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SERIES J: CABLE NETWORKS AND TRANSMISSION OF TELEVISION, SOUND PROGRAMME AND OTHER MULTIMEDIA SIGNALS

Digital transmission of television signals

Architecture for synchronised programme transfer with pull operation over IP-based networks

ITU-T Recommendation J.285

ITU-T

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Architecture for synchronised programme transfer with pull operation over IP-based networks

Summary

ITU-T Recommendation J.285 defines requirements of IP-based material transfer from remote sites to a broadcast station controlled by the broadcast station side. The requirements are based on the generic requirements defined in ITU-T Recommendation J.284 with the analysis of several use cases which are also described in this Recommendation.

To satisfy the requirements, this Recommendation also defines the architecture for programme material transfer in synchronization with pull operation. The architecture is only relevant to transfer of file-based materials such as computer files. That is, transfer of unfiled materials such as signals from equipment like cameras and microphones are not taken into account in this Recommendation. The architecture also enables synchronized transfer of multiple files simultaneously, which offers the opportunity for the receiver to switch receiving files from one to the others according to an edit decision list (EDL).

Source

ITU-T Recommendation J.285 was approved on 14 December 2007 by ITU-T Study Group 9 (2005-2008) under the ITU-T Recommendation A.8 procedure.

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Introduction

Broadband IP network infrastructure is being promoted and becoming more widely used for transfer of broadcast materials, and computerised equipment for producing news and other programmes is becoming widely implemented. Therefore, the IP-based transfer of programme materials with compatibility for computers is considered to be another major transfer method in addition to other conventional methods such as satellite news gathering (SNG) transmission.

The editing process usually requires storing materials locally prior to edit. However, an IP network can be used to establish a relatively simple technique which enables to edit materials even while transferring them.

ITU-T Recommendation J.285

Architecture for synchronised programme transfer with pull operation over IP-based networks

1 Scope

This Recommendation defines requirements of IP-based material transfer from remote sites to a broadcast station controlled by the broadcast station side. The requirements are based on the generic requirements defined in [ITU-T J.284] with the analysis of several use cases which are also described in this Recommendation.

To satisfy the requirements, this Recommendation also defines the architecture for programme material transfer in synchronization with pull operation. The architecture is only relevant to transfer of file-based materials such as computer files. That is, transfer of unfiled materials such as signals from equipment like cameras and microphones are not taken into account in this Recommendation. The architecture also enables synchronized transfer of multiple files simultaneously, which offers the opportunity for the receiver to switch receiving files from one to the others according to an edit decision list (EDL).

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T J.284] ITU-T Recommendation J.284 (2007), *Requirements and framework for gathering electronic content over IP-based network.*

[ITU-R BT.1563] Recommendation ITU-R BT.1563 (2002), *Data encoding protocol using key-length-value*.

[ITU-R BT.1775] Recommendation ITU-R BT.1775 (2006), *File format with editing capability, for the exchange of metadata, audio, video, data essence and ancillary data for use in broadcasting*.

[IETF RFC 768] IETF Request for Comments 768 (1980), *User Datagram Protocol*.

[IETF RFC 791] IETF Request for Comments 791 (1981), *Internet Protocol*.

[IETF RFC 793] IETF Request for Comments 793 (1981), *Transmission Control Protocol*.

[IETF RFC 959] IETF Request for Comments 959 (1985), *File Transfer Protocol*.

[IETF RFC 3550] IETF Request for Comments 3550 (2003), *RTP: A Transport Protocol for Real-Time Applications*.

3 Definitions

3.1 Terms defined elsewhere

None

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 synchronization packet: A TCP packet that controls a sender's transfer rate in the application layer. The packet is transmitted from a receiver to a sender.

NOTE – The packet is not the TCP SYN segment.

