             DVB-IPTV Application-Layer Hybrid FEC Protection
                     draft-ietf-fecframe-dvb-al-fec-03

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Abstract

   The Annex E of the DVB-IPTV technical specification defines an
   optional Application-layer Forward Error Correction (AL-FEC) protocol

to protect the streaming media carried over RTP transport. The DVB-
IPTV AL-FEC protocol uses two layers for FEC protection. The first
(base) layer is based on the 1-D interleaved parity code. The second
(enhancement) layer is based on the Raptor code. By offering a
layered approach, the DVB-IPTV AL-FEC protocol offers a good
protection against both bursty and random packet losses at a cost of
decent complexity. This document describes how one can implement the
DVB-IPTV AL-FEC protocol by using the 1-D interleaved parity code and
Raptor code that have already been specified in separate documents.

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1. Introduction

In 2007, the IP Infrastructure (IPI) Technical Module (TM) of the
Digital Video Broadcasting (DVB) consortium published a technical
specification [ETSI-TS-102-034v1.3.1] through European
Telecommunications Standards Institute (ETSI). This specification
covers several areas related to the transmission of MPEG2 transport
stream-based services over IP networks.

The Annex E of [ETSI-TS-102-034v1.3.1] defines an optional protocol
for Application-layer Forward Error Correction (AL-FEC) to protect
the streaming media for DVB-IP services carried over RTP [RFC3550]
transport. In 2009, DVB updated the specification in a new revision
that has been published as a DVB Bluebook [DVB-A086r8] and serves as
draft ETSI TS-102-034v1.4.1 until the final ETSI publication
(expected late 2009). Among others, some updates and modifications
to the AL-FEC protocol have been made.

The DVB-IPTV AL-FEC protocol uses two layers for protection: a base
layer that is produced by the 1-D interleaved parity code (also
simply referred to as parity code in the remainder of this document),
and an enhancement layer that is produced by the Raptor code.
Whenever a receiver supports the DVB-IPTV AL-FEC protocol, the
decoding support for the base-layer FEC is mandatory while the
decoding support for the enhancement-layer FEC is optional. Both the
interleaved parity code and the Raptor code are systematic FEC codes,
meaning that source packets are not modified in any way during the
FEC encoding process.

The normative DVB-IPTV AL-FEC protocol considers protection of
single-sequence source RTP flows only. In the AL-FEC protocol, the
source stream can only be an MPEG-2 transport stream. The FEC data
at each layer are generated based on some configuration information,
which also determines the exact associations and relationships
between the source and repair packets. This document shows how this
configuration may be communicated out-of-band in the Session
Description Protocol (SDP) [RFC4566].

In DVB-IPTV AL-FEC, the source packets are carried in the source RTP
stream and the generated FEC repair packets at each layer are carried
in separate streams. At the receiver side, if all of the source
packets are successfully received, there is no need for FEC recovery
and the repair packets may be discarded. However, if there are
missing source packets, the repair packets can be used to recover the
missing information.

The block diagram of the encoder side for the systematic DVB-IPTV AL-
FEC protection is sketched in Figure 1. Here, the source packets are

