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Radiocommunication Sector of ITU

Recommendation ITU-R BT.1888-1

(09/2011)

Basic elements of file-based broadcasting systems

BT Series

Broadcasting service (television)

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RECOMMENDATION ITU-R BT. 1888-1

Basic elements of file-based broadcasting systems

(3/2011-9/2011)

Scope

This Recommendation describes basic elements of file-based broadcasting systems to facilitate the transfer of files from a content provider to an end user. The files transferred in both real-time and non real-time are stored in a receiver to be played at a time convenient to the end user. The Recommendation provides some basic implementation characteristics of a receiver.

The ITU Radiocommunication Assembly,

considering

a) that there is a growing consumer demand for the capability to view TV programmes at their convenience;

b) that there is growing consumer interest in viewing all types of content including audio/video and multi-media content;

c) that large-capacity storage devices have become available for a receiver;

d) that file-based systems are capable of delivering any kind of content including audio/video as well as multimedia data in non-real-time transfer;

e) that high-quality content encoded at higher bit rate than that in real-time broadcasting can be delivered using non real-time transfers;

f) that services using file-based content delivery have already been introduced using telecommunication networks;

g) that it is desirable to provide interoperability between different systems,

recommends

1 that the basic elements described in Annex 1 should be used for development of file-based broadcasting systems;

2 that NOTE 1 is considered to be part of the Recommendation.

NOTE 1 – Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure e.g. interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words “shall” or some other obligatory language such as “must” and the negative equivalents are used to express requirements. The use of such words shall in no way be construed to imply partial or total compliance with this Recommendation.

NOTE 2 – Example of practical implementation of a file-based broadcasting system is given in Appendix 1 and Appendix 2 for information.

Annex 1

Basic elements for file-based broadcasting systems

1 Introduction

File-based broadcasting systems have the capability to be independent of the content to be delivered, end user storage devices are also independent of the content being stored. This results in huge flexibility in what a content provider may deliver to the end user. Content can be delivered in shorter or longer periods than the real-time duration. High-quality content can be delivered by encoding the content at higher bit rates than the maximum bit rate of the delivery channel. In the case of mobile reception, while reception errors often occur, errors may be corrected through various techniques in the case of non real-time transmission.

The basic elements described in this annex apply to requirements for file-based broadcasting systems, receiver configuration for the systems, metadata, and a file transport method over a broadcast channel.

2 Abbreviations

BML	Broadcast markup language
CID	Context identification
DLC	Download control
DRM	Digital rights management
ECG	Electronic content guide
FEC	Forward error correction
FLUTE	File delivery over unidirectional transport
HCfB	Header compression for broadcasting
IANA	Internet assigned numbers authority
IP	Internet protocol
LLI	Licence link information
RMT	Reliable multicast transport
ROHC	Robust header compression
TLV	Type length value
ULE	Unidirectional lightweight encapsulation
URI	Uniform resource identifier
URL	Uniform resource locator

3 Requirements for file-based broadcasting systems

3.1 System requirements

To develop a file-based broadcasting system, the following requirements should be met:

1. A receiver for the system shall be equipped with a storage device to store content and play the content. Play of content may be output from the storage device through a copy protected interface.
2. Information necessary for setting up a scheduled download should be delivered over the broadcast channel.
3. It should be possible to set up a scheduled download of additional content related to real-time broadcasting programme.
4. Receiver tuning shall be controlled by the specific information.
5. Any rescheduling of content shall be possible through the scheduling information.
6. Lost or corrupted file should be detected by a receiver prior to its use.
7. Large files should be delivered with a small overhead.
8. Delivered content can be protected to restrict the use by the end user.
9. An expiration date for the use of the content may be sent.
10. Stored content in a receiver may be deleted by the end user.

3.2 Required files

In the system, the following files should be delivered:

1. Media file.

   Coded audio/video signals or other multimedia data.
2. License link information (LLI).

   Information on license and rights management for the content. It describes constraints on the use of content. It also provides information to obtain a license if required.
3. Metadata:
   - Metadata for establishing the download schedule.

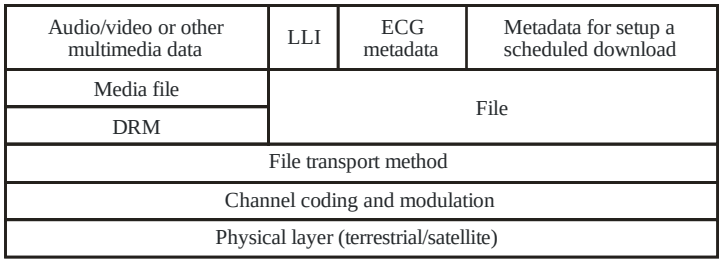
     Information necessary for a receiver to obtain all files including a media file, LLI, and ECG metadata. It describes URLs of servers or URI and start/end times of the delivery session that carries these files. Details are described in § 5.
   - ECG metadata.

     Information on content such as title and genre. It is used by an end user to select content to store. It may also be used to select stored content to use. Details are described in § 6.

Figure 1 shows a protocol stack of general file-based broadcasting systems to transfer these files.

FIGURE 1

Protocol stack of general file-based broadcasting systems



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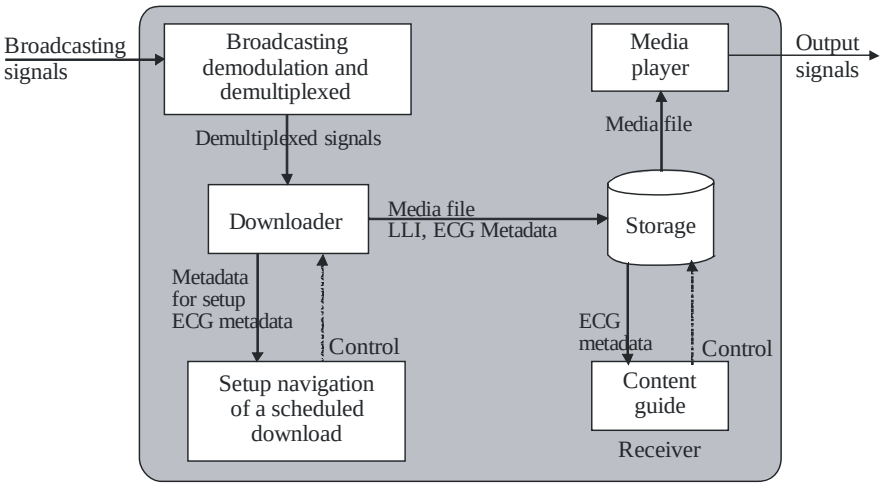
4 Receiver configuration for a file-based broadcasting system

4.1 Main components in a receiver for the system

A receiver for the system shall have storage to store the delivered content. The main components in a receiver are shown in Fig. 2.

FIGURE 2

Main components in receiver for the system



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The functions of each module in a receiver are listed below.

