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Information technology — JPEG 2000 image coding system: Core coding system

AMENDMENT 4: Guidelines for digital cinema applications

Technologies de l'information — Système de codage d'images JPEG 2000: Système de codage de noyau

AMENDEMENT 4: Lignes directrices pour les applications de cinéma numérique

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INTERNATIONAL STANDARD
RECOMMENDATION ITU-T

Information technology – JPEG 2000 image coding system: Core coding system

Amendment 4

Guidelines for digital cinema applications

1) Modification to Annex J

Add the following new clause J.16 at the end of Annex J (i.e., immediately following J.15.3):

J.16 Guidelines for digital cinema applications

This clause is intended as guidelines for the usage of JPEG 2000 in the framework of digital cinema applications. It is split in four parts: the first is dedicated to multicast transmission; the second presents the recommended visual frequency weightings for digital cinema environment; the third deals with the use of JPEG 2000 for film archive applications, and finally the fourth gives guidelines for digital cinema distribution.

J.16.1 Reliable multicast transmission of JPEG 2000 codestreams

J.16.1.1 Introduction

Digital Cinema (D-Cinema) content may be delivered to the theatres by using several communication channels, and many of them can be wireless, such as, for example, DVB-T [50], DVB-S [51], and WiMAX [52]. The destination of the video contents, in this case, can also (at reduced resolution/quality) be a mobile user, such as, for instance, an audience located on a train or bus.

In addition to the file transfer approach, already used for digital cinema transfer to the theatres, the use of streaming would allow for applications such as live events exhibition and (Near) movie on demand (in this case, however, additional methods for the reduction of the bit rate must be adopted).

The delivery of JPEG 2000 compressed video is a well-known challenge for wireless IP networks. In the case of TCP, the variable delay is unacceptable for many types of real-time applications. D-Cinema will introduce even more stringent conditions, in terms of both the required bandwidth and the high quality demand.

As concerns the distribution, the requirements can be specified in the following terms:

- low required bandwidth occupancy, not only of the JPEG 2000 compressed content itself, but also considering some signalling overhead;
- reliable transmission of the contents, by use of forward error correction techniques (FEC) and/or selective retransmission of lost data (selective ARQ).

A possible solution can be that of adopting a multicast protocol, which can be adapted to the high bit rate and low packet loss rate necessary for the distribution of D-Cinema content. If using multicast transmission, a reliable protocol could be used, which guarantees the sender that every receiver has a copy equal to the original. NORM protocol [56] can be a viable solution for such needs: it uses a NACK-oriented reliable multicast, achieving reliability by means of negative ACKs that are sent back from the receivers to the sender. In addition, it is possible to specify even a small FEC layer, which reduces the retransmission rate at the expense of some added overhead.

Moreover, in case of multicast transmission of JPEG 2000 codestreams, there are some constraints in limited network bandwidth or capabilities of mobile devices.

New mechanisms are required to distribute D-cinema contents to local theatres, high-end mobile users via wireless networks under the constrained conditions.

In forwarding packets to a mobile user, an intermediate distributor may have such functions such as adjusting the image quality or resolution for network bandwidth, network convergence, or capability of mobile device purposes.

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J.16.1.2 Distribution model

Figure J.17 shows a possible scenario for content distribution. Different users, with different quality requirements/capabilities may be foreseen. In this scenario, an intermediate distributor is required with the role of adaptation of resolution/quality for forwarding capabilities.

In Figure J.17, cinema contents are transmitted from the production site (for example, studio post-production house) to regional theatres through satellite links. After that, some resolution or quality level is extracted from the original content and is distributed to local theatres, high-end mobile users, home and low-end mobile users by wireless network such as DVB-T, WiMAX and WLAN (IEEE 802.11n) [54].