fed into the parity encoder to produce the parity repair packets.
The source packets may also be fed to the Raptor encoder to produce
the Raptor repair packets. Source packets as well as the repair
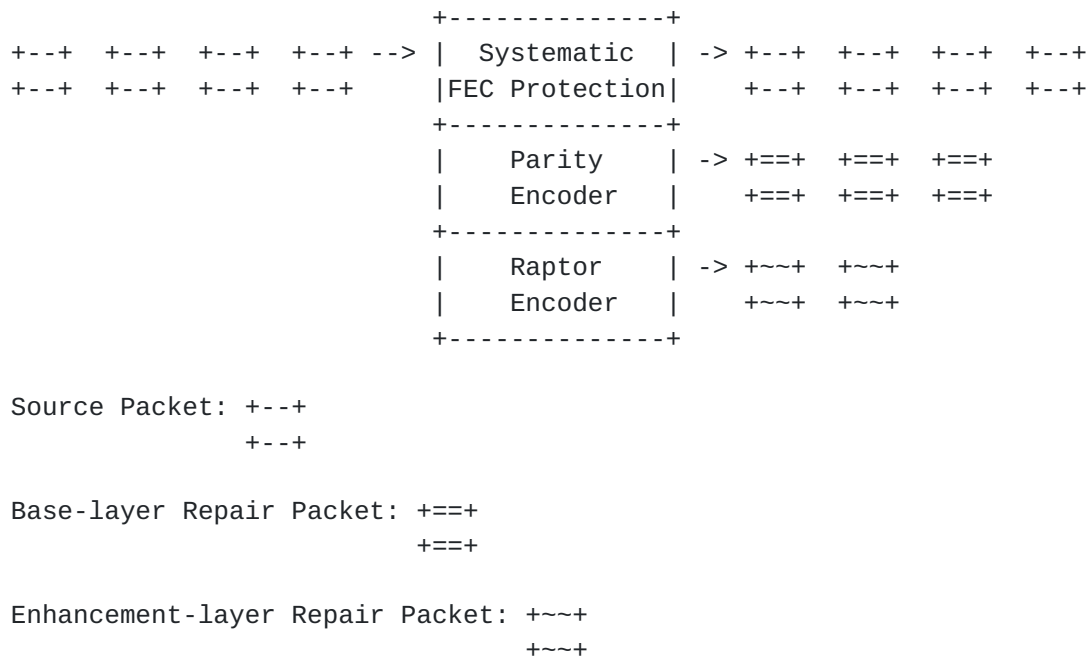packets are then sent to the receiver(s) over an IP network.

```
                              +--------------+
 +--+  +--+  +--+  +--+ --> | Systematic  | -> +--+  +--+  +--+  +--+
 +--+  +--+  +--+  +--+     |FEC Protection|    +--+  +--+  +--+  +--+
                              +--------------+
                              |    Parity    | -> +==+  +==+  +==+
                              |    Encoder   |    +==+  +==+  +==+
                              +--------------+
                              |    Raptor    | -> +~~+  +~~+
                              |    Encoder   |    +~~+  +~~+
                              +--------------+


   Source Packet: +--+
                  +--+

   Base-layer Repair Packet: +==+
                             +==+

   Enhancement-layer Repair Packet: +~~+
                                    +~~+
```

            Figure 1: Block diagram for the DVB-IPTV AL-FEC encoder

The block diagram of the decoder side for the systematic DVB-IPTV AL-
FEC protection is sketched in Figure 2. This is a Minimum
Performance Decoder since the receiver only supports decoding the
base-layer repair packets. If there is a loss among the source
packets, the parity decoder attempts to recover the missing source
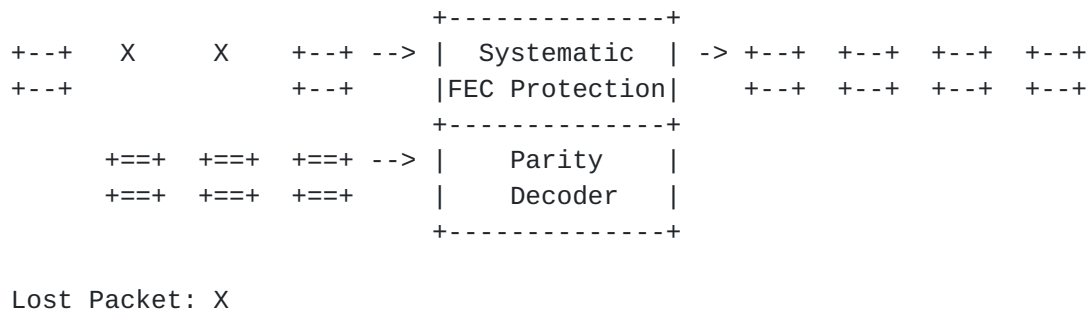packets by using the base-layer repair packets.

```
                              +--------------+
 +--+   X     X    +--+ --> | Systematic  | -> +--+  +--+  +--+  +--+
 +--+              +--+     |FEC Protection|    +--+  +--+  +--+  +--+
                              +--------------+
     +==+  +==+  +==+ --> |    Parity    |
     +==+  +==+  +==+     |    Decoder   |
                              +--------------+


   Lost Packet: X
```

