Annex E – File Management, Transfer Protocols, and Physical Connections

The transfer of program content can take place either as a continuous stream (as with existing analog playout) or in the form of a discontinuous file transfer.

All transfers require a number of operations, including:

- identification of the file or stream and its source
- the destination for the transfer
- the establishment of a physical connection
- the control of the transfer

File transfers also require:

- a logical connection
- the identification of the file at its destination
- notification to the user of completion of the transfer (or the reason for a failure)

Consequently, issues of file management, transfer protocols and physical connections must be considered.

This chapter sets out the user requirements in each of these areas.

The main area of application considered in this chapter is the transfer of content within a production facility. This implies a local area network environment. Wide Area Networks, on the other hand offer the possibility of incorporating remote storage devices within a logical cluster ("distributed video production"), but different requirements for content transfer, particularly the protocols, will be necessary. This report is currently limited in scope to operation within a local area network environment (LAN); the wide area network (WAN) context requires further study. Some pointers to such studies are given at the end of this chapter in "Wide Area Network Gateways."

In addition, attention is drawn to the desirability of common machine control interfaces to enable users to switch easily between devices from different suppliers.

E.1 Definitions:

Synchronous — "The essential characteristic of time-scales or signals such that their corresponding significant instants occur at precisely the same average rate."

Asynchronous — "The essential characteristic of time-scales or signals such that their corresponding significant instants do not necessarily occur at the same average rate."

Isochronous — "The essential characteristic of a time-scale or a signal such that the time intervals between consecutive significant instants either have the same duration or durations that are integral multiples of the shortest duration."

Note: In practice, variations in the time intervals are constrained within specified limits.

Interworking — "The practice of enabling disparate entities to achieve some level of cooperative working via the parts they have in common; an example would be filename compatibility between two different computer operating systems."

Latency — "The delay in time after a command or initiation before an associated action or flow starts; in the case of a data flow, the latency is not to be confused with the time the data spends traversing the channel between source and destination."

Metadata — "Data about data, e.g. about its identity, attributes, history or means of combination with other data; examples include timecode, an edit decision list and SMPTE Video Index."

Multicast — "Data flow from a single source to multiple destinations; a multicast may be distinguished from a broadcast in that the number of destinations may be limited."

Packetized data — "Data such as that representing video that is segmented into small pieces that are, for example, wrapped, labeled, numbered, addressed, error protected so as to survive transit through a heterogeneous or hostile environment; the small pieces are reassembled on completion of their journey."

Pathname — "The location of a file in a hierarchical file system consisting of levels of nested directories, normally described in terms of a starting point (the "root" directory) and the names of all the directories that must be traversed until the local or "home" directory in which the file resides is encountered; the directory names making up the path name are separated in a human readable or machine-readable representation by a character not allowed within the directory names themselves—this may be a "/" (front slash), "\" (back slash), ":" (colon), or other character;" for platform independence, a Universal Naming Convention (UNC) is recommended."

Point-to-multipoint	"An arrangement, either permanent or temporary, in which the same data flows or is transferred from a single origin to multiple destinations; the arrival of the data at all the destinations is expected to occur at the same time or nominally at the same time."
QoS ("Quality of Service")	"For a given data flow or transfer, the set of values of a range of parameters that determines the speed, reliability and other attributes of the data flow or transfer though a network, or part of a network; it is common for the QoS to be known or determined prior to the start and maintained throughout the duration of the data flow or transfer, and not to be changed because of the initiation of another flow within the same network; it is therefore common to refer to a "QoS contract" being set up that applies to all the physical net work elements involved in the data flow or transfer."
Streaming	"A data flow which is continuous and at a fixed rate of delivery; contrasts with "file transfer."

E.2 The OSI Reference Model

The terms physical and link layers are borrowed from the telecommunications vocabulary and refer to the 7-layer OSI reference model. This is a useful technique for identifying the interface specifications necessary to provide independence between different aspects of a communications system. As an example, Ethernet can be implemented on several different types of physical infrastructure because the physical layer has no impact on the definitions for network or transport layers. The OSI reference model is shown in Table E1 - the shaded areas indicate the scope of this chapter. The data transport function descriptions which follow respect the above model.