Module	Function
Broadcast demodulation and demultiplex	Demodulates received broadcasting signals and outputs demultiplexed signals that carry files
Downloader	Manages schedules for downloading content. Reconstructs a file from the demultiplexed signals when recording
Setup navigation of a scheduled download	Lets users set a scheduled download based on metadata for setup a scheduled download and ECG metadata
Storage	Stores reconstructed files by downloader
Content guide	Presents a list of stored content and provides a user interface to select and delete content based on ECG metadata
Media player	Plays stored content and outputs audio/video signals

4.2 Reference receiving procedures to obtain content

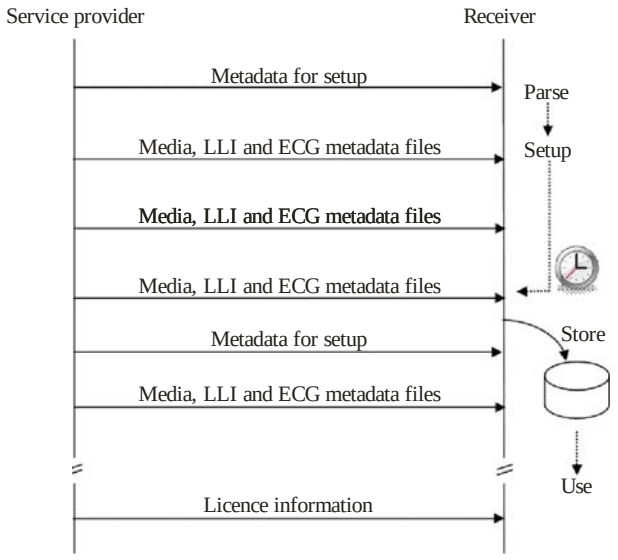
In a file-based broadcasting system, the following receiving procedures should be taken.

A receiver for the system needs metadata for setting up a scheduled download of the required content in advance. The metadata needs to be transferred by a service provider. Multiple files may make up one content. Therefore, metadata is important for the receiver to identify files of content and servers or sessions that provide those files. Based on this information, the receiver sets up a scheduled download.

At the scheduled time, the receiver tunes into the broadcast signal delivering the desired files, and stores the delivered files. These procedures are shown in Fig. 3.

FIGURE 3

Receiving procedures to obtain content



After the receiver stores the files, the content may be used at any time. As required the receiver shall obtain a valid license according to the LLI of the content.

5 Metadata

5.1 Metadata for setting up a scheduled download

Metadata describing all the information necessary for setting up a scheduled download should be transferred to the receiver prior to the content delivery. Metadata for setting up a scheduled download should include the following information:

1. Information on delivery schedules, namely start/end times.
2. Information on delivery session to identify the broadcast signal.
3. Information required to reconstruct files from transmitted data.
4. Information on file, namely the file name, file size, and file type.
5. Content identification.
6. Information on DRM server if required.

Prior to obtaining content, a receiver has to identify what content will be delivered and its delivery information on broadcast signal. All files comprising the content should also be identified.

Based on the metadata, a receiver stores the necessary files for the selected content at a specified time. The metadata may describe auxiliary information for a receiver to select the content.

5.2 ECG metadata

ECG metadata including the following information should be transferred to receivers:

1. Description of content title, abstraction, and genre. It may include thumbnail-size images of the content.
2. Properties of video/audio or other multimedia data.
3. Description of price and other information for billing.
4. Description of rights to use the content and other information to obtain the license.

ECG metadata is used for navigation to select. It is also used for navigation to select content to use from the stored content list.

6 File transport method over broadcast channel

All content and content related metadata, should be transferred by a reliable and efficient file transport method. Several files may be packaged into one file for a single transfer.

As in real-time broadcasting systems, it is important to minimize transfer delay in file-based broadcasting systems. However, delay variation has less impact in file-based broadcasting systems compared to real-time broadcasting systems. It is important to transfer and store a file without loss or corruption. A detection mechanism to detect lost or corrupted file fragments should be incorporated in file-based broadcasting systems. A system should be equipped with some mechanisms to repair lost or corrupted file fragments.

Appendix 1
(informative)

File-based broadcasting system for advanced-satellite broadcasting in Japan[1]

1 Overview

Digital broadcasting provides content to many viewers at once via terrestrial or satellite broadcasting channels in a stable manner. All viewers can enjoy broadcast programmes at the same time. However, it is difficult to respond to individual requests from all viewers.

In contrast with broadcasting, telecommunication provides requested content via bi-directional channels. However, it is subject to certain problems, e.g. limitations in the network bandwidth and the equipment throughput may result in deteriorated service quality when a large number of viewers make requests.

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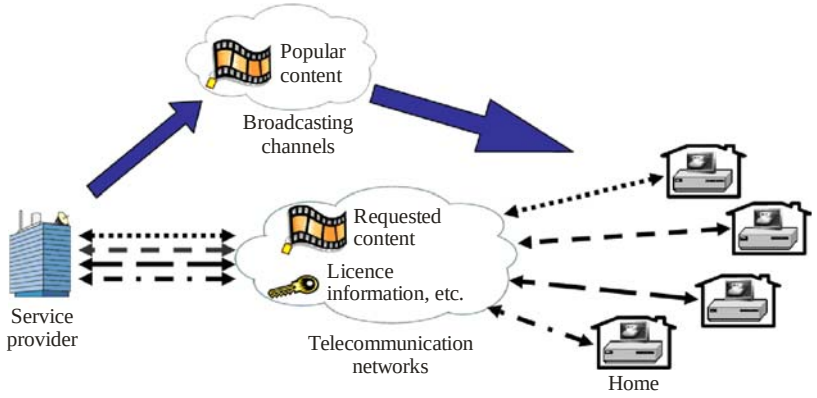
[1] This system is specified in Part 1 of ARIB STD-B45 v2.0 (2011): Content download system for broadcasting.

When these different delivery channels are combined to deliver content, they complement each other and lead to enriched multimedia services. The file-based broadcasting system developed in Japan delivers popular content over broadcasting channels in a short time and also delivers requested content on telecommunication networks. Figure 4 shows an overview of the system.

FIGURE 4

Overview of a file-based broadcasting system using broadcasting channels and telecommunication networks



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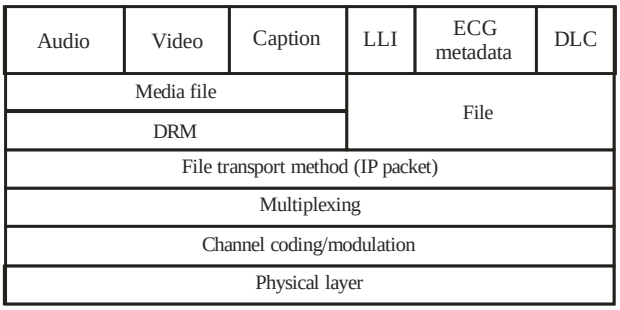
In this system, frequently requested content is provided to many users via broadcasting channels. Less frequently requested content is provided via telecommunication networks.

