, Checksums, and so on.

1.3 General requirements

Wrappers must be capable of including Essence, Metadata and Overhead in differing proportions and amounts, depending upon the exact Usage Profile of each Wrapper.

For example, a programme replayed from videotape might include Video, Audio, and Ancillary data streams, with almost no Metadata; an Edit Decision List might include Descriptive and Composition Metadata, but little or no Essence. Each particular variety of Wrapper will contain a minimum defined level of Essence, Metadata and Overhead.

Wrappers must be capable of including various structures which are combinations of Essence and Metadata, such as Content Elements, Content Items, or Content Packages defined above.

Metadata may be contained in a video or audio data stream (e.g., MPEG or SDI streams), but for ease of access could be replicated in a separate Metadata area. Real-time live transfer by streams may require repeating of Metadata and interleaving of structures.

As well as directly including Essence and Metadata, Wrappers may contain indirect references to either. This is discussed further below and also in Appendix B, Section 2, which also includes a list of some different varieties of Wrapper.

1.4 Breadth of application and wrapper profiles

Users would strongly prefer one solution to cover the widest range of applications.

Because of the limitations of technology and the concerns listed below, it is unlikely that a single Wrapper format will fit all applications. However, if multiple formats are to be developed, they must be created with a view to maximum commonality, understanding that programme material may appear in and be converted between any or all of the formats during its lifetime.

The range of applications can be encapsulated into Wrapper Profiles, each calling for one or more of the possible Wrapper formats.

A wide range of potential activities can be grouped into the following categories:

– pre-Production;

– production and Acquisition;

– post Production;

– distribution and Storage;

– emission and Transmission;

– archive.

Every application involves one or more of these processes, and each process makes use of Content in each of three forms:

– unwrapped (for example, a Videotape);

– streaming (for example, on an SDI channel or as an MPEG stream);

– rich (for example, a database together with signal storage, or an Edit Decision List).

As well as being used within each process, these three forms are all used as interfaces between processes.

There is therefore a requirement for at least two Wrapper formats (Streaming and Rich) in addition to the continued use of unwrapped Content.

1.5 Metadata requirements and metadata sets

Recognizing the breadth of varieties of Metadata, the naming scheme used for varieties of Metadata should be hierarchical. The hierarchy of varieties (categories, sub-categories and so on), the actual names and the definitions should be registered by a single independent registration authority such as SMPTE. The names must have a plain text representation.

Each application will employ different combinations and varieties of Metadata. There is therefore a requirement for Metadata Sets to provide a guideline as to what combination to employ in a particular application. The Metadata Sets should be developed as part of the recommended Metadata standardization process.

To maximize compatibility, there is a strong preference for Metadata to have a defined representation in plain text form, using an international character set such as ISO 646.

It is recognized that some varieties of Metadata are inherently not representable as plain text. Other varieties carry information in local language, and must be represented using a regionalized character set. Metadata which names, defines and describes other Metadata must be represented in the international character set.

Within each Metadata Usage Profile, a core set of **Mandatory** Metadata items must be provided with each Content structure (Content Component, Content Element, Content Item, or Content Package). This small core set provides for the basic management of the Content structure.

A further set of **Essential** Metadata items must either be provided, or else a sensible default value can be automatically inferred. These items are typically within the class of Descriptive Metadata.

Within certain Profiles, an additional arbitrary assortment of **Optional** Metadata items may be required to be carried.

1.6 Wrapper size

In some Usage Profiles, the size of some Wrappers will undoubtedly exceed the capacity of a single storage volume. Wrappers must therefore contain a mechanism to allow for dividing them into smaller parts if they become too big.

This may require that some Metadata is repeated in each of the parts; alternatively, Metadata needed by each part may be held in a Wrapper of its own, whence the data will be obtained by Referencing.

In this situation, Composition Metadata will be required, to describe the relationship between the parts.

1.7 Platform neutrality

Wrapper formats must be designed to be "Platform Neutral", so that Wrappers may be read by any machine with equal facility (although perhaps with different performance), no matter what machine was used to originally create the wrapper.

Typical considerations are byte ordering, and the organization of sample structures in customized word formats. The need for platform neutrality does not preclude creating a Wrapper in an optimal format for a particular machine.

Appendix B, Section 1 – Platform Neutrality, gives more information on this topic.

1.8 Interleaving

It is likely that information in Wrappers, particularly Essence Components, must be interleaved in various ways for optimization of storage, retrieval, presentation, and transmission.

Existing transport layers such as SDI or MPEG-2 Transport Stream may dictate the interleaving scheme. Wrapper formats must therefore permit conversion between interleaving schemes.

The Wrapper formats should insulate the user from the specific interleaving scheme which is used, so that both Essence and Metadata may be manipulated with equal simplicity (although perhaps with different performance) no matter how they are interleaved.

1.9 Unique identifiers

Content must be identified by some species of Unique Identifier. Unique Identifiers are classified as Mandatory Descriptive Metadata.

Unique Identifiers serve to identify the Content, irrespective of the physical location of the content, and independent of whether the Content is the original or a copy.

When Content is duplicated, it must retain the same Unique Identifier; however, whenever processing is performed on the copy, or when a copy is made of only a subsection of the Content, a new Unique Identifier must be assigned. In some Usage Profiles, traceability to the original Unique Identifier is required (see also "History" below).

In some other cases, identification of each specific instance or copy of the Content is required in addition to the Unique Identifier. This will probably involve linkage between Unique Identifiers and Filenames.

1.10 Immutability and generation numbering

In most cases, it is not known how many References have been made to Content from other Wrappers.

In these cases, it is important to provide identification of the specific generation number (or version number) of the Content, to avoid one user of the Content affecting another user of the same Content.

1.11 References

The Wrapper formats must allow Metadata to refer to points and regions within other wrappers, or within the same wrapper, or within external material by means of indexing. Indexing is discussed in the next section.

This basic capability is required for many purposes, including:

– creation of associations between Essence and Metadata;

– inclusion of external material (for example, from videotape or camera) within programmes;

– description of editing operations within Composition Metadata.

Although the use of References can improve the efficiency of systems by decreasing the use of copy operations, this may be offset by increases in the complexity of systems to manage the proliferation of separate Wrappers.

It is expected that both techniques will be required to accommodate different operational requirements; but Wrapper Profiles may indicate a preference for one or the other method.

1.12 Indexing

For the purpose of implementing References, Wrapper formats must allow indexing of points and regions within a Wrapper in either of the following ways:

– systematic indexing (for example, timecode, subframe or sample index);

– specific indexing (for example, named cue points, key frames).

