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Foreword

This Technical Specification has been produced by the 3GPP.

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1 Scope

This Technical Specification defines the Radio Network Layer user plane protocol being used over the Iu interface.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.

- [1] UMTS 25.401, 3rd Generation Partnership Project (3GPP) Technical Specification Group (TSG) RAN; UTRAN Overall Description.
- [2] UMTS 25.410, 3rd Generation Partnership Project (3GPP) Technical Specification Group (TSG) RAN; UTRAN Iu interface: general Aspects and Principles.
- [3] UMTS 25.413, 3rd Generation Partnership Project (3GPP) Technical Specification Group (TSG) RAN; UTRAN Iu interface RANAP protocol.
- [4] UMTS 25.414, 3rd Generation Partnership Project (3GPP) Technical Specification Group (TSG) RAN; Iu Interface Data Transport and Transport Signalling.
- [5] UMTS 23.110, 3rd Generation Partnership Project (3GPP) Technical Specification Group (TSG) SSA, UMTS Access Stratum, services and functions.
- [6] UMTS 23.121, 3rd Generation Partnership Project (3GPP) Technical Specification Group (TSG) SSA, Architectural requirements for Release 99.
- [7] ITU-T Recommendation I.363.2 (1997) - B-ISDN ATM Adaptation Layer type 2 specification.
- [8] ITU-T Recommendation I.366.1 (1998) - Segmentation and reassembly service specific convergence sublayer for the AAL type 2.
- [9] UMTS 25.990, 3rd Generation Partnership Project (3GPP) Technical Specification Group (TSG) RAN; Vocabulary.
- [10] UMTS 25.321, 3rd Generation Partnership Project (3GPP) Technical Specification Group (TSG) RAN; MAC Protocol Specification.
- [11] UMTS 25.322, 3rd Generation Partnership Project (3GPP) Technical Specification Group (TSG) RAN; RLC Protocol Specification.

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply.

Non Access Stratum (NAS) Data Streams:

Non Access Stratum Data Streams is a generic term to identify these data streams exchanged at the Dedicated Service Access Points between the Non Access Stratum and the Access Stratum.

RAB sub-flows: A RAB as defined in [9] is realised by UTRAN through one to several sub-flows. These sub-flows correspond to the NAS service data streams that have QoS characteristics that differ in a predefined manner within a RAB e.g. different reliability classes.

RAB sub-flows characteristics:

- 1) The sub-flows of a RAB are established and released together at the RAB establishment and release, respectively;
- 2) The sub-flows of a RAB are submitted and delivered together at the RAB SAP;
- 3) The sub-flows of a RAB are carried over the same Iu transmission connection;
- 4) The sub-flows of a RAB are organised in a predefined manner at the RAB SAP and over the Iu interface. The organisation is imposed by the NAS as part of its co-ordination responsibility.

RAB sub-flows numbering (applies to support mode for predefined SDU size only):

- 1) RAB sub-flows are numbered from 1 to N (N is the number of sub-flows);
- 2) RAB sub-flow number 1 corresponds to the highest reliability class and the RAB sub-flow number N corresponds to the lowest reliability class;

NOTE: It is FFS whether numbering of subflows can be based on something else than reliability classes.

- 3) RAB sub-flows order inside the Iu frame is predefined so that RAB sub-flow number one comes first and the RAB sub-flow number N comes last.

RAB sub-Flow Combination (RFC): A RAB sub-flow combination is defined as an authorised combination of the RAB sub-flows variable attributes (e.g. SDU sizes) of currently valid RAB sub-flows that can be submitted simultaneously to the Iu UP for transmission over Iu interface. Each combination is given by the CN and cannot be altered by the SRNC.

RAB sub-Flow Combination Indicator (RFCI): This indicator uniquely identifies a RAB sub-flow combination for the duration of the Iu UP peer protocol instances i.e. it is valid until the termination of the call or until a new initialisation is performed. Usage of RFCI applies only to Iu UP protocol operated in support mode for predefined SDU size.

Principles related to RFCI allocation and initialisation procedure:

- 1) RFCI value is present in every Iu user frame;
- 2) In the Initialisation procedure in Iu UP, the size of every RAB sub-flow SDU for each RFCI is signalled.

Syntactical error: A field is defined to be syntactically incorrect in a message if it contains at least one value defined as "reserved", or if its value part violates syntactic rules given in the specification of the value part. However it is not a syntactical error that a value specified as "spare" is being used.

Semantical error: A message is defined to have semantically incorrect contents if it contains information which, possibly dependant on the state of the receiver, is in contradiction to the resources of the receiver and/or to the procedural part.

3.2 Abbreviations

AMR	Adaptive Multi-Rate codec
AS	Access Stratum
CN	Core Network
DTX	Discontinuous Transmission
NAS	Non Access Stratum
QoS	Quality of Service
PDU	Protocol Data Unit
PCE	Procedure Control Extension
PME	Procedure Control Bitmap Extension
RAB	Radio Access Bearer

RANAP	Radio Access Network Application Part
RFC	RAB sub Flow Combination
RFCI	RFC Indicator
RNL	Radio Network Layer
SAP	Service Access Point
SDU	Service Data Unit
SMpSDU	Support Mode for predefined SDU size
SRNC	Serving RNC
SRNS	Serving RNS
SSSAR	Service Specific Segmentation And Reassembly
TFI	Transport Format Identification
TFO	Tandem Free Operation
TNL	Transport Network Layer
TrFO	Transcoder Free Operation
TrM	Transparent Mode
UP	User Plane
UUI	User to User Information

3.3 Concepts

Iu UP mode of operation:

One objective of the Iu User Plane (UP) protocol is to remain independent of the CN domain (Circuit Switched or Packet Switched) and to have limited or no dependency with the Transport Network Layer. Meeting this objective provides the flexibility to evolve services regardless of the CN domain and to migrate services across CN domains.

The Iu UP protocol is therefore defined with modes of operation that can be activated on a RAB basis rather than on a CN domain basis or (tele)service basis. The Iu UP mode of operation determines if and which set of features shall be provided to meet e.g. the RAB QoS requirements.

Iu UP protocol PDU Type:

The Iu UP protocol PDU Types are defined for a given Iu UP mode of operation. An Iu UP PDU Type represents a defined structure of an Iu UP protocol frame. For instance, a frame made of a certain Frame Header mask part and a Frame Payload part would be specified as a certain PDU type valid for a given Iu UP mode of operation.

Tandem Free Operation (TFO):

Configuration of a Speech or Multimedia call for which Transcoders are physically present in the communication path but transcoding functions are disabled or partially disabled. The Transcoders may perform control and/or protocol conversion functions.

Transcoder (TC):

Physical device present in the network responsible for the transcoding of the speech data between two speech codecs or coding schemes (The Transcoder may also include other functions, i.e. Rate Adaptation in GSM).

Transcoder Free Operation (TrFO):

Configuration of a Speech or Multimedia call for which Transcoders are not present in the communication path.

4 General

4.1 General aspects

The Iu UP protocol is located in the User plane of the Radio Network layer over the Iu interface: the Iu UP protocol layer.

The Iu UP protocol is used to convey user data associated to Radio Access Bearers.

One Iu UP protocol instance is associated to one RAB and one RAB only. If several RABs are established towards one given UE, then these RABs make use of several Iu UP protocol instances.

Iu UP protocol instances exist at Iu access point as defined [2] i.e. at CN and UTRAN. Whenever a RAB requires transfer of user data in the Iu UP, an Iu UP protocol instance exists at each Iu interface access points. These Iu UP protocol instances are established, relocated and release together with the associated RAB.

Whether these peer protocol instances perform some RAB related function depends on the mode of operation of the Iu UP as defined below.

The following figure illustrates the logical placement of the Iu UP protocol layer and the placement of the Data Streams sources outside of the Access Stratum.

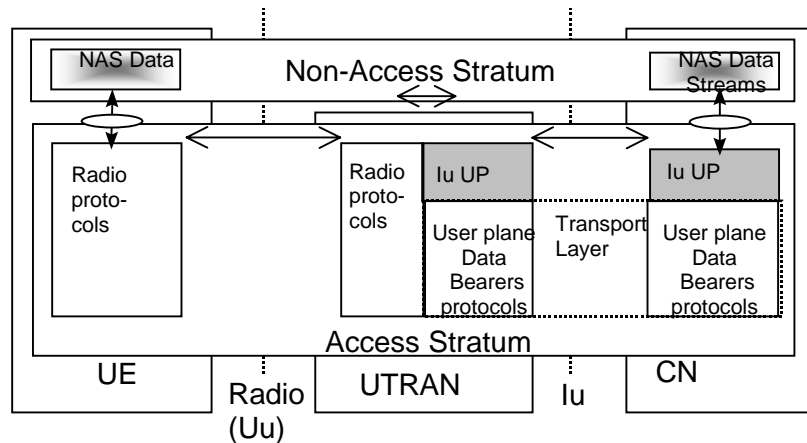


Figure 1: Iu UP protocol layer occurrence in UTRAN overall architecture (User Plane View)

4.2 Operational and Functional aspects

4.2.1 Iu UP protocol modes of operation

The Iu UP protocol operates in mode according to the concept described in earlier section.