     Figure 2: Block diagram for the DVB-IPTV AL-FEC minimum performance
                                 decoder

On the other hand, if the receiver supports decoding both the base-
layer and enhancement-layer repair packets, a combined (hybrid)
decoding approach is employed to improve the recovery rate of the
lost packets. In this case, the decoder is called an Enhanced
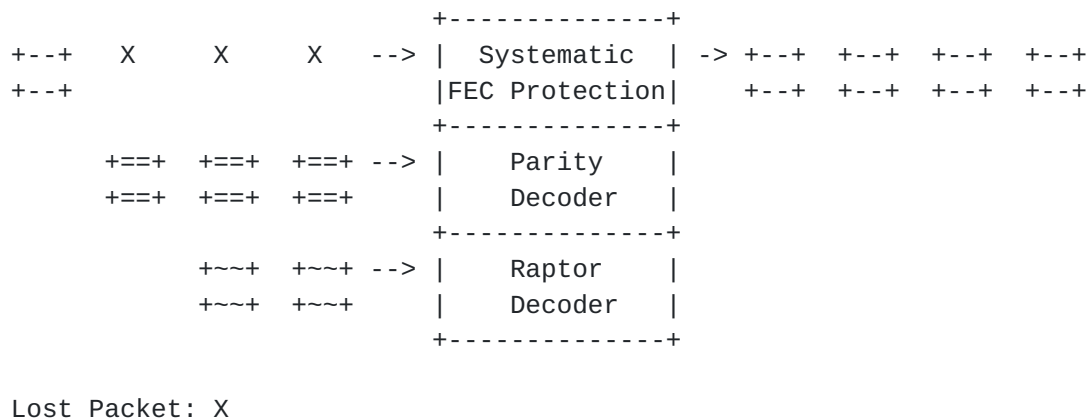Decoder. Section 2.3 outlines the procedures for hybrid decoding.

```
                              +--------------+
   +--+   X      X      X  --> |  Systematic  | -> +--+  +--+  +--+  +--+
   +--+                        |FEC Protection|    +--+  +--+  +--+  +--+
                              +--------------+
      +==+  +==+  +==+ --> |    Parity    |
      +==+  +==+  +==+     |    Decoder   |
                              +--------------+
         +~~+  +~~+ --> |    Raptor    |
         +~~+  +~~+     |    Decoder   |
                              +--------------+
```

Lost Packet: X

   Figure 3: Block diagram for the DVB-IPTV AL-FEC enhanced decoder

2. DVB-IPTV AL-FEC Specification

The DVB-IPTV AL-FEC protocol comprises two layers of FEC protection:
1-D interleaved parity FEC for the base layer and Raptor FEC for the
enhancement layer. The performance of these FEC codes has been
examined in detail in [DVB-A115].

2.1. Base-Layer FEC

The 1-D interleaved parity FEC uses the exclusive OR (XOR) operation
to generate the repair symbols. In a group of D x L source packets,
the XOR operation is applied to each group of D source packets whose
sequence numbers are L apart from each other to generate a total of L
repair packets. Due to interleaving, this FEC is effective against
bursty packet losses up to burst sizes of length L.

The DVB-IPTV AL-FEC protocol requires the D x L block of the source
packets protected by the 1-D interleaved FEC code to be wholly
contained within a single source block of the Raptor code, if both
FEC layers are used.

Originally, the DVB-IPTV AL-FEC protocol had adopted the 1-D
interleaved FEC payload format from [SMPTE2022-1] in
[ETSI-TS-102-034v1.3.1]. However, some incompatibilities with RTP
[RFC3550] have been discovered in this specification. These issues

have all been addressed in [I-D.ietf-fecframe-interleaved-fec-scheme]
(For details, refer to Section 1 of
[I-D.ietf-fecframe-interleaved-fec-scheme]). Some of the changes
required by [I-D.ietf-fecframe-interleaved-fec-scheme] are, however,
not backward compatible with the existing implementations that were
based on [SMPTE2022-1].

