INTERNATIONAL TELECOMMUNICATION UNION

ITU-T Q.1731

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

(06/2000)

SERIES Q: SWITCHING AND SIGNALLING

Signalling requirements and protocols for IMT-2000

Radio-technology independent requirements for IMT-2000 layer 2 radio interface

ITU-T Recommendation Q.1731

(Formerly CCITT Recommendation)

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ITU-T RECOMMENDATION Q.1731

RADIO-TECHNOLOGY INDEPENDENT REQUIREMENTS FOR IMT-2000 LAYER 2 RADIO INTERFACE

Summary

This Recommendation defines requirements for common services, functions and primitives for the radio-technology independent parts of the Layer 2 of the IMT-2000 radio interface, to ensure maximum commonality between IMT-2000 family members.

Source

ITU-T Recommendation Q.1731 was prepared by ITU-T Study Group 11 (1997-2000) and was approved under the WTSC Resolution No. 1 procedure on 15 June 2000.

Keywords

ACK, acknowledgement, aggregation, ARQ, assured mode, control plane, data link layer, fragmentation, function, IMT-2000, L2, LAC, Layer 2, layer, link access control, LLC, logical link control, mapping, NAK, octet stream, PDU, piggybacking, primitive, protocol instance, QoS, reassembly, SAP, SDU, segmentation, service, sublayer, transparent mode, unassured mode, user plane.

FOREWORD

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In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

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Recommendation Q.1731

RADIO-TECHNOLOGY INDEPENDENT REQUIREMENTS FOR IMT-2000 LAYER 2 RADIO INTERFACE

(Geneva, 2000)

1 Scope

The scope of this Recommendation is the definition of common services, functions and primitives for the radio-technology independent parts of the Layer 2 of the IMT-2000 radio interface, to ensure maximum commonality between IMT-2000 family members, consistent with ITU-T Recommendation Q.1711 [1].

The exact division of functionality between various sublayers of Layer 2 (sometimes referred to as LAC and MAC), as well as the exact placement of functionality of the layers and the sublayers in physical components of the radio access networks is considered to be IMT-2000 family member and/or implementation dependent, and is, thus, not addressed in this Recommendation.

Specifically, this Recommendation is concerned with:

1) Defining specifications and requirements for Layer 2 in terms of:
   - services offered by Layer 2 to the upper layers and Layer Management;
   - functions performed by Layer 2 to deliver those services.
2) Defining interfaces between Layer 2 and the adjacent layers, consisting of:
   - service access points (SAPs) where the identified services are offered;
   - primitives and their associated parameters.
3) Identifying the functionality in the Control Plane and the User Plane, as well as the interactions with Layer Management.

All the requirements are subject to market needs and may be met in phases.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; all users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published.

[1] ITU-T Recommendation Q.1711 (1999), *Network functional model for IMT-2000*.

3 Definitions

This Recommendation defines the following terms:

3.1 automatic repeat request (ARQ): Technique for providing reliable delivery of signals between communicating stations, involving autonomous retransmissions of the signals and transmission of acknowledgments until implicit or explicit confirmation of delivery is received.

3.2 function: An operational modality employed in the offering of a service.

3.3 information stream: The totality of data generated and transported, in time, and associated with a specific logical communication session.

3.4 layer 1: Layer 1 (Physical Layer) provides for the transmission and reception of radio signals between the radio access network and the mobile terminal.

3.5 layer 2: Layer 2 (Data Link Layer) provides for the correct transport and delivery of signalling messages and user data generated by Layer 3 (see below). In some implementations, Layer 2 may be seen as divided into an upper Link Access Control (LAC) sublayer and a lower Medium Access Control (MAC) sublayer. Layer 2 makes use of the services provided by Layer 1.

3.6 layer 3: Layer 3 originates and terminates signalling messages and user data according to the semantics and timing of the communication protocol between the radio access network and the mobile terminal. Layer 3 makes use of the services provided by Layer 2.

3.7 layering: A method of organization for communication protocols in which the sent or received information is transferred in pipeline fashion, within each station, in well-defined, encapsulated data units between coordinated processing entities ("layers"). A layer is defined in terms of its communication protocol to the peer layer in the other station and the services it offers to the next higher layer in its own station.

3.8 logical channel: A communication path between stations, described in terms of the intended use of, and access to the transferred data, and direction of transfer. A logical channel can be "mapped" to/from one or more physical channels.

3.9 mapping: In this context, technique for forming associations between logical and physical channels.

3.10 message: Signalling data unit being transferred between the radio access network (RAN) and the mobile terminal (MT).

3.11 octet stream: An information stream where data is organized in semantically meaningful fixed-size data units (octets) which are generated in a certain order and possibly, at a given rate. The octets can be assembled in blocks prior to transmission and have to be delivered in the same order and possibly, at the same rate, upon reception.

3.12 physical channel: A communication path between stations, described in terms of the RF characteristics such as coding, power control policies, etc.

3.13 piggybacking: ARQ efficiency technique, where information related to the acknowledgment of a prior transmitted PDU is carried together with a data PDU sent in the opposite direction, thus saving the transmission of a separate PDU containing only the acknowledgement information.

3.14 primitive: An atomic, well-defined method of transferring data and control information between two adjacent layers and sublayers. Conventionally represented as a function invocation with the data and/or control information as parameters.

3.15 protocol data unit: Encapsulated data being sent/received by a layer from the peer layer on the other station.

3.16 protocol instance: Set of state variables, fully describing the status of a communication session at any moment in time, and associated with the transmission/reception of a specific information stream. Multiple information stream may use the same protocol, but each will receive its own "instance".

3.17 protocol stack: Conceptual model of the layered architecture for communication protocols (see Layering) in which layers within a station are represented in the order of their numeric designation and requiring that transferred data be processed sequentially by each layer, in the order of their representation. Graphically, the "stack" is drawn vertically, with the layer having the lowest numeric designation at the base.

3.18 **service**: A semantically meaningful, consistently performed, well-defined functionality unit, offered by an entity at the interface with another entity, to be performed on data units exchanged between the entities.