E.3 File Management and File Systems

The intent of this section is to specify components on which asset management or other applications may be built.

File systems for audio/video servers are similar in concept to normal computer file systems but they do have some unusual requirements in terms of file size, real-time access and reliability. Although some of these issues have been addressed in large scale and real-time systems, the facilities are not available on a wide range of broadcast products. The primary objective is to have a consistent feature set between different broadcast file systems.

E.3.1 File System Attribute Requirements

- It should have consistent file name syntax and semantics. The path and file naming must permit at least 256 characters. See Annex D on Wrappers for a discussion of naming.
- It should support a read/write permission access mechanism.
- It should support access control based on user-names, passwords and user groups. The chosen mechanism should also support default parameters for users that do not require access control.
- It may support file access logging. The system access log may contain data about file creations, deletions, read operations, write, appends, attribute management functions, etc.
- The file system should support a hierarchical name space.
- Files can be specified by providing a full name path or by setting a working directory and supplying partial path and file name. If remote device access is provided, then the machine name of the remote device must be specified (or

Table E1: OSI seven layer reference model

Level	Name	Description	Unit of exchange
7	Application	User application process and management functions	Message
6	Presentation	Data interpretation, format and code transformation	Message
5	Session	Administration and control of sessions between two entities	Message
4	Transport	Transparent data transfer end-to-end control, multiplexing, mapping	Message
3	Network	Routing, switching, segmenting, blocking, error recovery, flow control	Packet
2	Data link	Establish, maintain, and release data links, error, and flow control	Frame
1	Physical	Electrical, mechanical, functional control of data circuits	Bit

a default may be defined or referenced) in the full path.

- Support for remote file systems shared over networks is optional. If it is implemented it must provide a consistent feature set.
- Files of at least 2^{48} bytes in length should be supported. This implies that a single file of length 281 Tera Bytes could be referenced. This limit does not place any restriction on the number of files in a file system(s) or their location addresses. Files are referenced by name and not by absolute address. Files are referenced by name and not absolute address and should have an unique identifier
- The file referred to by a pathname plus filename may be a Wrapper including Content , or some other data type.

E.3.2 File System Commands

This section describes the set of commands that must be provided to manipulate files and navigate the directory system. The local machine (the one the user is connected to) must respond to these commands. If remote machine access is provided then these same commands must be implemented on the remote machine.

- A command that lists the contents of the current directory name space and subtree name space.
- The properties of files and directories must be accessible from the list commands. The properties displayed should include: file size, creation date, last used date, protection attributes and possibly some content attribute information.
- A command set to move, copy, rename, and delete a file.
- A command set to create, rename and remove directories and to move (change directory) within the directory space are required.
- Optional ability to mount and dismount a remote file system and servers must be implemented in a consistent way.
- An optional command to remove files from the active name space, but not actually delete the data, and an expunge command to actually remove the hidden (inactive) files. A command to undelete the hidden (inactive) files is also required.

E.3.3 File System Layers

The following layers of file system functions must be allowed. The goal is to have each higher layer be a proper superset of the lower layers.

- A flat tape file system (this is an exception to the requirement of a hierarchical file system)
- A hierarchical tape file system (actually a flat file system with extended name syntax)
- A hierarchical disk file system on the local machine
- A hierarchical disk file system on remote machines

E.4 Digital Data Transfers

Digital data transfers are classed into "File Transfer" and "Content Play." The "File Transfer" is the transfer of any data wrapped with a known cover (the file). See the section on data Wrappers contained in Annex D of this document. The "Content Play" is raw data that is streamed from a serving device to one or more receivers. Typically this raw data represents video or audio. A method to transfer Files and to Stream real time video/audio is required. The two main methods of sending data are (see Table E2):

- Guaranteed-delivery "File Transfer" methods.
- Bounded-quality, asset streaming (" Content Play") transfer methods. Digital content may be streamed from a serving device at user-selectable payload rates for real time or slower/faster than real-time.