Modes of operation of the protocol are defined:

- 1) Transparent mode (TrM)
- 2) Support mode for predefined SDU size (SMpSDU)

Determination of the Iu UP protocol instance mode of operation is a CN decision taken at RAB establishment based on e.g. the RAB characteristics. It is signalled in the Radio Network layer control plane at RAB assignment and relocation for each RAB. It is internally indicated to the Iu UP protocol layer at user plane establishment.

The choice of a mode is bound to the nature of the associated RAB and cannot be changed unless the RAB is changed.

4.2.2 Transparent mode (TrM)

The transparent mode is intended for those RABs that do not require any particular feature from the Iu UP protocol other than transfer of user data.

The following figure illustrates the transparent mode of operation of the Iu UP protocol layer:

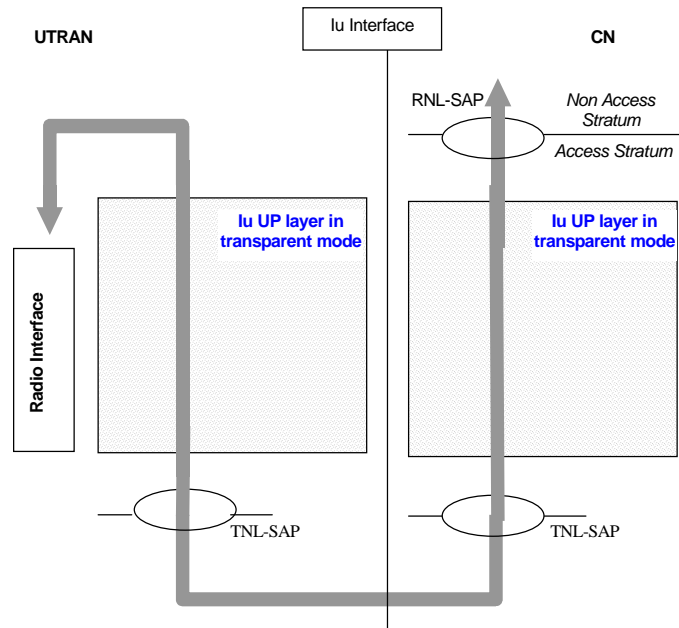


Figure 2: Iu UP protocol layer in transparent mode occurrence over Iu interface

In this mode, the Iu UP protocol instance does not perform any Iu UP protocol information exchange with its peer over the Iu interface: no Iu frame is sent. The Iu UP protocol layer is crossed through by PDUs being exchanged between upper layers and transport network layer.

For instance, the transfer of GTP-U PDUs could utilise the transparent mode of the Iu UP protocol.

4.2.3 Support mode

The support modes are intended for those RABs that do require particular features from the Iu UP protocol in addition to transfer of user data. When operating in a support mode, the peer Iu UP protocol instances exchange Iu UP frames whereas in transparent mode, no Iu UP frames are generated.

The following figure illustrates the functional model of the Iu UP protocol layer in support mode of operation:

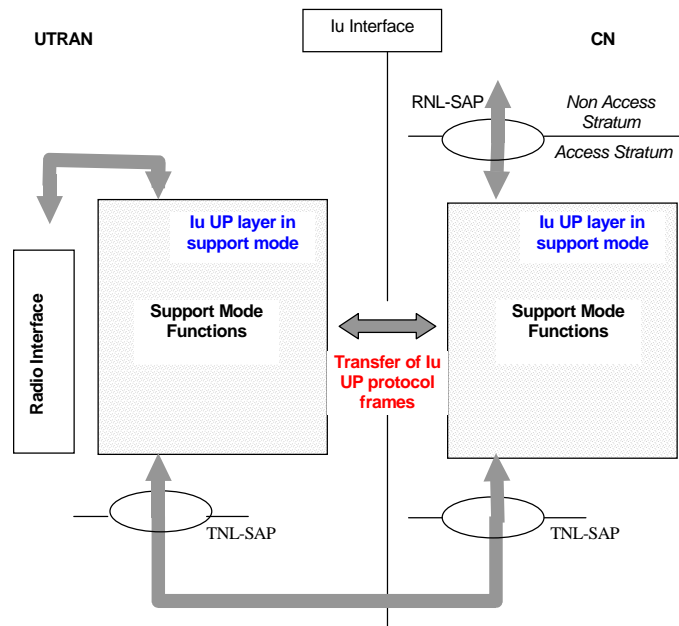


Figure 3: Iu UP protocol layer in support mode occurrence over Iu interface

Some RABs requesting Iu UP protocol support, constrain the Iu UP protocol and possibly the radio interface protocols in specific ways. For instance, certain RABs can have variable predefined rates.

The Iu UP support mode is prepared to support variations.

The only support mode defined here is the:

- Support mode for predefined SDU size (SMpSDU).

For instance, the transfer of AMR speech PDUs would utilise the support mode for predefined SDU size of the Iu UP protocol because it requires some procedure control functions and some data streams specific functions while the sizes of the user data being transferred can vary in a predefined manner.

5 Transparent mode

5.1 General

5.1.1 Operation of the Iu UP in Transparent mode

The Iu UP layer in Transparent mode is present in the Iu User plane for transferring data transparently over the Iu interface.

The two strata communicate through a Service Access Point for Non Access Stratum (NAS) Data Streams transfer.

5.1.2 Interfaces of the Iu UP protocol layer in Transparent mode

Interfaces of the Iu UP protocol layer in transparent mode are the transport network layer and the upper layers. The Iu UP protocol layer in Transparent Mode is an empty layer through which NAS Data Streams PDUs are crossing between the Transport Network Layer and upper layers.

The Iu UP protocol layer in transparent mode is using services of the Transport layers in order to transfer the Iu UP PDUs over the Iu interface.

5.2 Iu UP Protocol layer Services in Transparent mode

The following functions are needed to support this mode:

- Transfer of user data.

5.3 Services Expected from the UP Data Transport layer

The Iu UP protocol layer in Transparent mode expects the following services from the Transport Network Layer:

- Transfer of user data.

5.4 Elements for Iu UP communication in Transparent mode

5.4.1 Frame Format for transparent mode

The following shows the format of the PDU crossing the Iu UP protocol layer in transparent mode. This frame is transferred transparently between the Iu UP protocol upper layers and transport network layer (TNL-SAP).

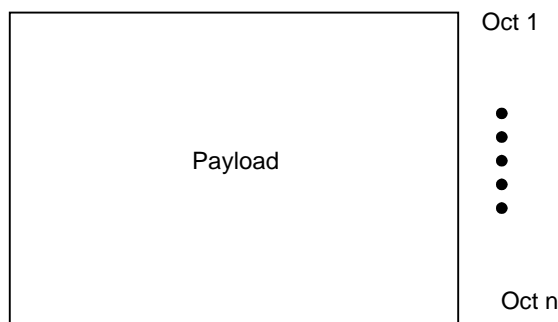


Figure 4: Frame format for transparent mode

This PDU has a variable length of n octets, whose maximum range depends on the type of user data (e.g. IP packet, Non Transparent CS data etc.). No explicit length indication is visible at the Iu UP protocol layer.

6 Support mode

6.1 General

6.1.1 Operation of the Iu UP in Support mode

The Iu UP protocol layer in Support mode is present for data streams that need frame handling in the UP.

The two strata communicate through a Service Access Point for Non Access Stratum (NAS) Data Streams transfer.

6.1.2 Interfaces of the Iu UP protocol layer in Support mode

As part of the Access Stratum responsibility, the Iu UP protocol layer in support mode provides the services and functions that are necessary to handle non access stratum data streams. The Iu UP protocol layer in support mode is providing these services to the UP upper layers through a Dedicated Service Access Point used for Information Transfer as specified in [5].

The Iu UP protocol layer in support mode is using services of the Transport layers in order to transfer the Iu UP PDUs over the Iu interface.

