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IP-recovery in The DVB-H link layer for TV on Mobile

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***Abstract*--In the nearby future, DVB-H Internet Protocol based TV on Mobile will be available in mobile devices. Due to transmission over error-prone channels, IP-datagrams may be corrupted. The DVB-H link layer is equipped with Forward Error Correction (FEC), allowing correction of defect IP-datagrams, using two-bit signaling. Locators are applied to find correctly received IP-datagrams and possible corrected IP-datagrams, for the situation that Forward Error Correction fails to correct all incorrectly received IP-datagrams. Experimental research has shown that for the situation that the received data cannot be fully corrected by the FEC, considerable number of IP-datagrams can be recovered using the locator information. The successful recovery depends on the received IP-datagram length and the error probability and results in an improved audiovisual decoding quality.**

I. INTRODUCTION

Recently, the European Telecommunications Standards Institute (ETSI), approved the Digital Video Broadcast Handheld (DVB-H) standard [1], [2], which is specifically tailored to mobile communication. Basically, the DVB-H standard is an extension to the DVB-T standard with extra features added to the physical layer and link layer. The link layer uses Multi Protocol Encapsulation (MPE), creating sections carrying either a single Internet Protocol (IP) datagram or the Forward Error Correction (FEC) parities. Both data types are transmitted using transport stream packets [3], [4]. Received IP-data and FEC-parity data are stored in an MPE-FEC frame to which FEC decoding is applied. In poor reception conditions, the FEC may not be able to correct the complete MPE-FEC frame. However, this frame may contain some correctly received IP-datagrams. The correct IP-datagrams most probably contain vital highly compressed audio/visual (AV) information. In case of a FEC failure using a straightforward approach, a received data is disregarded, even though a part of the data is correct. Loss of all data results in a degradation of the AV quality. To avoid this worst-case situation, we propose to identify *any* correctly received IP-datagram. In addition to this, we identify *corrected* MPE-FEC rows after FEC decoding to allow retrieval of other potentially corrected IP-datagrams, even if MPE-FEC frame as a whole could not be corrected. This paper addresses an elegant solution for recovering the previously mentioned IP-datagrams transmitted using a DVB-H network, and the corresponding FEC processing in the DVB-H link layer. Our solution provides a significant increase of the IP-recovery in erroneous MPE-FEC frames, so that the AV decoding quality is improved.

II. SYSTEM ASPECTS OF DVB-H LINK LAYER AND IMPROVED DATA RECOVERY

A common approach [2] in DVB-H receivers is to fill the MPE-FEC frame with correctly received IP-datagrams and FEC-parities, resulting in an MPE-FEC frame that may contain gaps. A better method is to apply smart de-encapsulation [5], using all correctly received IP-datagrams or FEC-data fragments to constitute the MPE-FEC frame. After FEC decoding, the MPE-FEC frame is either correct or not correct (binary decision). Readout of the MPE-FEC frame relies on the length field of an IP-datagram header. If the length field of the first IP-datagram cannot be determined, reliable readout of all IP-datagrams becomes impossible. To prevent this, a number of robustness measures are taken during reception of the IP-data and appropriate processing is applied.

- **Find correctly received IP-datagrams**. This requires the storage of the IP-datagram locator in the MPE-FEC frame.
- **Find *corrected* IP-datagrams**. This requires knowledge of the FEC decoding stage regarding the remaining erroneous rows in the MPE-FEC frame.
- **Use two-bit erasure flags**. The Transport Stream (TS) packets that are used to transmit the MPE-section can be subjected to transmission errors. As a result, a Transport Error Indicator (TEI) flag is raised indicating that the received TS packets have 9 or more errors. In a more severe situation, TS packets get lost resulting in a signal gap. Two internal signaling bits are used to indicate up to four different types of erasure information.
- **Filter correct IP-datagrams from a defect MPE-FEC frame**. This requires the IP-datagram locator information and the result of the FEC decoding stage. On top of this information, undesired IP-datagrams are filtered using source and destination addresses, to reduce the load on the TCP/IP stack.

The above measures lead to the following solution. First of all, the locators of the correctly received IP-datagrams are stored in an Internet Protocol Entry Table (IPET). This provides a reliable grid for IP-data recovery and is not

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affected by any subsequent processing. Having this grid, possible gaps can be identified. If after FEC decoding one or more rows turn out to be erroneous, a novel Corrected Row

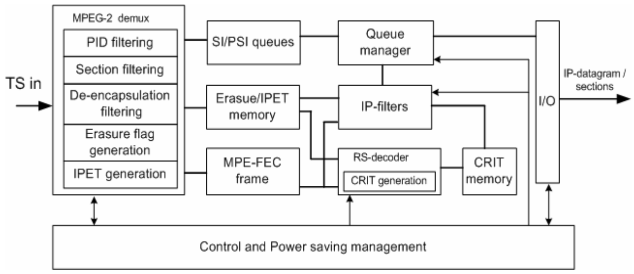

Fig.1. Conceptual link-layer block diagram.