Files storing audio/video code and associated metadata are delivered over broadcasting channels to every receiver. In addition to these files, the receiver individually obtains the license information from the server using telecommunication networks when needed. The size of license information is small compared to the content itself, keeping the network and server loads low. This system utilizes characteristics of broadcasting channels and telecommunication networks.

Figure 5 shows the protocol stack over the broadcasting channels. Audio/video signals and metadata are delivered as a file over broadcasting channels by the file transport method described in § 6.

FIGURE 5

Protocol stack over broadcasting channels



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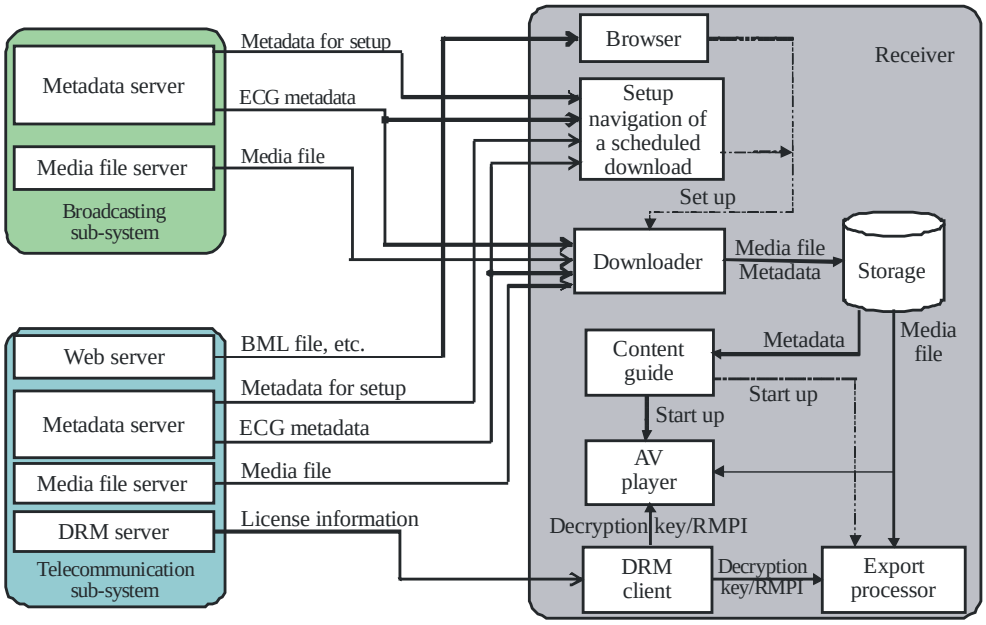
2 Entity model for the system

In the system, the service provider has two sub-systems: one is a broadcasting sub-system, and the other is a telecommunication sub-system. Figure 6 shows the entity model for the system.

FIGURE 6

Entity model for the system



The functions of each entity in the two sub-systems are listed below:

Entity		Function
Broadcasting sub-system	Metadata server	Provides metadata for setup a scheduled download and ECG metadata
	Media file server	Provides media file of content
Telecommunication sub-system	Web server	Connects to browser in receiver and introduces provided content to user
	Metadata server	Provides metadata for setup a scheduled download and ECG metadata
	Media file server	Provides media file of content
	DRM server	Manages rights of content and provides license information needed to play back content to DRM client in receiver

The functions of each entity in the receiver are listed below:

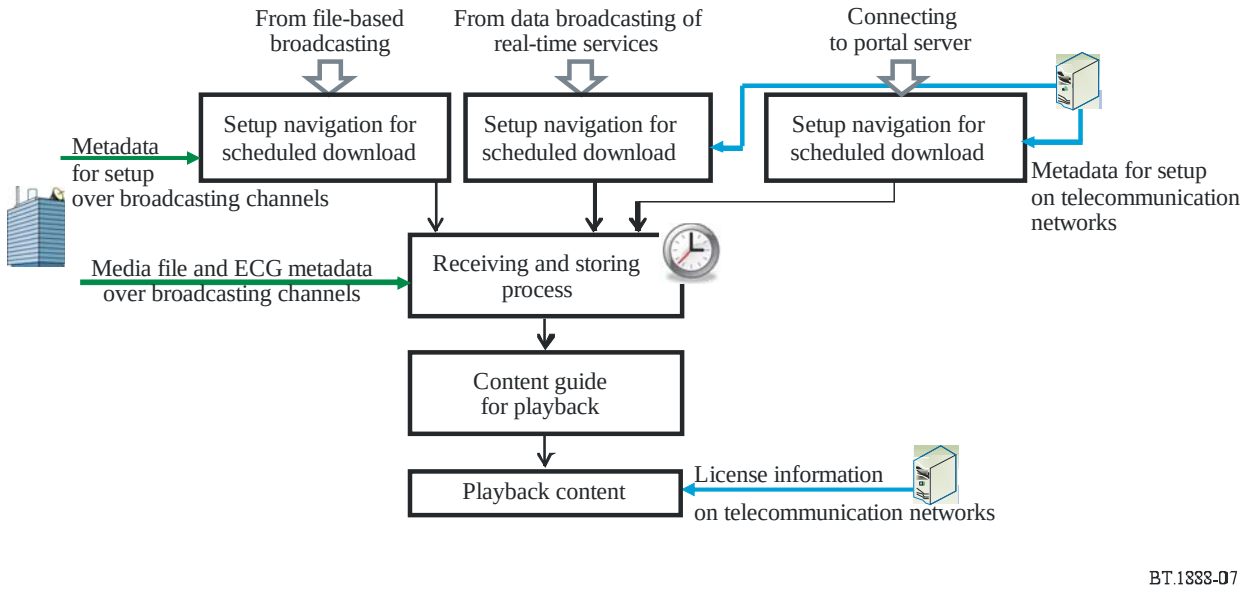
Entity	Function
Browser	Presents web content to user
Setup navigation of a scheduled download	Lets users set up a scheduled download based on metadata for setup a scheduled download and ECG metadata
Downloader	Manages schedules for downloading content. At the scheduled time, receives IP packets and reconstructs a file
Storage	Stores reconstructed files by downloader
Content guide	Presents a list of stored content and provides a user interface to select, delete, retrieve, and export content based on ECG metadata
AV player	Plays stored content and outputs audio/video signals
DRM client	Embedded module to manage rights of content
Export processor	Module to copy stored content outside receiver

3 Procedures to obtain content

A receiver can set up a scheduled download based on the metadata delivered on either the broadcasting sub-system or the telecommunication sub-system. Figure 7 shows a flow diagram from setting up a scheduled download to playing back the stored content at a receiver.