6.2 Iu UP Protocol layer Services in Support mode

Support mode for predefined SDU size Service

The following functions are needed to support this mode:

- Transfer of user data;
- Initialisation;
- Rate Control;
- Time Alignment (FFS);
- Handling of error event;
- Frame Quality Classification.

6.3 Services Expected from the UP Data Transport layer

The Iu UP protocol layer expects the following services from the Transport Network Layer:

- Transfer of user data.

6.4 Functions of the Iu UP Protocol Layer in Support mode

6.4.1 Functional model of the Iu UP Protocol Layer in Support mode

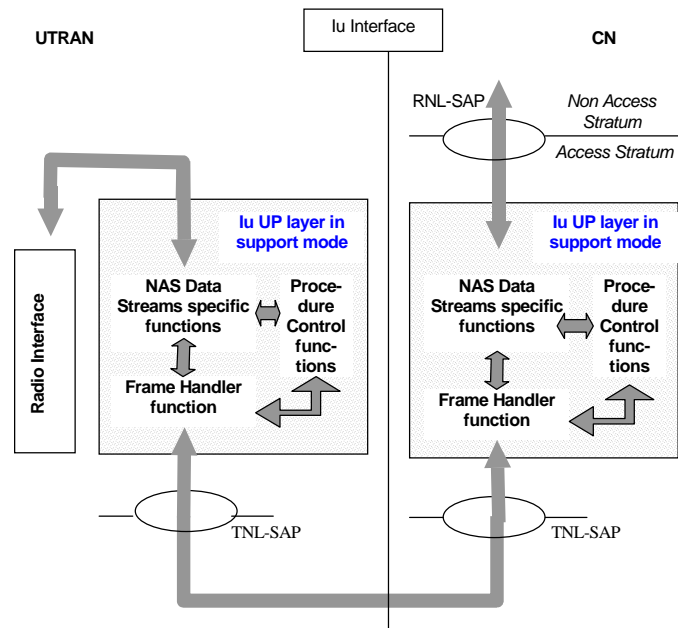


Figure 5: Functional model of the Iu UP protocol layer in Support mode

The Iu UP protocol layer in Support mode is made of three sets of functions:

- 1) Frame Handler function
- 2) Procedure Control functions
- 3) Non Access Stratum Data Streams specific functions.

6.4.2 Frame Handler function

This function is responsible for framing and de-framing the different parts of an Iu UP protocol frame. This function takes the different parts of the Iu UP protocol frame and set the control part field to the correct values. It also ensures that the frame control part is semantically correct. This function is responsible for interacting with the Transport layers. This function is also responsible for the CRC check of the Iu UP frame header. The Iu UP frame with header CRC check error is discarded.

6.4.3 Procedure Control functions

This set of functions offers the control of a number of procedures handled at the Iu UP protocol level. These functions are responsible for the procedure control part of the Iu UP frames.

Namely, these procedures are:

- **Rate Control:** is the procedure which controls over the Iu UP the set of permitted rates among the rates that can be controlled. The set of rates is represented by RFCI indicators and (when applicable) downlink send intervals. The function controlling this procedure interacts with functions outside of the Iu UP protocol layer.

- **Initialisation:** is the procedure which controls the exchange of initialisation information that is required for operation in support mode for predefined SDU size. Such information can contain the RFCI Set to be used until termination of the connection or until the next initialisation procedure.
- **Time Alignment (FFS):** is the procedure that controls the information exchanged over the Iu related to the sending time of Iu UP frames. The function controlling this procedure interacts with functions outside of the Iu UP protocol layer.
- **Handling of Error Event:** is the procedure that controls the information exchanged over the Iu related to detection of a fault situation. The function controlling this procedure interacts with functions outside of the Iu UP protocol layer.

6.4.4 Non Access Stratum Data Streams specific function(s)

These functions are responsible for a "limited manipulation" of the payload and the consistency check of the frame number. If a frame loss is detected due a gap in the sequence of the received frame numbers, this shall be reported to the procedure control function. These functions are responsible for the CRC check and calculation of the Iu UP frame payload part. These functions are also responsible for the Frame Quality Classification handling as described below.

These functions interact with the upper layers by exchanging Iu data stream blocks of Iu UP frame payload. These functions also handles the padding and depadding of the Iu UP frame payloads when needed.

These functions interact with the procedure control functions.

These functions provide service access to the upper layers for the procedure control functions.

6.4.4.1 Frame Quality Classification function

6.4.4.1.1 General

On the Iu UP in Support Mode the frames are classified with the Frame Quality Classifier (FQC). This classifying is based on the radio frame classification and the setting of the RAB attributes 'Delivery of erroneous SDUs'. The RAB attribute 'Delivery of erroneous SDUs' tells if erroneous frames shall be delivered or not.

Figure 6 below shows the main input and output information for frame quality classification function on the Iu UP.

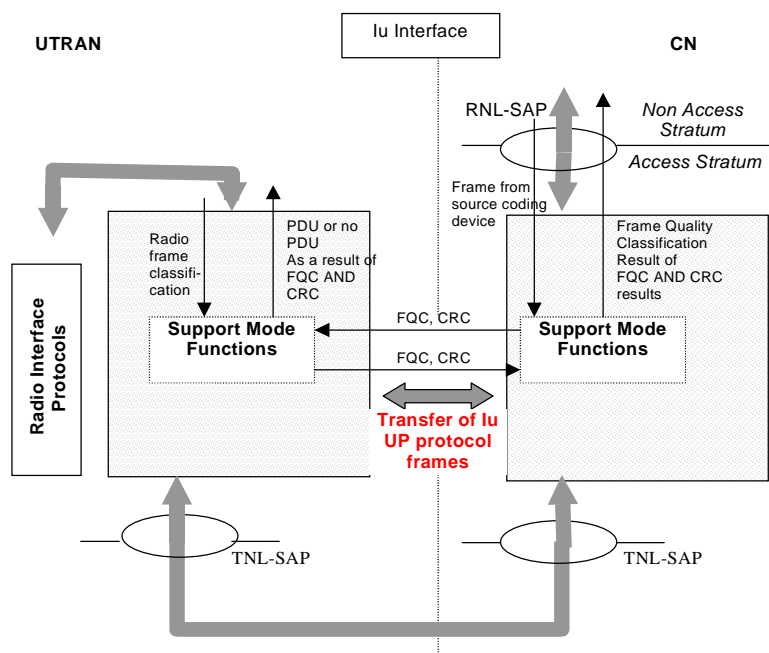


Figure 6: Frame quality classification in Iu UP

6.4.4.1.2 Handling of FQC information

In SRNC on the sending side, the Support Mode Functions takes as input the radio frame quality information together with the frame. Based on this, the FQC is set for the frame, a CRC is added, if needed and the frame is sent to CN. The following table shows the FQC field setting:

INPUT		ACTION
Delivery of erroneous SDUs	Radio Frame Classification	Action taken in SRNC on the sending side
Yes	Bad	Set FQC to 'bad radio'
No	Bad	Drop frame
Not Applicable	Any value	Set FQC to good
Any value	Good	Set FQC to good

The Support Mode Functions in CN on the receiving side makes a CRC check of the frame payload, if CRC is present and passes the frame and the frame quality classification information through the RNL-SAP.

INPUT		ACTION
Delivery of erroneous SDUs	Payload CRC check result	Actions taken at CN on the receiving side
Yes	Not OK	Frame forwarded with FQC set to 'bad'
No	Not OK	Drop frame, send lu-UP-Status primitive indicating 'No data' at the RNL-SAP
Not Applicable	Any result	Frame forwarded with FQC as set by UTRAN
Any value	OK	Frame forwarded with FQC as set by UTRAN

The Support Mode Functions in CN on the sending side adds a CRC, if necessary to the frame payload and passes it together with the FQC (in the transcoded case always set to good).

The Support Mode Functions in SRNC then makes a CRC-check, if CRC present. Based on the received FQC and eventually the CRC check, decision is made whether to deliver the frame or not.

INPUT			ACTION
Delivery of erroneous SDUs	FQC	CRC check (if payload CRC present)	Actions taken at SRNC on the receiving side
Yes	Bad	Any result	Drop frame
No	Bad	Any result	Drop frame
Yes	Bad radio	Any result	Drop frame
No	Bad radio	Any result	Drop frame
Yes	Any value	Not OK	Drop frame
No	Any value	Not OK	Drop frame
N/A	Any value	Any result	Pass the frame to radio interface protocols
Any value	Good	OK	Pass the frame to radio interface protocols

NOTE: The case where SRNC receives a frame with the FQC set to "bad radio" (respectively: "bad"), corresponds to a TrFO (respectively: TFO) case. The frame is then trashed by the receiving RNC since there is currently no means to pass down to the UE the frame quality indicator.