In a recent liaison from IETF AVT WG to DVB TM-IPI, it has been
recommended that DVB TM-IPI defines a new RTP profile for the AL-FEC
protocol since in the new profile, several of the issues could easily
be addressed without jeopardizing the compliance to RTP [RFC3550].

At the writing of this document, it was not clear whether or not a
new RTP profile would be defined for the AL-FEC protocol. DVB TM-IPI
attempted to address some of the issues in the updated specification
[DVB-A086r8], however, there are still outstanding issues. Note that
[DVB-A086r8] does not obsolete [ETSI-TS-102-034v1.3.1] but DVB TM-IPI
will exclusively use [DVB-A086r8] for any future revisions of the DVB
IPTV Handbook.

The following is a list of the exceptions that need to be considered
by an implementation adopting
[I-D.ietf-fecframe-interleaved-fec-scheme] to be in compliant with
the DVB-IPTV AL-FEC protocol as specified in [DVB-A086r8].

o SSRC
   The DVB-IPTV AL-FEC protocol requires the SSRC fields of the FEC
   packets to be set to zero.

   This requirement conflicts with RTP [RFC3550]. Unless signaled
   otherwise, RTP uses random SSRC values with collision detection.
   An explicit SSRC signaling mechanism is currently defined in
   [RFC5576] and can be used for this purpose.

o CSRC
   The DVB-IPTV AL-FEC protocol does not support the protection of
   the CSRC entries in the source packets. Thus, in an
   implementation compliant to DVB-IPTV AL-FEC protocol, the source
   stream must not have any CSRC entries in its packets and
   subsequently the CC fields of the source RTP packets will be zero.

   Note that if there are no RTP mixers used in a system running the
   DVB-IPTV AL-FEC protocol, the CC field of the source RTP packets
   will be zero and this is no longer an issue. Thus, if defined,
   the new RTP profile for the DVB-IPTV AL-FEC protocol should forbid
   the use of any RTP mixers.

   o Timestamp
      In the DVB-IPTV AL-FEC protocol, the timestamp fields of the FEC
      packets are ignored by the receivers.

   o Payload Type
      The DVB-IPTV AL-FEC protocol sets the PT fields of the FEC packets
      to 96.

      A static payload type assignment for the base-layer FEC packets is
      outside the scope of [I-D.ietf-fecframe-interleaved-fec-scheme].
      If defined, the new RTP profile for the DVB-IPTV AL-FEC protocol
      may assign 96 as the payload type for the base-layer FEC packets.

   In implementations that are based on
   [I-D.ietf-fecframe-interleaved-fec-scheme] and are willing to be in
   compliant with the DVB-IPTV AL-FEC protocol as specified in
   [ETSI-TS-102-034v1.3.1], all these exceptions must be considered as
   well, however, in this case, the sender does not have to select a
   random initial sequence number for the FEC stream as suggested by
   [RFC3550].

   Note that neither [ETSI-TS-102-034v1.3.1] nor [DVB-A086r8] implements
   the 1-D interleaved parity code as specified in
   [I-D.ietf-fecframe-interleaved-fec-scheme]. Thus, the payload format
   registered in [I-D.ietf-fecframe-interleaved-fec-scheme] must not be
   used by the implementations that are compliant with the
   [ETSI-TS-102-034v1.3.1] or [DVB-A086r8] specification.

2.2. Enhancement-Layer FEC

   The Raptor code is a fountain code where as many encoding symbols as
   needed can be generated by the encoder on-the-fly from source data.
   Due to the fountain property of the Raptor code, multiple enhancement
   layers may also be specified, if needed.

   The details of the Raptor code are provided in
   [I-D.ietf-fecframe-raptor]. The RTP payload format for Raptor FEC is
   specified in [I-D.watson-fecframe-rtp-raptor].

   It is important to note that the DVB-IPTV AL-FEC protocol in the
   latest specification [DVB-A086r8] allows only RTP-over-UDP
   encapsulation for the enhancement-layer FEC stream. The initial
   specification [ETSI-TS-102-034v1.3.1] exclusively permits UDP-only
   encapsulation for the enhancement-layer FEC stream.

