International Telecommunication Union

ITU-R

Radiocommunication Sector of ITU

Recommendation ITU-R BT.1887

(03/2011)

Carriage of IP packets in MPEG-2 transport streams in multimedia broadcasting

BT Series

Broadcasting service (television)

International Telecommunication Union

Foreword

The role of the Radiocommunication Sector is to ensure the rational, equitable, efficient and economical use of the radio-frequency spectrum by all radiocommunication services, including satellite services, and carry out studies without limit of frequency range on the basis of which Recommendations are adopted.

The regulatory and policy functions of the Radiocommunication Sector are performed by World and Regional Radiocommunication Conferences and Radiocommunication Assemblies supported by Study Groups.

Policy on Intellectual Property Right (IPR)

ITU-R policy on IPR is described in the Common Patent Policy for ITU-T/ITU-R/ISO/IEC referenced in Annex 1 of Resolution ITU-R 1. Forms to be used for the submission of patent statements and licensing declarations by patent holders are available from http://www.itu.int/ITU-R/go/patents/en where the Guidelines for Implementation of the Common Patent Policy for ITU-T/ITU-R/ISO/IEC and the ITU-R patent information database can also be found.

Series of ITU-R Recommendations

(Also available online at http://www.itu.int/publ/R-REC/en)

Series	Title
BO	Satellite delivery
BR	Recording for production, archival and play-out; film for television
BS	Broadcasting service (sound)
BT	**Broadcasting service (television)**
F	Fixed service
M	Mobile, radiodetermination, amateur and related satellite services
P	Radiowave propagation
RA	Radio astronomy
RS	Remote sensing systems
S	Fixed-satellite service
SA	Space applications and meteorology
SF	Frequency sharing and coordination between fixed-satellite and fixed service systems
SM	Spectrum management
SNG	Satellite news gathering
TF	Time signals and frequency standards emissions
V	Vocabulary and related subjects

Note: *This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.*

Electronic Publication
Geneva, 2011

RECOMMENDATION ITU-R BT.1887

Carriage of IP packets in MPEG-2 transport streams in multimedia broadcasting

(Question ITU-R 45-2/6)

(2011)

Scope

This Recommendation deals with carriage of IP packets in MPEG-2 transport streams in digital multimedia broadcasting. Specifications are given for encapsulation techniques and IP header compression techniques.

The ITU Radiocommunication Assembly,

considering

a) that various kinds of signals for multimedia services may be delivered in digital broadcasting;

b) that ITU-T Recommendation H.222.0 (MPEG-2 systems) is adopted as service transport and service multiplex methods of most digital broadcasting systems;

c) that an IP packet has become another transport method for various kinds of signals with the increasing growth of IP-based telecommunication networks;

d) that there is a growing demand to harmonize broadcasting services with telecommunication services;

e) that for existing digital broadcasting systems that only support MPEG-2 transport stream as their input stream format, it is desirable to have the capability of carrying IP packets into an MPEG-2 transport stream;

f) that it is desirable to limit the number of different encapsulation schemes across different broadcasting systems,

recommends

1 that for carriage of IP packets in MPEG-2 transport streams in multimedia broadcasting, the encapsulation schemes described in Annex 1 should be used;

2 that compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (e.g. to ensure 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.

Annex 1

Carriage of IP packets in MPEG-2 transport streams in multimedia broadcasting

References

Normative references

[1] ITU-T Recommendation H.222.0 (2006) – Information technology – Generic coding of moving pictures and associated audio information: Systems.

[2] ISO/IEC 13818-6 (1998) – Information technology – Generic coding of moving pictures and associated audio information – Part 6: Extensions for DSM-CC.

[3] Recommendation ITU-R BT.1869 (2010) – Multiplexing scheme for variable-length packets in digital multimedia broadcasting systems.

[4] ETF RFC 3095 (July 2001): Robust Header Compression (ROHC): Framework and four profiles: RTP, UDP, ESP, and uncompressed.

This IETF standard is available at the following address: http://www.ietf.org/rfc/rfc3095.txt

[5] IETF RFC 4326 (December 2005): Unidirectional Lightweight Encapsulation (ULE) for Transmission of IP Datagrams over an MPEG-2 Transport Stream (TS).