The term "Bounded quality" is used for a transfer method that is designed to move the payload from source to destination(s) but without the absolute certainly of true guaranteed delivery. Traditional analogue video is moved with bounded quality in a "Content Play" method today. Also, payload data that is moved over the ITU-R BT.656 serial digital interface is moved in a bounded quality way. Usually, bounded-quality links are used to transport streamed, real time content. "Guaranteed delivery" indicates that the entire payload will reach the destination without bit errors, barring a failure of the physical link.

E.4.1 "File Transfer" Requirements for point-to-point Connections

A pure "File Transfer" needs to meet the following minimum user requirements:

- Error-free transfer (by means of using a return path requesting the re-send of corrupted packets).
- The connection between sender and receiver must be bidirectional.
- File Transfer "as fast as possible" (AFAP) must be supported. When the link connecting the source to the destination has unknown payload capacity, the AFAP mode is used. An AFAP transfer only guarantees that the file will eventually be moved to the destination but the time of completion is undefined.
- User-selectable payload transfer rates for real time or < or > real time must be supported when the links that connect the sender and the receiver support a known and definable payload transfer rate. For example, SMPTE 259M supports a known rate so files moved over this link

can be sent at user-selectable rates within the limits of the link, sender and receiver.

- File transfer initiation from either the destination or the source must be supported.
- Machine and file access and permission control are required.
- A universal default file transfer protocol (see Note 1) must also be provided to accomplish the needs of this application.

Note 1: to be defined

E.4.2 "File Transfer" Requirements for point-to-multipoint Connections

This application is the same as for the point-to-point case above with the following exceptions:

- This file transfer mode is optional.
- If implemented, point-to-multipoint must be supported with at least 32 simultaneous receiver nodes.
- The file transfer protocol may be different from that used for the point-to-point case.

E.4.3 "Content Play" Requirements for point-to-multipoint Connections

A "Content play" has to meet the special user requirement of "playing" video, audio, data etc. in a television production environment. Because re-sends of video data (and the resulting delay or latency) caused by corrupted data cannot be tolerated, some errors must be accepted and a return path must not be used. The actual payload to be streamed might not be a file but the raw video/audio Essence. For example, streaming MPEG2 compressed data over a serial digital interface link (with appropriate data framing to carry compressed data) at real time rates is a typical application.

Other important unique television production requirements are:

- Bounded quality based on the QoS of the link. The Rate, Delay, Jitter and Loss of the link determine the quality of the streamed content.
- Links that support the streamed assets must be unidirectional in nature.
- There is no AFAP mode as required in the "File Transfer" case above.
- Streaming rates may be at real time or faster or slower than real time with real time being the default mode.
- The machine control methods for the sending device are not specified by this document.
- File access and permission control are required.
- Standards need to be provided for carrying payload data in the connecting link(s); e.g. how to transport MPEG2 data as payload in a serial digital interface link.?

Browsing, which is also a "content-play" application, has requirements which differ from the "on-air" content-play application in the following respects:

- error rate, bandwidth and delay of the links may not be well defined.
- Point-to-point is typical. Point-to-Multipoint is not required.
- Access/permission controls are required.

E.5 Transport mechanisms

There are many choices and tradeoffs available in the transport of data and the suitability is based on the particular application. The type of transport is in general defined by the quality and cost constraints of the application. The quality aspect is determined primarily by the video type. The higher the quality and performance requirements, the higher the interface and physical layer requirements.

The transport mechanism is used to build the link between the data to be transported (i.e. the file format) and the physical layer. It has to provide attributes such as bandwidth reservation and synchronization as required by the application (e.g. content play requires synchronous delivery).

Two families of transport mechanisms have been identified:

- serial digital interface (ITU-R BT.656) based mechanism
- network-based transport mechanism

A clear user requirement is the interoperability in each of the transport mechanism families by themselves and between the two families (see 1.3.6).

The following sections describe requirements which are necessary to meet the users' expectations on transport mechanism and to achieve interoperability in the transport layer between different systems.

Requirements need to be defined in the areas of:

- synchronization
- transfer modes and quality of service parameters
- transfer initiation and transfer phase parameters
- transfer interaction management and error reporting
- basic interworking protocols

A method is presented for categorizing QoS parameter values according to the application.