6.5 Elementary procedures

6.5.1 Transfer of User Data procedure

6.5.1.1 Successful operation

The purpose of the transfer of user data procedure is to transfer Iu UP frames between the two Iu UP protocol layers at both ends of the Iu interface. Since an Iu UP instance is associated to a RAB and a RAB only, the user data being transferred only relate to the associated RAB.

The procedure is controlled at both ends of the Iu UP instance i.e. SRNC and the CN.

The transfer of user data procedure is invoked whenever user data for that particular RAB needs to be sent across the Iu interface.

The procedure is invoked by the Iu UP upper layers upon reception of the upper layer PDU and associated control information: RFCI.

In SRNC, the upper layers may deliver a frame quality classification information together with the RFCI.

The NAS Data streams functions makes the padding of the payload (if needed) so that the Iu UP frame payload will be an integer number of octets. Then the NAS Data streams functions perform, if needed, CRC calculation of the Iu frame payload and passes the Iu UP frame payload down to the frame handler together with the RFCI.

The frame handler function retrieves the frame number from its internal memory, format the frame header and frame payload into the appropriate PDU Type and sends the Iu UP frame PDU to the lower layers for transfer across the Iu interface.

Upon reception of a user data frame, the Iu UP protocol layer checks the consistency of the Iu UP frame as follows:

- The Frame handler checks the consistency of the frame header. If correct, the frame handler stores the frame number and passes the Iu UP frame payload and associated CRC, if any to the NAS Data Streams functions. The received RFCI is passed to the Procedure Control Function.
- The NAS Data Streams functions check the payload CRC, if any. If the RFCI is correct and matches the Iu UP frame payload as indicated by the Procedure Control functions, the NAS Data Streams removes the padding bits from the Iu UP frame payload based on the RFCI information. Then the NAS Data Streams forwards to the upper layers the RFCI and the payload.

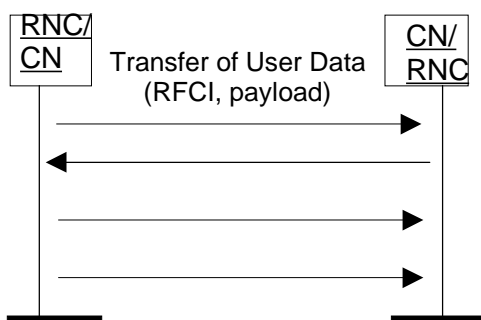


Figure 7. Successful Transfers of User Data

6.5.1.2 Unsuccessful operation

If the Iu UP frame carrying the user data is incorrectly formatted or cannot be correctly treated by the receiving Iu UP protocol layer, the Iu UP protocol layer shall either discard the frame or pass it to the upper layers with a frame classification indicating a corrupted frame. This decision is based on configuration data of the Iu UP instance for that particular RAB (i.e. if the RAB requests delivery of corrupted frame).

If the Iu UP protocol layer detects a frame loss because of a gap in the received frame number sequence while the frame number does not relate to time (see section Time Alignment), the receiving Iu UP protocol layer shall report this to the procedure control function.

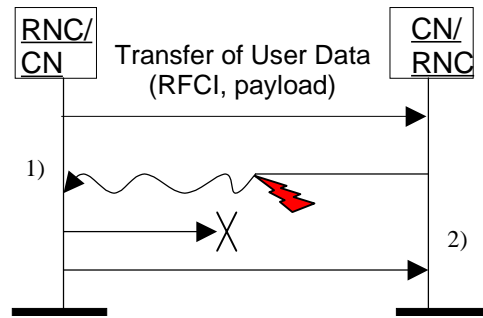


Figure 8. Unsuccessful Transfers of User Data: 1) Corrupted Frame, 2) Detection of Frame loss

6.5.2 Initialisation procedure

6.5.2.1 Successful operation

This procedure is mandatory for RABs using the support mode for predefined SDU size. The purpose of the initialisation procedure is to configure both termination points of the Iu UP with the RFCIs and associated RAB Sub Flows SDU sizes necessary during the transfer of user data phase. Additional parameters may also be passed.

The initialisation procedure is always controlled by the entity in charge of establishing the Radio Network Layer User Plane i.e. SRNC.

The initialisation procedure is invoked whenever indicated by the Iu UP Procedure Control function e.g. as a result of a relocation of SRNS or at RAB establishment over Iu.

When this procedure is invoked all other Iu UP procedures are suspended until termination of the initialisation procedure.

The SRNC allocates a RAB sub-Flow Combination indicator (RFCI) to each RAB sub-Flow Combination. The association of indicators to RAB Flow Combinations is valid in the Iu UP until a new initialisation procedure is performed or the connection is terminated.

The procedure control function may also generate additional Iu UP protocol parameters necessary for the RAB service to operate properly over Iu.

To each RAB sub-Flow combination indicator is associated the size of each RAB sub-Flow SDU of that combination. The list of RAB Flow Combination Indicators and their respective SDU sizes constitutes the RAB sub-Flow Combination set passed over the Iu UP in the initialisation frame i.e. into an appropriate Iu UP PDU Type.

The first RAB sub-Flow Combination proposed in the list of RAB sub-Flow Combination indicates the initial RAB sub-Flow Combination i.e. the first RAB sub-Flow Combination to be used when starting the communication phase i.e. the transfer of user data procedure.

The complete set of information is framed by the Iu UP Frame Handler function and transferred in an Iu UP initialisation frame. If needed, the initialisation frame CRC is calculated and set accordingly in the respective frame field.

A supervision timer T_{INIT} is started after sending the Iu UP initialisation frame. This timer supervises the reception of the initialisation acknowledgement frame.

Upon reception of a frame indicating that an initialisation control procedure is active in the peer Iu UP entity, the Iu UP protocol layer forwards to the upper layers the RAB sub-Flow Combination set to be used by the Control procedure function. It also stores the RAB sub-Flow Combination set in order to control during the transfer of user data, that the Iu UP payload is correctly formatted (e.g. RFCI matches the expected Iu UP frame payload total length).

If the initialisation frame is correctly formatted and treated by the receiving Iu UP protocol layer, this latter sends an initialisation acknowledgement frame.

Upon reception of an initialisation acknowledgement frame, the Iu UP protocol layer in the SRNC stops the supervision timer T_{INIT} .

If the initialisation procedure requires that several frames are to be sent, each frame shall be acknowledged individually.

If several initialisation frames are used for the initialisation procedure, the next frame shall wait for the acknowledgement of the previous frame to be received before sending. The supervision timer is used individually for each frame in a chain.

The frame number is always set to zero for the first frame in a chain and it shall be incremented in the sending direction for each sent frame. The acknowledgement or negative acknowledgement carries the frame number of the frame being acknowledged.

Upon reception of an initialisation negative acknowledgement frame or at timer T_{INIT} expiry, the Iu UP protocol layer in the SRNC shall reset and restart the T_{INIT} supervision timer and repeat an initialisation frame. The repetition can be performed n times, n being chosen by the operator (default $n=3$).

Consequently, when in the communication phase (as indicated by internal functions in the Radio Network layer), the frame transmission starts in downlink in the initial RFCI.

In the case where an SRNC receives an Iu frame indicating that an initialisation procedure is active at the other end of the Iu UP, RFCI is applied as follows:

- For the sending frame, i.e. UL direction, RNC uses the RAB sub-Flows Combination set indicated in Initialisation phase of the peer TFO or TrFO partner.
- For the receiving frame, i.e. DL direction, RNC uses the RAB sub-Flows Combination set as sent in its own initialisation frame.

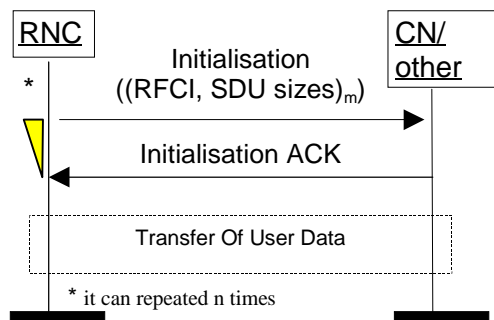


Figure 9: Successful Initialisation of Iu UP for m RFCIs

6.5.2.2 Unsuccessful operation

If the initialisation frame is incorrectly formatted and cannot be correctly treated by the receiving Iu UP protocol layer, this latter sends an initialisation negative acknowledgement frame.