This IETF standard is available at the following address: http://www.ietf.org/rfc/rfc4326.txt

[6] ATSC Doc. A/90 (July 2000): ATSC Data Broadcast Standard.

[7] ATSC Doc. A/92 (January 2002): ATSC Standard: Delivery of IP Multicast Sessions over ATSC Data Broadcast.

[8] ETSI EN 301 192 v1.5.1 (2009-11): Digital Video Broadcasting (DVB); DVB specification for data broadcasting.

[9] IETF RFC 791 (September 1981): Internet Protocol.

This IETF standard is available at the following address: http://www.ietf.org/rfc/rfc791.txt

[10] IETF RFC 2460 (December 1998): Internet Protocol, Version 6 (IPv6) Specification.

This IETF standard is available at the following address: http://www.ietf.org/rfc/rfc2460.txt

[11] ISO/IEC 8802-2 (1998): Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 2: Logical link control.

[12] ISO/IEC TR 8802-1 (2001): Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 1: Overview of Local Area Network Standards.

[13] ITU-T Recommendation J.122 (2007) – Second-generation transmission systems for interactive cable television services – IP cable modems.

[14] ITU-T Recommendation J.222.2 (2007) – Third-generation transmission systems for interactive cable television services – IP cable modems: MAC and Upper Layer protocols.

Abbreviations

ATSC	Advanced Television Systems Committee
CRC	Cyclic Redundancy Check
DSM-CC	Digital Storage Media-Command and Control
DVB	Digital Video Broadcast
ESP	Encapsulating Security Payload
ETSI	European Telecommunications Standards Institute
HCfB	Header Compression for Broadcasting
IEC	International Electrotechnical Commission
IETF	Internet Engineering Task Force
IP	Internet Protocol
ISO	International Organization for Standardization
LLC	Logical Link Control
MAC	Media Access Control
MPE	Multi-Protocol Encapsulation
MPEG	Moving Pictures Experts Group
PDU	Protocol Data Unit
PES	Packetized Elementary Stream
RFC	Request For Comment (IETF standard)
ROHC	Robust Header Compression
RTP	Real-time Transport Protocol
SNAP	SubNetwork Attachment Point
SNDU	SubNetwork Data Unit
TS	Transport Stream
UDP	User Datagram Protocol
ULE	Unidirectional Lightweight Encapsulation

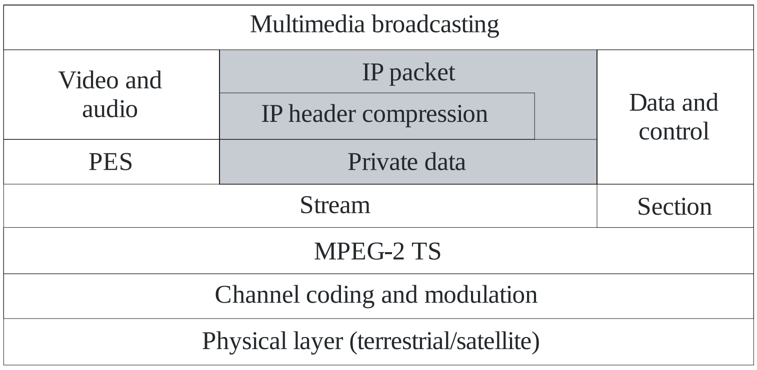
1 Introduction

Many of the already deployed digital broadcasting systems transfer an MPEG-2 TS [1] as their input stream format. There are two possible procedures for carrying IP packets in an MPEG-2 TS in such broadcasting systems: one is encapsulation into a private stream of an MPEG-2 TS, as depicted in Fig. 1, and the other is encapsulation into a section of an MPEG-2 TS, as depicted in Fig. 2.

Because IP header information is not necessary over broadcasting channels, it can be compressed before encapsulation, increasing the efficiency.