Note that there are many issues of consistency of indexing when dealing with the diverse sample rates and synchronization methods in present televisions systems – such as the relationship between audio samples and video frames, and the relationship between film frames and video frames. These relationships must be accommodated by the Indexing method, in combination with Association Metadata.

Appendix B, Section 2 - Wrapper referencing, gives more information on this topic.

1.13 History

Two types of historical information may be included in the Metadata:

– Derivation history information, which may include any Content used to create the current version of the Content, this type of historical information allows the production process to be reversed or reproduced with or without modification. This includes any editing history or signal transformation data.

– Transaction logging, allowing the steps taken to produce the current version of the Content from its source material to be traced but not necessarily reversed. This includes version and source information.

1.14 Access control

Features for operational security may be included in a Wrapper format to prevent unauthorized access to Content.

Operational security requires the use of a log-in procedure (or decryption key) and supports the user as an individual or a member of a group. Files may be protected by their location and by time limits. Access rights may be provided at several levels. Encryption is the only feasible mechanism of protecting components within a Wrapper.

Appendix B, Section 3 – Access Control and Copyright, gives more information on this topic.

1.15 Support of transactions

Wrappers will be subject to many transactions both for commercial purposes and in the operation of production systems. These transactions will include copying, moving, and modification of Wrappers.

Metadata in support of these transactions may be included within Wrappers.

1.16 Property rights

Metadata recording the ownership of Content and the history of ownership may be stored in the wrapper in order to facilitate the establishment and preservation of copyright.

Appendix B, Section 3 – Access Control and Copyright, gives more information on this topic. This subject is also discussed in the section on File Transfer Methods.

1.17 Asset management

Wrapper formats must support indirect references to content – that is, references to objects which are themselves references to Content. This is a basic requirement used to support all manner of different material management systems.

Effective asset management is required by the users. This may be provided by either manual or automatic methods as appropriate. Wrapper referencing of Content can work most effectively where automation tools are provided for storage administration tasks and to ensure cohesive referencing when files are moved or copied.

Specification of material management systems is outside the scope of this section, and this is discussed in the section on File Transfer Methods.

1.18 Application programming interface (API)

Specific Wrapper Profiles, particularly those emphasizing richness of data description may require a standard application programming interface (API) to simplify the process of reading and writing the Wrapper format.

1.19 Compatibility and conversion

Wrappers must be compatible with existing formats, including formats for Essence (however stored or transported), and formats for Metadata. In addition, the use of Wrappers must be compatible with established working practices.

It is recognized, however, that when existing Essence and Metadata formats are included within programme material, some of the benefits to be obtained from new Wrapper formats may not be available.

– A format is Compatible with a Wrapper format when Metadata or Essence can be directly placed in a Wrapper from the source format or directly exported from a Wrapper.

– Lossless Conversion is possible when Metadata or Essence cannot be directly used but can be translated to or from the Wrapper with some processing, and the conversion can be fully reversed.

– Lossy Conversion is possible when Metadata or Essence cannot be directly used but can be translated to or from the Wrapper with some processing, and some loss of meaning or quality, and the conversion cannot be fully reversed.

Users require Lossless Conversion or better in all cases, except where Content from outside a Wrapper is involved; in which case, users require Lossy Conversion or better.

1.20 Extensibility

Any new Wrapper format to be developed is required to be standardized and to have reasonable longevity, of decades or more. It is certain that new Metadata types and Essence formats will be required within the life of any standards document. Therefore, every Wrapper format is required to be extensible in the following ways:

– by addition of new Essence and Metadata types;

– by extension or alteration of data syntax and semantics.

To achieve maximum backwards compatibility, the addition of new Essence and Metadata types must be achieved without change to the underlying Wrapper data syntax with an efficient but complete documentation process, to ensure that any extensions are equally accessible to all implementations. This will depend upon maintenance of a proper Registry of data identifiers.

When unknown identifiers are encountered in the processing of a Wrapper, they (and any attendant data) should be ignored gracefully.

APPENDIX B

Wrappers and platforms in television production

Introduction

Platform neutrality when handling collections of programme related data is important for broadcaster because it allows to expand the choice between equipment of different vendors by the provision of interoperability between such equipment. Platform neutrality normally refers only to the byte-ordering of multi-byte data items in Files. It also refers to the limitations of file lengths through the storage filing system (a common limit is 4 Gbyte). A format is platform-neutral if the implementation complexity is roughly equal on any platform. It also embraces the notion of efficient encoding and decoding simultaneously on different platforms.

1 Platform neutrality

1.1 Bit ordering

All computers and many other items of broadcast equipment use a minimum symbol size of 8 bits. Bit ordering within each byte therefore presents no problems for media interchange. However, if symbols are serialized for transmission, the bit order must be defined to ensure that the decoded bytes match the bit order from the transmitter. Both “MSB first” and “LSB first” are used for different inter-connects but provided a given order is defined by the transmission protocol, byte reconstruction at the receiver will be consistent with the transmitted bytes. There is thus no requirement for a “bit-Endian-ness flag” nor the accompanying complexity.

1.2 Multi-byte data

Suppose a 32-bit word, 0 x 76543210 is contained in a Wrapper. If it was written on a Little-Endian (Intel) machine, it will be stored in the sequence: 10 32 54 76. If it was written on a Big-Endian (Motorola and others) machine, it will be stored in the sequence: 76 54 32 10. Clearly this presents problems for interchange between the two Endian forms whether by media transfer or transmission.

Words which are part of Overhead (i.e., not Essence or Metadata) would be expected to always be one way (Little- or Big-Endian) in order to avoid the definition of decoders which first need to refer to an Endian-ness flag before deciding how to decode.

In the case of words which are part of the Essence or Metadata: if the data is Presented or Transported as a File (i.e. it is going from A to B as a unit), and is transported transparently, the decoder will accurately reconstruct the original File contents. This applies whether the File is being transmitted or transferred by media exchange.

However, if the data is being Presented or Transported as a Stream in which interpretation of the data is required (e.g. for a downstream MPEG decoder), then the Byte order of file transfer becomes very important.

In some cases, we are assisted because the data format defines the answer. For example, MPEG bit stream syntax is one-bit serial, and elementary streams are mapped onto a byte stream, MSB first; the byte stream is Endian-free (a byte string is always stored the same way on both Intel and Motorola processors). Also, any Metadata which is character string based is Endian-free.

It would be desirable to have Essence data which is Endian-free but allow encoded Metadata (for example, position measured as a 16 bit number of pixels) to be either way.