3.2.2 acknowledge data: Transfer control data transmitted by a receiver as an affirmative response to the sender. The acknowledge data is included in the synchronization packet.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

EDL	Edit Decision List
FS	File Server
KLV	Key-Length-Value coding
MXF	Material Exchange Format
MXF-GC	Material Exchange Format Generic Container
PM	Programme Material
TC	Time Code

5 Conventions

None.

6 The Recommendation

6.1 Use cases

This clause describes use cases for transfer of programme materials from one or more remote sites to a broadcast station over IP networks, as shown in Figure 1. In all cases, the transfers are controlled by the receiver side.

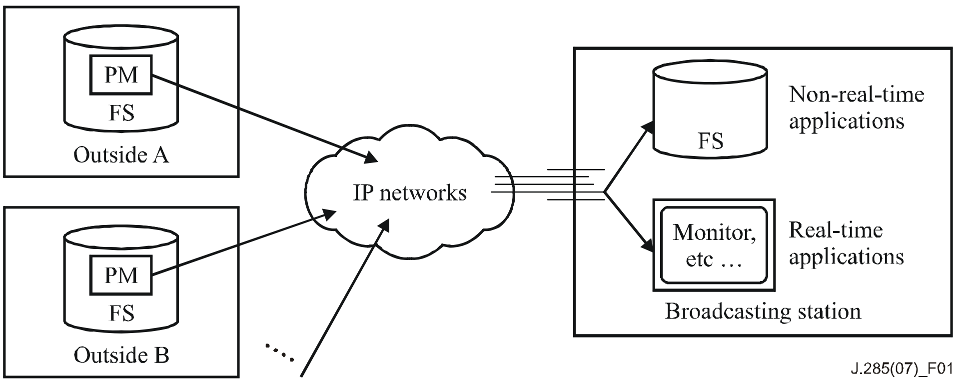


Figure 1 – Programme material transfer over IP networks

6.1.1 File transfer

File transfer is the transfer of material files from a remote server over an IP network, as shown in Figure 2-a. File transfer requires processing to recover lost packets but does not require the real-time characteristic.

For simultaneous multiple file transfers from remote servers to one broadcast station, the receiver side may control the bit rate of the material transmission at the application layer to prioritize the file transfer as shown in Figure 2-b.