FIGURE 1

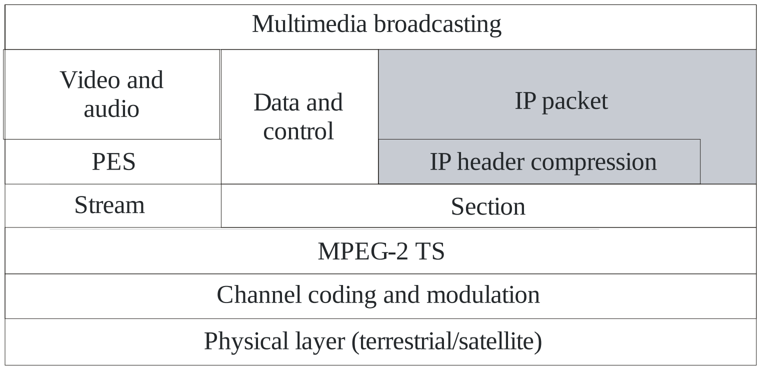
Protocol stack of encapsulation of IP packet into private stream of MPEG-2 TS



BT.1887-01

FIGURE 2

Protocol stack of encapsulation of IP packet into section of MPEG-2 TS



BT.1887-02

2 Techniques for encapsulating IP packets into an MPEG-2 TS

2.1 Encapsulation of IP packets into a private stream of MPEG-2 TS

Unidirectional Lightweight Encapsulation (ULE) specified in IETF RFC 4326 [5] is an encapsulation technique for IP packets and other network protocol packets over an MPEG-2 transport stream as private data.

A transferred packet such as an IP packet is called a Protocol Data Unit (PDU). Each PDU is encapsulated into a SubNetwork Data Unit (SNDU) by adding an encapsulation header and an integrity check trailer. Table 1 indicates the syntax of SNDU. An SNDU is fragmented into a series of one or more MPEG-2 TS packets.

TABLE 1

Syntax of SNDU

Syntax	No. of bits	Mnemonic
SNDU {		
destination_address_absent_flag	1	bslbf
length	15	uimsbf
type	16	uimsbf
if(destination_address_absent_flag==“0”)		
destination_address	48	uimsbf
if(type==0x0800)		
IPv4_packet ()		
else if (type==0x86DD)		
IPv6_packet ()		
else if (type==[T.B.D])		
compressed_ip_packet ()		
else if (type==[T.B.D])		
compressed_ip_packet_ROHC ()		
CRC_32	32	rpchof
}		

destination_address_absent_flag – This indicates the absence of a destination_address field. A value of “0” indicates the presence of the destination_address field. A value of “1” indicates that a destination_address field is not present.

length – This indicates the length, in bytes, of the SNDU counted from the byte following the type field to and including the CRC_32 field.

type – This indicates the type of payload carried in an SNDU, or the presence of a next-header.

destination_address – This identifies the receiver(s) that process(es) a received SNDU.

IPv4_packet () – This indicates an IPv4 packet, which has an IPv4 header defined in RFC791 [9].

IPv6_packet () – This indicates an IPv6 packet, which has an IPv6 header defined in RFC 2460 [10].

compressed_ip_packet () – This indicates an IP packet having compressed headers presented in § 3.1 of this Recommendation and § 4 of Recommendation ITU-R BT.1869.

compressed_ip_packet_ROHC () – This indicates an IP packet having compressed headers using Robust Header Compression (ROHC) [4] shown in § 3.2 of this Recommendation.

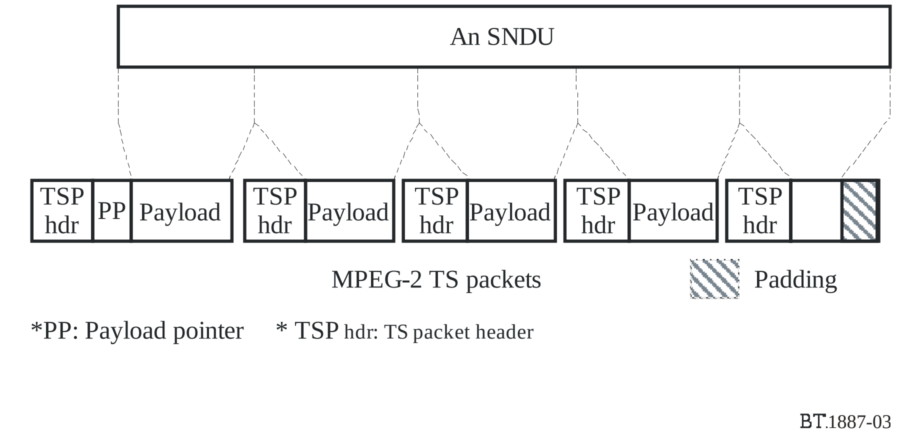
CRC_32 – This field complies with ITU-T Recommendation H.222.0.