3.19 **service data unit**: Data being transferred to/from a layer from/to the layer immediately "above" it, in the protocol stack. Unless stated otherwise, in this Recommendation, SDU refers to the Layer 3 service data unit being transferred to/from Layer 2.

3.20 **service access point (SAP)**: Conceptual place at the interface between two adjacent layers where services are provided to the upper layer and data and protocol information is exchanged between layers.

3.21 **sublayer**: A protocol layer of finer granularity, within another protocol layer or sublayer. Layer 2 may be seen as having a LAC sublayer and a MAC sublayer. In turn, those sublayers may have several sublayers of their own.

3.22 **upper layers**: General reference to Layer 3 and the layers above it.

4 Abbreviations

This Recommendation uses the following abbreviations:

ACK	(Positive) Acknowledgement
ARQ	Automatic Repeat Request
FCS	Frame Check Sequence
LAC	Link Access Control
L1	Layer 1
L2	Layer 2
L3	Layer 3
MAC	Medium Access Control
MT	Mobile terminal
NAK	Negative Acknowledgement
PDU	Protocol Data Unit
QoS	Quality of Service
RAN	Radio Access Network
SAP	Service Access Point
SDU	Service Data Unit

5 Services

5.1 General requirements

1) *Efficiency*

   In providing services to Layer 3 and Layer Management, Layer 2 should make efficient use of resources, especially radio resources.

2) *Support for multiple protocol instances*

   Layer 2 should be able to support multiple information streams, independent of each other, by assigning a different instance of the Layer 2 protocol engine to each stream.

3) *Prioritization among different information streams*

Layer 2 should be able to prioritize the order of transmission among SDUs from different information streams. Priority may be based on the type of the traffic in the information stream, e.g. voice, data, signalling, etc.

5.2 Control Plane Services

5.2.1 [Reserved]

5.2.2 Delivery Modes

Layer 2 shall provide the following modes of delivery of C-plane SDUs on a per SDU basis:

- Assured Delivery.
- Unassured Delivery.

The transmitting Layer 3 entity indicates to Layer 2 the delivery mode to be used for each SDU.

5.2.2.1 Assured Delivery Mode

When providing Assured Delivery service, Layer 2 shall satisfy the following requirements:

1) *Guaranteed delivery*

Layer 2 shall deliver every SDU submitted to it by Layer 3 for delivery to its peer. If Layer 2 is unable to deliver an SDU to the peer, it shall notify the transmitting Layer 3 entity and/or Layer Management of the failure, if so requested.

2) *Error-free delivery*

Layer 2 shall deliver to the receiving Layer 3 entity only those SDUs that are free of transmission errors.

3) *Unique delivery*

Layer 2 shall deliver each SDU to the receiving Layer 3 entity only once.

When providing Assured Delivery service, Layer 2 should deliver SDUs according to the indication from the transmitting Layer 3, either In-sequence or Immediate, as follows:

4) *In-sequence delivery*

Layer 2 shall deliver SDUs to the receiving Layer 3 entity in the same order as the transmitting Layer 3 entity submits them to Layer 2.

5) *Immediate delivery*

Layer 2 shall deliver an SDU to the Layer 3 receiving entity as soon as it arrives at the receiver. Thus, the order of delivery of SDUs to the receiving Layer 3 entity may be different from the order in which they were submitted by the transmitting Layer 3 entity, e.g. due to retransmissions.

When providing Assured Delivery service, Layer 2 should also offer the following services:

6) *Priority transmission*

Layer 2 should transmit SDUs with higher priority (as specified by the transmitting Layer 3 entity) ahead of other SDUs.

7) *Latency reduction*

If requested by the transmitting Layer 3 entity, Layer 2 should be able to alter the transmission techniques to reduce the transfer delay of an SDU. The employed techniques may include, for example: repeated transmissions, indications to Layer 1 to transmit with higher power, or using different coding techniques, etc.

8) *Confirmation of delivery*

Layer 2 should provide a confirmation to the transmitting Layer 3 entity of the delivery of an SDU to the receiving Layer 3 entity, if requested by the transmitting Layer 3 entity.

5.2.2.2 Unassured Delivery Mode

When providing Unassured Delivery service, Layer 2 shall satisfy the following requirements:

1) *Error-free delivery*

Layer 2 shall deliver to the receiving Layer 3 entity only those SDUs that are free of transmission errors.

2) *Immediate delivery*

Layer 2 shall deliver an SDU to the Layer 3 receiving entity as soon as it arrives at the receiver.

When providing Unassured Delivery and requested by Layer 3, Layer 2 shall provide unique delivery as follows:

3) *Unique delivery*

Layer 2 shall deliver each SDU to the receiving Layer 3 entity only once, if requested by the transmitting Layer 3 entity. Unique delivery may not be required by the transmitting Layer 3 entity for certain SDUs, e.g. SDUs carrying broadcast messages.

When providing Unassured Delivery service, Layer 2 should offer the following services:

4) *Priority transmission*

Layer 2 should transmit SDUs with higher priority (as specified by the transmitting Layer 3 entity) ahead of other SDUs.

5) *Enhanced probability of delivery*

When requested by the transmitting Layer 3 entity, Layer 2 should be able to alter the transmission techniques to increase the probability of successful delivery of an SDU. The employed techniques may include, for example: repeated transmissions, indications to Layer 1 to transmit with higher power, etc.

5.3 User Plane Services

Some of the requirements stated in this subclause apply if the delivery of user traffic with given QoS parameters is provided by Layer 2. It is possible, that in some systems, QoS delivery is enforced at other Layers.

5.3.1 General requirements

1) *Support of QoS*

When PDUs from multiple information streams are available for transmission and/or delivery, Layer 2 should be able to configure the maximum number of ARQ retransmissions, if applicable, and select the order in which individual PDUs are transmitted and/or delivered, based on the QoS characteristics (e.g. bandwidth constraints, delay constraints, etc.) of the individual information streams.

2) *Octet stream transport*

Layer 2 may provide the capability to accumulate octets or groups of octets submitted by Layer 3 for transmission, into Layer 2 PDUs, and deliver those octets or groups of octets to the receiving Layer 3 entity in the same format, order and rate (if required) that they were submitted for transmission.