If after n repetition, the initialisation procedure is unsuccessfully terminated (because of n negative acknowledgement or timer T_{INIT} expires), the Iu UP protocol layers (sending and receiving) take appropriate local actions.

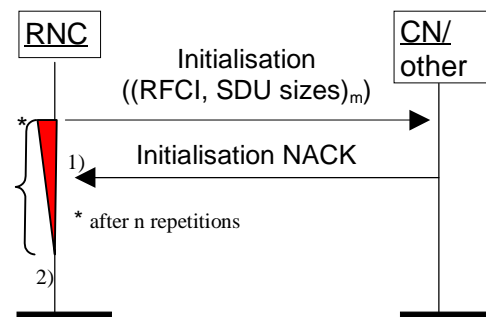


Figure 10: Unsuccessful initialisation of Iu UP: 1) n negative acknowledgement or 2) n timer expires

NOTE: The case where an SRNC receives an Iu frame indicating that an initialisation procedure is active at the other end of the Iu UP could be related to a TFO or TrFO negotiation. How TFO or TrFO protocol and codec negotiation is performed is FFS.

6.5.3 Iu Rate Control procedure

6.5.3.1 Successful operation

The purpose of the rate control procedure is to signal to the peer Iu UP protocol layer the permitted rate(s) over Iu in the reverse direction of the sent rate control frame.

The rate control procedure over Iu UP is normally controlled by the entity controlling the rate control over UTRAN i.e. SRNC. In some cases, as TrFO and TFO, it is also controlled by the remote partner at the other end of the Iu UP.

The Iu rate control procedure is invoked whenever the SRNC decides that the set of downlink permitted rates over Iu shall be modified. This set can be made of only one permitted rate among the rates that are permitted for rate control or several rates among the rates that can be rate controlled by the SRNC.

The rates that can be controlled by the SRNC are indicated to the Iu UP at establishment in addition to the rates that cannot be controlled by the RNC e.g. such as DTX rates for certain RABs.

The procedure can be signalled at any time when transfer of user data is not suspended by another control procedure.

The Procedure control function upon request of upper layer prepares the Rate control frame payload containing the permitted rates of the reverse direction of the rate control frame. The permitted rate is given as RFCI indicators and (when applicable) the downlink send intervals.

The frame handler function calculates the frame CRC, formats the frame header into the appropriate PDU Type and sends the Iu UP frame PDU to the lower layers for transfer across the Iu interface.

Upon reception of a rate control frame, the Iu UP protocol layer checks the consistency of the Iu UP frame as follows:

- The Frame handler checks the consistency of the frame header and associated CRC. If correct, the frame handler passes procedure control part to the procedure control functions.
- The procedure control functions check that the new permitted rate(s) are consistent with the RFCI set received at initialisation. They also verify that non-rate controllable rates are still permitted. If the whole rate control information is correct, the procedure control functions passes the rate control information to the NAS Data Streams specific functions.
- The NAS data streams specific functions forward to the upper layers the rate control information in a Iu-UP-Status indication primitive.

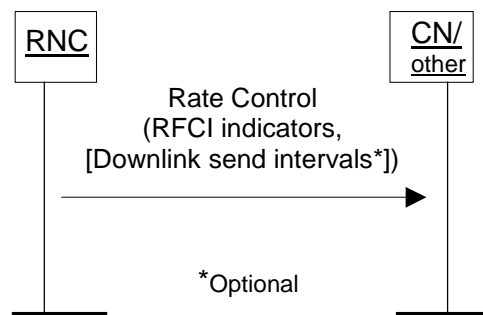


Figure 11: Successful Rate Control sent from SRNC

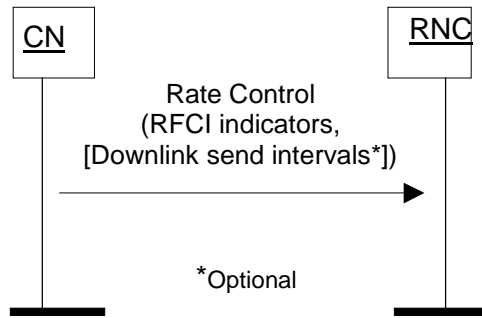


Figure 12: Successful Rate Control sent from CN

6.5.3.2 Unsuccessful operation

If the Iu UP in the SRNC detects that the rate control command has not been correctly interpreted or received (e.g. the rate is outside the set of permitted rates in the reverse direction of the rate control frame), the Iu UP shall retrigger a rate control procedure. If after "m" repetitions, the error situation persists, the Iu UP protocol layers (sending and receiving) take the appropriate local actions.

If the Iu UP protocol layer receives a rate control frame that is badly formatted or corrupted, it shall ignore the rate control frame.

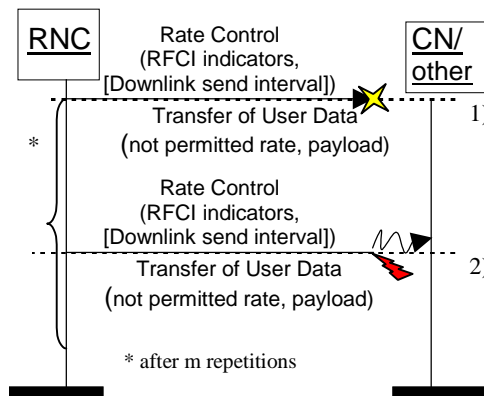


Figure 13: Unsuccessful Transfers of rate control from RNC: 1) Frame loss 2) Corrupted Frame

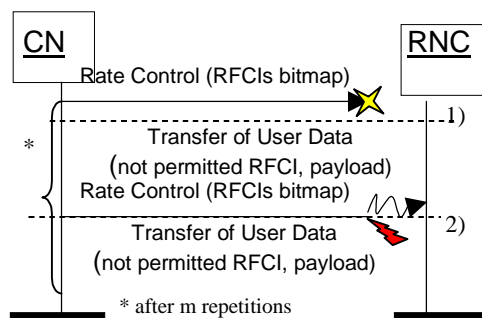


Figure 14: Unsuccessful Transfers of rate control from CN: 1) Frame loss 2) Corrupted Frame

6.5.4 Time Alignment procedure (FFS)

6.5.5 Handling of Error Event procedure

6.5.5.1 Successful operation

The purpose of the Error event procedure handles the error reporting. Over the Iu UP protocol the error reports are made with Error event frames. The Error event procedure in the Iu UP can be triggered by:

- an error detected by the Iu UP functions (by receiving an erroneous frame or by receiving a frame with unknown or unexpected data). In this case an Iu UP- Status Indication may be used to inform the upper layers.
- a request by the upper layers

When an Error event is reported by an Error event frame the following information shall be included:

- A cause value.
- Error distance (=0 if Iu UP function detected, =1 if requested by upper layers).

Upon reception of an Error report frame the Iu UP functions should take appropriate local actions based on the cause value. This may include to report the error to the upper layers with an Iu UP status indication.

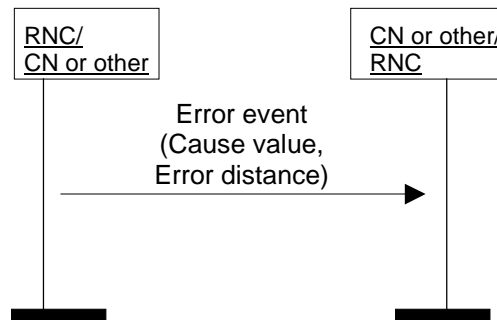


Figure 15: Successful Error event

6.5.5.2 Unsuccessful operation

If the error event frame is incorrectly formatted and cannot be correctly treated by the receiving Iu UP protocol layer appropriate local actions are taken (e.g. upper layers are informed). An error in an Error event frame should not generate the sending of an ne Error event frame.

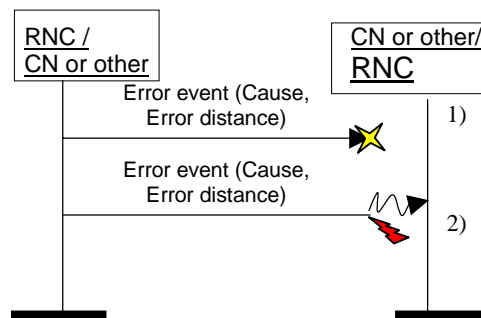


Figure 16: Unsuccessful Transfers of Error event frame: 1) Frame loss 2) Corrupted Frame

6.5.6 Frame Quality Classification

The Frame Quality Classification procedure uses the services of the Transfer of User Data procedure to exchange across the Iu UP interface the Frame Quality Classification information.