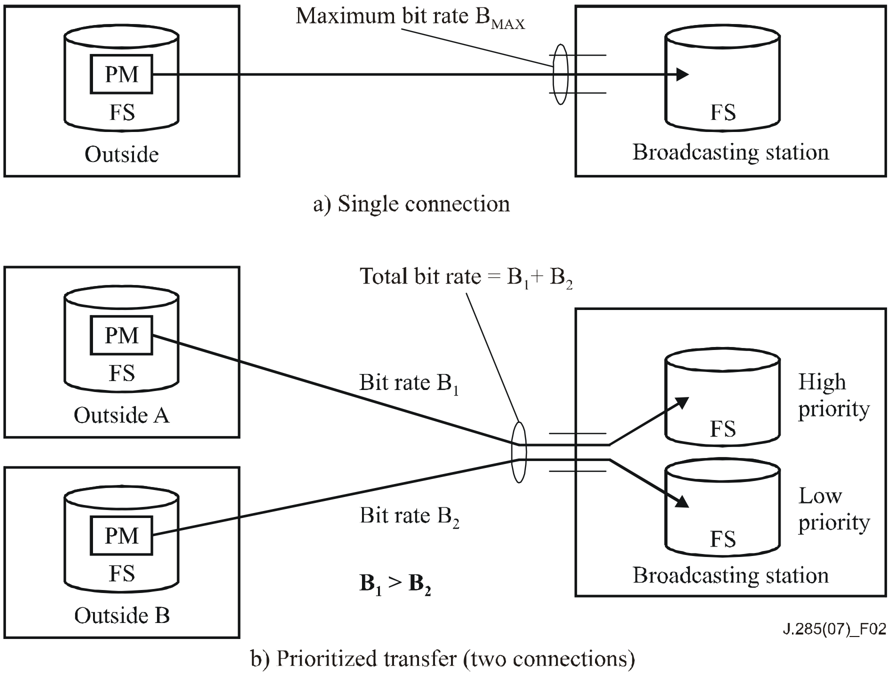


Figure 2 – File transfer

6.1.2 Real-time streaming transfer

Real-time streaming transfer is used to display material from a server directly on a display, as shown in Figure 3. Real-time streaming requires the real-time characteristic for the time line of the receiving side. It does not require processing to recover lost packets. Certain latency from the start time of transfer at the sender side to the start time of playing the stream at the receiver side may be allowed. Therefore, conditional recovery processing can be optionally used unless it degrades the real-time characteristic of playing the audiovisual stream at the receiver side.

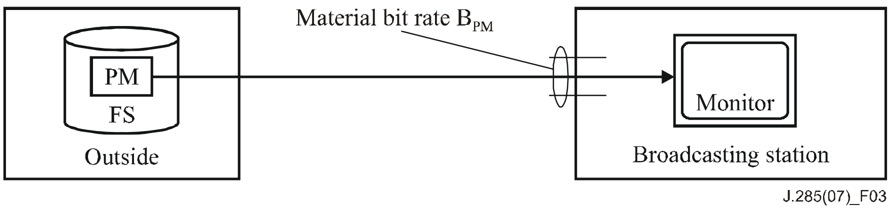
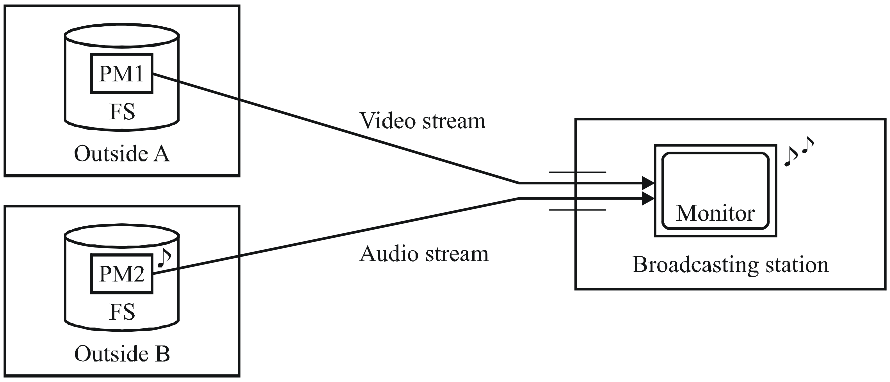


Figure 3 – Real-time streaming transfer

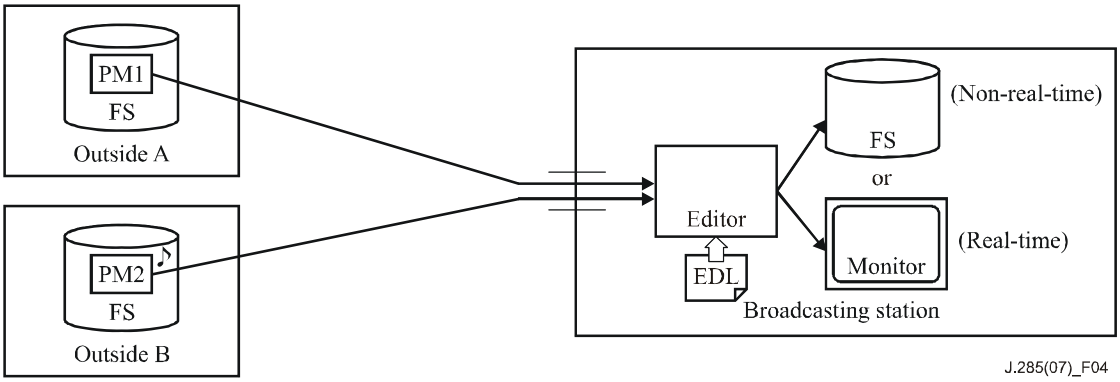
6.1.3 Synchronized transfer

Synchronized transfer is the transfer of multiple materials from remote servers in synchronization, as shown in Figure 4-a. It is used to play video and sound with a synchronized time line when the video and sound files are stored on separate servers. It synchronizes multiple data streams transferred to receiving application in order to prevent overflow and underflow of the reception buffer. It needs to keep synchronization between the video and sounds (lip-sync).