5.3.2 Delivery Modes

Layer 2 shall provide the following modes of delivery of U-plane SDUs on a per SDU basis:

- Assured Delivery (e.g. file transfer).
- Time Constrained Unassured Delivery (e.g. video).
- Time Constrained Adaptive Delivery (e.g. browsing, video games).
- Transparent Delivery (e.g. speech).

The transmitting Layer 3 entity indicates to Layer 2 the delivery mode to be used for each SDU.

5.3.2.1 Assured Delivery

When providing Assured Delivery, Layer 2 shall satisfy the following requirements:

1) *Guaranteed delivery*

   Layer 2 shall deliver every SDU submitted to it by Layer 3 for delivery to its peer. If Layer 2 is unable to deliver an SDU to the peer, it shall notify the transmitting Layer 3 entity and/or Layer Management of the failure, if so requested.

2) *Error-free delivery*

   Layer 2 shall deliver to the receiving Layer 3 entity only those SDUs that are free of transmission errors.

3) *Unique delivery*

   Layer 2 shall deliver each SDU to the receiving Layer 3 entity only once. Unique delivery may not be necessary when immediate delivery is used.

When providing Assured Delivery, Layer 2 should deliver SDUs according to the indication from the transmitting Layer 3, either In-sequence or Immediate, as follows:

4) *In-sequence delivery*

   Layer 2 shall deliver SDUs to the receiving Layer 3 entity in the same order as the transmitting Layer 3 entity submits them to Layer 2.

5) *Immediate delivery*

   Layer 2 shall deliver an SDU to the Layer 3 receiving entity as soon as it arrives at the receiver. Thus, the order of delivery of SDUs to the receiving Layer 3 entity may be different from the order in which they were submitted by the transmitting Layer 3 entity, e.g. due to retransmissions.

When providing Assured Delivery, Layer 2 may offer the following services:

6) *Priority transmission*

   Layer 2 should transmit SDUs with higher priority (as specified by the transmitting Layer 3 entity) ahead of other SDUs.

7) *Latency reduction*

   When requested by the transmitting Layer 3 entity, Layer 2 should be able to alter the transmission techniques to reduce the transfer delay of an SDU. The employed techniques may include, for example: repeated transmissions, indications to Layer 1 to transmit with higher power, etc.

8) *Confirmation of delivery*

   When requested by the transmitting Layer 3 entity, Layer 2 should provide a confirmation to the transmitting Layer 3 entity of the delivery of an SDU to the receiving Layer 3 entity.

5.3.2.2 Time Constrained Unassured Delivery

When providing Time Constrained Unassured Delivery, Layer 2 shall satisfy the following requirements:

1) *Error-free delivery*

   Layer 2 shall deliver to the receiving Layer 3 entity only those SDUs that are free of transmission errors.

2) *Corrupted data delivery*

   This services provides for the delivery of all received SDUs. Layer 2 shall be able to distinguish between PDUs affected by transmission errors and error-free PDUs. Layer 2 may be able to further assess the degree of corruption of received PDUs with finer granularity. If Layer 3 defines criteria for data delivery based on degrees of corruption assessable by Layer 2, Layer 2 shall deliver to Layer 3 only those SDUs transported via PDUs that meet the data delivery criteria established by Layer 3.

3) *Time constrained delivery*

   Layer 2 shall be able to ensure that, if an SDU is being delivered, the time interval between the moment when an SDU is submitted for transmission by Layer 3 and the moment when the SDU is delivered to the receiving peer Layer 3 entity is constrained by upper and lower bounds established by Layer 3 on a per information stream basis. If the timing requirements cannot be met, the SDU may be discarded before transmission or during the time interval between reception and delivery.

4) *Delivery in transmission order*

   Unless instructed otherwise, Layer 2 shall not deliver an SDU out-of-sequence with regard to other SDUs, where the sequence is based on the order in which the SDUs were transmitted.

When providing Time Constrained Unassured Delivery and requested by Layer 3, Layer 2 shall provide unique delivery as follows:

5) *Unique delivery*

   Layer 2 shall deliver each SDU to the receiving Layer 3 entity only once.

When providing Time Constrained Unassured Delivery, Layer 2 may offer the following services:

6) *Enhanced probability of delivery*

   When requested by the transmitting Layer 3 entity, Layer 2 should be able to alter the transmission techniques to increase the probability of successful delivery of an SDU. The employed techniques may include, for example: repeated transmissions, indications to Layer 1 to transmit with higher power, etc.

5.3.2.3 Time Constrained Adaptive Delivery

When providing Time Constrained Adaptive Delivery, Layer 2 shall satisfy the following requirements:

1) *Delivery with minimum bandwidth*

   Layer 2 shall attempt to deliver every SDU submitted to it by Layer 3 for delivery to its peer, without lowering the overall throughput under the guaranteed bandwidth. If Layer 2 is unable to deliver an SDU to the peer, it shall notify the transmitting Layer 3 entity and/or Layer Management of the failure, if so requested.

2) *Error-free delivery*

Layer 2 shall deliver to the receiving Layer 3 entity only those SDUs that are free of transmission errors.

3) *Unique delivery*

Layer 2 shall deliver each SDU to the receiving Layer 3 entity only once.

4) *Time constrained delivery*

Layer 2 shall be able to ensure that the time interval between the moment when an SDU is submitted for transmission by Layer 3 and the moment when the SDU is delivered to the receiving peer Layer 3 entity is constrained by upper and lower bounds established by Layer 3 on a per information stream basis. If the timing requirements cannot be met, Layer 2 shall notify Layer 3 and/or Layer Management.

When providing Time Constrained Adaptive Delivery, Layer 2 should deliver SDUs according to the indication from the transmitting Layer 3, either In-sequence or Immediate, as follows:

5) *In-sequence delivery*

Layer 2 shall deliver SDUs to the receiving Layer 3 entity in the same order as the transmitting Layer 3 entity submits them to Layer 2.

