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Networks and Transfer Protocols

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The Networks and Transfer Protocols subgroup of the Task Force had the responsibility of finding the best technologies to enable different data types to be moved around a networked production environment. It had the task of identifying the best methods for (i) audio/video streaming in real-time (and faster than real-time), (ii) file transfer (also at different speeds) and (iii) file access.

The chosen methods should guarantee the interoperable transfer of programme content between devices, and these transfers should meet the high-end requirements of the TV broadcast world. An additional part of the subgroup's work was to identify and define the further work that needs to be carried out by standardization organizations.

1. Introduction

The Networks and Transfer Protocols subgroup issued a so-called Request For Technology (RFT) to the different parts of the industry concerned with networks, interfaces and transfer protocols which can be applied to our television environment. We received a variety of responses:

- *Advanced Streaming Format* (ASF), from Microsoft Inc.;
- *QuickTime*, from Apple Computers Inc.;
- *Fibre Channel Audio/Video*, from the Fibre Channel community;
- the *ATM Forum* sent a representative to participate in our meetings;
- the proponents of *SDTI* became heavily involved in our work.

The manufacturers and users, all of whom made valuable contributions to the work, finally came to the definition of a so-called *Reference Architecture* (RA) as shown in *Fig. 1*. Al Kovalick of HP should be given special mention here because he had the idea of the RA for interopera-

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ble content exchange. For the RA, we had to select a few suitable technologies from a universe of offers submitted by the computer and related industries. For the streaming of content in real-time and faster, we had to consider the mapping of different applications into the available transport mechanisms – for example, DV into ATM, MPEG into Fibre Channel. We also had to recommend a limited number of interfaces from the growing list of candidates: Ethernet, Fast Ethernet, Gigabit Ethernet, FC, SDTI, SDI, ATM, different flavours of ATM, etc.

We had to identify a number of interfaces and transfer protocols for general-purpose use and low-performance applications, and a number of interfaces and transfer protocols for very high-performance use, specialized applications and, of course, for coping both with remote and local transfers.

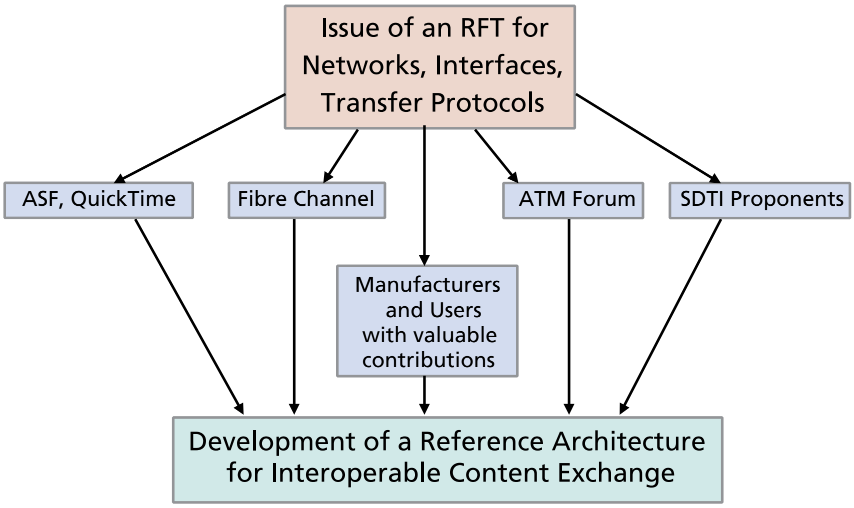

Figure 1
Workflow of the subgroup.

2. Streaming

Streaming means that you have to "push" content across channels and networks in a point-to-point or in a point-to-multipoint topology. This is similar to the way in which we currently handle our broadcast content. The important requirement here is to transfer the content in real-time, which is not easily met by interfaces such as FC or ATM.

The links for streaming are often uni-directional, and the receiver should be able to "join" a stream which has already started. The consequence of having uni-directional links is the

Abbreviations

ANSI	American National Standards Institute
ASF	(Microsoft) Advanced Streaming Format
ATM	Asynchronous transfer mode
A/V	Audio / video (visual)
FTP	File transfer protocol
IEC	International Electrotechnical Commission
IEEE	(US) Institute of Electrical and Electronics Engineers
IP	Internet protocol
ISO	International Organization for Standardization
FC	Fibre Channel
MPEG	(ISO/IEC) Moving Picture Experts Group
QoS	Quality of service
RA	Reference architecture
RFT	Request for technology
SDI	Serial digital interface
SDTI	Serial data transport interface
SMPTE	(US) Society of Motion Picture and Television Engineers
TCP/IP	Transmission control protocol / Internet protocol
WAN	Wide-area network

bounded quality of the received signal – there is no mechanism in the receiver to flag a corrupted signal, which means that we have to apply certain Quality- of-Service (QoS) parameters to the link in use. Amongst these parameters are the bit-rate, the jitter and wander, the transmission delay and also synchronization issues.