1.3 Endian-ness flag issues

Byte order is simply handled by having an Endian-ness flag (Little- or Big- Endian). Then all data types: short, long and long-long use the Endian-ness flag to change the byte order if necessary.

It is not possible to enforce a particular byte order in all cases, so a byte order flag is a requirement. If a Wrapper contains data with the wrong byte order value, and the platform cannot operate with that byte order, then the data has to be converted. This is necessary and time-consuming, but unavoidable.

For operational simplicity, it would be desirable to have all the data within a wrapper be of the same byte order to ensure the most efficient playout.

For applications which merge data of different byte order, there are two possibilities:

– convert the data at the time it is copied, or use a reference between two Wrappers; and

– allow a change of byte order from one Wrapper to the other.

The byte order flag within a Wrapper can occur in two places:

– as early as possible in the Wrapper Overhead;

– as part of the Composition Metadata referring to another wrapper.

Note that only one of these two is required; and if both are present, they must be the same. From one Wrapper to the next, there would be two opportunities to signal the Endian-ness: once in the reference pointing out of the parent Wrapper, and once in the Overhead of the Wrapper being referred to.

1.4 10-bit data and ITU-R BT.601 C_b Y C_r [Y] sample structure

The bit packing of Essence data must be designed with a view to efficient decoding on all platforms since no perfect Endian-neutral scheme exists. Complex data packing such as required to accommodate, for example, a 10 bit per sample RGB sampling structure occupying 30 bits per Word, must be organized to avoid placing the optimal pattern in favour of one value of Endian-ness.

2 Wrapper referencing

2.1 Wrapper varieties

Programme material will involve at least six different varieties of Wrapper:

a) Unwrapped Content – for example, signals from today's equipment, or from foreign, non-conforming systems.

b) Wrappers whose Content is predominantly Essence, but which may include some Metadata.

c) Wrappers whose Content includes no Essence, and only includes Metadata. If Essence is involved it will be kept elsewhere (wrapped or unwrapped), and these Wrappers will include references to it.

d) Wrappers which include predominantly Composition Metadata, and presumably therefore include many references to Content of type A or B kept elsewhere.

e) Wrappers which include Composition Metadata and Essence.

f) Wrappers which include Composition Metadata and additional Descriptive Metadata, which in turn refers to Content kept elsewhere.

Type C is particularly intriguing. The Metadata forms an Index or Directory of Content. This is one variety of Association Metadata.

A simple example from current practice is to refer to a segment of video tape from within an EDL. This is achieved today using “reel numbers” and two timecodes, the “source in-point” and “source out-point”.

A reference is one variety of Composition Metadata. A reference might point to the following:

– an entire Wrapper;

– a point within some Content (e.g. a single frame, or instant);

– a specific item of Metadata;

– a region within some Content (e.g. a “sub-clip” of a shot).

2.2 Referencing content

There are at least five ways that Content may be referenced from within a Wrapper (typically from within Composition Metadata):

1) Content is contained within the same file.

2) Content is referenced in an external unwrapped file (e.g. media in some “raw” or “native” format). Note that in this case there is no way to guarantee that this Content is the correct material, except that data format, length, and perhaps name if available in that external format can be checked against the Metadata description of the Content.

3) Content is referenced in an external Wrapper with the same UID as the original reference. (There may be indirection here, where a referenced Wrapper does not contain Content but references yet another wrapper that does.)

4) Content is referenced in an external wrapper, but has been replaced by new Content from the same original source by an application that retains the original Metadata (perhaps recreated at a different resolution, or perhaps because it was deleted to conserve storage and then re-created when needed again).

   It would be desirable to have two levels of UID – a “handle” and one for the actual Content. All Content references would be to the handle's UID. Then a Content item could be replaced with a new UID, and its handle would have its reference to the Content updated. All external references to the handle would remain valid.

5) Content is recreated in a separate environment from the same original source. In this case there is no way to have UID references. An application could examine the original source information (e.g. tape and timecode range) and determine that this Content is equivalent to the original Content, and update the reference to the new UID.

2.3 Reference types

The cases of references are therefore as follows:

1a) from a “user” Wrapper to the whole of a “source” Wrapper;

1b) from a “user” Wrapper to a point within a “source” Wrapper;

1c) from a “user” Wrapper to an item within a “source” Wrapper;

1d) from a “user” Wrapper to a segment of a “source” Wrapper.

Example: the “user” Wrapper is Composition Metadata, the “source” Wrapper is Essence;

2a) from a Wrapper to another point within the same Wrapper;

2b) from a Wrapper to another item within the same Wrapper;

2c) from a Wrapper to a segment elsewhere in the same Wrapper.

Example: the user Wrapper is a conglomeration of Composition Metadata and Essence;

3a) from a Wrapper to the whole of an external file, tape or other storage means;

3b) from a Wrapper to a point within an external file, etc.;

3c) from a Wrapper to an item within an external file, etc.;

3d) from a Wrapper to a segment of an external file, etc.

Example: the user Wrapper is Composition Metadata, the external tape is a timecoded videotape.

Note that in this example, the external file has a “natural” labelling method (in this case, timecode); so, even though it doesn't have a header or anything to say exactly what range of timecodes is on the tape, the Wrapper can point directly to the portion required.

A more general case would employ a directory (or index) between the user and the source, to locate the actual Content.

4a) from a Wrapper via a directory to the whole of an external file, etc.;

4b) from a Wrapper via a directory to a point within an external file, etc.;

4c) from a Wrapper via a directory to a segment of an external file, etc.

Example: the user Wrapper is Composition Metadata, the directory contains Association Metadata to translate timecode into byte address (e.g. “12:23:34.07 is at offset 0 x 157A3C in the file”), the external file is a data file on a disk array.

We should also consider:

5a) from a Wrapper via a directory to the whole of a source Wrapper;

5b) from a Wrapper via a directory to a point within a source Wrapper;

5c) from a Wrapper via a directory to an item within a source Wrapper;

5d) from a Wrapper via a directory to a segment of a source Wrapper.

3 Access control and copyright

3.1 Access control

Operational security should be implemented to prevent unauthorized operational access to the data. There are a number of access control methods available which address the users requirements from which the most appropriate one can be selected. The access control method may involve randomization or encryption of the Metadata in order to prevent unauthorized access.

It is expected that all users will initially access a system via a log-in process on a local machine. Permissions will be granted to a user according to a log-in status map defined below.

Authorized users (i.e. those who have passed the log-in process) will be granted access to Wrappers at three levels of user identification:

– as a named user;

– as a member of a named group;

– as any user;

– additionally, users may be restricted to access of Wrappers within the limits of the following locations:

  – local machine;

  – site (e.g. the company building);

  – corporation;

  – anywhere.