6) *Immediate delivery*

Layer 2 shall deliver an SDU to the Layer 3 receiving entity as soon as it arrives at the receiver. Thus, the order of delivery of SDUs to the receiving Layer 3 entity may be different from the order in which they were submitted by the transmitting Layer 3 entity, e.g. due to retransmissions.

When providing Time Constrained Adaptive Delivery, Layer 2 may offer the following services:

7) *Priority transmission*

Layer 2 should transmit SDUs with higher priority (as specified by the transmitting Layer 3 entity) ahead of other SDUs.

8) *Enhanced probability of delivery/time constraint enforcement*

When requested by the transmitting Layer 3 entity and/or to enforce the guaranteed throughput and time constraints, Layer 2 should be able to alter the transmission techniques to match the transfer delay of an SDU to the set time limits and to provide the set throughput. The employed techniques may include, for example: repeated transmissions, indications to Layer 1 to transmit with higher power, etc.

9) *Confirmation of delivery*

When requested by the transmitting Layer 3 entity, Layer 2 should provide a confirmation to the transmitting Layer 3 entity of the delivery of an SDU to the receiving Layer 3 entity.

5.3.2.4 Transparent Delivery

When providing Transparent Delivery, Layer 2 shall transfer higher layer PDUs without adding any protocol overhead. Some functionality (e.g. segmentation and reassembly) may still be provided.

6 Functions

The following functions may be used for both the Control Plane and the User Plane, except where noted otherwise.

Layer 2 performs the following functions, to deliver services to Layer 3 and Layer Management:

1) *Sequence Integrity Delivery*

   This function ensures that the order of delivery of SDUs to the receiving Layer 3 entity is the same as the order in which SDUs were submitted for transfer by the transmitting Layer 3 entity.

2) *Out-of-Sequence Delivery*

   This receiving entity function performs the delivery of SDUs to the receiving Layer 3 entity without regard to the order in which the SDUs were submitted for transfer by the transmitting Layer 3 entity.

3) *Error Correction through Selective Retransmissions*

   This function corrects sequence errors by retransmitting missing PDUs.

4) *Event Reporting*

   This function identifies and reports the occurrences of conditions for which Layer 3 and/or Layer Management registered interest. Such events can be retransmissions of PDUs, discarding PDUs due to transmission errors, etc.

5) *Keep Alive*

   This function takes the necessary actions, if any, to check that once a Layer 2 connection is established, the communicating peer entities remain in a connected state in case of prolonged absence of data transfer.

6) *Connection Control*

   This function performs the establishment, release, and re-synchronization of a Layer 2 link. It may also allow the transmission of variable length user-to-user information without guarantee of delivery.

7) *FCS Error Detection*

   This receiving entity function provides for the detection of corrupt Layer 2 PDUs through computation and checking of the FCS (Frame Check Sequence). The objective is to ensure that only error-free PDUs are delivered to Layer 3.

8) *Error Handling*

   This receiving entity function provides for the handling of the corrupt Layer 2 PDUs. The objective is to ensure that only error-free PDUs are treated by the receiver entity. Corrupt Layer 2 PDUs are corrected, if possible, otherwise they are discarded.

9) *SDU Segmentation and Reassembly*

   This function performs the segmenting of SDUs submitted for transmission into smaller data units that can be transported via PDUs and the assembling of the SDUs at the receiving entity from the smaller data units transferred via the received PDUs.

10) *Fragmentation and Aggregation*

    This function performs a type of segmentation and reassembly in which the size of each segment (here called fragment, for differentiation) is determined immediately prior to transmission in such a way that it can be best fitted into lower layer transport blocks or frames, for efficiency.

11) *Acknowledged Data Transfer*

This function provides for the transmitter entity to become aware of the correct reception of transmitted PDUs. PDUs can be acknowledged explicitly (positive acknowledgment, ACK) or implicitly (lack of negative acknowledgment, NAK), individually or in a group. ACKs and NAKs can be piggybacked on PDUs transferring data.

12) *Unacknowledged Data Transfer*

This function provides for the transfer of Layer 2 PDUs without acknowledgments.

13) *Override of default handling of SDUs*

This transmitting entity function allows individual Layer 2 SDUs to be treated differently than other SDUs in the same information stream, in order to achieve a specific goal: e.g. increase the probability of delivery, decrease latency of the transfer, increase capacity, minimize interference, etc. The exact mechanism is IMT-2000 family member and/or implementation dependent. Examples of use are:

- a Layer 2 SDU may be transmitted several times (quick repeat) to increase the likelihood of delivery;
- a Layer 2 SDU may be processed differently by the physical layer, such as being transmitted at a higher power than other SDUs.

14) *Transmission Priority*

This transmitting entity function allows an SDU to be transmitted ahead of other (lower priority) SDUs.

15) *Duplicate Detection and Elimination*

This receiving entity function detects PDUs received more than once and ensures that each SDU is delivered only once to Layer 3.

16) *Guaranteed Integrity of Reassembled SDUs*

This function guarantees the integrity of reassembled PDUs. This may be done by having a frame check sequence over the entire SDU, by fully protecting the integrity of the segments or by other means.

17) *Distribution function*

This transmission entity function selects the logical channel to be used for the transfer of an SDU, based on the availability and characteristics of logical channels.

18) *Online Tuning*

This function allows changes in the operational parameters (e.g. number of retransmissions, values of timers, etc.) of a protocol instance without having to interrupt or resynchronize the protocol engine.

19) *Encryption and Decryption*

This function performs the encryption of the SDU submitted by the transmitting Layer 3 entity prior to the transfer and the decryption of the SDU prior to its delivery to the receiving Layer 3 entity.

NOTE 1 – Encryption and decryption may take into consideration special features of the radio-technology.

20) *SDU Concatenation and PDU Padding*

This function groups together different SDUs or different segments of SDU into a PDU large enough to accommodate them. If an SDU (or a segment of an SDU) does not completely fill a PDU and there is no more data available for transfer, the remainder of the

PDU is filled with padding bits. On reception, the SDUs (or the segments) are separated from the PDU and delivered individually; the padding bits are discarded.

21) *PDU Prioritization between Different Information Streams*

This function ensures scheduling of PDUs from different information streams for transmission based upon their relative priority.