Synchronized transfer is used to directly edit programmes with materials from distant servers according to an edit decision list (EDL), which is created prior to processing, as shown in Figure 4-b. There are two types of synchronized transfer. One is *non-real-time processing* in which multiple materials are processed and stored as a file, and the other is *real-time processing* in which multiple materials are processed and displayed on a monitor. *Non-real-time processing* requires the recovering of lost packets, whereas *real-time processing* can optionally support conditional recovery processing unless such recovery degrades the real-time characteristic of the audiovisual streams playing at the receiving side.



a) Synchronized real-time streaming transfer



b) Synchronized editing transfer (real-time and non-real-time)

Figure 4 – Synchronized transfer

6.2 Requirements

The architecture for synchronized material transfer is required to satisfy the following requirements:

– Applicable to all types of transfer applications described in clause 6.1.

– Maintains transfer performance, even over a long-distance network.

– Transfer upon standard TCP/IP and UDP/IP protocol stacks.

– Applicable to any encoding scheme of the material files.

And additional requirements of which applicability varies with applications are listed below:

– Recovery processing against data packet loss.

– Flow control from the receiver side for the prioritized file transfer.

– Flow control from the receiver side for synchronized reception.

Table 1 classifies the applicability of the additional requirements for the transfer applications described in clause 6.1.

Table 1 – Classification of the additional requirements for synchronized transfer applications

	File transfer	Real-time streaming transfer	Synchronized transfer		
			Synchronized streaming	Synchronized editing	
				Real-time	Non-real-time
Recovery processing against data packet loss	required	optional	optional	optional	required
Flow control for prioritized transfer	required	n/a	n/a	n/a	n/a
Flow control for synchronization	n/a	n/a	required	required	required

6.3 Architecture

This clause defines the architecture for synchronized programme transfer with pull operation that meets the requirements described in clause 6.2.

6.3.1 Structure of programme materials

The transfer of programme materials is controlled video frame by video frame. [ITU-R BT.1775] defines the file format called material exchange format (MXF) for use in a broadcasting environment and the methods to wrap many types of encoded essence data for exchanging programme materials.

Figure 5 shows the structure of frame-based wrapping in the MXF generic container (MXF-GC). The MXF-GC contains video, sound, data and compound essence all together for which the encoding methods are independent of the MXF, and these items are encoded frame by frame by using the key-length-value (KLV) coding protocol [ITU-R BT.1563].

The MXF-GC frame-based wrapping covers the structure of programme materials in the architecture. This makes it possible to transfer the data frame by frame regardless of the differences in the encoding methods.

K	L	V	K	L	V	• • • • • • •

K: SMPTE universal label
L: Data length
V: Value (frame data)

Figure 5 – The structure of MXF-GC frame-based wrapping

6.3.2 Transfer model

Figure 6 shows the transfer model. The senders have programme materials.