E.5.1 Synchronization of associated data (e.g. Audio-Video-Metadata)

Maintaining the synchronization of audio and video and associated data (e.g. Time Code) is a critical issue for streaming, isochronous and synchronous transfers. Users require that future implementations of both SDI-based and network-based transmission should meet the specifications described in ITU-R BT.717 (or EBU Tech. R37).

E.5.2 Transfer modes and QoS parameters

In a mainstream television production environment three types of time relationship (depending on the application as described later) between the source data-clock and the received data-clock of a signal are necessary. These are: synchronous, isochronous and asynchronous transmission in both bounded and guaranteed-quality transmission.

The synchronization aspects which are of importance for professional television transmission differ greatly in some respects from those used in the computer industry.

These time relationship aspects combine with two main methods of transfer described in section E.4 to produce six combinations applicable to a mainstream television production environment. These are shown in Table E2.

The notation A1 through B3 is used as a shorthand for these six modes and it is used in the examples and in Table E8, below.

E.5.3 Transfer initiation parameters

Essential parameters during the initiation or pre-roll phase of a transfer (independent of the transfer modes) are:

- response time for the interaction (e.g. press/click on play, copy etc. and the delay until the system confirms the action)
- set-up-time (e.g. time required for the establishment of a connection-oriented transmission over, for example, a Fibre Channel or ATM link).

Suggested ranges of values for these parameters are shown in Table E3.

Note 1: In typical applications the response time and the set-up-time will differ from the first initiation of, for example, a connection over a network and any subsequent requests over the same connection. The numbers shown in the table are maximum values for the first initiation of the process. All parameter values need to be verified.

The parameters are carried forward to Table E5, below, as part of an example.

E.5.4 Transfer phase

Once a transfer has commenced, a defined transmission quality must be guaranteed. Parameters which determine this are: bit-rate, delay, Bit-Error-Rate (BER) and jitter.

These parameters are specified in Table E4 for end-to-end applications and are referred to as Quality of Service (QoS) parameters.

Note 1: Bitrate depends on the application. For example, if a faster than real-time transfer is required interfaces with higher bit rates may be used. For example, a packetized studio interface with a transfer data rate of 50 Mbit/s is unlikely to be used. 4 x transfer would lead to data rates in the 200 Mbit/s region which would be more applicable.

Note 2: When BER = 0 is required by the application a resending capability is required

Note 3: UI = Unit Interval. Wander is a serious problem for video transmission over wide-area networks and is presently under consideration by SMPTE

The parameters are carried forward to Table E5, below, as part of an example.

Table E2: Transfer modes

	Guaranteed delivery	Bounded quality
Isochronous	B1	A1
Synchronous	B2	A2
Asynchronous	B3	A3

Table E3: Transfer initiation parameters (Note 1)

Identifier	0	1	2	3	4
Parameter					
Response time	Unspecified	≤3s	≤1s	≤0.25s	≤10ms
Set up time	Unspecified	≤1s	≤100ms	≤50ms	≤5ms

E.5.5 Example of the specification of a class of transfer

According to the previous definitions the transfer of data can be specified as shown in Table E5.

See also Table E8 for examples of transfer initiation and transfer phase parameter usage

E.5.6 Transfer interaction management, exception reporting

The transfer interaction management usually runs in the background of the system and is not visible to the user.

Some functions required of this interaction management are:

- establishment, maintenance and release of the data link
- the framing, mapping of data to be transmitted
- error control
- flow control

However the system must report non-recoverable exceptions to the user, for example, as shown in Table E6.

E.5.7 Basic transport protocols

For content transfer via the serial digital interface (ITU-R BT.656) in packetized form, users require a single open transport mechanism. A standard for such a transport mechanism is currently under development in SMPTE and EBU. This transport mechanism must be implemented in products according to the user requirements and specification made above.

For content transfer via a network, users require at least one open standardized baseline protocol such as IP. However existing protocols have not been developed to meet the mainstream television production requirements; therefore optimized protocols which meet the user requirements defined above need to be developed and standardized.