So which technologies have we identified? In the physical domain (see *Fig. 2*), SDI is of course very important for internal studio applications. SDH and SONET are very important for wide-area transmissions; so too are the physical layer of Fibre Channel, and of course Ethernet, Fast Ethernet and Gigabit Ethernet.

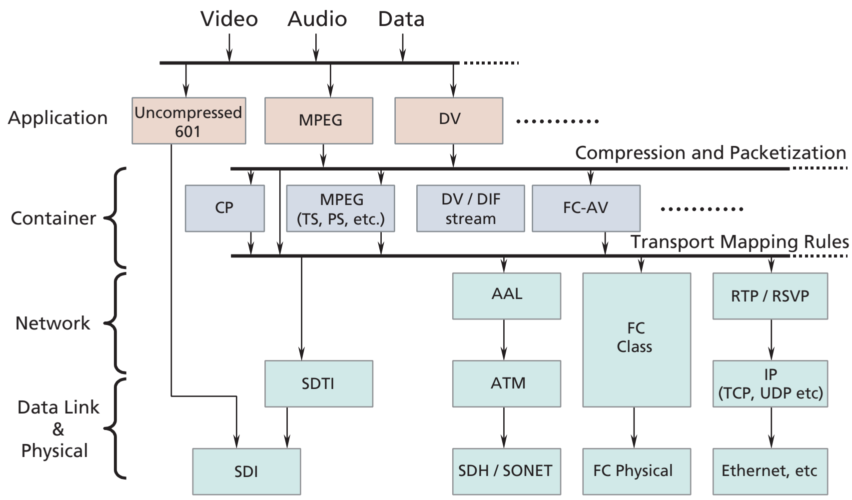

Figure 2
Streaming technologies.

In the Data Link and Network area, SDTI is one of the hot topics concerning the transmission of compressed signals within the studio. ATM is very suitable for WANs, and we should not ignore FC and IP.

What was urgently required was a certain type of mapping rule to enable us to map programme containers such as DV, MPEG and FC A/V into the transport mechanisms mentioned above. We have identified a couple of mappings whose standardization has already been completed. However, other identified mappings will have to be further worked on, in the follow-up activities of the SMPTE.

The subgroup has generated the following recommendations within the RA for streaming (and this is not an exhaustive listing):

- **SDTI** is currently the choice for internal studio interconnects. This means that in order to transmit compressed signals without re-encoding within the studio, SDTI is the right choice – if you have to do it in real-time and at faster than real-time.
- **Fibre Channel** is a high-performance file transfer mechanism. The FC A/V project is also working on a streaming implementation, but this is only on paper for the moment. So we encourage and require all the supporters of FC to implement this standard for streaming in the form of real hardware products.
- **ATM** is the choice for WAN streaming – no doubt about that. However we have identified that there is still a problem, especially between North America and Europe. The AAL1 and AAL5 issue needs to be sorted out. We also need a guideline on how the wander and jitter issues can (probably) be solved.

Gateways are needed between the studio and the WAN – for example, how can we move SDTI payloads over wide-area networks?

The Final Report of the Task Force includes a mapping table (in Section 5.7.3.) which was developed by our subgroup. This table shows (by means of a “C” for “complete”) which of the transports are already defined. For example, we have an MPEG transport stream mapping into ATM, and thus no further standardization work is required in this case. Non-defined mappings are flagged in this table with an “R” for “required”. For example, mapping over FC is an ongoing project which needs to be supervised by the SMPTE and the EBU, in order to give the broadcasters enough input. Also, DV mapping into ATM is not defined for the moment, but it is needed to bring these signals out of the studio and to effect transfers of these signals between studios.

3. File transfer

File transfer – the movement of file contents in “push” or “pull” modes over point-to-point and point-to-multipoint topologies – is going to play an increasing role in all the future studio interconnects. It is a guaranteed, error-free, bit-by-bit copy of the content. This requires that the links between the devices participating in the file transfer need to allow for the re-sending of corruptly-received data. This implies bi-directional links.

File transfer allows for different transfer rates:

- slower than real-time;
- real-time (which means that a file containing a 90 minute programme is transferred in 90 minutes);
- faster than real-time.

Why is the last of these so important? Well, if you save time on the transfer, you also save money.

A file transfer is described by a header and after that the content follows. The header is usually sent once only, so that if the file transfer has already started, receivers cannot “join” the transfer in mid-progress.

File transfer is supported for many different types of links (in the physical layer). *Fig. 3* is a rather complex overview of the file transfer technologies we have identified. Very important to note is that there are different types of transport mechanisms which can be used for file transfer – we have ATM, FC, Ethernet, IEEE 1394 (Firewire) and others. However, in order to achieve the interoperability we so much all require, we have defined only a limited number of file transfer protocols. For example, if you are using FC and you have to realize a very, very fast file transfer, then you can use the ANSI standard for FC and the so-called FTP+ protocol. For core (baseline) file exchanges, we recommend the use of FTP as a really basic communications protocol that should be supported by everybody. Distributed file access is only an intermediate solution, simply because it is available at the moment.