22) *Flow Control*

This function allows the receiver to control the rate at which the peer transmitter may send data. Flow control may be implicitly provided by the use of positive acknowledgment retransmission schemes for error correction.

23) *Transmission at Committed Bandwidth (User Plane only)*

This transmitting entity function guarantees that all submitted SDUs will be transmitted as long as the submission rate is limited to a specific (committed) value. If this is not possible, Layer 3 and/or layer management will be notified.

24) *Transmission within committed time constraint (User Plane only)*

This transmitting entity function guarantees that all submitted SDUs will be transmitted within a specified (committed) time constraint after submission. If this is not possible, the SDUs may be discarded and layer management will be notified.

NOTE 2 – Time sensitive PDUs may need to be queued due to heavy traffic of other higher priority data streams; in such cases, "stale" information should be discarded.

25) *Transmission at committed bandwidth with committed time constraint (User Plane only)*

This transmitting entity function guarantees that all submitted SDUs will be transmitted within a specified (committed) time constraint interval after submission, as long as the submission rate is limited to a specific (committed) value. If this is not possible, the SDU may be discarded and layer management will be notified.

26) *PDU Prioritization within an Information Stream (User Plane only)*

This transmission entity function prioritizes the order of transmission of PDUs according to the following criteria:

i) Supervisory PDUs (e.g. acknowledgments, polling, etc.);

ii) PDUs retransmitted due to lack of acknowledgment of their reception;

iii) PDUs transmitted for the first time; and

iv) PDUs retransmitted to increase probability of delivery in unassured transfers.

NOTE 3 – These could be further divided into priority sub-classes. Other priority schemes and criteria may also be used.

27) *Idle Frames (User Plane only)*

This function is used to send protocol information in the absence of the traffic so as to indicate that the connection is still up and to maintain the protocol engines synchronized. For example, on a NAK-based protocol, the idle frames may be used to communicate the last transmitted frame sequence number to the peer entity. On physical channels with discontinuous transmission, idle frames may be sent intermittently.

7 Primitives

These primitives are abstract and their concrete representations may vary from implementation to implementation. Therefore they shall not be considered to be a testable entity.

7.1 Control Plane Primitives

7.1.1 Primitives at the Upper Boundary

7.1.1.1 Primitives at the Assured Delivery Mode SAP

These primitives are summarized in Table 7.1.1.1-1, and are defined as follows:

a) *L2-AM-DATA.request, .indication, .confirm*

This primitive is used by a Layer 3 entity to convey a Layer 3 PDU to its peer entity. When requested by the transmitting Layer 3 entity, the L2-AM-DATA.confirm primitive provides a confirmation to the transmitting Layer 3 entity of the delivery of a Layer 3 PDU to the receiving Layer 3 entity.

b) *L2-IN-SERVICE.indication*

This primitive indicates that the Layer 2 link is able to exchange data with the peer entity (Note 1).

c) *L2-OUT-OF-SERVICE.indication*

This primitive indicates that the Layer 2 link is unable to exchange data with the peer entity (Note 1).

d) *L2-ESTABLISH.request, .indication, .response, .confirm*

This primitive performs the establishment of a Layer 2 connection (Note 2).

e) *L2-RELEASE.request, .indication, .confirm*

This primitive terminates a Layer 2 connection (Note 2).

f) *L2-RESET.request, .indication, .confirm*

This primitive synchronizes the receiver and transmitter participating in a Layer 2 connection (Notes 2 and 3).

NOTE 1 – These primitives are used to convey the availability of permanent Layer 2 connections.

NOTE 2 – These primitives are used to establish and release on-demand Layer 2 connections.

NOTE 3 – These primitives are for further study.

Table 7.1.1.1-1/Q.1731 – Primitives and parameters of the Assured Delivery Mode Service Access Point

Primitive Generic Name	Type			
	Request	Indication	Response	Confirm
L2-AM-DATA	MU, MUI, IMD, PRI, LAR	MU	–	MUI
L2-IN-SERVICE	–	(Note)	–	–
L2-OUT-OF-SERVICE	–	(Note)	–	–
L2-ESTABLISH	L2NI	L2NI	L2NI	L2NI
L2-RELEASE	(Note)	Cause	–	(Note)
L2-RESET	(Note)	(Note)	–	(Note)
– This primitive is not defined. NOTE – This primitive has no parameters.				

Parameters

The following parameters are associated with the Assured Delivery Mode primitives:

a) *Message Unit (MU)*

The Message Unit parameter contains a Layer 3 PDU. The Message Unit can be of variable length. The length is an integral number of octets.

b) *Message Unit Identifier (MUI)*

The Message Unit Identifier parameter, if present, requests a confirmation of the delivery of the Layer 3 PDU. Its value is assigned by Layer 3 and used to notify Layer 3 of the successful delivery of the associated Layer 3 PDU by Layer 2. The value of the Message Unit Identifier is of relevance only to Layer 3; it is neither interpreted nor modified by Layer 2.

c) *Immediate Delivery (IMD)*

If the IMD parameter is set to "TRUE", the transmitted PDU is marked in such way that the receiving Layer 2 protocol entity performs immediate delivery; otherwise, the delivery is in-sequence.

d) *Priority (PRI)*

The Priority parameter indicates to the transmitting Layer 2 protocol to transfer the message unit ahead of other message units of lower priority; otherwise, the order of transmission is the same as the order in which the Layer 3 submits message units to Layer 2.

e) *Latency Reduction (LAR)*

The Latency Reduction parameter may be set to a value indicating to the transmitting Layer 2 protocol entity to override the default transmission parameters for the message unit; otherwise, the default transmission parameters apply.

f) *Cause*

The Cause parameter is for further study.

g) *Layer 2 Network Information (L2NI)*

The optional Layer 2 Network Information parameter conveys negotiation parameters such as timer values and window size.

7.1.1.2 Primitives at the Unassured Delivery Mode SAP

These primitives are summarized in Table 7.1.1.2-1, and are defined as follows:

a) *L2-UM-DATA.request, .indication*

This primitive is used by a Layer 3 entity to convey a Layer 3 PDU to its peer entity. The delivery is not guaranteed.