FIGURE 7

Flow diagram from setting up a scheduled download to playing back the content



As shown in Fig. 7, there are three means to set up a scheduled download.

1. From file-based broadcasting.

   A scheduled download is set up based on the metadata delivered over the broadcasting channels. The broadcasting channels have a large transmission capacity, and the consumed resources, such as transmitters and frequency bandwidth, are constant regardless of the number of receivers. A large amount of content, which meets the preferences of many users, is stored in a receiver without consuming telecommunication resources. It is convenient for users to store their favourite content in advance.

2. Navigation from data broadcasting of real-time services.

   A list of content related to real-time broadcast programmes is presented to users in the data broadcasting of real-time services. A user selects content to download from the list. The receiver then obtains the metadata for setup the scheduled download from the server by using telecommunication networks. Based on the metadata, the receiver sets up the scheduled download.

3. Connecting to portal server.

   This works in the same way as telecommunication download services. A list of provided content is presented to users at the portal site in the telecommunication networks. After a user selects content with a browser, the receiver obtains the metadata for setup the scheduled download and sets up the scheduled download in the same way as 2).

   At the same portal site, a list of content provided in the telecommunication download services is also presented. When a user selects content provided in the telecommunication download services, the content is delivered to the user immediately.

For the service provider, it is easy to switch the delivery channels from broadcasting channels to telecommunication networks and vice versa. It is also easy to present some recommended content to users.

In each case, a list of stored content in a receiver is presented to the user, from which the user selects and plays back content in the same way as content delivered on telecommunication networks.

4 Download control information as metadata for setup a scheduled download

A receiver sets up a scheduled download based on Download control (DLC) specified in this section. DLC is delivered on either broadcasting channels or telecommunication networks as depicted in Fig. 7. DLC is an XML document describing all information necessary for receivers to tune into the broadcasting signals and store delivered files.

DLC describes the following information:

– Name of content provider.
– Description of content.
– URL of metadata server to obtain ECG metadata when it is provided on telecommunication networks.
– URL of DRM server with its signature.
– Certificate-related information.
– Delivery information of broadcasting signals such as IP address and port number, or service identification.
– Start and end times of the delivery session.
– Content identification.
– Information on file repair mechanism such as URLs of repair servers.

5 File transport method for the system

In the system, files are transported after being encapsulated into IP packets in order to achieve the maximum effect of hybrid delivery using broadcasting channels and telecommunication networks. The constructed IP packets are multiplexed in broadcasting channels using the multiplexing scheme for variable-length packets[2].

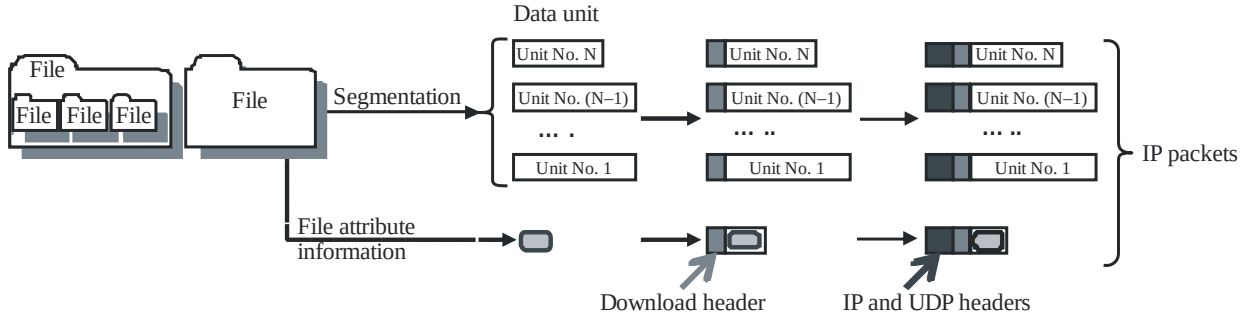
5.1 Constructing IP packets from a file

A file is segmented into data units of a given size. Besides these data units, file attribute information, which describes the file identification and size, is generated. IP packets are constructed from each data unit and the file attribute information by adding download, IP, and UDP headers. Figure 8 shows an overview of the process of constructing IP packets from a file to be transferred.

[2] See Recommendation ITU-R BT.1869 – Multiplexing scheme for variable-length packets in digital multimedia broadcasting systems.

FIGURE 8

Process of constructing IP packets from a file



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5.2 File attribute information

File attribute information is contained in an XML document that describes information necessary for receivers to reconstruct the file from received data units. It also describes the configuration of a download header. An XML scheme for the file attribution information is shown below.

```
<? xml version="1.0" encoding="UTF-8" ?>
<xs:scheme xmlns:xs="http://www.w3.org/2001/XMLScheme">
 <xs:element name="FileInfo" type="FileInfoType"/>
 <xs:complexType name="FileInfoType">
  <xs:sequence>
   <xs:element name="File" type="FileType" maxOccurs="1"/>
  </xs:sequence>
  <xs:attribute name="Width-Of-BlockNumber" type="xs:positiveInteger"
use="required"/>
  <xs:attribute name="Last-SN-Of-FileInfo" type="xs:positiveInteger"
use="optional"/>
  <xs:attribute name="Max-Unit-In-Block" type="xs:unsignedLong" use="optional"/>
  <xs:attribute name="Size-Of-DataUnit" type="xs:positiveInteger"
use="optional"/>
  <xs:attribute name="FEC-Encoding-ID" type="xs:unsignedLong" use="optional"/>
  <xs:attribute name="Expires" type="xs:string" use="required"/>
 </xs:complexType>
 <xs:complexType name="FileType">
  <xs:attribute name="Content-Location" type="xs:anyURI" use="required"/>
  <xs:attribute name="Content-Type" type="xs:string" use="required"/>
  <xs:attribute name="Content-Length" type="xs:unsignedLong" use="required"/>
  <xs:attribute name="Last-BlockNumber" type="xs:unsignedLong" use="required"/>
  <xs:attribute name="Last-SN" type="xs:unsignedLong" use="required"/>
  <xs:attribute name="Transfer-Encoding" type="xs:string" use="optional"/>
  <xs:attribute name="Transfer-Length" type="xs:unsignedLong" use="optionl"/>
 </xs:complexType>
</xs:scheme>
```

The meaning of each element and attribute is below:

Name of element/attribute	Description
FileInfo	This element includes information on the file attribute information. This element contains one “File” element
Width-Of-Block-Number	This attribute identifies the number of bits for the block_number field in the download header
Last-SN-Of-FileInfo	This attribute identifies the last sequence number of the packet carrying the file attribute information
Max-Unit-In-Block	This attribute identifies the maximum number of data units in a block
Size-Of-DataUnit	This attribute identifies the size of the data unit in bytes
FEC-Encoding-ID	This attribute identifies the type of FEC as the number registered for “Reliable Multicast Transport (RMT) FEC Encoding IDs and FEC Instance IDs” at IANA
Expires	This attribute identifies the expiry data for the file attribute information
File	This element includes information on file identification and data units
Content-Location	This attribute identifies identification of the file as a URI
Content-Type	This attribute identifies the content type of the file
Content-Length	This attribute identifies the size of the file in bytes
Last-BlockNumber	This attribute identifies the last block number to which the last packet carrying data units belongs.
Last-SN	This attribute identifies the last sequence number of the packet carrying data units in the last block
Transfer-Encoding	This attribute identifies the type of transfer encoding if the file is encoded
Transfer-Length	This attribute identifies the transferred size if the file is encoded

5.3 Download header

The download header indicated in Table 1 is added to each data unit and the file attribute information.