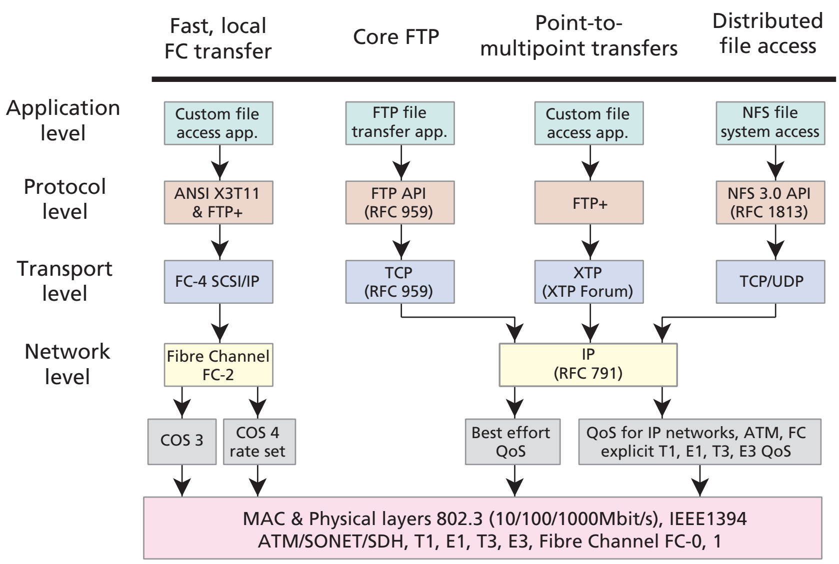

Figure 3
Overview of File Transfer technologies.

The enhanced protocol already mentioned, FTP+ (which has been defined in part by the Task Force), is now the subject of further work within the SMPTE to complete the standardization process. FTP+ uses an FTP baseline protocol (a public standardized protocol) and uses TCP/IP for the underlying transport mechanism. We discovered that FTP (as currently defined) does not meet all our requirements, especially in the case of point-to-multipoint transfers, partial file transfer and, of course, for the very high-speed requirement we have in our applications.

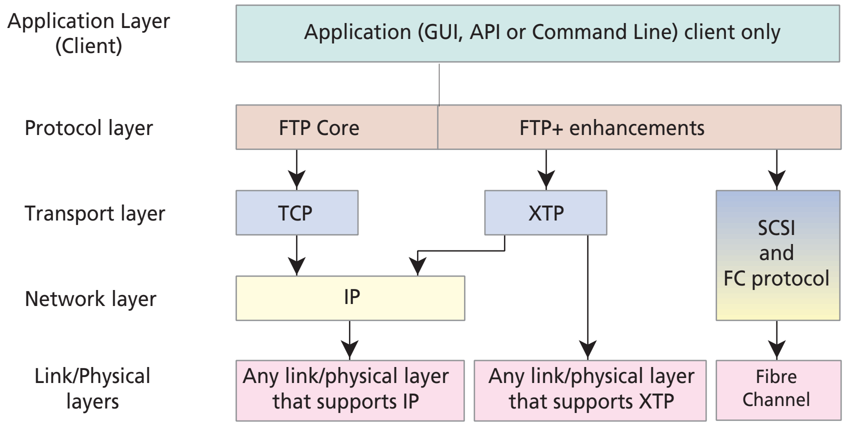

Figure 4
"Special" File Transfer technologies.

The subgroup has generated the following recommendations for file transfer:

- **FC A/V** for high-performance local-area networks, because we all know that new hard disks will have an FC adapter fitted;
- **ATM** is the choice for wide-area networks.
- **IP-based** interfaces can be used, because IP provides a standardized interface on which our file transfer protocols can sit. So, interoperability is achieved.
- **XTP** is our current choice to meet the requirement for point-to-multipoint file transfer.

4. Conclusions

In conclusion, we have defined a Reference Architecture which allows us to move digital content between the devices of different manufacturers. We have made some choices for general- purpose streaming and for file transfer. We have identified special technologies required to meet our high-end TV broadcast requirements. We have also identified the follow-up work which is necessary to standardize all these new technologies and to expand on the ideas we have already generated. And finally, if every manufacturer and system designer follows just one or two parts of this Reference Architecture, *interoperability* (at least in the physical area, the data-link area and the network area) is guaranteed.

Hans Hoffmann *studied Electronic Communication Engineering in Munich and joined the IRT in 1993 where he developed a jitter measurement device for SDI. Today his work at the IRT is concerned mainly with packetized interfaces (SDTI, Fibre Channel, ATM etc.) and the transfer protocols which will allow the use of packetized bit-rate-reduced signals in a studio environment.*

Since 1993, Mr Hoffmann has been a member of several national and international working groups. He has chaired EBU project groups P/BRRTV and P/PITV, and was very involved in the standardization of the SDTI. He is a member of various SMPTE working groups and contributes to ITU-R Working Group 11B.

Hans Hoffmann chaired the EBU/SMPTE Task Force subgroup on Networks and Transfer Protocols and then, in November 1998, he became Chairman of SMPTE Committee N26 (File Management and Networking Technology).