Users may be further restricted to access of Wrappers by time limitations as follows:

– from a defined time;

– to a defined time;

– between two defined time intervals; and

– anytime.

(NOTE – The method of identifying defined times is not specified but would normally be through a script defining the valid times and allowing repeats such as days in a week, hours in a day, holidays, etc.).

Authorized users may be granted access to Wrappers according to a profile of user capabilities including:

– the right to access (i.e. make the Wrapper visible to the user);

– the right to play (read);

– the right to create (new write);

– the right to modify (re-write);

– the right to erase (delete);

– the right to administer (change any of the restrictions above);

– rights such as browse and other rights may be added but need further consideration.

Note that these rights are granted only for the specific file accessed and may change when accessing another file.

The granting of these rights may also be controlled by an API interacting with Metadata describing Ownership, Ratings control and so on.

Operational security measures as above may be implemented in each Wrapper so that access requests and responses may be coordinated through the Application Programming Interface (API).

In order to reduce duplicate security measures, equipment may bypass one or more of the above access levels where the underlying operating system provides equivalent security level replacements.

It would be desirable if the access control could be monitored to provide an audit trail for the tracking of faulty operations, unauthorized access, and commercial transactions.

3.2 Intellectual property rights

The Wrapper should contain ownership parameters for Content as follows:

– content originator;

– content copyright; and

– content owner.

The Content originator is the name of the creator of that content. It is a permanent name since the creator can never change. This value will be maintained over any Content operation such as copy, move, modify etc.

The Content Copyright is the name of the owner of any copyright contained in the content material. An example is a picture of a work of art, where the copyright of the artist must be associated with the Content. The Content Copyright is permanent except where the copyright owner has given express permission for a change of owner.

The Content Owner is the current owner of the Content and may change.

Each of these values may be associated with any defined frame or segment of the Content. Furthermore, since the Content can be represented as a sequence of Content Components (e.g. a frame of video), all parts of that Content Component is associated with the values of the whole Content Component. For example, if a small still picture is created from a frame of video, that small picture must copy the Intellectual Property Rights (IPR) values from that frame.

If any parameter has no owner, then the value is null.

A charging transaction mechanism is required for the automatic billing of resource usage, which might be provided through an API.

APPENDIX C

Future work on wrappers and metadata in television production

Introduction

The following deliberations identify future work and include an analysis of applications, ideas for future implementations, consideration of possible solutions to the requirements given, or notes on the constraints of present technology.

1 Future work

1.1 Applications

In considering the categories of Applications for the Wrapper Profiles and Metadata Sets, as many potential activities as possible were enumerated, and these were then grouped into the major categories used in the main Wrappers and Metadata Annex.

This list also forms the preliminary list of Metadata Sets which will be required.

I Pre-Production
- a) Scripting
- b) Music Composing
- c) News Assignment (Event)
- d) Planning/Design
  - 1) Storyboarding
  - 2) Location Research
  - 3) Budgeting and Contracting
  - 4) Sets, Props, Costume
  - 5) Modelling

II Production /Acquisition
- a) Live News and Sports
- b) Live Production
- c) Video/Audio Recording
- d) Film Shooting
- e) Graphics
- f) Animation
- g) Motion Capture

III Post Production
- a) Editing
  - 1) Off-line Editing
  - 2) Field Editing
  - 3) A/B roll and On-line Editing
  - 4) Film Editing
  - 5) Screening, Workprint and Negative Conforming
- b) Compositing/Manipulation
  - 1) DVE, Keying, Paint, Rotoscoping, Colorizing
  - 2) Real-Time Graphic Workstations
  - 3) Multiple M/E Linear On-line Editing

c) Sound
   1) Dialogue Editing
   2) Foley, ADR
   3) Music and Effects Editing
   4) Mixing, Audio Sweetening, Re-recording
d) Multimedia Authoring
   1) Pre-Mastering, Assembling, Linking, Encoding, Bit-budget Allocation
e) Film Negative Cutting
f) Foreign Language Dubbing, Titling, Captioning, Sub-Titling, Internationalization

IV Distribution/Storage
a) Routing, Client/Server Access, DDRs VTRs and ATRs
b) Receiving Feeds, Internet Download, Archive Retrieval, Inter-facility Transfer, Relay, Backhaul
c) Standards Conversion
d) Lay-back
e) Quality Control
f) Asset Management
g) Uplinking

V Emission
a) Playlist Preparation, Log Creation
b) Wholesale Delivery
   1) Uplinking
   2) Cable Headends
   3) Satellite Headends
   4) Shipping to Theaters
   5) Shipping Master to Duplicator
c) Broadcast
d) Commercial Insertion
e) Motion Picture Projection

VI Archival
a) Near-Line Storage
b) Long Term Storage
c) Deep Archiving
d) Asset Management

1.2 Usage of essence and metadata

Various attributes of the Content were evaluated in each category of activity. The attributes were:

– the absolute amounts of Essence and Metadata;
– the absolute bit rates of the Essence;
– the relative proportions of each category of Metadata;
– the extent to which Content is consolidated into a single Wrapper;
– the kinds of access to Content.

Approximate ranges were assigned to each attribute as noted in the table headings (except for access kinds), and the values were normalized to the range 0-10.

It was clear that with few exceptions, each activity required formats optimized for both streaming and richness, and for both sequential and random access.

TABLE 1

Essence and metadata attributes in each activity

CATEGORY of ACTIVITY	ESSENCE		METADATA							
	AMOUNT	BITRATE	AMOUNT	DESCRIPTION	COMPOSITION	ASSOCIATION	CONSOLIDATION	RANDOM	MIXED	SEQUENTIAL
Scale 1 Scale 10	Little Lots	1 Mbps 200 Mbps	Kilobytes Megabytes				Many Wrappers Single Wrapper			
Pre-Production	1	1	3	3	1	0	1		X	
Production/ Acquisition	10	7–10	2–7	7	1	2	5–8			X
Post - Production (Edit, Composite, Sound, Multimedia Authoring)	3	8–10	10	9	10	2	1–5	X	X	X
Distribution/Storage	2	7–10	1–5	5	2	4	1(in) 7–10 (out)	X		X
Emission/Mastering	1	5–10	1–3	1	1	2	10			X
Archive	2–10	1–10	10	10	10	2	5 (Regular) 7–10 (Deep)	X		X

1.3 References and labels

The internal method of storing references may change according to the adopted file system and may include methods such as sample offset and sub-files.

1.4 Security

It might be desirable to include a platform-independent decryptor within the Wrapper (such as a Java applet) unless standard encryption methods are used.