TABLE 1

Download header

Syntax	No. of bits	Mnemonic
download_header {		
transport_file_id	32	uimsbf
block_number	n	uimsbf
sequence_number	32-n	uimsbf
}		

transport_file_id – This identifies the file being transferred.

block_number – This indicates the sequential number of blocks and is incremented for each block with the same transport_file_id. A block is defined as a collection of data units.

sequence_number – This indicates the sequential number of packets and is incremented for each packet with the same transport_file_id. The total number of bits for block_number and

sequence_number fields is 32 bits. The number of bits for the block_number field is configured from the file attribute information.

The packets carrying the file attribute information are transferred prior to all other packets carrying data units of that file. The first packet carrying file attribute information has a download header whose block and sequence numbers are 0.

5.4 IP header compression

IP and UDP headers of the constructed IP packets are compressed using HCfB of TLV multiplexing scheme since these headers are not necessary over broadcasting channels.

HCfB replaces IP and UDP headers with either a full header, which includes all IP and UDP header information, or a compressed header, which does not include all IP and UDP header information. To decompress the compressed header, at least one packet with a full header needs to be transferred prior to packets with a compressed header. CID_header_type is used to indicate which type of header the packet has.

To deliver files, it is also necessary to transfer the packets carrying file attribute information prior to packets carrying data units. When header information of the first packet carrying the file attribute information is replaced with a full header, and the header information of all other packets is replaced with a compressed header, the overhead of IP and UDP header information is maximally reduced. Therefore, packet headers are compressed as listed in Table 2 and shown in Fig. 9.

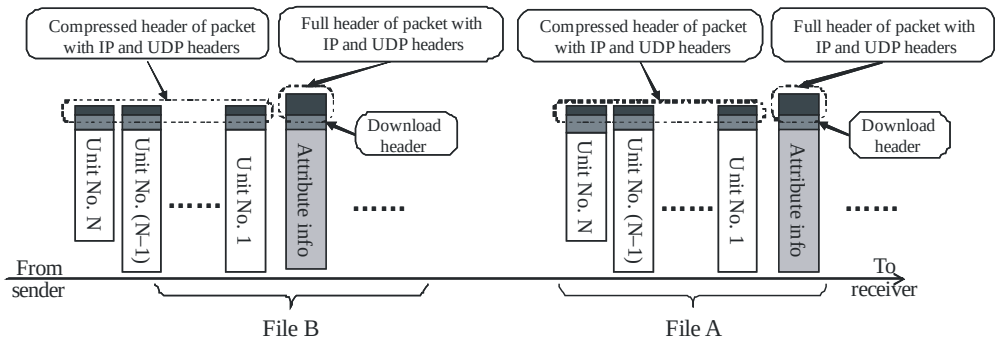
TABLE 2

CID_header_type assignment of each packet

Packet	Value of CID_header_type	Description
The first packet carrying the file attribute information	0x20 (for IPv4 packet) 0x60 (for IPv6 packet)	Full header of packet with IP and UDP headers
All packets other than that listed above	0x21 (for IPv4 packet) 0x61 (for IPv6 packet)	Compressed header of packet with IP and UDP headers

FIGURE 9

Overview of packet header



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These compressed header packets are transferred over the broadcasting channels.

5.5 Detection of lost or corrupted file fragments

Lost and corrupted file fragments can be detected as follows:

– Corrupted data units are detected by checking a checksum of IP and UDP headers.

– Lost data units are detected by checking a sequential number of a download header.

A receiver identifies whether or not the transferred file is identical to that of the transmitter. When the integrity of a file is not maintained, the receiver may repair the file by using the repair server identified in the DLC.

Appendix 2
(informative)

File-based broadcasting system for mobile reception ISDB-T multimedia broadcasting in Japan[3]

1 Overview

The purpose of this file-based broadcasting system is to broadcast media-content files to mobile terminals. As the radio channels between transmitters and mobile terminals are unstable, transmission-error-compensation technologies, such as forward-error correction (FEC), are indispensable. However, if the receiving condition is so bad that the transmission cannot be completed only through the broadcasting channel, it is effective to utilize communication channels to retrieve the missing portions of the content. The system also uses communication channels to deliver information on access control and digital-rights management. Figure 10 shows an overview of the system.

In regard to this file-based broadcasting system, contents are mainly transmitted over broadcasting channels. In the case that a portion of the contents at the receivers is missing, "content-complementation data" is transmitted through communications channels.

Files containing audio, video, and other multimedia contents are delivered over broadcast channels using the protocol illustrated in Fig. 11. The content of the media file is identified by the media type indicated by the metadata or the transport parameters. The ECG metadata contains information on content such as title and genre. It also contains links to licence information (LLI). The download-control metadata contains the information that receivers need in order to obtain scheduling information for content download. The file-transport methods used by the system are FLUTE, AL-FEC, UDP/IP, ROHC, ULE, and MPEG-2 TS, which are described in detail in § 5. For the physical layer, Multimedia System "F" defined in Recommendation ITU-R BT.1833 is used.

[3] This system is specified in Part II of ARIB STD-B45 v2.0 (2011): Content download system for broadcasting.