The SNDU is assigned into a series of TS packet payloads. There are two assigning procedures: padding and packing. The overviews of the packing and padding procedures are shown in Figs 3 and 4, respectively. The packing procedure is optional and may be determined on a per-session or per-SNDU basis.

In the padding procedure, after one SNDU is encapsulated into a series of MPEG-2 TS packets, another SNDU is not encapsulated immediately even if space is available in a partially filled TS packet. This procedure trades decreased efficiency for improved latency.

FIGURE 3

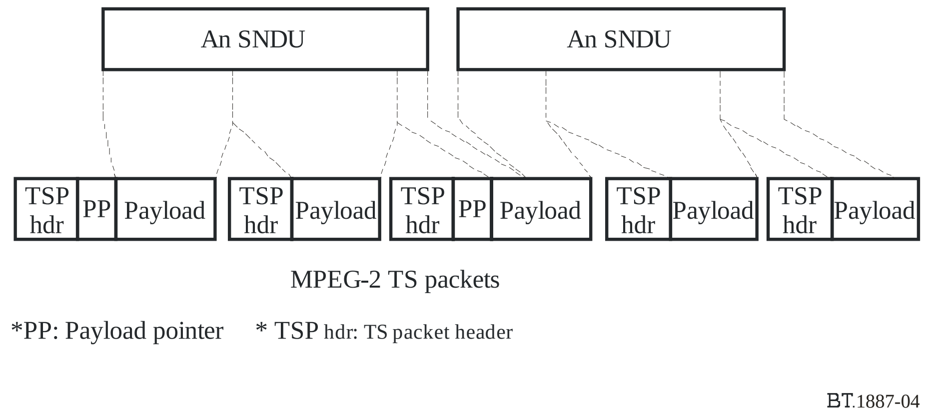
Encapsulation of an SNDU into MPEG-2 TS packets using padding procedure



On the other hand, in the packing procedure, when more SNDUs are waiting to be transferred, and an MPEG-2 TS packet has sufficient space remaining in the payload, a previously encapsulated SNDU is followed with another SNDU using the next available byte of the TS packet payload.

FIGURE 4

Encapsulation of SNDUs into MPEG-2 TS packets using packing procedure



2.2 Encapsulation of IP packets into a section of MPEG-2 TS

The following two schemes are available for encapsulating IP packets into a section of an MPEG-2 TS.

2.2.1 Multi-Protocol Encapsulation [6]; [7]

An IP packet is encapsulated into a DSM-CC addressable section. The syntax of the DSM-CC addressable section for encapsulating IP packet is indicated in Table 2. The mapping of the section into MPEG-2 TS packets is defined in ITU-T Recommendation H.220.0.

TABLE 2

Syntax of DSM-CC_addressable_section

Syntax	No. of bits	Mnemonic
DSMCC_addressable_section () {		
table_id	8	uimsbf
section_syntax_indicator	1	bslbf
error_detection_type	1	bslbf
reserved	2	bslbf
section_length	12	uimsbf
deviceID[7...0]	8	uimsbf
deviceID[15...8]	8	uimsbf
reserved	2	bslbf
payload_scrambling_control	2	bslbf
address_scrambling_control	2	bslbf
LLC_SNAP_flag	1	bslbf
current_next_indicator	1	bslbf
section_number	8	uimsbf
last_section_number	8	uimsbf
deviceID[23...16]	8	uimsbf
deviceID[31...24]	8	uimsbf
deviceID[39...32]	8	uimsbf
deviceID[47...40]	8	uimsbf
if (LLC_SNAP_flag==“1”) {		
LLC_SNAP()		
} else {		
for (j=0; j<N; j++) {		
IPv4_packet ( )		
}		
}		
if(section_number == last_section_number) {		
for(j=0; j<N; j++) {		
stuffing_byte	8	bslbf
}		
}		
if (error_detection_type==“1”) {		
checksum	32	uimsbf
} else {		
CRC_32	32	rpchof
}		
}		

table_id – This field identifies the DSM-CC section type to which the section belongs. It is set to “0x3F” in the case of a DSM-CC addressable section.