1.5 API

It is desirable to have a standard API available to lower the barrier for reading and writing the Wrapper format. It might be desirable to include platform-independent executable code such as Java within the Wrapper itself for self-unpacking/packing of both the Wrapper Metadata and Content. An advantage of a built-in API is that it hides the internal organization and specific storage methods of the Wrapper data, so the structure can be changed as long as a correct API is included.

1.6 Essence extraction

Means for coding and/or decoding Content might be provided in the API by supporting various methods such as:

– hardware devices accessed by device drivers;

– executable code specific to a processor architecture; and

– platform independent executable code such as Java.

These methods may be implemented as plug-in modules to provide user extensibility and future upgradability. Software code may be attached to the Content to provide features such as self extraction.

1.7 Efficiency and completeness

Different uses of Wrappers place different requirements on the performance of the Wrapper format.

For Content which is to be presented as a stream, there is an emphasis on encoding efficiency and efficiency of information retrieval. For other data, there is an emphasis on richness of data description.

It is recognized that there may be a conflict between efficiency and completeness in some applications. To help resolve this conflict, mechanisms to automatically prune or ignore optional Metadata may be required within Wrapper format converters, importers or application programmer interfaces (APIs). In the interests of efficiency, it is also desired to avoid the copying of data (particularly Essence) when converting between Presentations.

Real-time live transfer by streams may require repeating of Metadata and interleaving of structures. Certain synchronous Metadata falls into a category closely bound to the Essence, for example Timecode. There is little value in separating such Metadata from the Essence when it does not need to be accessed independently of the Content.

1.8 Extensibility

Any new Wrapper format to be developed is required to be standardized and to have reasonable longevity, of decades or more. It is certain that new Metadata types and Essence formats will be required within the life of any standards document. Therefore, every Wrapper format is required to be extensible in the following ways:

– by addition of new Essence and Metadata types;

– by extension or alteration of data syntax and semantics.

To achieve maximum backwards compatibility, the addition of new Essence and Metadata types must be achieved without change to the underlying Wrapper data syntax with an efficient but complete documentation process, to ensure that any extensions are equally accessible to all implementations. This will depend upon maintenance of a proper Registry of data identifiers.

When unknown identifiers are encountered in the processing of a Wrapper, they (and any attendant data) should be ignored gracefully.

The extension or alteration of data syntax poses a greater problem in providing for backward compatibility. To facilitate future extensions, every Wrapper format is required to carry a Version Number, to be managed as follows:

– The Wrapper Version Number will be carried in every Wrapper, within the Overhead.

– The Version Number will be assigned by the standards body which documents the Wrapper format, and will be published in a Registry.

– Every device or application which accepts the Wrapper format must decode and check the Version Number.

– Every device or application which accepts the Wrapper format must decode every earlier published version of the format.

– The Version Number will be changed every time that that the Wrapper format is changed in a way which is not absolutely transparent to every implementation of an earlier version.

– The Wrapper format must never be changed in a way that makes decoding of the Version Number impossible or unreliable.

1.9 Immutability and generation numbering

In the general case, the Content in a Wrapper should not be changed because of the possibility of unknown references to the Content in this Wrapper. Changes can be achieved by altering a copy of the Content with a different UID (this does not apply where it is known that there are no references to this Content - but reference counting is possible only within closed systems).

A possible solution is to include a Generation Number as a part of the Reference, so that the Composition Metadata in a downstream Wrapper can indicate the generation which was current at the time of creation. When content is changed, it is not altered in place, but a new copy is made with a new generation number. Then, if the previous generation is deleted for whatever reason, the downstream user can be offered the choice of trying to use the later generation or sending off a request to retrieve the older one.

1.10 Endian-ness of 10-bit sample structures

When 10 bit data is carried in an 8 bit channel, issues of word sync exist. For example, 10 bit Y C_b C_r components might be packed into 32 bit words at 3 components per word, so that we have a packing of 6 samples into 4 words (16 bytes):

C_b	Y	C_r	[Y]	C_b	Y	C_r	[Y]	C_b	Y	C_r	[Y]
w1			w2			w3			w4		

There are many choices for the actual bit-by-bit packing of the components into the words. Four are considered here - “straightforward”, “LSBs separate”, “sparse”, and “tight”. The choice of packing method may strongly affect the efficiency of decoding the components on a different platform from the originator.

1.10.1 “Straightforward” packing

“Straightforward” packing is as follows

AAAA AAAA aaBB BBBB BBbb CCCC CCCC ccxx

where aa bb and cc are the LSBs of the 10 bit words, and A B C are the MSBs.

After being stored big-Endian, read little-Endian (or vice versa), this bit pattern would become:

CCCC ccxx BBbb CCCC aaBB BBBB AAAA AAAA

All similar alternatives create similar or even more complex permutations. For example:

xxAA AAAA AAaa BBBB BBBB bbCC CCCC CCcc

becomes:

CCCC CCcc BBBB bbCC AAaa BBBB xxAA AAAA

Software algorithms to untwist these are inefficient. Hardware implementations may require an additional stage of multiplexers or shifters plus an Endian-ness flag.

1.10.2 “LSBs separate” packing

“LSBs separate” packing is as follows

AAAA AAAA BBBB BBBB CCCC CCCC xxaa bbcc

After being stored big-Endian, read little-Endian (or vice versa), this bit pattern would become:

xxaa bbcc CCCC CCCC BBBB BBBB AAAA AAAA

This still requires untwisting, but the permutation is the same for reading and writing in all cases, whether the Endian-ness of the destination is the same as the source or is the opposite.

Hardware implementations of this scheme still require an Endian-ness flag, but no additional multiplexing or shifting is required.

1.10.3 "Sparse" packing

"Sparse" packing expands 10 bit samples to 16 bits each, and is as follows:

AAAA AAAA aaxx xxxx BBBB BBBB bbxx xxxx

After being stored big-Endian, read little-Endian (or vice versa), this bit pattern would become:

bbxx xxxx BBBB BBBB aaxx xxxx AAAA AAAA

This is quite simple for either software or hardware to process, but at the expense of considerable storage overhead.

1.10.4 "Tight" packing

"Tight" packing leaves no bits unused, and is as follows:

AAAA AAAA aaBB BBBB BBbb CCCC CCCC ccAA AAAA AAaa BBBB BBBB bbCC CCCC etc.

After being stored big-Endian, read little-Endian (or vice versa), this bit pattern would become:

CCCC ccAA BBbb CCCC aaBB BBBB AAAA AAAA Cccc *AAAA* bbCC CCCC BBBB BBBB etc.