FIGURE 10

Overview of a file-based broadcasting system using broadcasting channels and telecommunications networks

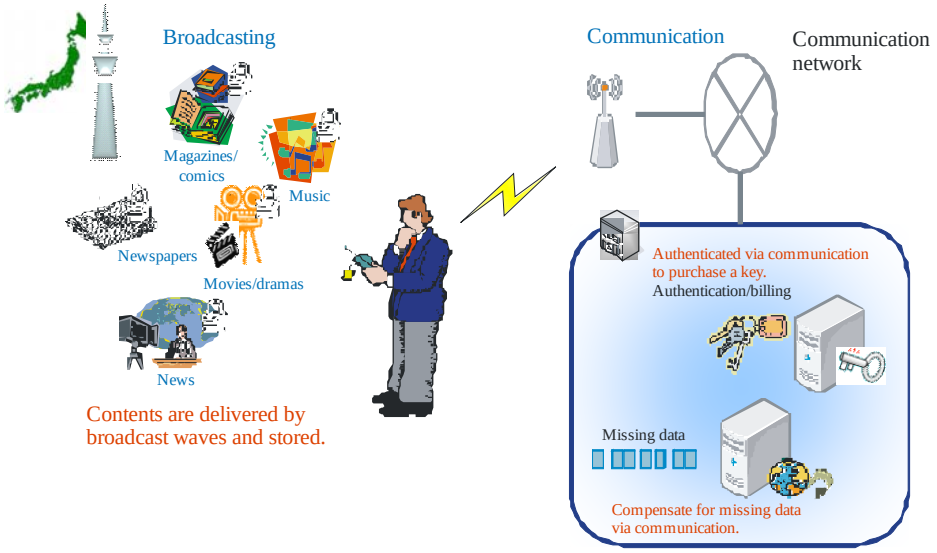

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FIGURE 11

Protocol stack over broadcasting channels

Media file	**ECG metadata download control metadata**
FLUTE / AL- FEC	
UDP / IP / ROHC	
ULE	
MPEG-2 TS	
Multimedia systems “F” p hysical layer (including channel coding and modulation)	

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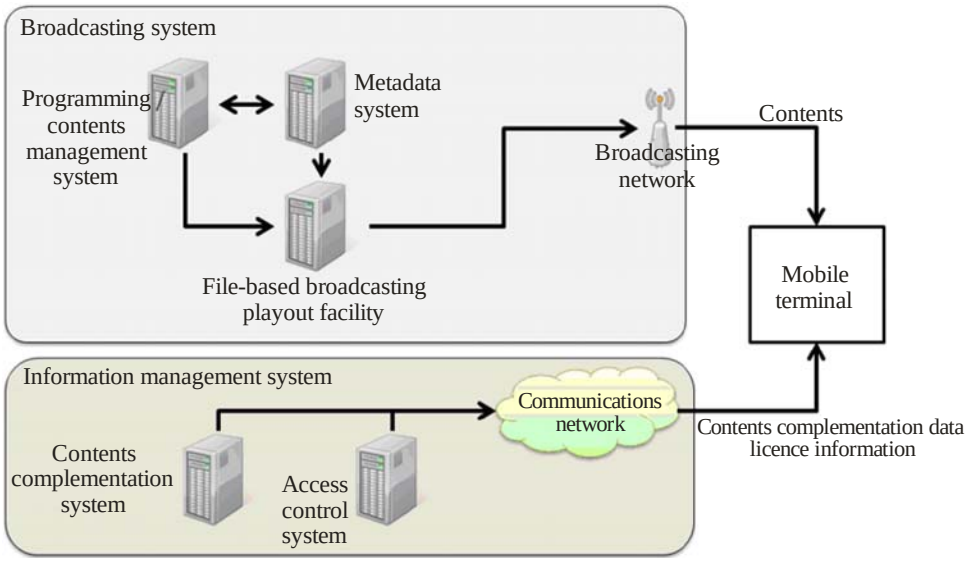
2 Entity model for the system

In the case of this file-based broadcasting system, information is delivered to mobile terminals from two sub-systems: a broadcasting system and an information-management system. As shown in Fig. 12, the broadcasting system uses broadcasting networks to deliver contents, and the information-management system uses communication channels to transmit content-complementation data and licence information.

FIGURE 12

Entity model for the system

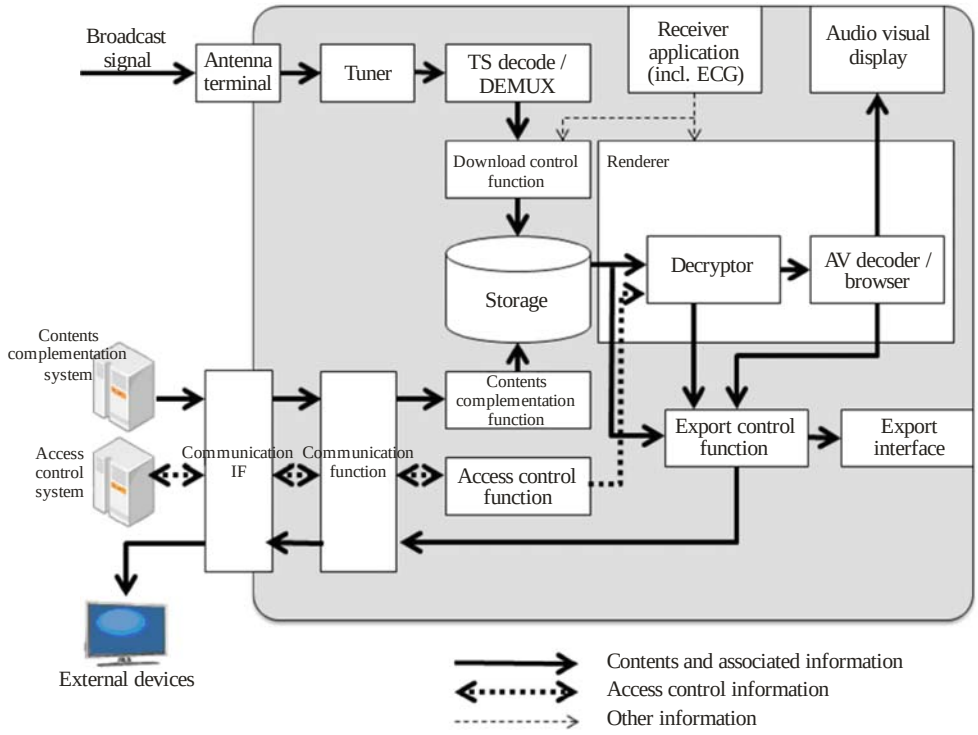


Entity		Function
Broadcasting system	Programming/contents-management system	Controls broadcasting schedule/manages media contents
	Metadata system	Manages metadata
	File-based broadcasting playout facility	Provides downloading bit stream to broadcasting network
	Broadcasting network	Delivers media contents to mobile terminals
Information-management system	Contents-complementation system	Provides missing portion of contents to mobile terminals
	Access-control system	Provides access-control information
	Communications network	Delivers content-complementation data and access-control information to mobile terminals

The entity model of the mobile terminals is shown in Fig. 13.

FIGURE 13

Entity model for mobile terminal



The functions of each entity in the receiver are listed below:

Entity	Function
Antenna terminal	Receives signal from antenna
Tuner	Demodulates digital broadcasting signal
TS decode/DEMUX	Decodes transport stream and selects intended stream (de-multiplexing)
Download control function	Reconstructs scheduled download contents from transport stream (incl. FLUTE/AL-FEC)
Storage	Stores reconstructed download contents
Communication IF	Interfaces with communications networks
Communication function	Handles communications protocols
Contents complementation function	Detects missing portion for reconstructing contents and requests complementation data
Access-control function	Accesses control function at mobile terminal
Renderer	Playbacks audio, visual, and hyper-text contents
Decryptor	Decrypts encrypted contents
AV decoder/browser	Playbacks decrypted audio, visual, and hyper-text contents
Audio visual display	Presents audio, visual, and hyper-text contents
Export control function	Exports contents to external devices (with appropriate access control)
Export interface	Logical and physical interface to external devices
Receiver application	Provides user interface for ECG, download scheduling, charging, etc.