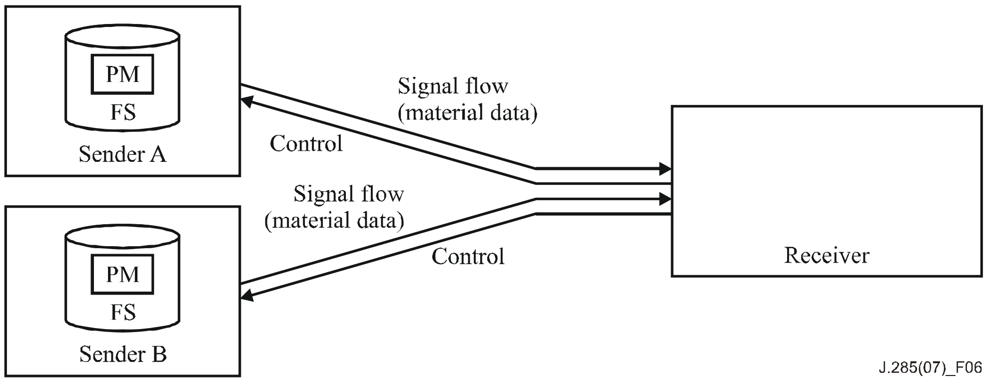


Figure 6 – An example of transfer model

The transfer model consists of signal flows and controls. The sender produces data packets from material data, and transfers them on a signal flow. The signal flow goes from the sender to the receiver. The receiver controls the transfer rate from each sender by synchronization packets.

Figure 7 shows the protocol stack for the architecture.

Transfer applications	**Transfer applications**
Signal flow	Control
RTP	
UDP	TCP
IP	IP

Figure 7 – Protocol stack

The TCP and UDP are widely used as standard transport protocols for IP networks. Because of their compatibility with computer environments, these protocols are suitable for transferring IP-based programme materials. However, TCP/IP may not be suitable for file transfers over a long-distance network because TCP congestion control may not provide enough bandwidth for large size materials in high network latency conditions.

The UDP/IP protocol, on the other hand, is suitable for transferring one real-time stream. It needs an additional mechanism for synchronizing multiple streams because UDP/IP has no flow control algorithm. In addition, it requires processing to recover lost packets because it has no guarantee against packet loss.

6.3.3 Signal flow

The block diagram shown in Figure 8 illustrates the transfer architecture.

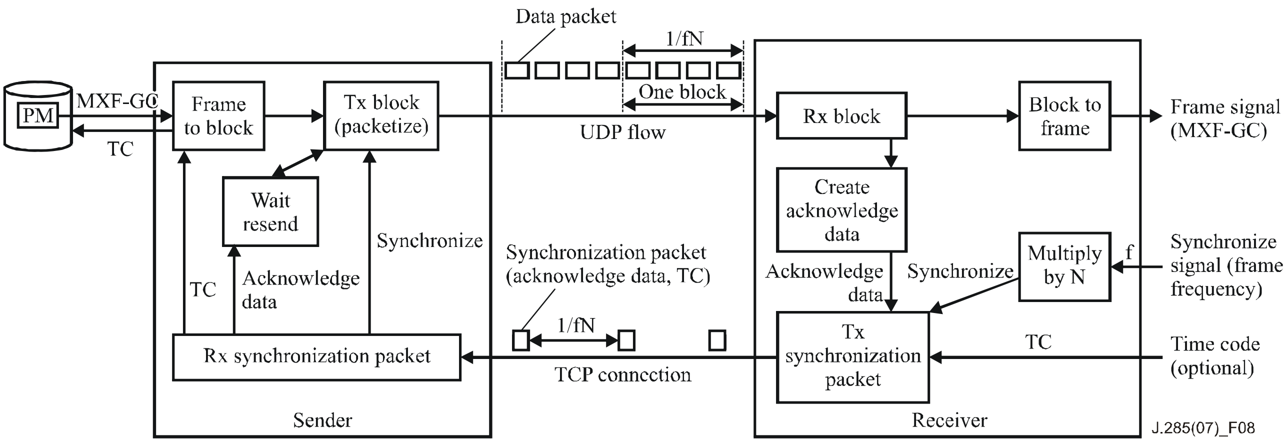


Figure 8 – Block diagram of the transfer architecture

The sender packetizes the programme material and sends the data packet by UDP/IP synchronized with the received synchronization packet. N is the number of video frame divisions. The sender divides one frame into N blocks. The sender transfers the blocks as data packets which is suitable for UDP/IP. The sender transfers a block of data packets every time it receives one synchronization packet.