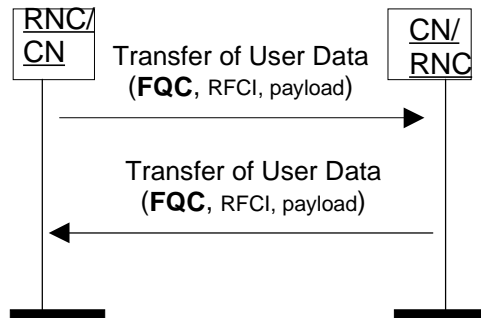


Figure 17: Successful Transfers of User Data with FQC information

6.6 Elements for Iu UP communication in Support mode

6.6.1 General

In this specification the structure of frames will be specified by using figures similar to Figure 18 below.

Bits								Number of Octets	Octet	Part
7	6	5	4	3	2	1	0			
Field 1				Field 2				1	Octet 1	Header part
Field 3						Field 4		2	Octet 2	
Field 4 continue				Spare					Octet 3	
Field 6								2	Octet 4	Payload part
Field 6 continue				Padding						

Figure 18: Example frame format

Unless otherwise indicated, fields which consist of multiple bits within an octet will have the more significant bit located at the higher bit position (indicated above frame in Figure 18). In addition, if a field spans several octets, more significant bits will be located in lower numbered octets (right of frame in Figure 18).

On the Iu interface, the frame will be transmitted starting from the lowest numbered octet. Within each octet, the bits are sent according decreasing bit position (bit position 7 first).

Spare bits should be set to 0 by the sender and should not be checked by the receiver.

The header part of the frame is always an integer number of octets. The payload part is octet rounded (by adding 'Padding' when needed).

6.6.2 Frame Format for predefined size SDUs

6.6.2.1 PDU Type 0

PDU Type 0 is defined to transfer user data over the Iu UP in support mode for pre-defined SDU sizes. Error detection scheme is provided over the Iu UP for the payload part.

The following shows the Iu frame structure for PDU type 0 of the Iu UP protocol at the SAP towards the transport layers (TNL-SAP):

Bits								Number of Octets	
7	6	5	4	3	2	1	0		
PDU Type (=0)				Frame Number				1	Frame Control Part
FQC		RFCI						1	
Header CRC						Payload CRC		2	Frame Check Sum Part
Payload CRC									
Payload Fields								0-n	Frame Payload part
Payload Fields				Padding					

Figure 19: Iu UP PDU Type 0 Format

The Iu UP PDU Type 0 is made of three parts:

- 1) Iu UP Frame Control part (fixed size)
- 2) Iu UP Frame Check Sum part (fixed size)
- 3) Iu UP Frame Payload part (pre-defined SDU sizes)

The Iu UP Frame Control Part and the Iu UP Frame Check Sum constitute the Iu UP PDU Type 0 Frame Header.

6.6.2.2 PDU Type 1

PDU Type 1 is defined to transfer user data over the Iu UP in support mode for pre-defined SDU sizes when no payload error detection scheme is necessary over Iu UP (i.e. no payload CRC).

The following shows the Iu frame structure for PDU type 1 of the Iu UP protocol at the SAP towards the transport layers (TNL-SAP):

Bits								Number of Octets	
7	6	5	4	3	2	1	0		
PDU Type (=1)				Frame Number				1	Frame Control Part
FQC		RFCI						1	
Header CRC						Spare		1	Frame Check Sum Part
Payload Fields								0-n	Frame Payload part
Payload Fields				Padding					

Figure 20: Iu UP PDU Type 1 Format

The Iu UP PDU Type 1 is made of three parts:

- 1) Iu UP Frame Control part (fixed size)
- 2) Iu UP Frame Check Sum part (fixed size)
- 3) Iu UP Frame Payload part (pre-defined SDU sizes)

The Iu UP Frame Control Part and the Iu UP Frame Check Sum constitute the Iu UP PDU Type 1 Frame Header.

6.6.2.3 PDU Type 14

6.6.2.3.1 General

PDU Type 14 is defined to perform control procedures over the Iu UP in support mode for pre-defined SDU sizes. The control procedure is identified by the procedure indicator. The Frame Payload contains the data information related to the control procedure.

Figure 21 below shows the Iu frame structure for PDU Type 14 of the Iu UP protocol at the SAP towards the transport layers (TNL-SAP):

Bits								Number of Octets	
7	6	5	4	3	2	1	0		
PDU Type (=14)				Ack/Nack (=0, i.e. procedure)		PDU Type 14 Frame Number		1	Frame Control Part
Procedure Indicator								1	
Header CRC						Payload CRC		1	Frame Checksum Part
Payload CRC								1	
Reserved for procedure data								0-n	Frame payload part

Figure 21: Iu UP PDU Type 14 Format for procedure sending

The Iu UP PDU Type 14 is made of three parts:

- 1) Iu UP Frame Control part (fixed size)
- 2) Iu UP Frame Check Sum part (fixed size)
- 3) Iu UP Frame Payload part (variable length, rounded up to octet)

The Iu UP Frame Control Part and the Iu UP Frame Check Sum constitute the Iu UP PDU Type 14 Frame Header.

6.6.2.3.2 Positive Acknowledgement

When the PDU Type 14 is used to positively acknowledge a control procedure, the PDU Type 14 frame takes the following structure at the TNL-SAP:

Bits								Number of Octets	
7	6	5	4	3	2	1	0		
PDU Type (=14)				Ack/Nack (=1, i.e. Ack)		PDU Type 14 Frame Number		1	Frame Control Part
Procedure Indicator (indicating the procedure being positively acknowledged)								1	
Header CRC						Spare		1	Frame Checksum Part
Spare								1	

Figure 22: Iu UP PDU Type 14 Format for positive acknowledgement

The Iu UP PDU Type 14 for positive acknowledgment is made of two parts:

- 1) Iu UP Frame Control part (fixed size)

2) Iu UP Frame Check Sum part (fixed size)

The Iu UP Frame Control Part and the Iu UP Frame Check Sum constitute the Iu UP PDU Type 14 Frame Header for positive acknowledgement.

6.6.2.3.3 Negative Acknowledgement

When the PDU Type 14 is used to negatively acknowledge a control procedure, the PDU Type 14 frame takes the following structure at the TNL-SAP:

Bits								Number of Octets	
7	6	5	4	3	2	1	0		
PDU Type (=14)				Ack/Nack (=2, i.e. Nack)		PDU Type 14 Frame Number		1	Frame Control Part
Procedure Indicator (indicating the procedure being negatively acknowledged)								1	
Header CRC						Spare		1	Frame Checksum Part
Spare								1	
Error Cause value						Spare		1	Frame payload part

Figure 23: Iu UP PDU Type 14 Format for negative acknowledgement

The Iu UP PDU Type 14 for negative acknowledgement is made of three parts:

- 1) Iu UP Frame Control part (fixed size)
- 2) Iu UP Frame Check Sum part (fixed size)
- 3) Iu UP Frame Payload part (fixed size)

The Iu UP Frame Control Part and the Iu UP Frame Check Sum constitute the Iu UP PDU Type 14 Frame Header for negative acknowledgement.

6.6.2.3.4 Procedures Coding

6.6.2.3.4.1 Initialisation

The figure below specifies how the initialisation procedure frame is coded.

Bits								Number of Octets	
7	6	5	4	3	2	1	0		
PDU Type (=14)				Ack/Nack (=0. I.e. Procedure)		PDU Type 14 Frame Number		1	Frame Control Part
Procedure Indicator (=0)								1	
Header CRC						Payload CRC		2	Frame Checksum part
Payload CRC									
Spare				Number of subflows per RFCI (N)		Chain Ind		1	Frame payload part
Spare	LI	1 st RFCI						1	
Length of subflow 1								1 or 2 (dep. LI)	
Length of subflow 2 to N								(N-1)x(1 or 2)	
Spare	LI	2 nd RFCI						1	
Length of subflow 1								1 or 2 (dep. LI)	
Length of subflow 2 to N								(N-1)x(1 or 2)	
...									

Figure 24: lu UP PDU Type 14 used for Initialisation

6.6.2.3.4.2 Rate Control

The Figure below specifies how the rate control procedure frame is coded when the rate control uses only RFCI indicators.