(where **AA** is from the second group and ***AA*** is from the third sample group). As can be seen, this method causes the most involved permutations of all.

1.10.5 Permutation during the transfer

Certain transport and interconnect technologies (for example, Fibre Channel) provide some facilities for automatic conversion of byte order during the transfer.

These facilities must also be taken into account when defining data packing. In some cases, automatic conversion can improve the efficiency of importing data from a foreign platform. However, without proper identification of the original byte order and adjustment of the flag after conversion, the automatic process might actually worsen compatibility.

1.10.6 Conclusion

The conclusion to be reached from this discussion is that 10 bit samples add considerable complexity to the choice of a platform-neutral scheme, probably implying that Endian-ness flags must be carried as part of the Format Metadata for each Essence Component.

1.11 Ideas for wrapper referencing - SMPTE 258M and HTML

One approach to References might be based upon extensions of HTML to reflect current practice within EDLs, as described in this section.

Within HTML, the concepts of labelling points within a file and referring to them from within another file are provided (by "<a name=nnnn>" and "<a href=rrrr>" respectively).

In addition, the concept of a directory or index is provided (in HTML, this is achieved by the "<img ismap src=dddd>" construct).

However, some issues are not dealt with cleanly by employing the exact scheme used in HTML. In particular, the need to address a segment of a source file, and the very common use of timecode in television do not presently map to HTML.

It is possible that a new variety of URL could be devised to address these needs, for example:

tfhs://server/mount/path/filename#hh:mm:ss.ff--hh:mm:ss.ff

In this example, the fields are as follows:

– "tfhs:" identifies the service, just like "http:" or "ftp:";

– "server" identifies the location of the material. It may be a physical address, or a local name, or an absolute name; following HTML precedent, it might include user names and passwords for access control;

– “mount” and “path” are the route through the file system;

– “filename” is the name of the Wrapper; in the case of a videotape, it might be the tape reel name;

– “#hh:mm:ss.ff--hh:mm:ss.ff” identifies a segment of material. There might also be “#hh:mm:ss.ff” to identify a point, and “#anchor” to identify a specific item of Metadata, and so on.

Further work is required to understand how this notation would be applied in all the cases above. But it seems that there are some intriguing possibilities:

The source reference in today's EDL:

0001 tape66 VA1A2 C 12:12:12.00 12:12:17.00 10:00:00.00 10:00:05.00

Could become:

tfhs:tape66#12:12:12.00--12:12:17.00

(following normal HTML “defaulting” rules, if server, mount, path are omitted, they would refer to obvious defaults).

APPENDIX D

Abbreviations and specialized terms

Specialized terms, frequently used in the context of innovative television production are listed in an alphabetic order below.

-A-

A/D	Analogue to Digital conversion
AAL (ATM adaptation layer)	The AAL translates digital voice, image, video, and data signals into the ATM cell format and vice versa. Five AALs are defined: AAL1 supports connection-oriented services needing constant bit rates and specific timing and delay requirements. (e.g., DS-3 circuit) AAL2 supports connection-oriented services needing variable bit rates. (e.g., certain video transmission schemes) AAL3/4 supports both connectionless and connection-oriented variable rate services. AAL5 supports connection-oriented variable bit rate data services. AKA: Simple and Efficient Adaptation Layer (SEAL)
Adaptive predictor	A predictor whose estimating function is made variable according to the short term spectral characteristics of the sampled signal. For ADPCM in particular, an adaptive predictor is a time-varying process that computer an estimate of the input signal from the quantized difference signal.
Adaptive quantizing	Quantizing in which some parameters are made variable according to the short-term statistical characteristics of the quantized signal.
Address Translation	The process of converting external addresses into standardized network addresses and vice versa. It facilitates the interconnection of multiple networks in which each have their own addressing scheme.

ADPCM (adaptive differential pulse code modulation)	ADPCM algorithms are compression algorithms that achieve bit rate reduction through the use of adaptive prediction and adaptive quantization.
Analogue	A type of transmission in which a continuously variable signal encodes an infinite number of values for the information being sent. (Compare with "digital.")
Analogue signal	A signal one of whose characteristic quantities follows continuously the variations of another physical quantity representing information.
Anisochronous	The essential characteristic of a time-scale or a signal such that the time intervals between consecutive significant instants do not necessarily have the same duration or durations that are integral multiples of the shortest duration.
ANSI	The American National Standards Institute is a US-based organization that develops standards and defines interfaces for telecommunications systems.
API (Application Programming Interface)	A set of interface definitions (functions, subroutines, data structures, or class descriptions) which together provide a convenient interface to the functions of a subsystem and insulate the application programmer from the minutiae of the implementation.
Asynchronous	The essential characteristic of time-scales or signals such that their corresponding significant instants do not necessarily occur at the same average rate.
Asynchronous transmission	A term used to describe any transmission technique that does not require a common clock between the two communicating devices, but instead derives timing signals from special bits or characters (i.e., start/stop bits, flag characters) in the data stream itself. (Compare with "synchronous.")
ATM (Asynchronous Transfer Mode)	A form of digital transmission based on the transfer of units of information known as cells. It is suitable for the transmission of image, voice, video, and data.
ATM Layer	The protocol layer that relays cells from one ATM node to another. It handles most of the processing and routing activities including: each cell's ATM header, cell muxing/demuxing, header validation, payload-type identification, quality-of-service specification, prioritization, and flow control.
-B-	
Bandwidth	A measure of capacity, usually, the capacity of a communications line to transmit voice, data, video, or image traffic through a network. Bandwidth is usually expressed in bits per second (bit/s), thousands of bits per second (kbit/s), millions of bits per second (Mbit/s), or billions of bits per second (Gbit/s).
BER	Bit error ratio (or rate)
Binary digit *(bit)*	A member selected from a binary set. Bit is an abbreviation for binary digit.
Broadband	A service or system requiring transmission channels capable of supporting rates greater than the Integrated Services Digital Network (ISDN) primary rate (1.544 Mbit/s (e.g. USA) or 2.048 Mbit/s (e.g. Europe)).
Broadcast (Messages)	Transmissions sent to all stations (or nodes, or devices) attached to the network.