Interworking between the serial digital and network-based transfer protocols is a strong user requirement and open standardized gateways between them need to be defined.

Table E4: Transfer phase parameters and values (all parameter values need to be verified).

Identifier	**0**	**1**	**2**	**3**	**4**
Parameter					
Bit-Rate (Note 1)	Available Bit-Rate	> 10 Mbits/s	>50 Mbits/s	≥ 270 Mbits/s	≥ 1.2Gbits/s
Delay	Unspecified	≤ 1 s	≤ 500 ms	≤ 250 ms	≤ 20 ms
BER better than (Note 2)	10^{-6}	10^{-8}	10^{-10}	10^{-12}	0
Jitter (for Wander see Note 3)	Unspecified	≤0.6 UI	≤0.4 UI	≤0.2 UI (see SMPTE 259M)	≤0.135 UI (see SMPTE 297M)

Table E5: Specification example

Application	Transfer modes	Transfer initiation parameters	Transfer phase parameters
	A2	4.1	3.4.3.3
Live interview between two performers in the studio	(synchronous, bounded quality)	(response-time<10ms, set-up-time<1s)	(bit-rate≥ 270 Mbits/s, delay ≤ 20 ms, BER≤10^{-12}, jitter=0.2UI)

Table E6: Exception Reporting

	SDI based transport	Network
Alarm when Link-BER degrades to:	≤10^{-10}	degrades more than 10^{-2} from the QoS agreed on.
Synchronization errors	bit, character, frame, picture	bit, character, frame, picture
Bandwidth degradation	unlikely	due to traffic management error
Priority change	due to traffic management error	due to traffic management error
delay change more than 1	0% from QoS value	10% from QoS value
Recovery time after a break of 50ms exceeds	500ms	500ms

E.6 Physical Interfaces

E.6.1 Physical layer

This layer deals with the physical medium used to provide the means to transmit data between devices as well as defining the interface between devices.

Examples of physical media include:

- Twisted pair
- Coaxial cable
- Optical fiber
- Radio

For example in the 270 Mbit/s and 360 Mbit/s Serial Digital Interface (SDI) used for serial digital video, the physical medium is coaxial cable with 75-ohm characteristic impedance.

Details of the interface include:

- Mechanical Type of connector
- Electrical (voltage levels, bit rates, rise times, distance requirements)
- Functional (Data, control, timing)
- Data coding

Similarly, for ANSI/SMPTE Recommendation 259M, the mechanical requirement defines a 75-ohm BNC connector. The electrical requirements define an unbalanced circuit with signal levels of 800 mV p-p across a 75-ohm load with rise times between 0.75 ns and 1.5 ns. Bit rate for 4:2:2 standard video is 270 Mbit/s.

Functionally the data word length is 10 bits with the LSB of any data word transmitted first. Flow control is not required due to the streaming nature of video data.

Examples of existing physical interfaces are given in Table E7.

Table E 7: Physical Interfaces

	Electrical Interface		Optical Interface	
	point-to point	Network	point-to point	Network
	transmission according to ITU-R BT.656 should be transmitted according to SMPTE 259M		transmission according to ITU-R BT.656 should be transmitted according SMPTE 297M	Network Multi-Mode Fibre Interface according to ISO/IEC 11801 Single Mode Fibre Interface according to ITU-T G957
Bitrate	see Note 1 (>270Mbit/s)	Application-specific, see Note 1	see Note 1 (>270Mbit/s)	Application-specific, see Note 1
Delivered error rate after error correction	better than 10^{-12}	better than 10^{-12}	better than 10^{-12} for LED based MM for SW Laser based MM for Laser based SM	better than 10^{-12} for LED based MM for SW Laser based MM for Laser based SM
Medium	coaxial cable 75Ω nominal impedance	a) coaxial cable 75Ω nominal impedance; b) Cat 5 UTP	Fibre 62,5/125 micron for MM 8-10/125 micron for SM	Fibre 62,5/125 micron for MM 8-10/125 micron for SM
Interconnect length	length up to 250m	application dependent	MM up to 500m SM: short reach up to 2km intermediate reach up to 15km	MM up to 500m SM: short reach up to 2km intermediate reach up to 15km
Transmitter and receiver characteristics	as defined in ITU-R BT656-4	network specific	as defined in SMPTE 297M	as defined in ITU-T G957 for single- and multi-mode
Jitter	defined in SMPTE RP 184 and 192	network specific	defined in SMPTE RP 184 and 192 for SDI based transmission and in ITU-T G958 for networks	as defined in ITU-T G958 (see Note 2)
Connector	standard BNC type (IEC Publication 169-8), and its electrical characteristics should permit it to be used at frequencies up to 850 MHz in 75-ohm circuits.	a) BNC/TNC b) RJ45 c) IEEE-1394 d) DB-9	SC types as defined by IEC874-14 and IEC 11801	SC types as defined by IEC874-14 and IEC 11801