Bits								Number of Octets	
7	6	5	4	3	2	1	0		
PDU Type (=14)				Ack/Nack (=0, i.e. Procedure)		PDU Type 14 Frame Number		1	Frame Control Part
Procedure Indicator (=1)								1	
Header CRC						Payload CRC		1	Frame Checksum Part
Payload CRC								1	
Spare	Rate control type (=0)	Number of RFCIs (N)						1	Frame payload part
RFCI 0 Ind.	RFCI 1 Ind	...	RFCI N-1 Ind	Padding				0-n	

Figure 25: Iu UP PDU Type 14 Format used for Rate Control

The Figure below specifies how the rate control procedure is coded when both RFCI indicators and Downlink send intervals are used.

Bits								Number of Octets	
7	6	5	4	3	2	1	0		
PDU Type (=14)				Ack/Nack (=0)		PDU Type 14 Frame Number		1	Frame Control Part
Procedure Indicator (=1)								1	
Header CRC						Payload CRC		1	Frame Checksum Part
Payload CRC								1	
Spare	Rate Contr. Type (=1)	Number of RFCI Indicators (N)						1	Frame payload part
RFCI 0 Ind.	Downlink send interval (for RFCI 0)			RFCI 1 Ind.	Downlink send interval (for RFCI 1)			0-n	
...	...			RFCI N-2 Ind	Downlink send interval (for RFCI N-2)				
RFCI N-1 Ind.	Downlink send interval (for RFCI N-1)			Padding					

Figure 26: lu UP PDU Type 14 Format used for Rate Control

6.6.2.3.4.3 Time Alignment (FFS)

6.6.2.3.4.4 Error Event

The Figure below specifies how the Error Event procedure is coded.

Bits								Number of Octets	
7	6	5	4	3	2	1	0		
PDU Type (=14)				Ack/Nack(=0)		PDU Type 14 Frame Number		1	Frame Control Part
Procedure Indicator (=3)								1	
Header CRC					Payload CRC			1	Frame Checksum Part
Payload CRC								1	
Error distance		Error Cause value						1	Frame payload part

Figure 27: Iu UP PDU Type 14 Format used for Error Event

6.6.3 Coding of information elements in frames

6.6.3.1 PDU Type

Description: The PDU type indicates the structure of the Iu UP frame. The field takes the value of the PDU Type it identifies: i.e. 0 for PDU Type 0. The PDU type is in bit 4 to bit 7 in the first octet of the frame.

Value range: {0-14, 15=reserved for future PDU type extensions}

Field length: 4 bits

6.6.3.2 Ack/Nack

Description: The Ack/Nack field tells if the frame is:

- a control procedure frame
- a positive acknowledgement (ACK) of a control procedure frame
- a negative acknowledgement (NACK) of a control procedure frame.

Value range: {0=control procedure frame, 1=ACK, 2=NACK, 3=reserved}

Field length: 2 bits

6.6.3.3 Frame Number

Description: The Iu UP frame numbering is handled by a Frame Number. The purpose of the Frame Number is to provide the receiving entity with a mechanism to keep track of lost Iu UP frames. For a given user data connection, there is no relations between the frame numbers of frames sent in the downlink direction and the frame numbers of frames sent in the uplink direction.

Value range: {0-15}

Field length: 4 bits

6.6.3.4 PDU Type 14 Frame Number

Description: The Iu UP frame numbering is handled by a Frame Number. The purpose of the PDU Type 14 Frame Number is to provide the receiving entity with a mechanism to keep track of lost Iu UP frames. It is also used to relate the acknowledgment frame to the frame being acknowledged i.e. the same PDU Type 14 Frame Number is used in the

acknowledgement frame as the one used in the frame being acknowledged.

Value range: {0-3}

Field length: 2 bits

6.6.3.5 Frame Quality Classification (FQC)

Description: Frame Quality Classification is used to classify the Iu UP frames depending on whether errors have occurred in the frame or not. Frame Quality Classification is dependent on the RAB attribute 'Delivery of erroneous SDUs'.

Value range: {0=frame good, 1=frame bad, 2=Frame bad due to radio, 3=spare}

Field length: 2 bits

6.6.3.6 RAB sub-Flow Combination Indicator (RFCI)

Description: The RFCI identifies the structure of the payload. This can be used to specify the sizes of the subflows.

Value range: {0-62, 63=RFCI not applicable}

Field length: 6 bits

6.6.3.7 Procedure Indicator

Description: The Procedure Indicator identifies the control procedure in the current frame.

Value range: {0=initialization, 1=rate control, 2=time alignment, 3=abnormal event, 4-255=reserved}

Field length: 8 bits

6.6.3.8 Header CRC

Description: This field contains the CRC of all fields in Frame Control Part. The CRC is a 6-bit checksum based on the generator polynomial $G(D) = D^6 + D^5 + D^3 + D^2 + D^1 + 1$. With this CRC all error bursts shorter than 7 bits are detected, as well as all odd number of bits faulty (and two-bit faults) when the protected area is shorter than 24 bits, (max 3 octets).

Field length: 6 bits

6.6.3.9 Payload CRC

Description: This field contains the CRC of all the fields (including Padding) of the Frame Payload. The CRC is a 10-bit checksum based on the generator polynomial $G(D) = D^{10} + D^9 + D^5 + D^4 + D^1 + 1$. With this CRC all error bursts shorter than 11 bits are detected, as well as all odd number of bits faulty (and two-bit faults) when the protected area is shorter than 500 bits (max 62 octets).

Field length: 10 bits

6.6.3.10 Chain Indicator

Description: Chain indicator is used to indicate whether the control procedure frame is the last frame related to the control procedure.

Value range: {0=this frame is the last frame for the procedure, 1=additional frames will be sent for the procedure}

Field length: 1 bit

6.6.3.11 Number of Subflows per RFCI

Description: Number of Subflows per RFCI field indicates the number of subflows the RAB is made of. It is used to decode the SDU size information data lengths. All RFCs consist of the same number of subflows within a specific

RAB.

Value range: {0=reserved, 1-7}

Field length: 3 bits

6.6.3.12 Length Indicator (LI)

Description: Length Indicator, indicates if 1 or 2 octets is used for the RAB subflow size information.

Value range: {0=one octet used, 1=two octets used}

Field length: 1 bit

6.6.3.13 Number of RFCI Indicators

Description: Number of RFCI indicators indicates the number of RFCI indicators present in the control procedure frame.

Value range: {0-63}

Field length: 6 bits

6.6.3.14 RFCI n Indicator

Description: RFCI n Indicator points to an RFCI number e.g. RFCI 0 Indicator points to RFCI 0, RFCI 1 Indicator points to RFCI 1, etc...

Value range: {0=RFCI allowed, 1=RFCI barred}

Field length: 1 bit

6.6.3.15 Error distance

Description: Indicates if the error occurred at the error reporting entity (=0) or in a more distant entity. The error distance is incremented by one (or kept at its maximum value) when an error report is forwarded.

- 0: Reporting local error
- 1: First forwarding of error event report
- 2: Second forwarding of error event report
- 3: Reserved for future use

Value range: {0: Reporting local error, 1: First forwarding of error event report, 2: Second forwarding of error event, 3: Reserved for future use}

Field length: 2 bit

6.6.3.16 Error Cause value

Description: Cause value is used to indicate what kind of error caused the error.

- 0: CRC error of frame header
- 1: CRC error of frame payload
- 2: Unexpected frame number
- 3: Frame loss
- 4: PDU type unknown
- 5: Unknown procedure
- 6: Unknown reserved value
- 7: Unknown field
- 8: Frame too short
- 9: Missing fields
- 10-15: spare

16: Unexpected PDU type
 18: Unexpected procedure
 19: Unexpected RFCI
 20: Unexpected value
 21–41: spare

42: Initialisation failure
 43: Initialisation failure (timer expiry)
 44: Initialisation failure (repeated NACK)
 45: Rate control failure
 46: Error event failure
 47–63: spare

Value range: {0–15 Used for syntactical protocol errors, 16–41 Used for semantical protocol errors, 42–63 Used for other errors }

Field length: 6 bit

6.6.3.17 Rate Control Type

Description: Specifies the type of Rate control the current frame relates to. There are two types of Rate control:

- Rate control for fixed periodicity services. Only RFCI indicators present.
- Rate control for services with varying periodicity. RFCI indicators and Downlink send interval present.

Value range: {0=Rate control using only RFCI indicators, 1=Rate control including both RFCI indicators and Downlink send interval }

Field length: 1 bit

6.6.3.18 Downlink send interval

Description: Specifies the Interval the downlink frames should be sent.

Value range: {0=10ms, 1=20ms, 2=40ms, 3–7= Spare }

Field length: 3 bit

6.6.3.19 Padding

Description: This field is an additional field used to make the frame payload part an integer number of octets when needed. Padding is set to 0 by the sender and is not interpreted by the receiver.