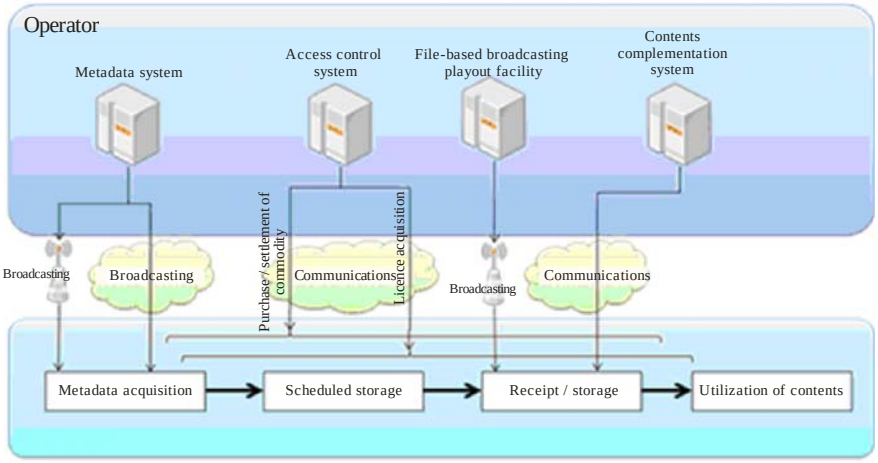
3 Procedures for obtaining content

The receiver first obtains the ECG metadata that contains the title of the content, a link to the purchase information, etc. and then obtains the download-control metadata (which contains broadcasting date and other detailed information necessary for downloading the content). The metadata is transmitted via broadcasting networks; however, in the case that the receiver cannot obtain the metadata by broadcasting, it can also be obtained via communications networks.

The receiver then programs the download schedule according to the information in the metadata, and it starts downloading when the intended contents are broadcasted. To save battery power, the receiver sleeps and does not always receive broadcasting radiowaves. If the content is not completely downloaded, the remaining portions can be retrieved via communication networks. Before the content is used, licence information and related payment procedures are executed through communication networks. A typical service flow is shown in Fig. 14.

FIGURE 14

Typical service flow



BT.1888-14

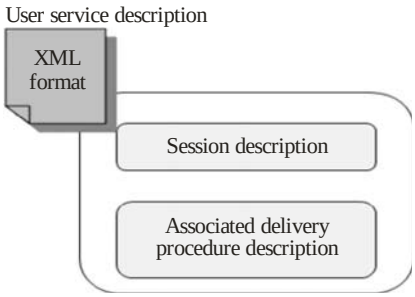
4 ECG metadata and download control metadata

The ECG metadata is an XML document describing content such as title and genre. It also contains a link to licence information (LLI) and a link to download control metadata.

The download-control metadata contains a “User service description” used to describe the information needed for tuning into broadcasting signals (Session description) and for performing the content complementation procedures (Associated delivery procedure description), as shown in Fig. 15.

FIGURE 15

Download control metadata



The contents of the user service description are as listed in the following table:

Entity		Definition
User-service description		Contains user service description
	Version	Version for user service description
	Program	Reference ID of content (CRID)
	Session description	Session description
	Associated-procedure description	Associated delivery procedure description

5 Manifest file

A downloaded content can contain multiple files as media resources, as shown in Fig. 16. To manage resource files in content and to manage playback scenarios of the content, an XML document (Manifest file) is contained in the content. The structure of the manifest file is shown in Fig. 17.

FIGURE 16

Structure of download contents

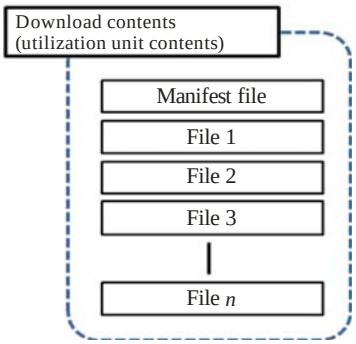


FIGURE 17

Structure of manifest file

Entity	Description
manifests	Root entity of manifest file
manifest	Parent node for each version
@version	Manifest version
assets	Container for each resource file
@count-asset-id	ID for representative resource file for playback count
asset	Describing resource-file attributes, including ID, file name, encryption status, and scene-IDs for playback control
scenario	Container for playback-scenario control information
sequence	Information on playback timeline

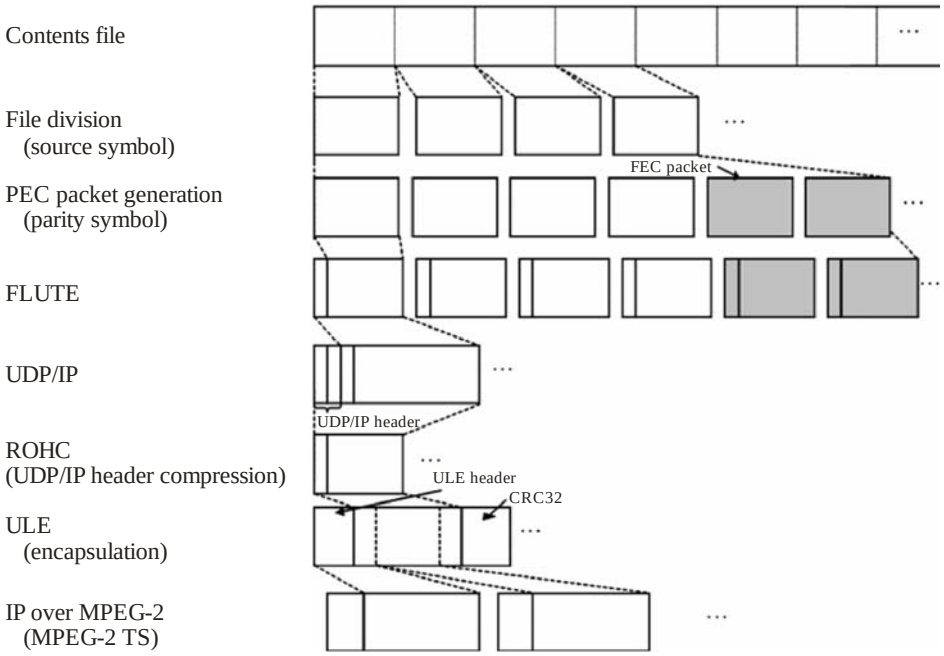
BT.1888-17

6 File transport method for the system

Media files transmitted over a broadcasting channel are fragmented into a MPEG-2 TS (transport stream) defined in ITU-T Recommendation H.222.0, as shown in Fig. 18.