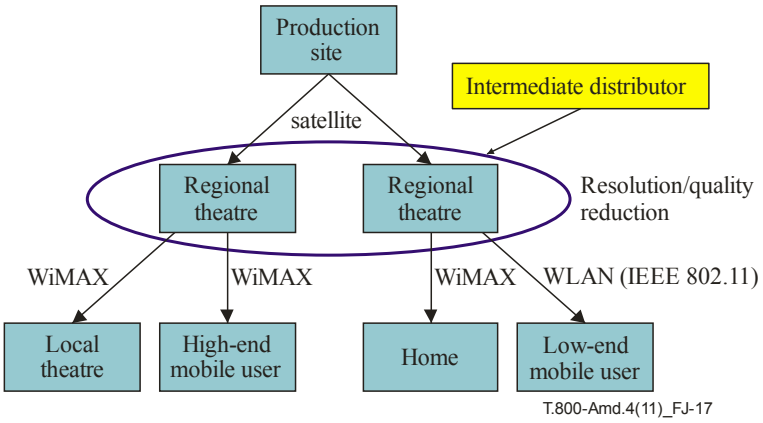

Figure J.17 – Distribution scenario for D-Cinema and live event

There are mainly three main problems in network delivery:

1) limited bandwidth;
2) convergence;
3) packet loss.

In forwarding a digital cinema stream to mobile users, an intermediate distributor such as a regional theatre might have functions of adjusting the image quality or resolution for network bandwidth, network convergence, or the capability of mobile device purposes.

J.16.1.3 Multicast protocol overview

NORM (NACK oriented reliable multicast) is a multicast protocol designed to provide end-to-end reliable multicast transfer. This protocol uses generic IP multicast capabilities, and on top of that tries to achieve reliable transfer using NACKs (negative acknowledgments). It can work both on reciprocal multicast network (i.e., wireless or wired LAN) or unidirectional link (such as a unidirectional satellite); in this way, it can satisfy all of the transmission needs for digital cinema distribution [53].

NORM repair capabilities are based on the use of negative acknowledgments (NACKs), sent from the receivers to the sender upon detection of an erroneous or missing packet. The sender transmits packets of data, segmented according to a precise strategy, each of which is identified by symbol numbers. As a receiver detects a missing packet, it initiates a repair request with a NACK message. Upon reception of NACKs, the sender prepares the appropriate repair messages, using FEC (forward error correction) blocks. Each receiver can reinitiate a repair procedure if it does not receive repair blocks.

Feedback suppression is applied, using a random back-off algorithm; each receiver, before sending a NACK for a certain packet, waits for a random-duration interval, during which it senses the medium and checks if other receivers requested a repair for the same packet: if so, it discards the NACK; otherwise, it sends it and waits for repair bits. When the sender receives the NACK, it enqueues repair bits (or the entire lost packet). Feedback suppression works efficiently in this protocol, and can achieve good results.

NACK packets can be sent both in multicast or unicast mode, using the sender's address. In the second case, feedback suppression can be achieved using multicast advertising messages, sent from each sender, which allow the receivers to know which packets have a pending repair request.

A NORM sender can even autonomously add FEC parity bits to each packet, thus enabling the receiver to correct errors and recover losses without starting a NACK procedure.