E.6.2 User Requirements for Physical Interfaces

It is recognized that the choice of physical and link layer implementations is restricted by the choice of network. The choice of network is itself dependent on system and application requirements such as QoS and bit rate.

Given these restrictions, the following user requirements have been identified:

- The operation of the interface must be invisible to the system user.
- Network interfaces for content transfer must be chosen from the available industry-standard interfaces. At the present time these are considered to be:
  - IEEE 802 Ethernet (see Note 1)
  - Fibre Channel ANSI X3230-1994 and related standards (See Note 1)
  - ATM (See Note 1)
  - IEEE 1394
  - SMPTE [ ] SDT (the SMPTE [ ] Serial Data Transport compatible to SMPTE 259M)

Note 1: Not all classes of service, particularly real time video transfers, are available at the present time

- Implementations must comply with all relevant aspects of the chosen network interface.
- Connectors must be of appropriate robustness and durability for a professional broadcasting environment. Where, for a particular network interface, a choice of connector exists, the chosen connector should ensure the maximum level of compatibility between equipment.
- It is desirable that equipment network interfaces be available in a variety of forms, to suit the industry-standard networks listed above.
- It is desirable that an equipment interface be capable of upgrading to take advantage of higher network bandwidths as these become available.

Note 1: Bitrate depends on the application; e.g. if a faster than real-time transfer is required, interfaces with higher bit rates must be used.

Note 2: After buffering and jitter removal the residual jitter must meet that specified in SMPTE 259M.

ITU-T G957: Optical interfaces for equipment and systems relating to the synchronous digital hierarchy

ITU-T G958: Digital line systems based on the synchronous digital hierarchy for use on optical fiber cables

E.7 High Level Management Functions

Due to the complexity of networked systems with multi-user access and the involvement of interconnected server-based systems, further high level operational user requirements must be provided by the system management. These include, for example:

- Mission critical network requirements:

  Data security/shadowing/backup must run automatically in the background

  Localized failure recovery where possible

  No concentrations of failure points

  Automatic failure condition notification and logging

- Distributed Resource Management

  The distributed resource manager has to provide all the functions which are necessary to make the transfer between systems possible and which parameters are necessary for the transfer to be accomplished (and inform the user about exceptions if necessary).

  Examples are:

  - provide information about the slowest/fastest rate any destination can accept, (e.g. whether the intended bit rate is higher than the destination can accept), and what storage is available at a particular destination

  - allow a transfer with a certain speed and a certain file size in, for example, a point-to-multipoint topology

  - perform payload compatibility check (e.g. DV-to-MPEG) and notify transfer initiator

  - determine whether a prior negotiation is needed

  - updating pathname of associated file(s) automatically after move operation

- Plug and Play (hot plugging) and operating system issues

  This is defined as dynamic resource detection without reboot. For example, if a new server is connected to an existing server environment, the system management must detect and install the new system automatically with appropriate messages to the user and with no disruption to ongoing operations during the reconfiguration. This also requires multi-operating system support in order to achieve an easy data exchange and interoperability in the operating system and file association domain.

- Control interfaces

  Machine control commands need to be openly defined in order to support multi-vendor equipment.

E.8 Application example

Table E8 gives examples of different applications and the required QoS parameters.