   When SDP is used for signaling, the transport protocol identifier
   permits to distinguish whether an RTP-over-UDP or UDP-only
   encapsulation is used. In case of any other signaling framework, the

differentiation of the protocol for the enhancement-layer stream is
achieved either explicitly through a protocol identifier or
implicitly by the version number of the DVB IPTV Handbook. If none
of the above signaling is provided, the receiver shall concur from
the packet size of the repair packets if RTP-over-UDP or UDP-only
encapsulation is used.

2.3. Hybrid Decoding Procedures

The receivers that support receiving and decoding both the base and
enhancement-layer FEC perform hybrid decoding to improve the repair
performance. The following steps may be followed to perform hybrid
decoding:

1. Base-layer (Parity) Decoding: In this step, the repair packets
    that are encoded by the parity encoder are processed as usual to
    repair as many missing source packets as possible.

2. Enhancement-layer (Raptor) Decoding: If there are still missing
    source packets after the first step, the repair packets that are
    Raptor encoded are processed with the source packets already
    received and the source packets that are recovered in the first
    step.

3. Hybrid Decoding: If there are still missing source packets after
    the second step, the unprocessed base-layer (parity) repair
    packets are converted to a form in which they can be added to the
    Raptor decoding process. With this additional information,
    Raptor decoding may potentially recover any remaining missing
    source packet.

The procedure that should be followed to benefit from the base-layer
repair packets in the Raptor decoding process is explained in detail
in Section E.5.2 of [ETSI-TS-102-034v1.3.1] and [DVB-A086r8].

3. Session Description Protocol (SDP) Signaling

This section provides an SDP [RFC4566] example for [DVB-A086r8]. The
example uses the FEC grouping semantics [I-D.ietf-mmusic-rfc4756bis].

In the example, we have one source video stream (mid:S1), one FEC
repair stream (mid:R1) that is produced by the 1-D interleaved parity
FEC code as well as another FEC repair stream (mid:R2) that is
produced by the Raptor FEC code. We form one FEC group with the
"a=group:FEC-XR S1 R1 R2" line. The source and repair streams are
sent to the same port on different multicast groups. The source,
base-layer FEC and enhancement-layer FEC streams are all encapsulated

in RTP.

Due to the exceptions described in Section 2.1, a [DVB-A086r8]-
compliant implementation must not use the RTP payload format defined
in [I-D.ietf-fecframe-interleaved-fec-scheme]. Instead, it may use
the payload format that has been registered by DVB TM-IPI for
[ETSI-TS-102-034v1.3.1].

```
v=0
o=ali 1122334455 1122334466 IN IP4 fec.example.com
s=DVB-IPTV AL-FEC Example
t=0 0
a=group:FEC-XR S1 R1 R2
m=video 30000 RTP/AVP 100
c=IN IP4 233.252.0.1/127
a=rtpmap:100 MP2T/90000
a=mid:S1
m=application 30000 RTP/AVP 96
c=IN IP4 233.252.0.2/127
a=rtpmap:96 vnd.dvb.iptv.alfec-base/90000
a=mid:R1
m=application 30000 RTP/AVP 111
c=IN IP4 233.252.0.3/127
a=rtpmap:111 vnd.dvb.iptv.alfec-enhancement/90000
a=mid:R2
```

Note that in the example above, the payload type has been chosen as
96 for the base-layer FEC stream and there is no "a=fmtp:" line to
specify the format parameters. Due to the lack of the format
parameters for "vnd.dvb.iptv.alfec-base", it is not possible to learn
the FEC parameters from the SDP description.

4. Security Considerations

There are no security considerations in this document.

5. IANA Considerations

There are no IANA considerations in this document.

6. Acknowledgments

This document is based on [ETSI-TS-102-034v1.3.1] and [DVB-A086r8].
Thus, the authors would like to thank the editors of
[ETSI-TS-102-034v1.3.1] and [DVB-A086r8]. The authors also would

like to thank those who reviewed earlier versions of this document.

7. References

7.1. Normative References

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7.2. Informative References

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