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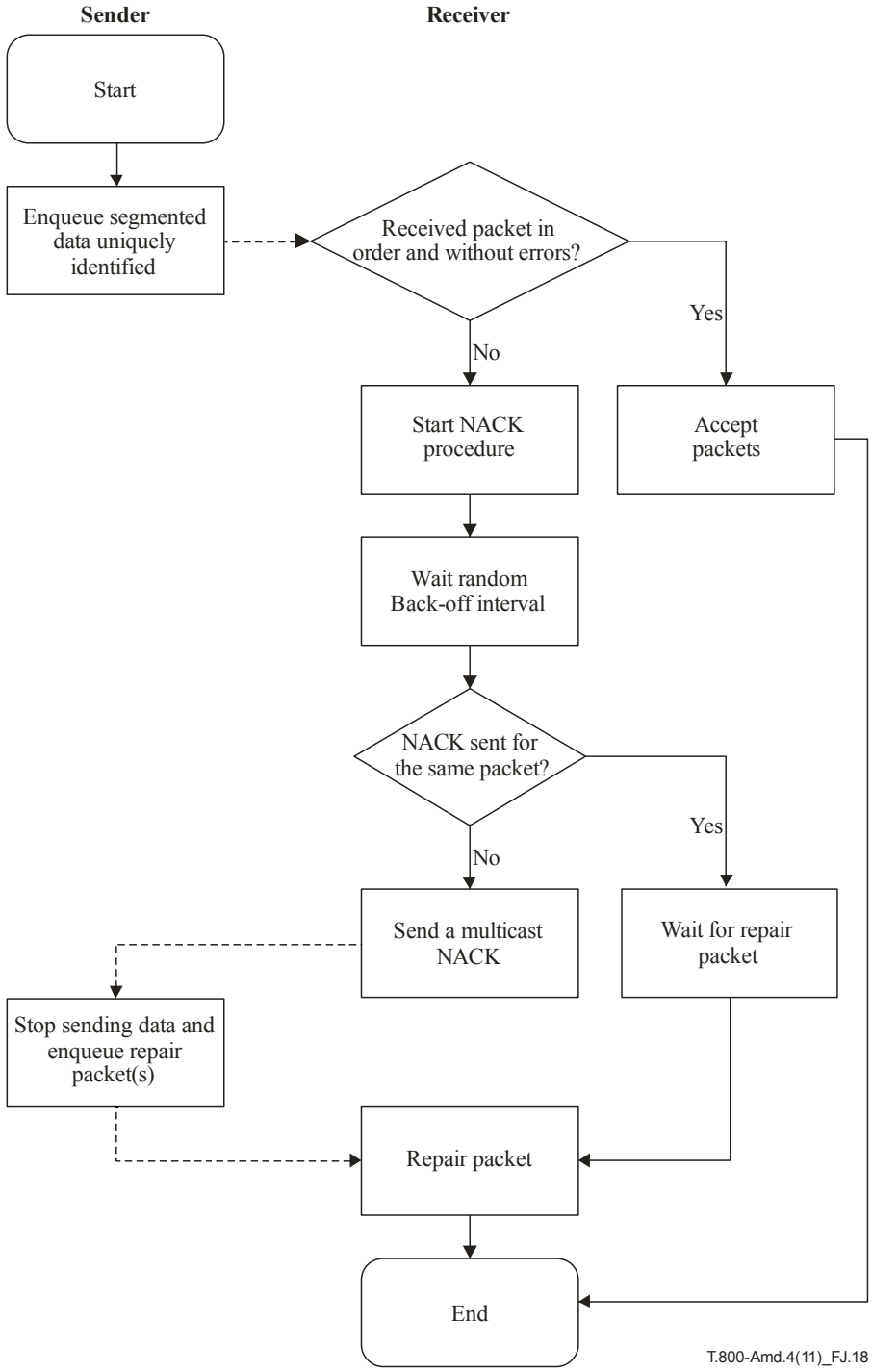

Figure J.18 – Sender and receiver sequence of operations

Figure J.18 shows a sequence of operations performed by a NORM sender and receiver during the normal transmission session. The sender node enqueues data packets, segmented according to parameters that can be changed by the user to accommodate for particular needs: in this case, JPEG 2000 codestreams are encapsulated and an additional header is included at the end of the NORM packet header. It also periodically enqueues control messages, such as round-trip collection and rate congestion control feedback.

Each receiver controls if the packet is in order and error-free: in this case, it accepts the packet and passes it to the destination application. Otherwise, it enters the NACK procedure: this consists in picking a random back-off delay, based on some parameters such as the greatest round-trip delay, usually supplied by the sender, and delaying NACK transmission until this interval is passed. In the meantime, if it receives a repair request for the same packet or the repair bits, the NACK is dropped; otherwise, it sends the NACK in multicast mode. Sending the NACK in multicast is useful for feedback suppression, as described previously.

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