Buffer	An area of storage that provides an uninterrupted flow of data between two computing devices.
-C-	
CBO	Continuous bit-stream oriented (services)
CBR	Constant bit rate
CBR (Constant Bit Rate)	A type of traffic that requires a continuous, specific amount of bandwidth over the ATM network (e.g., digital information such as video and digitized voice).
CCITT	The Consultative Committee on International Telephony and Telegraphy, now the Telecommunication Standardization Sector of the International Telecommunication Union (ITU), which is an international organization that develops standards and defines interfaces for telecommunications systems.
Cell	A transmission unit of fixed length used in cell relay transmission techniques such as ATM. An ATM cell is made up of 53 bytes (octets) including a 5-byte header and a 48-byte data payload.
Cell Relay	Any transmission technique that uses packets of a fixed length. ATM, for example, is a version of cell relay using 53-byte cells. Other versions use cells of a different length.
CEPT	The Conference on European Post and Telegraph is a European organization that develops standards and defines interfaces for telecommunications systems.
Channel, transmission channel	A means of unidirectional transmission of signals between two points.
Circuit Switching	A switching technique in which a dedicated path is set up between the transmitting device and the receiving device, remaining in place for the duration of the connection. (e.g., a plain old telephone call is a circuit-switched connection)
Clock	Equipment that provides a timing signal.
Codec	A combination of an encoder and a decoder operating in opposite directions of transmission in the same equipment.
Compression	The process of reducing the number of bits required to represent information by removing redundancy. In the case of information content such as video and audio it is usually necessary to extend this process by removing in addition information that is not redundant but is considered less important.
Connectionless	A type of communication in which no fixed path exists between a sender and receiver, even during a transmission. (e.g., packet switching) Shared media LANs are connectionless.
Connection-oriented	A type of communication in which an assigned path must exist between a sender and a receiver before a transmission occurs. (e.g., circuit switching) ATM networks are connection-oriented.
CRC	Cyclic redundancy check

CVD (Cell Delay Variation)	A measurement of the allowable variation in delay between the reception of one cell and the next. (Usually expressed in thousandths of a second, or milliseconds (ms.). Important in the transmission of voice and video traffic, CDV measurements determine whether or not cells are arriving at the far end too late to reconstruct a valid packet.
-D-	
DCT	Discrete cosine transform
DEMUX	Demultiplexer
Descrambler	A device that performs the complementary operation to that of a scrambler.
Digital	A type of transmission that encodes a discrete value (e.g., “0” or “1”) for each unit of information being encoded. (Compare with “analogue.”)
Digital channel, digital transmission channel	The means of unidirectional digital transmission of digital signals between two points.
Digital connection	A concatenation of digital transmission channels, switching and other functional units set up to provide for the transfer of digital signals between two or more points in a network, to support a single communication.
Digital demultiplexing	The separation of a (larger) digital signal into its constituent digital channels.
Digital multiplexing	A form of time division multiplexing applied to digital channels by which several digital signals are combined into a single (larger) digital signal.
Digital signal	A discretely timed signal in which information is represented by a number of well-defined discrete values that one of its characteristic quantities may take in time.
Digital transmission	The transmission of digital signals by means of a channel or channels that may assume in time any one of a defined set of discrete states.
DPCM (differential pulse code modulation)	A process in which a signal is sampled, and the difference between each sample of this signal and its estimated value is quantized and converted by encoding to a digital signal.
DSP	Digital signal processor
-E-	
Error ratio [error rate]	The ratio of the number of digital errors received in a specified period to the total number of digits received in the same period.
Error, digital error	An inconsistency between a digit in a transmitted digital signal and the corresponding digit in the received digital signal.

-F-

Frame	Variable-length packet of data used by traditional LANs such as Ethernet and Token Ring as well as WAN services such as X.25 or Frame Relay. An edge switch will take frames and divide them into fixed-length cells using an AAL format. A destination edge switch will take the cells and reconstitute them into frames for final delivery.
FSK	Frequency shift keying

-G-

Gbit/s (Gigabit per second)	A digital transmission speed of billions of bits per second.

-H-

Header Error Control (HEC)	An 8-bit Cyclic Redundancy Code (CRC) computed on all fields in an ATM header; capable of detecting single bit and certain multiple bit errors. HEC is used by the Physical Layer for cell delineation.

-I-

Interface	The common boundary between two associated systems.
Internet Protocol (IP) Address	An identifier for a network node; expressed as four fields separated by decimal points (e.g., 136.19.0.5.); IP address is site-dependent and assigned by a network administrator.
IP-over-ATM	The adaptation of TCP/IP and its address resolution protocol for transmission over an ATM network. It is defined by the IETF in RFCs 1483 and 1577. It puts IP packets and ARP requests directly into protocol data units and converts them to ATM cells. This is necessary because IP does not recognize conventional MAC-layer protocols, such as those generated on an Ethernet LAN.
ISDN	Integrated services digital network
Isochronous	A term used to describe signal timing techniques that require a uniform reference point (usually embedded in the data signal).

- J -

Jitter	Short-term non-cumulative variations of the significant instants of a digital signal from their ideal positions in time.

-K-

kbit/s (kilobit per second)	A digital transmission speed of thousands of bits per second.

-L-

LAN (Local Area Network)	A system consisting of computer and communications hardware and software connected by a common transmission medium, usually limited to a scope of a few miles.

LAN Emulation	The process of implementing enough of the MAC layer protocol of a LAN (i.e., Ethernet or Token Ring) to allow existing higher layer protocols (and applications) to be used unchanged over another network, such as an ATM network.
Latency	The time that it takes to process an input bit stream through a compression and decompression process. Buffering and transmission can be major contributors to processing delays
Link	Any physical connection on a network between two separate devices, such as an ATM switch and its associated end point or end station.
LSB	Least significant bit
-M-	
MAN	Metropolitan area network
Master clock	A clock that is used to control the frequency of other clocks.
Mbit/s (Megabit per second)	A digital transmission speed of millions of bits per second.
Megabits Per Second (Mbit/s)	A digital transmission speed of millions of bits per second.
Metadata	Data describing other data
MSB	Most significant bit
Multicast Messages	A subset of broadcast in which a transmission is sent to all members of a pre-defined group of stations, nodes, or devices.
Multipoint	A term used by network designers to describe network links that have many possible endpoints.
MUX	Multiplexer
-N-	
NNI (Network-to-Network Interface)	In an ATM network, the interface between one ATM switch and another, or an ATM switch and a public ATM switching system.
- O -	
Octet	A group of eight binary digits or eight signal elements representing binary digits operated upon as an entity.
OSI	Open system interconnection
-P-	
Packet Switching	A switching technique in which no dedicated path exists between the transmitting device and the receiving device. Information is formatted into individual packets, each with its own address. The packets are sent across the network and reassembled at the receiving station.
PCM (pulse code modulation)	A process in which a signal is sampled, and each sample is quantized independently of other samples and converted by encoding to a digital signal.
PDH	Plesiochronous digital hierarchy
PDU (Protocol Data Unit)	A unit of information (e.g., packet or frame) exchanged between peer layers in a network.

