

SMPTE STANDARD

Forward Error Correction for
Real-Time Video/Audio
Transport Over IP Networks



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Foreword

SMPTE (the Society of Motion Picture and Television Engineers) is an internationally-recognized standards developing organization. Headquartered and incorporated in the United States of America, SMPTE has members in over 80 countries on six continents. SMPTE's Engineering Documents, including Standards, Recommended Practices and Engineering Guidelines, are prepared by SMPTE's Technology Committees. Participation in these Committees is open to all with a bona fide interest in their work. SMPTE cooperates closely with other standards-developing organizations, including ISO, IEC and ITU.

SMPTE Engineering Documents are drafted in accordance with the rules given in Part XIII of its Administrative Practices.

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Introduction

This section is entirely informative and does not form an integral part of this document.

IP-based networks have become increasingly important for delivery of compressed content as MPEG-2 Transport Streams. However, existing transport protocols do not fully meet the user requirements, especially for a standardized forward error correction technique required for interoperability between different manufacturers. This standard defines a forward error correction technique to be used to correct for errors induced when video/audio payloads are transported over IP networks.

This document defines a structured mechanism for FEC. Nothing in this standard defines when this FEC mechanism should be used. It is up to the implementer to determine whether FEC is required over the IP network in use, and whether the mechanism presented here meets their application requirements.

This standard is intended for real-time audio/video applications such as contribution, distribution, and "e-cinema". The applications addressed by this standard may employ any transport scheme that is supported by the video/audio transport Standards. This standard defines two levels of FEC – Level A and Level B. Level A uses one FEC stream and Level B uses two FEC streams.

1 Scope

This standard defines a forward error correction technique for the carriage of real-time Video/Audio content over IP networks.

2 Conformance Notation

Normative text is text that describes elements of the design that are indispensable or contains the conformance language keywords: "shall", "should", or "may". Informative text is text that is potentially helpful to the user, but not indispensable, and can be removed, changed, or added editorially without affecting interoperability. Informative text does not contain any conformance keywords.

All text in this document is, by default, normative, except: the Introduction, any section explicitly labeled as "Informative" or individual paragraphs that start with "Note:"

The keywords "shall" and "shall not" indicate requirements strictly to be followed in order to conform to the document and from which no deviation is permitted.

The keywords, "should" and "should not" indicate that, among several possibilities, one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required; or that (in the negative form) a certain possibility or course of action is deprecated but not prohibited.

The keywords "may" and "need not" indicate courses of action permissible within the limits of the document.

The keyword "reserved" indicates a provision that is not defined at this time, shall not be used, and may be defined in the future. The keyword "forbidden" indicates "reserved" and in addition indicates that the provision will never be defined in the future.

3 Normative References

The following standards contain provisions which, through reference in this text, constitute provisions of this recommended practice. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this recommended practice are encouraged to investigate the possibility of applying the most recent edition of the standards indicated below.

IETF RFC 3550, RTP: A Transport Protocol for Real-Time Applications

IETF RFC 2733, An RTP Payload Format for Generic Forward Error Correction

IETF RFC 4340, Datagram Congestion Control Protocol (DCCP)

4 Acronyms (Informative)

ASI: Asynchronous Serial Interface

CSRC: Contributing Sources List

FEC: Forward Error Correction

IANA: Internet Assigned Numbers Authority

IP: Internet Protocol

RTCP: Real Time Control Protocol

RTP: Real Time Protocol

SDI: Serial Digital Interface

SDTI: Serial Digital Transport Interface

SNbase: Base RTP Sequence Number

SSRC: Synchronization Source List

TS: Timestamp

UDP: User Datagram Protocol

XOR: Exclusive OR

5 Definitions

5.1 Traffic Shaping

The process of reducing peak variations in instantaneous bit rate so as to produce a more constant data flow.

5.2 XOR

The term XOR is an acronym for exclusive-OR, a Boolean operation.

5.3 Latency

Latency is the time for data to become available for a subsequent process.

5.4 Delay

Delay is time consumed by all sources such as processing delay, accumulation and de-accumulation delay, FEC processing delay, IP transfer delay, IP delay variation buffering and FEC latency delay.

6 Background (Informative)

In many applications, errors are generally not acceptable; therefore support for some sort of FEC scheme may be required. The use of FEC as defined in this Standard is recommended, but there are applications where occasional errors are preferable to the overhead of the FEC, so manufacturers may support a non-FEC mode.

On IP networks, packet losses typically come from three sources – gross reordering, bit-error induced packet drops and burst losses/drops. For any FEC scheme to operate properly, the error from these sources needs to be low enough so that the FEC scheme can correct these errors to meet the application requirements. Implementers should be aware of limitations of any FEC scheme and take steps to ensure that application of this Standard will meet their objectives, given uncorrected link performance.

Because, when using the protocols in this Standard, the entire packet will be discarded if there is even a single bit error, there is no requirement for an error correction scheme that can handle packets containing errors – every packet will either arrive correctly or not at all.

An RTP payload format for Generic Forward Error Correction Packets has been defined in the RFC 2733 to enable error correction of real time media. RFC2733 allows the use of traditional error correcting codes. A major advantage of this scheme is that it can be used with any standardized video/audio transport (ASI, SDI,

SDTI,...) as long as it is encapsulated in an RTP packet. However, RFC2733 limits the scope of packets used to generate the Forward Error Correction payload, to 24 consecutive packets.

To recover burst loss, an extension to the existing RFC is proposed. The same traditional error correcting codes are applied to non-consecutive media packets that can be spaced over more than 24 packets. Each FEC packet is associated to packets periodically selected. Therefore, consecutive RTP packets can be recovered from consecutive FEC packets.

7 Encapsulation Scheme

This clause defines the limitations on construction of the media packets which will be protected by the FEC scheme.

7.1 RTP/UDP/IP Layer

The use of RTP shall be required, as it provides a standard header for the packets.

Equipment shall only use RTP as specified in RFC 3550 and consequently shall not require the use of any additional communication.

The following additional constraints on RFC3550 shall apply:

The usage, by senders and receivers, of the following bits shall be defined by the associated video/audio transport standards:

The Padding (P) bit

The Marker (M) bit

The Extension (X) bit, with the additional constraint that the extension bit and the length of the extension shall be constant for the duration of the session.

The following parameters shall be set by the sender as indicated:

The CSRC count (CC) field shall be set to zero. This means there are no entries in the CSRC (Contributing SouRCes list).

The value of the SSRC field shall not be relied upon at the receiver; the transmitter is free to assign this to any value.

There is no requirement for the initial sequence number to be randomly assigned, as suggested in RFC3550.

8 FEC Scheme

8.1 FEC Packet Arrangement

The FEC scheme constitutes an extended version of RFC2733. Each FEC packet is associated with media packets periodically selected. Therefore, consecutive media packets can be recovered from consecutive FEC packets. The process is detailed in Figure 1. In this Standard, L shall designate the number of columns of protected packets and D shall designate the number of rows.

The main advantage of this scheme over RFC2733 is the burst error correction capacity. The error correcting function chosen is XOR which has the ability to recover any one lost packet. If a one dimensional scheme based on XOR is used (i.e. applied to D consecutive packets), a burst error of two or more lost packets is not