Table E8: Application examples and QoS parameters (see also Table E5)

	Application example	Transfer mode (Table E2)	Transfer initiation (Table E3)	Transfer phase params. (Table E4)	Example Data Types	Notes
1	**Hard real-time isochronous live multicast** (e.g. interaction between performers, live 2 way interview, people and machines)	A1	4.4	3.4.3.3	601, DV422, MPEG422 + Audio + Ancilary + time code + metadata	link is a channel. ex. SDI 259M payload
2	**Isochronous real-time delivery with delay** (e.g. Program distribution channel) [def. Required contribution versus distribution]	A1	3.3	3.3.3.3	601, DV422, MPEG422 + Audio + Ancilary + time code + metadata	link is more a channel
3	**Synchronous real-time delivery**	A2	3.3	2.4.2.2	601, DV422, MPEG422 + Audio + Ancilary + time code + metadata	ex. ATM over SONET/SDH
4	**Selectable transfer rate** (e.g. 4 times transfer, 200 Mbt/s moves (50 Mbit/s) at 4x play speed	A1 or A2	2.2	3.2.3.2	601, DV422, MPEG422 + Audio + Ancilary + time code + metadata	transfer time is well defined
5	**Asynchronous delivery of real-time content**	A3	1.1	0.0.0.0	Web video and audio content	ex. Audio, video delivered over Internet to Web client
6	**File transfer with guaranteed delivery** (e.g. digitized content and/or metadata transfer)	B3, B2	2.2	2.0.4.0	data	transfer is AFAP (as fast as possible)
7	**File transfer "bounded quality/ multicast version"** (e.g. video email over cable modem)	A3	2.2	2.0.3.0	data	application still evolving; time/transfer is not "an issue".
8	**As 5, but point to multipoint** (e.g. digitized content and/or metadata transfer)	A3	2.2	2.2.3.0	data	time/transfer is "an issue" (related to cost of transmission)
9	**As 5, but at selectable rate** (sending a payload within a specified amount of time)	A3	2.2	2.2.3.0	data	time/transfer is "an issue" (related to cost of transmission)
10	**Browsing** There is a UR for browsing acquired material.	B3	?	?	data	requires further study

E.9 Wide Area Network Gateway

Wide Area Networks (WAN) used to interconnect facilities for production and distribution present additional diverse and difficult challenges beyond those of Local Area Networks. The QoS of WANs especially in the areas of latency, rate, jitter, and BER require special equipment to interface the facility to the WAN, i.e. through a gateway. The gateway not only has to adapt the QoS of the WAN to match the facility requirements stated earlier but must also perform protocol and signal translation as needed. This includes segmenting and addressing bit streams (digital video and audio) as well as self routing capabilities so they may find their way through a WAN. Protocols on the WAN side of the gateway must adhere to national and international conventions. Gateway and network management services need to be included for set-up, accounting and control including security. A co-ordination intercom may be needed for set-up and maintenance. Discussion of the myriad of protocols is beyond the scope of this document. A concept diagram (Figure E1) shows a possible gateway configuration.

E.10 User Requirements for standards

In order to achieve interoperability between different vendors, which is a basic user requirement, the following standards need to be defined:

- File Formats for content transfer
- Link Protocols for guaranteed and bounded quality transfer: e.g. protocols for different classes of service, transfer mode commands, transfer initiation commands, transfer phase commands, the format of data being interchanged, number of bits per element, type of encoding scheme, synchronization information
- Flow Control: methods to control the flow of data between two devices (e.g. to avoid overflow of storage

at the receiver)
- Error Control: e.g. type of error detection and control
- Inter-Layer commands: e.g. error messaging between different layers
- Machine Control (see note 1)
- Networks and interfaces
- Gateways between networks, LAN and WAN and SDI based transport systems
- Payload and mapping documents (e.g. the mapping of content blocks into the packets of a transport mechanism)
- User interfaces
- Platform independent file system management interfaces
- Timecode-based scheduling for filesystem actions such as browsing