Table 7.1.1.2-1/Q.1731 – Primitives and parameters of the Unassured Delivery Mode Service Access Point

Primitive Generic Name	Type			
	Request	Indication	Response	Confirm
L2-UM-DATA	MU, UNIQ, PRI, EPD	MU	–	–
– This primitive is not defined.				

Parameters

The following parameters are associated with the Unassured Delivery Mode primitives:

a) *Message Unit (MU)*

The Message Unit parameter contains a Layer 3 PDU. The Message Unit can be of variable length. The length is an integral number of octets.

b) *Unique Delivery (UNIQ)*

If the UNIQ parameter is set to "TRUE", the transmitted PDU carries information that the receiving Layer 2 protocol entity can use to perform duplicate detection and elimination.

c) *Priority (PRI)*

The Priority parameter indicates to the transmitting Layer 2 protocol to transfer the message unit ahead of other message units of lower priority; otherwise, the order of transmission is the same as the order in which the Layer 3 submits message units to Layer 2.

d) *Enhanced Probability of Delivery (EPD)*

The Latency Reduction parameter may be set to a value indicating to the transmitting Layer 2 protocol entity to override the default transmission parameters for the message unit; otherwise, the default transmission parameters apply.

7.1.2 Primitives at the Lower Boundary

7.1.2.1 Non-fragmented data delivery primitives

These primitives are summarized in Table 7.1.2.1-1, and are defined as follows:

a) *L2-NF-DATA.request, .indication, .confirm*

This primitive is used to submit for transmission a non-fragmented PDU. The L2-NF-DATA.confirm primitive provides a confirmation immediately upon the actual transmission of the PDU. The L2-NF-DATA.indication transfers a received PDU.

Table 7.1.2.1-1/Q.1731 – Primitives and parameters for the non-fragmented data delivery

Primitive Generic Name	Type			
	Request	Indication	Response	Confirm
L2-NF-DATA	MU, MUI, L1IND	MU	–	MUI
– This primitive is not defined.				

Parameters

The following parameters are associated with the Non-fragmented Data Delivery primitives:

a) *Message Unit (MU)*

The Message Unit parameter contains a PDU. The Message Unit can be of variable length. The length is an integral number of octets.

b) *Message Unit Identifier (MUI)*

The Message Unit Identifier parameter, if present, requests a confirmation immediately, upon the transmission of the PDU.

c) *Layer 1 Indication*

The L1IND parameter is used by Layer 1 to override the default transmission parameters for the message unit.

7.1.2.2 Fragmented data delivery primitives

These primitives are summarized in Table 7.1.2.2-1, and are defined as follows:

a) *L2-F-DATA-AVAILABLE.request, .indication*

This primitive is used by the upper layer to request the transmission of data of specified size and by the lower layer to announce the instantaneous available transport capacity (fragment size).

b) *L2-F-DATA-XFER.request, .indication*

This primitive is used to transfer a data fragment.

Table 7.1.2.2-1/Q.1731 – Primitives and parameters for the Fragmented Data Delivery

Primitive Generic Name	Type			
	Request	Indication	Response	Confirm
L2-F-DATA-AVAILABLE	STRID, TOT-SIZE	STRID, SIZE	–	–
L2-F-DATA-XFER	STRID, FRAGMENT, SIZE	STRID, FRAGMENT, SIZE	–	–
– This primitive is not defined.				

Parameters

The following parameters are associated with the Fragmented Data Delivery primitives:

a) *Stream Identifier (STRID)*

Parameter which uniquely identifies the logical connection ("stream") set for the transport of the PDU. In general, multiple streams may be active at the same time.

b) *Fragment Size (SIZE)*

Of data to transfer.

c) *Total PDU Size (TOT-SIZE)*

The size of the PDU prior to segmentation/fragmentation or after reassembly.

d) *Data Fragment (FRAGMENT)*

Part of the PDU, to be transported in one physical frame. Fragments are the result of splitting the PDU into pieces whose sizes match well the available space in a physical frame.

7.2 User Plane Primitives

7.2.1 Primitives at the Upper Boundary

NOTE 1 – Some of the primitives have QoS parameters (e.g. bandwidth) as arguments, which is necessary if the QoS delivery is functionally placed in or below Layer 2. The QoS delivery can also be placed functionally at other layers (e.g. Layer 3), in which case the QoS parameters may not be necessary. Alternatively, these primitives may be placed at the interface to the Layer Management, rather than to Layer 3.

These primitives are summarized in Table 7.2.1-1, and are defined as follows:

a) *L2-AM-DATA.request, .indication, .confirm*

This primitive is used by a Layer 3 entity to convey a Layer 3 PDU to its peer entity. When requested by the transmitting Layer 3 entity, the L2-AM-DATA.confirm primitive provides a confirmation to the transmitting Layer 3 entity of the delivery of a Layer 3 PDU to the receiving Layer 3 entity.

b) *L2-UM-DATA.request, .indication*

This primitive is used by a Layer 3 entity to convey a Layer 3 PDU to its peer entity. The delivery is not guaranteed.

c) *L2-TM-DATA.request, .indication*

This primitive is used by a Layer 3 entity to convey a Layer 3 PDU to its peer entity. The delivery is transparent.

d) *L2-AVAIL-BW.indication*

This primitive indicates that the Layer 2 link is able to exchange data with the peer entity at the indicated bandwidth. The indicated bandwidth can be 0, indicating inability to exchange data (Note 2).

e) *L2-ESTABLISH.request, .indication, .response, .confirm*

This primitive performs the establishment of a Layer 2 connection, with the specified bandwidth and time delay constraints (Note 3).

f) *L2-RELEASE.request, .indication, .confirm*

This primitive terminates a Layer 2 connection (Note 3).

g) *L2-MODIFY.request, .indication, .response, .confirm*

This primitive performs maintenance of the connection such as the establishment of a new set of bandwidth and time delay constraints for the connection and/or synchronization of the receiver and transmitter participating in a Layer 2 connection (Notes 3 and 4).

NOTE 2 – These primitives are used to convey the availability of permanent Layer 2 connections.