section_syntax_indicator – This is a 1-bit flag. When set to “1”, it indicates the presence of the CRC_32 field. When set to “0”, it indicates the presence of the checksum field.

error_detection_type – This is a 1-bit flag. When set to “1”, it indicates the presence of the checksum field. When set to “0”, it indicates the presence of the CRC_32 field.

reserved – This 2-bit field is set to “11”.

section_length – This field specifies the number of remaining bytes of the section immediately following the section_length field up to the end of the section including the checksum field or CRC_32 field.

deviceId – This 48-bit field identifies the intended receiver device. The deviceId field is reconstructed from the in order concatenation of the deviceId[47…40], deviceId[39…32], deviceId[31…24], deviceId[23…16], deviceId[15…8], and deviceId[7…0] fields, representing bit number 47 to 40, bit number 39 to 32, bit number 31 to 24, bit number 23 to 16, bit number 15 to 8, and bit number 7 to 0, respectively.

payload_scrambling_control – This field defines the scrambling mode of the payload. This includes the payload that starts after the deviceId[47..40] byte and excludes the checksum or CRC_32 field.

address_scrambling_control – This field defines the scrambling mode of deviceId.

LLC_SNAP_flag – This a 1-bit flag. If this flag is set to “1”, the payload carries an LLC/SNAP encapsulated datagram following the deviceID[47..40] field. The LLC/SNAP structure indicates the type of the packet conveyed. If this flag is set to “0”, the section contains an IPv4 packet without LLC/SNAP encapsulation.

current_next_indicator – This is a 1 bit flag. If the value of the table_id field has a value in the range of 0x3A to 0x3C, this bit is set to “1”. Otherwise, the value and use of this field are defined by the user.

section_number – The value and use of this field are defined by the user.

last_section_number – This field is set to the maximum value that is encoded in the section_number field for the same table_id field.

LLC_SNAP() – This structure contains the datagram according to the ISO/IEC 8802-2 Logical Link Control (LLC) [11] and ISO/IEC 8802-1 SubNetwork Attachment Point (SNAP) Standards [12].

IPv4_packet ( ) – This indicates an IPv4 packet, which has an IPv4 header defined in RFC 791 [9].

stuffing_byte – This is an optional 8-bit field whose value is not specified.

checksum – A 32-bit checksum calculated over the entire DSMCC_addressable_section. It is calculated by treating the DSMCC_addressable_section as a sequence of 32-bit integers and performing one’s complement addition (an Exclusive-Or operation) over all the integers, with the most significant byte first, then taking the one’s complement of the result.

CRC_32 – This field complies with ITU-T Recommendation H.222.0.

2.2.2 Multi-Protocol Encapsulation [8]

An IP packet is encapsulated into datagram_section, which is compliant with the DSMCC_section format [2]. The syntax of datagram_section is indicated in Table 3. The mapping of the section into MPEG-2 TS packets is defined in ITU-T Recommendation H.222.0.

TABLE 3

Syntax of datagram_section

Syntax	No. of bits	Mnemonic
datagram_section () {		
table_id	8	uimsbf
section_syntax_indicator	1	bslbf
private_indicator	1	bslbf
reserved	2	bslbf
section_length	12	uimsbf
MAC_address_6	8	uimsbf
MAC_address_5	8	uimsbf
reserved	2	bslbf
payload_scrambling_control	2	bslbf
address_scrambling_control	2	bslbf
LLC_SNAP_flag	1	bslbf
current_next_indicator	1	bslbf
section_number	8	uimsbf
last_section_number	8	uimsbf
MAC_address_4	8	uimsbf
MAC_address_3	8	uimsbf
MAC_address_2	8	uimsbf
MAC_address_1	8	uimsbf
if (LLC_SNAP_flag == “1”) {		
LLC_SNAP()		
} else {		
for (j=0; j<N; j++) {		
IPv4_packet ( )		
}		
}		
if(section_number == last_section_number) {		
for(j=0; j<N; j++) {		
stuffing_byte	8	bslbf
}		
}		
if (section_syntax_indicator ==“0”) {		
checksum	32	uimsbf
} else {		
CRC_32	32	rpchof
}		
}		

table_id – This field identifies the DSM-CC section type to which the section belongs. It is set to "0x3E" in the case of DSM-CC sections containing private data.

section_syntax_indicator – This is a 1-bit flag. When set to "1", it indicates the presence of the CRC_32 field. When set to "0", it indicates the presence of the checksum field.

private_indicator – This is a 1-bit flag. It is set to the complement value of section_syntax_indicator flag.

reserved – This 2-bit field is set to "11".

section_length – This field specifies the number of remaining bytes of the section, immediately following the section_length field up to the end of the section including the checksum field or CRC_32 field.