NOTE 1: Machine control commands need to be openly defined: a central, external control system must be able to con trol all system elements without the need for multiple customized drivers or command translators; (e.g. would support ES-LAN Server dialect)

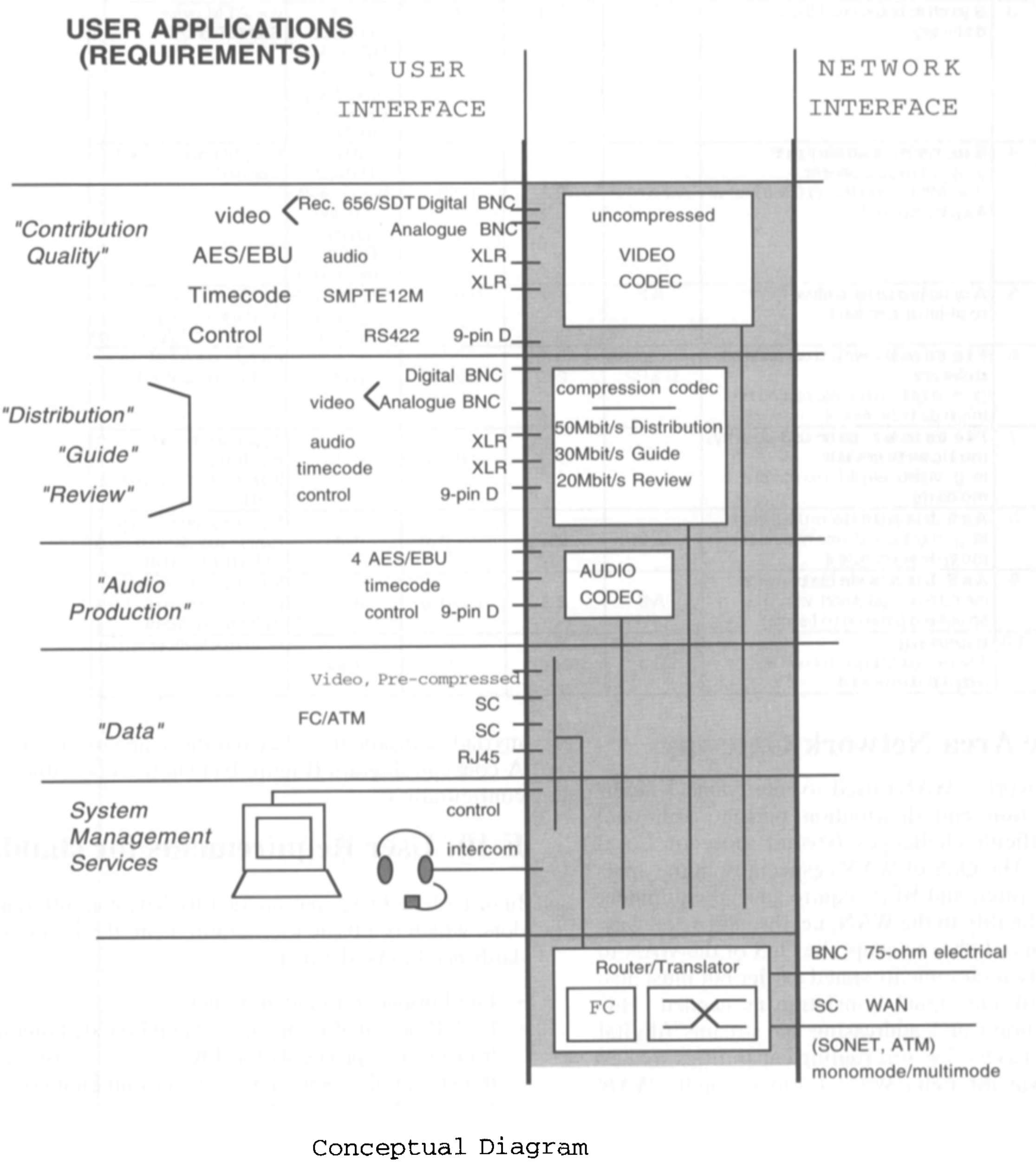

Figure E1. Wide Area Network Gateway