Figure 9 shows the relation between video frames, blocks and data packets. It also shows examples of frame ID, block ID and packet ID. The frame ID identifies the video frame, the block ID gives the number of blocks in a frame, and the packet ID gives the number of data packets in a block.

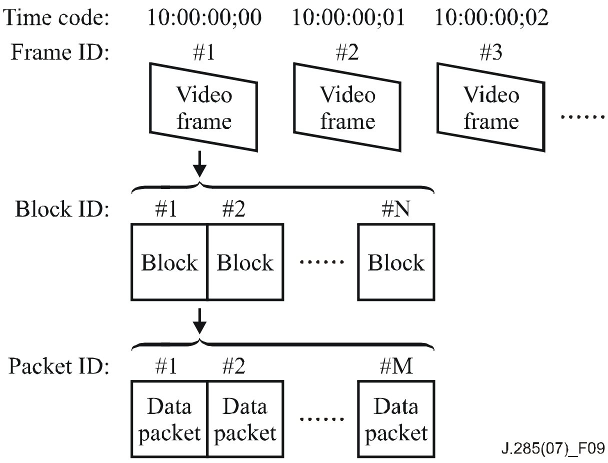


Figure 9 – Relation between frame, block and data packet

Appendix I gives an example of the data packet structure.

6.3.4 Transfer control

The transfer rate of the data packet is controlled by adjusting the transmission interval of the synchronization packets from the receiver's side. The receiver produces a synchronization packet, and sends it by TCP/IP with a frequency of N times that of the frame. The synchronization packet includes the time code of the frame that the receiver requests the sender to transfer.

Appendix I gives an example of the structure of a synchronization packet.

The synchronization packet can contain acknowledge data in the TCP payload. The acknowledge data is produced when a receiver completes reception of one block of data packets. The acknowledge data informs the reception status of the data packets of the block indicated by block ID in the synchronize header. The acknowledge data consists of pairs of start packet ID and end packet ID. The start packet ID indicates the first packet of a sequence of packets that was received correctly, and the end packet ID indicates the last packet of the sequence. When the pair matches one of the senders for the block indicated by the block ID, all the data carried by the block have been received correctly.

The sender's behaviour for the recovery of the lost packets is controlled by the acknowledge data contained in the synchronization packets. The recovery criteria are listed below.

– Recovery of the lost packets is performed when the synchronization packets contain acknowledge data and the synchronization packets are sent until a normal data packet is received.

– Recovery of the lost packets is not performed if the synchronization packets do not contain acknowledge data.

– Recovery processing is performed to a limited extent for the real-time file transfer application when the synchronization packets contain acknowledge data and is sent just one time.