Index Table (CRIT) allows localization of corrected IP-datagrams, that were incorrectly received but FEC-corrected afterwards. Further implementation details are as follows. Figure 1 depicts a conceptual link-layer block diagram, based on the aforementioned system aspects. Starting at the left side of Figure 1, the received TS enters the MPEG-2 demultiplexer of the link-layer subsystem. The MPEG-2 demux is equipped with Packet Identifier (PID) filters, selecting the TS packets of an elementary stream, and filtering of Service Information (SI), Program Specific Information (PSI) and application information. Selected SI/PSI sections are stored in their corresponding queues and transmitted by the queue manager. The selected service information is subjected to several operations, prior to transmission to the application engine. Starting at the MPEG-2 demux, internal two-bit erasure flags are assigned to the received service TS packets for classifying three situations: “hard erasure” in case of TS packet loss, “soft erasure” in case the TS packet flag TEI=1, and finally no error (TEI=0). Correctly received IP-datagrams (or FEC-parities), or fragments of them, are stored in the MPE-FEC frame. Correctly received IP-datagrams are traced within the MPE-FEC frame using the Internet Protocol Entry Table (IPET). To determine whether an incorrectly received IP-datagram is corrected, the Corrected Row Index Table (CRIT) is generated during FEC-decoding, which indicates if an MPE-FEC row is correct or incorrect. After applying the FEC, the IP-filter retrieves IP-datagrams using the CRIT and IPET to locate the correctly received and successfully corrected IP-datagrams in the MPE-FEC frame and finally applies the IP-source and destination-address filtering to block undesired IP-datagrams.

III. EXPERIMENTS AND CONCLUSIONS

An experimental set-up has been build using the IPET concept and MPE-FEC decoding with two-bit erasure support. Correctly received IP- or FEC-payload sections are stored in the MPE-FEC frame. If a reception error occurs, only the part of the section is stored, that has been correctly received, where the rest of that particular section is ignored. The system has been evaluated for different transport stream packet error probabilities (TS-PER) and IP-datagram length. Fig. 2 indicates that FEC decoding using two-bit erasure decoding, can reconstruct, all incorrectly received IP-datagrams for error probabilities below 0.03 for IP-datagrams of size 1356 Bytes and 0.07 for IP-datagrams of size 62 Bytes. The IPET concept allows IP-datagram recovery up to more than 90 %, all depending on the IP-datagram length and the TS-PER. These values were obtained with an MPE-FEC frame of 1024 rows, containing a minimum amount of padding bytes, resulting in 144 IP-datagrams of 1356 Bytes and 3154 IP-datagrams of 62 Bytes each, using un-punctured FEC. In our experiments, the transmission of a single MPE-FEC frame was 1000 times received by the system. The right-hand part of Fig. 2 provides the major advantage of our

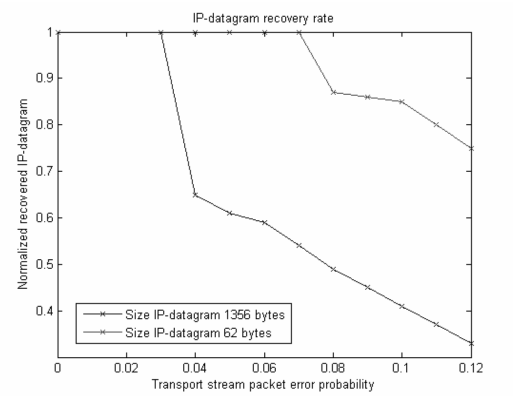

Fig. 2. IP-datagram recovery rate for various TS packet error probabilities of incorrect MPE-FEC frames, after FEC decoding using two-bit signaling.

system: instead of having no IP-datagrams at all, we retrieve a gradually decreasing number of useful IP-datagrams for an increasing error probability. Hence, the proposed IPET link-layer concept offers identification of correctly received IP-datagrams, even if the FEC decoder is not capable of correcting all MPE-FEC rows. Adding the CRIT concept will further elevate the IP-recovery rate, resulting in an increased AV playback quality.

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