FIGURE 18

Process of constructing transport stream packets from a file



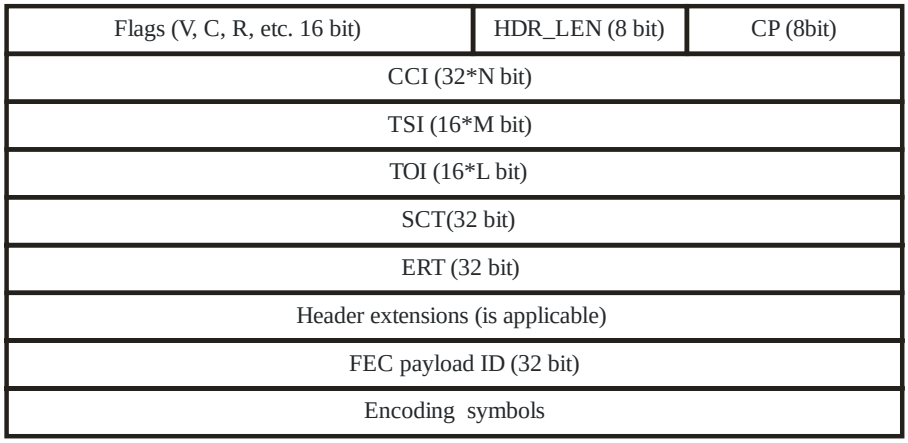
BT.1888-18

6.1 Constructing IP packets from a file

The media file is divided into source-symbol fragments and combined with the AL-FEC (application-layer forward error correction) parity symbols for resilience against transmission error in mobile broadcasting channels. The symbols are then encapsulated into file-delivery-over-unidirectional-transport (FLUTE) packets and then transmitted on UDP/IP. The packet structure of FLUTE is shown in Fig. 19.

FIGURE 19

FLUTE packet structure



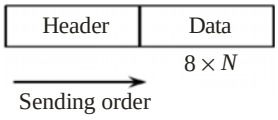
Field	Definition
Flags	Various flags including version number, congestion control, field length of CCI, TSI, and TOI, and existence of SCT and ERT
HDR_LEN	Contains header length in 32-bit units
CP	Code point (which may be used to specify FEC_encoding_ID)
CCI	Congestion-control information
TSI	Transport-session identifier
TOI	Transport-object identifier
SCT	Sender current time in milliseconds
ERT	Expected residual time in milliseconds
Header extensions	Additional information
FEC payload ID	Contains source block number and encoding symbol ID of encoding symbols
Encoding symbols	Payload

6.2 IP header compression

IP and UDP headers are compressed using robust header compression (ROHC), as shown in Figs 20 and 21.

FIGURE 20

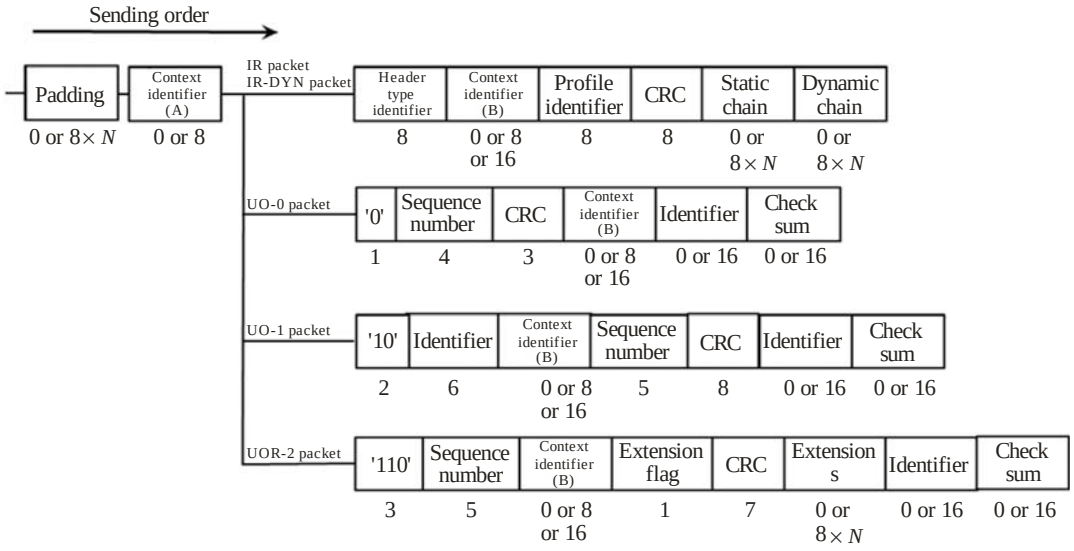
ROHC packet structure



BT.1888-20

FIGURE 21

ROHC header structure



BT.1888-21

Field	Description
Padding	Padding information
Context identifier	ID for ROHC context
Header-type identifier	‘1111 1101’: IR packet ‘1111 1000’: IR-DYN packet
Profile identifier	0x0002 (UDP profile)
Static chain	Static part of UDP header information
Dynamic chain	Dynamic part of UDP header information

6.3 Encapsulation into transport stream packets[4]

The header-compressed IP packets are encapsulated into MPEG-2 transport-stream packets using unidirectional lightweight encapsulation. The structure of ULE is shown in Fig. 22.

[4] See Recommendation ITU-R BT.1887 – Carriage of IP packets in MPEG-2 transport streams in multimedia broadcasting.

FIGURE 22

ULE packet structure

BT.1888-22

Field	Description
D	0: Destination-address field exists 1: Destination-address field does not exit
Data length	Length of data field in bytes
Packet type	0x8000: IPv4 packet 0x22F1: ROHC compressed IP packet 0x22F2: HCfB compressed IP packet 0x86DD: IPv6 packet
Destination address	48-bit-length destination address
Data	ULE encapsulated data bytes
CRC	Cyclic redundancy check

6.4 Detection of lost or corrupted file fragments

Lost and corrupted file fragments can be detected as follows:

– Lost symbols are detected by checking FEC payload ID in the FLUTE header.

– Corrupted IP packets are detected by checking the checksum of the UDP headers.

– Corrupted ULE packets are detected by checking the checksum of the ULE packets.

– Lost MPEG-2 TS packets are detected by checking the TS header.

Corrupted or lost symbol packets are discarded, and the original file is reconstructed by using AL-FEC decoding. If the file is not perfectly reconstructed, the receiver may repair the file by using the contents-complementation system identified by the download-control metadata.

7 Digital-rights management

For the purpose of digital-rights management, the entire content file can be encrypted before transmission. The encryption key is delivered through the communication channels after appropriate authentication procedures are performed.