MAC_address – This 48-bit field contains the MAC address of the destination. The MAC address is fragmented in 6 fields of 8-bits, labelled MAC_address_1 to MAC_address_6.

payload_scrambling_control – This field defines the scrambling mode of the payload. This includes the payload that starts after the MAC_address_1 byte and excludes the checksum or CRC_32 field.

address_scrambling_control – This field defines the scrambling mode of the MAC address.

LLC_SNAP_flag – This a 1-bit flag. If this flag is set to "1", the payload carries an LLC/SNAP encapsulated datagram following the MAC_address_1 field. The LLC/SNAP structure indicates the type of the packet conveyed. If this flag is set to "0", the section contains an IPv4 packet without LLC/SNAP encapsulation.

current_next_indicator – This is a 1-bit flag. If the value of the table_id field has a value in the range of 0x3A to 0x3C, this bit is set to "1". Otherwise, the value and use of this field are defined by the user.

section_number – If the datagram is carried in multiple sections, this field indicates the position of the section within the fragmentation process. Otherwise it is set to "0".

last_section_number – This field indicates the number of the last section that is used to carry the datagram, i.e. the number of the last section of the fragmentation process.

LLC_SNAP() – This structure contains the datagram according to the ISO/IEC 8802-2 Logical Link Control (LLC) [11] and ISO/IEC 8802-1 SubNetwork Attachment Point (SNAP) Standards [12].

IPv4_packet ( ) – This indicates an IPv4 packet, which has an IPv4 header defined in RFC 791 [9].

stuffing_byte – This is an optional 8-bit field whose value is not specified.

checksum – A 32-bit checksum calculated over the entire DSMCC_addressable_section. It is calculated by treating the DSMCC_addressable_section as a sequence of 32-bit integers and performing one's complement addition (an Exclusive-Or operation) over all the integers, with the most significant byte first, then taking the one's complement of the result.

CRC_32 – This field complies with ITU-T Recommendation H.222.0.

3 IP header compression

Each IP packet generally has at least 20 bytes of an IPv4 header or 40 bytes of an IPv6 header. Based on these headers, routers in telecommunication networks need to decide which way each packet is to be transferred. Hence, these headers are very important in telecommunication networks.

On the other hand, they are not necessary on broadcasting channels, since all packets in broadcasting channels are just transferred to receivers. Transfer throughput can be increased if this unused header information is compressed.

A header-compressed packet can be carried in MPEG-2 TS packets using ULE or MPE. The following two schemes are available for compressing IP header information. It is necessary to identify which header compression scheme is used.

3.1 Header compression for broadcasting [3]

This header compression technique specified in § 4 of Recommendation ITU-R BT.1869 replaces IP and UDP headers with 3 or 5 bytes of compressed header for most packets. When content is delivered on IP packets, most fields in these headers are constant during connection. Once an uncompressed header is transferred, these fields with the same values in the following packets may not necessarily be transferred. Based on this principle, IP and UDP headers with all of the information are transferred at long intervals, and the compressed headers are transferred for almost all packets.

The compressed headers are restored at a receiver by filling them with the header of a preceding packet that has all the header information.

3.2 Robust Header Compression U-mode [4]

This is a highly robust and efficient header compression technique for RTP/UDP/IP, UDP/IP, and ESP/IP headers. This has been developed because existing header compression techniques do not work well when used over links with significant error rates and long round-trip times.

To achieve the robustness, three modes of operation are defined and used depending on the situation: Unidirectional mode (U-mode), Bidirectional Optimistic mode (O-mode), and Bidirectional Reliable mode (R-mode). Though this header compression technique is usually used over bidirectional channels, it can be used over unidirectional channels such as broadcasting if operated in U-mode.