Permanent Virtual Circuit (PVC)	A generic term for any permanent, provisioned communications medium. NOTE: PVC does not stand for permanent virtual channel. No such term has been defined by any standards organization. Neither has the term “permanent virtual path (PVP).” In ATM, there are two kinds of PVCs: permanent virtual path connections (PVPCs) and permanent virtual channel connections (PVCCs).
Physical Layer	The first layer in the OSI Model. It specifies the physical interface (e.g., connectors, voltage levels, cable types) between a user device and the network.
Plesiochronous	The essential characteristic of time-scales or signals such that their corresponding significant instants occur at nominally the same rate, any variation in rate being constrained within specified limits. Two signals having the same nominal digit rate, but not stemming from the same clock are usually plesiochronous.
Point-to-point	A term used by network designers to describe network links that have only one possible destination for a transmission.
Predictor	A device that provides an estimated value of a sampled signal derived from previous samples of the same signal or from a quantized version of those samples.
-Q-	
QoS (Quality of Service)	The ATM Forum has outlined five categories of performance (Classes 1 through 5) and recommends that ATM's quality of service should be comparable to that of standard digital connections.
Quantizing	A process in which a continuous range of values is divided into a number of adjacent intervals, and any value within a given interval is represented by a single predetermined value within the interval.
- R -	
Reference clock	A clock of very high stability and accuracy that may be completely autonomous and whose frequency serves as a basis of comparison for the frequency of other clocks.
Regeneration	The process of receiving and reconstructing a digital signal so that the amplitudes, waveforms and timing of its signal elements are constrained within specified limits.
-S-	
Sample	A representative value of a signal at a chosen instant, derived from a portion of that signal.
Sampling	The process of taking samples of a signal, usually at equal time intervals.
Sampling rate	The number of samples taken of a signal per unit time.
SCR (Sustainable Cell Rate)	A measure of the maximum throughput that can be achieved by bursty traffic over a given virtual connection without the risk of cell loss.
Scrambler	A device that converts a digital signal into a pseudo-random digital signal having the same meaning and the same digit rate.
SDH (Synchronous Digital Hierarchy)	International version of SONET that is based on 155 Mbit/s increments rather than SONET's 51 Mbit/s increments.

Signal	A physical phenomenon one or more of whose characteristics may vary to represent information.
Signalling (ATM)	The procedures used to establish connections on a ATM network. Signalling standards are based on the ITU-T Q.93B Recommendation.
Slip	The loss or gain of a digit position or a set of consecutive digit positions in a digital signal resulting from an aberration of the timing processes associated with transmission or switching of a digital signal.
SONET (Synchronous Optical NETwork)	A set of standards for the digital transmission of information over fibre optics. Based on increments of 51 Mbit/s.
SPVC (Soft Permanent Virtual Circuit)	A generic term for any communications medium which is permanently provisioned at the end points, but switched in the middle.
STM (Synchronous Transfer Mode/Synchronous Transport Module)	In ATM, a method of communications that transmits data streams synchronized to a common clock signal (reference clock). In SDH, it is “Synchronous Transport Module” and is the basic unit (STM-1=155 Mbit/s, STM-4=622 Mbit/s, STM-16=2.5 Gbit/s) of the Synchronous Digital Hierarchy.
SVC (Switched Virtual Circuit)	A generic term for any switched communications medium. NOTE: SVC does not stand for switched virtual channel. No such term has been defined by any standards organization. Neither has the term “switched virtual path (SVP).” In ATM, there are two kinds of SVCs: switched virtual path connections (SVPCs) and switched virtual channel connections (SVCCs).
Switch	Device used to route cells through an ATM network.
Symbol rate	The number of signal elements of the signal transmitted per unit time. The baud is usually used to quantify this, one baud being equal to one single element per second.
Synchronization	The process of adjusting the corresponding significant instants of signals to make them synchronous.
Synchronous	A term used to describe a transmission technique that requires a common clock signal (or timing reference) between two communicating devices to coordinate their transmissions. (Compare with “asynchronous.”)
Synchronous network	A network in which the corresponding significant instants of nominated signals are adjusted to make them synchronous.

-T-

TDM (Time-division multiplexing)	Multiplexing in which several signals are interleaved in time for transmission over a common channel.
Telecommunication	Any transmission and/or emission and reception of signals representing signs, writing, images and sounds or intelligence of any nature by wire, radio, optical or other electromagnetic systems.
Timing recovery [timing extraction]	The derivation of a timing signal from a received signal.
Timing signal	A cyclic signal used to control the timing of operations.

Traffic Policing	A mechanism used to detect and discard or modify cells (traffic) that do not conform to the Quality of Service parameters specified in the call setup procedure.
Traffic Shaping	A mechanism used to control traffic flow so that a specified Quality of Service is maintained.
Transmission	The action of conveying signals from one point to one or more other points.
Transparency, digital transparency	The property of a digital transmission channel, telecommunication circuit or connection, that permits any digital signal to be conveyed over it without change to the value or order of any signal elements.
-U-	
UNI (User-to-Network Interface)	A connection that directly links a user's device to a network (usually, through a switch). Also, the physical and electrical demarcation point between the user device and the switch.
-V-	
VBR (Variable Bit Rate)	A type of traffic that, when sent over a network, is tolerant of delays and changes in the amount of bandwidth it is allocated. (e.g., data applications)
VC (Virtual Circuit)	A generic term for any logical communications medium.
VCI (Virtual Channel Identifier)	The field in the ATM cell header that labels (identifies) a particular virtual channel.
Virtual Channel Connection (VCC)	A logical communications medium identified by a VCI and carried within a VPC. VCCs may be permanent virtual channel connections (PVCCs), switched virtual channel connections (SVCCs), or smart permanent virtual channel connections (SPVCC). Further, VCC is an end-to-end logical communications medium. Another acronym, VCL (virtual channel link), is more precise, referring to the single segment object identified by a VCI and carried within a VPC. Similarly, a VPC is an end-to-end object and a Virtual Path Link (VPL) is identified a VPI within a link.
Virtual LAN	A logical association of users sharing a common broadcast domain.
VPC (Virtual Path Connection)	A logical communications medium in ATM identified by a virtual path identifier (VPI) and carried within a link. VPCs may be permanent virtual path connections (PVPCs), switched virtual path connections (SVPCs), or smart permanent virtual path connections (SPVPCs). VPCs are uni-directional.
-W-	
WAN	Wide area network
Wander	Long-term non-cumulative variations of the significant instants of a digital signal from their ideal positions in time.