Appendix I

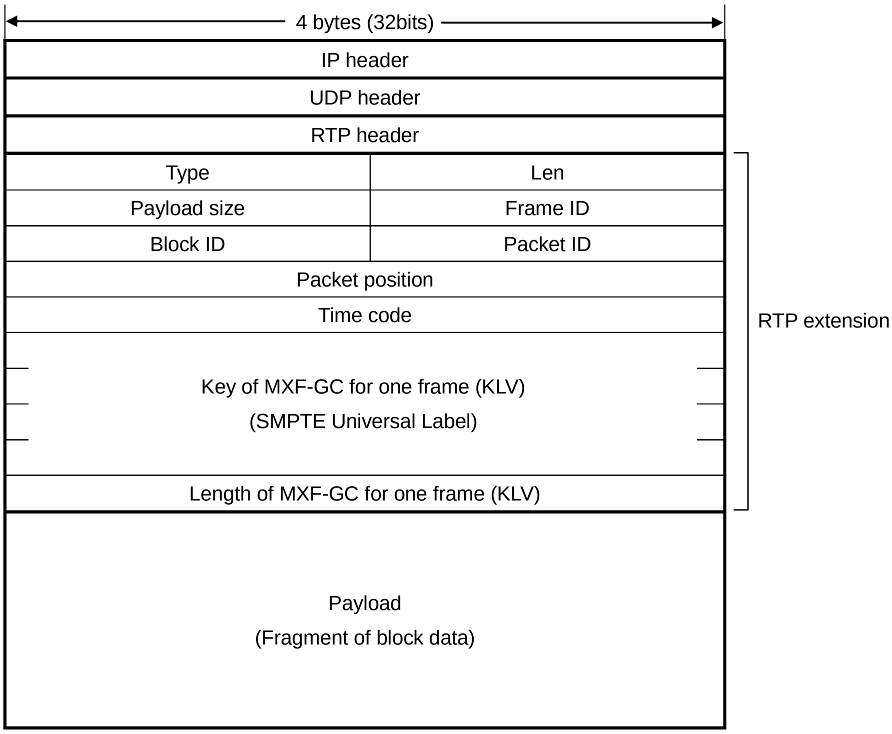
Example packet structures

(This appendix does not form an integral part of this Recommendation)

This appendix provides examples of the data packet structure described in clause 6.3.3 and the synchronization packet structure described in clause 6.3.4.

I.1 Example data packet structure

Figure I.1 shows an example of a data packet structure. A data packet contains the frame ID, the block ID, the packet ID and time code. It also contains the key and length of MXF-GC.

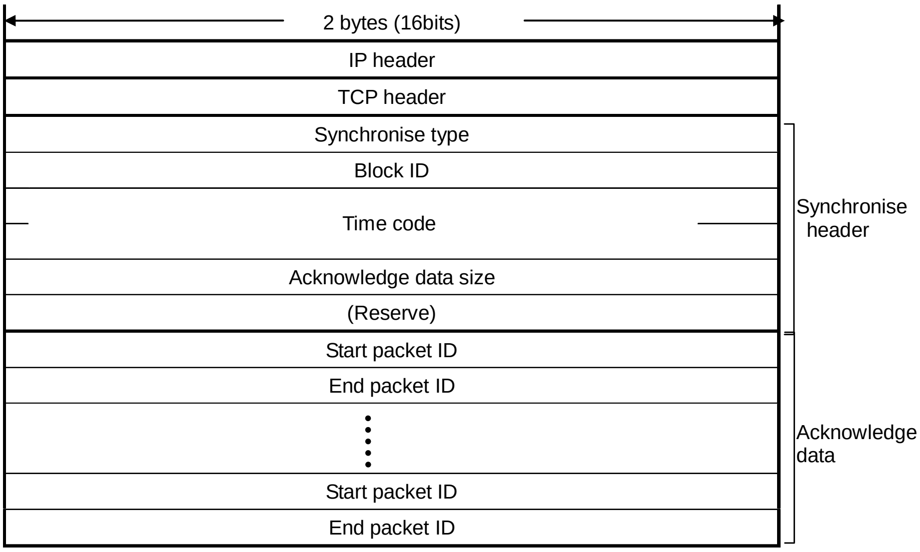


Field Name	Meaning
Type	Type of RTP extension header
Len	Length of RTP extension header (=9)
Payload size	Payload size of this packet
Frame ID	Frame ID of this packet
Block ID	Block ID of this packet
Packet ID	Packet ID of this packet
Packet position	Position of this payload data in the frame
Time code	Time code of the frame included in this packet
Key of MXF-GC	Key of KLV wrapped frame data
Length of MXF-GC	Length of KLV wrapped frame data

Figure I.1 – Example structure of a data packet

I.2 Example synchronization packet structure

Figure I.2 shows an example of the structure of a synchronization packet.



Field Name	Meaning
Synchronise type	Type of RTP extension header
Block ID	Target block ID of this sync packet for acknowledge
Time code	Request time code from receiver
Acknowledge data size	Acknowledge data size of the synchronisation packet

Figure I.2 – Example structure of a synchronization packet

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