NOTE 3 – These primitives are used to establish and release on-demand Layer 2 connections.

NOTE 4 – These primitives are for further study.

Table 7.2.1-1/Q.1731 – Primitives and parameters at the User Plane Service Access Points

Primitive Generic Name	**Type**			
	Request	**Indication**	**Response**	**Confirm**
L2-AM-DATA	DU, DUI, IMD, PRI, LAR	DU	–	DUI
L2-UM-DATA	DU, UNIQ PRI, EPD	DU	–	–
L2-TM-DATA	DU	DU	–	–
L2-AVAIL-BW	–	BW	–	–
L2-ESTABLISH	L2NI, BW, LTDC, HTDC	L2NI, BW, LTDC, HTDC	L2NI, BW, LTDC, HTDC	L2NI, BW, LTDC, HTDC
L2-RELEASE	(Note)	Cause	–	(Note)
L2-MODIFY	L2NI, RESET, BW, LTDC, HTDC	L2NI, BW, LTDC, HTDC	L2NI, BW, LTDC, HTDC	L2NI, BW, LTDC, HTDC
– This primitive is not defined. NOTE – This primitive has no parameters.				

Parameters

The following parameters are associated with the Assured Delivery Mode primitives:

a) *Data Unit (DU)*

The Data Unit parameter contains a Layer 3 PDU. The Data Unit can be of variable length. The length is usually an integral number of octets.

b) *Data Unit Identifier (DUI)*

The Data Unit Identifier parameter, if present, requests a confirmation of the delivery of the Layer 3 PDU. Its value is assigned by Layer 3 and used to notify Layer 3 of the successful delivery of the associated Layer 3 PDU by Layer 2. The value of the Data Unit Identifier is of relevance only to Layer 3; it is neither interpreted nor modified by Layer 2.

c) *Immediate Delivery (IMD)*

The Immediate Delivery parameter is used to indicate to the transmitter to mark the PDU in such way that the receiving Layer 2 protocol entity becomes aware of whether to perform in-sequence or immediate delivery.

d) *Priority (PRI)*

The Priority parameter indicates to the transmitting Layer 2 protocol to transfer the data unit ahead of other data units of lower priority; otherwise, the order of transmission of the data units is the same as the order in which Layer 3 submits the data units to Layer 2.

e) *Latency Reduction (LAR)*

The Latency Reduction parameter may be set to a value indicating to the transmitting Layer 2 protocol entity to override the default transmission parameters for the data unit; otherwise, the default transmission parameters apply.

f) *Cause*

The Cause parameter is for further study.

g) *Layer 2 Network Information (L2NI)*

The optional Layer 2 Network Information parameter conveys negotiation parameters such as timer values, window size, QoS parameters, etc.

h) *Reset (RESET)*

Disposition to reset the connection.

i) *Bandwidth (BW)*

Requested or committed bandwidth.

j) *Lower Time-Delay Constraint (LTDC)*

Requested or committed lower constraint for the time-delay of the traffic.

k) *Higher Time-Delay Constraint (HTDC)*

Requested or committed higher constraint for the time-delay of the traffic.

l) *Unique Delivery (UNIQ)*

If the UNIQ parameter is set to "TRUE", the transmitted PDU carries information that the receiving Layer 2 protocol entity can use to perform duplicate detection and elimination.

m) *Enhanced Probability of Delivery (EPD)*

The Enhanced Probability of Delivery parameter may be set to a value indicating to the transmitting Layer 2 protocol entity to override the default transmission parameters for the data unit; otherwise, the default transmission parameters apply. In particular, if some data

units have to be dropped because of inability to meet time constraints, the EPD may be used to indicate which data units can be dropped first.

7.2.2 Primitives at the Lower Boundary

7.2.2.1 Non-fragmented data delivery primitives

These primitives are summarized in Table 7.2.2.1-1, and are defined as follows:

a) *L2-NF-DATA.request, .indication, .confirm*

This primitive is used to submit for transmission a non-fragmented PDU. The L2-NF-DATA.confirm primitive provides a confirmation immediately upon the actual transmission of the PDU. The L2-NF-DATA.indication transfers a received PDU.

Table 7.2.2.1-1/Q.1731 – Primitives and parameters for the non-fragmented data delivery

Primitive Generic Name	Type			
	Request	Indication	Response	Confirm
L2-NF-DATA	DU, DUI, L1IND	DU	–	DUI
– This primitive is not defined.				

Parameters

The following parameters are associated with the Non-fragmented Data Delivery primitives:

a) *Data Unit (DU)*

The Data Unit parameter contains a PDU. The Data Unit can be of variable length. The length is an integral number of octets.

b) *Data Unit Identifier (DUI)*

The Data Unit Identifier parameter, if present, requests a confirmation immediately, upon the transmission of the PDU.

c) *Layer 1 Indication*

The L1IND parameter is used to indicate Layer 1 to override the default transmission parameters for the data unit.

7.2.2.2 Fragmented data delivery primitives

These primitives are summarized in Table 7.2.2.2-1, and are defined as follows:

a) *L2-F-DATA-AVAILABLE.request, .indication*

This primitive is used by the upper layer to request the transmission of data of specified size and by the lower layer to announce the instantaneous available transport capacity (fragment size).

b) *L2-F-DATA-XFER.request, .indication*

This primitive is used to transfer a data fragment.

Table 7.2.2.2-1/Q.1731 – Primitives and parameters of the Fragmented Data Delivery

Primitive Generic Name	Type			
	Request	Indication	Response	Confirm
L2-F-DATA-AVAILABLE	STRID, TOT-SIZE	STRID, SIZE	–	–
L2-F-DATA-XFER	STRID, FRAGMENT, SIZE	STRID, FRAGMENT, SIZE	–	–
– This primitive is not defined.				

Parameters

The following parameters are associated with the Fragmented Data Delivery primitives:

a) *Stream Identifier (STRID)*

Parameter which uniquely identifies the logical connection ("stream") set for the transport of the PDU. In general, multiple streams may be active at the same time.

b) *Fragment Size (SIZE)*

Of data to transfer.

c) *Total PDU Size (TOT-SIZE)*

The size of the PDU prior to segmentation/fragmentation or after reassembly.

d) *Data Fragment (FRAGMENT)*

Part of the PDU, to be transported in one physical frame. Fragments are the result of splitting the PDU into pieces whose sizes match well the available space in a physical frame.

8 Interactions with Layer Management

8.1 Services provided to Layer Management

Event Reporting

This service provides reports of the occurrences of conditions for which Layer Management registered interest. Such events can be retransmissions of PDUs, discarding PDUs due to transmission errors, etc.

8.2 Primitives

These primitives are abstract and their concrete representations may vary from implementation to implementation. Therefore they shall not be considered to be a testable entity.

The primitives between Layer Management and Layer 2 are summarized in Table 8.2-1, and are defined as follows:

a) *ML2-ERROR.indication*

This primitive indicates to layer management that an operational error occurred. These error indications include for example: connection establishment failure, recovered transmission errors, exhaustion of transmission credits, etc.

b) *ML2-RELEASE.request, .indication*

This primitive is used by Layer Management to request the release of a Layer 2 connection; in addition, any release of such a connection is indicated to layer management.

c) *ML2-ADJUST.request*

This primitive allows layer management to provide Layer 2 with new operational parameter values. The new values take effect immediately.

Table 8.2-1/Q.1731 – Primitives and parameters between Layer 2 and Layer Management

Primitive Generic Name	Type			
	Request	**Indication**	**Response**	**Confirm**
ML2-ERROR	–	EC	–	–
ML2-RELEASE	(Note)	Cause	–	–
ML2-ADJUST	NP	–	–	–
– This primitive is not defined. NOTE – This primitive has no parameters.				

Parameters

The following parameters are associated with the data-delivery primitives:

a) *Error Code (EC)*

Layer Management recognizes the specific error event from Layer 2.

b) *Cause*

The Cause parameter is for further study.

c) *New Parameters (NP)*

Layer Management provides new operational parameters (e.g. maximum number of retransmissions, timer values, etc.).

9 Logical channels

The upper layers should send and receive signalling and user information on **logical channels**, thus avoiding the need to be sensitive to the radio characteristics of the **physical channels** used at Layer 1. Multiple instances of the same logical channel may be deployed. Traffic on independent logical channels flows in parallel. On the same logical channel, traffic flows one data unit after the other, in a deterministic manner. Since the traffic on each logical channel is ultimately carried via one or more physical channels, associations between logical channels and physical channels are provided, typically at Layer 2 or below. A logical channel may have permanent and exclusive use of a physical channel, or may have temporary and exclusive use of a physical channel, or may share the physical channel with other logical channels (requiring a multiplex function to perform the mapping, possibly on a data unit by data unit basis).

9.1 Logical channel designation

The designation scheme for logical channels has the following characteristics:

- Technology and IMT-2000 family member independence.
- Uniformity and consistency.
- Directionality: It is directly apparent from the designation of a logical channel in which direction the information is being moved (forward, reverse or both).
- Functionality: The designation provides an indication of the main use of the logical channel.

- Accessibility: It is directly apparent from the designation scheme if the functional channel is private (dedicated to a specific user), sequentially shared among users (multiplexed channel), or simultaneously shared by all users (common channel).
- Traffic-type independence: The logical channel designation does not depend on particular type of traffic being carried (e.g. circuit voice, packet data, geographical position), since the IMT-2000 protocols are extensible and adding new type of traffic does not necessarily require adding new channels.

The designation scheme for a logical channel is:

Direction + Function + Access + "LC"

Table 9.1-1 shows the values for the Direction, Function and Access for various logical channels:

Table 9.1-1/Q.1731 – Logical Channel Designation Scheme

Direction	Function	Access	"Logical Channel"
f – forward r – reverse b – bidirectional	B – Broadcast C – Control M – Multicast P – Paging S – Sync T – Traffic X – Unspecified	C – Common D – Dedicated S – Shared	LC

NOTE – This designation scheme is provided for clarity and uniformity in logical channel naming for the IMT-2000 family as a whole and does not imply that commonly used names of logical channels in various IMT-2000 family members systems must be changed.

9.2 Examples

The functional description for the IMT-2000 channels is given in Table 9.2-1.

Table 9.2-1/Q.1731 – Example logical channel designation

Logical channel name	Designation	Function	Prevalent Layer 2 characteristics
Broadcast	fBCLC	Broadcast configuration and access information.	Unassured delivery w/o duplicate detection.
Synchronization	fSCLC	Synchronization information. (Note 1)	Unassured delivery w/o duplicate detection.
Paging	fPCLC	Paging mobile terminals.	Assured, immediate delivery. Unassured delivery w. duplicate detection.
Common Control	FCCLC RCCLC bCCLC	Signalling to/from individual mobile terminal on common channel. Random access may be employed on the reverse link.	Assured, in-sequence and immediate delivery. Unassured delivery w. duplicate detection.

Table 9.2-1/Q.1731 – Example logical channel designation *(concluded)*

Dedicated Control	fCDLC rCDLC bCDLC	Signalling to/from individual mobile terminal on dedicated channel.	Assured, in-sequence and immediate delivery. Unassured delivery w. duplicate detection.
Dedicated Traffic	fTDLC rTDLC bTDLC	User traffic to/from individual mobile terminal on dedicated channel.	Assured, in-sequence and immediate delivery, w. and w/o guaranteed bandwidth and time delay constraints. Unassured delivery w. duplicate detection, w and w/o time delay constraints.
Shared Traffic	bTSLC	Intended for user packet traffic. The channel may be asymmetrical, by having different bandwidth allocations between the forward and the reverse links and between users.	Assured, in-sequence and immediate delivery, w. and w/o guaranteed bandwidth and time delay constraints. Unassured delivery w. duplicate detection, w and w/o time delay constraints.
NOTE 1 – The Synchronization Logical Channel is present only for synchronous systems. NOTE 2 – Various IMT-2000 family members may define some, all, extra or other logical channels, and may assign different functionality and/or characteristics for them.			

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18309

Printed in Switzerland
Geneva, 2000