Value range: {0–127 }

Field length: 0–7 bits

6.6.4 Timers

T_{INIT}

This Timer is used to supervise the reception of the initialisation acknowledgement frame from the peer Iu UP instance. This Timer is set by O&M.

6.7 Handling of unknown, unforeseen and erroneous protocol data

6.7.1 General

Error handling in Iu UP protocol is applicable only for Iu UP in Support mode.

The Error Event procedure is the procedure handling error reporting. The Error event procedure in the Iu UP can be triggered by:

- an error detected by the Iu UP functions (by receiving an erroneous frame or by receiving a frame with unknown or unexpected data)
- a request by the upper layers
- an Error event frame over the Iu UP protocol

The error can be reported either by:

- an Error event frame over the Iu UP protocol
- an Iu UP Status Indication to upper layers (e.g. to be used by O&M)

When an Error event is reported, either by an Iu-UP-Status-Indication, or by an Error event frame the following information shall be included:

- Type of the error (syntactical error, semantical error or other error)
- Error distance, i.e. information where the error occurred

6.7.2 Error detected by Iu UP functions

When an error is detected within the Iu UP functions (by receiving a frame containing erroneous, unknown or unexpected data) one of the following actions is taken depending on the type of the error

1. Error indicated to upper layers by sending a Iu-UP-Status-Indication primitive
2. Error event frame sent
3. Error event frame sent and error indicated to upper layers by sending a Iu-UP-Status-Indication primitive
4. No action

6.7.3 Request by upper layers

When the Iu UP receives an Iu-UP-Status-Request indicating Error event then an Error event frame should be sent over the Iu UP protocol indicating the appropriate error type.

6.7.4 Error event frame over the Iu UP protocol

When an Error event frame is received over the Iu UP protocol an Iu-Status-Indication with 'Error event' information indicating the error type should be made to the upper layers. The Error event report contains an 'Cause value' that tells the type of the error. The Error event report also contains a field 'Error distance' that tells the distance to the entity reporting the error event. The 'Error distance' is 0 when the error is originally sent. When an Error event report is forwarded the 'Error distance' is incremented by one.

6.7.5 Handling of error reports

6.7.5.1 General

The Figure 28 below shows the external error case when the error event procedure is originally triggered by an Iu-UP-Status-Request. As an action on this the error event procedure sends an error event frame over the Iu UP. On the other side the reception of error event frame triggers the error event procedure, and an Iu-UP-Status-Indication is sent to upper layers. The handling is symmetrical over the Iu UP protocol.

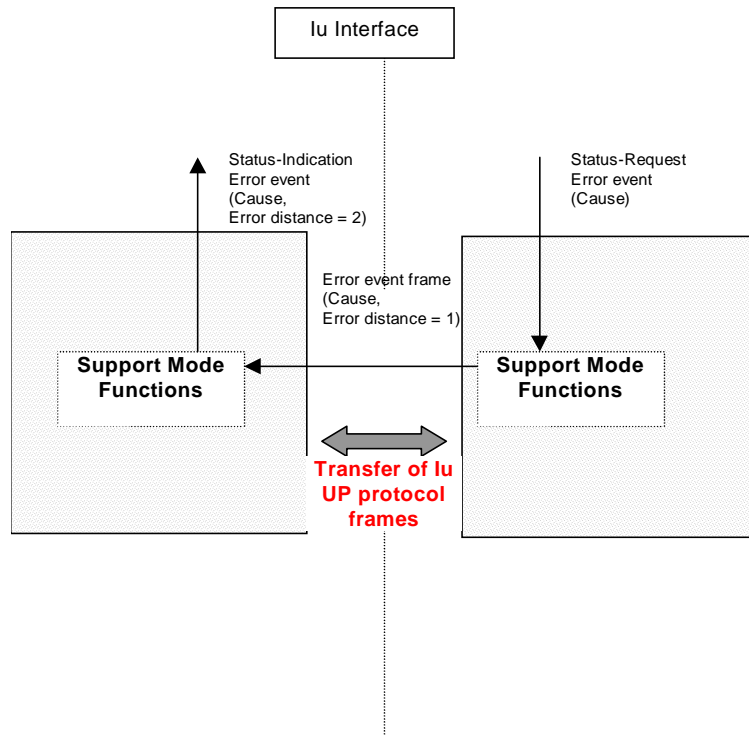


Figure 28: External error

The figure below shows the internal error case when the error event procedure is originally triggered by the Iu UP functions. As an action on this the error event procedure sends an error event frame over the Iu UP. On the other side the reception of error event frame triggers the error event procedure, and an Iu-UP-Status-Indication is sent to the upper layers. The handling is symmetrical over the Iu UP protocol.

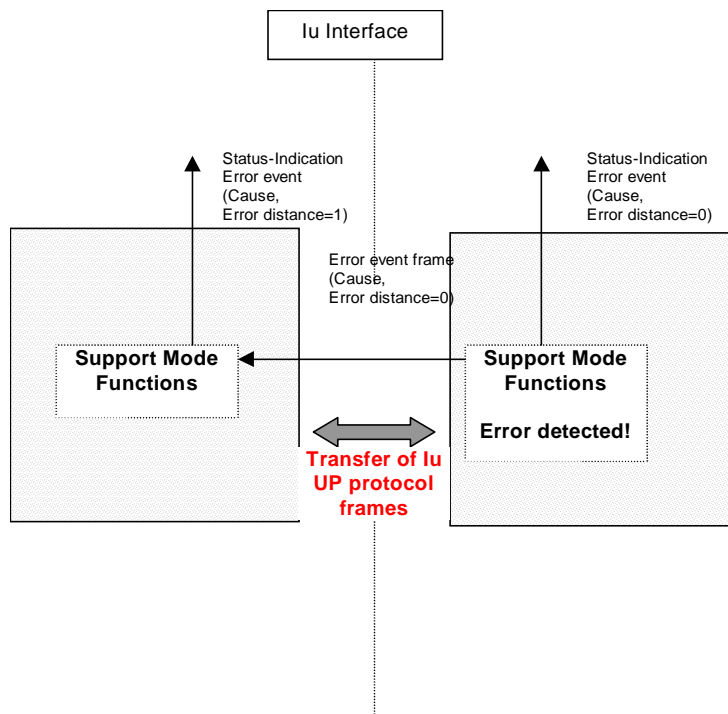


Figure 29: Internal error

6.7.5.2 Error distance

In an error event frame the error distance has the following meaning:

0: Error report relates to an Iu UP function error at the other side

1: Error report relates to an error at the other side reported by the upper layers

In an Iu UP-Status indication the error distance has the following meaning:

0: Error report relates to an local Iu UP function error

1: Error report relates to an Iu UP function error at the other side

2: Error report relates to an error at the other side reported by the upper layers

6.7.6 List of errors in Iu UP

Error Type	Error Cause	Recommended action by Error event procedure	Possibly detected by function	Comment
Syntactical	Bit error in Frame payload (CRC check)	No action	NAS data streams functions	Handled by Frame Quality Classification, when applied
	Bit error in Frame Header (CRC check)	Iu-UP-Status-Indication(Error event)	Frame handler functions	Frame trashed
	Unexpected Frame Number	Iu-UP-Status-Indication(Error event)	NAS data streams functions	
	Frame loss	Iu-UP-Status-Indication(Error event) and Error event frame	NAS data streams functions	
	Unknown PDU type	Iu-UP-Status-Indication(Error event) and Error event frame	Frame handler functions	
	Unknown procedure	Iu-UP-Status-Indication(Error event) and Error event frame	Frame handler functions	
	Unknown or unexpected value	Iu-UP-Status-Indication(Error event) and Error event frame	Procedure control functions	
	Frame too short	Iu-UP-Status-Indication(Error event) and Error event frame	Frame handler functions	
	Missing fields	Iu-UP-Status-Indication(Error event) and Error event frame	Frame handler functions	
Semantical	Unexpected PDU type	Iu-UP-Status-Indication(Error event) and Error event frame	Frame handler functions	
	Unexpected procedure	Iu-UP-Status-Indication(Error event) and Error event frame	Frame handler functions	
	Unexpected RFCI	Iu-UP-Status-Indication(Error event) and Error event frame	NAS data streams functions	
	Unexpected value	Iu-UP-Status-Indication(Error event) and Error event frame	Procedure control functions	
Other error	Initialisation failure (outside Iu UP)	Error event frame	Function outside Iu UP	
	Initialisation failure (network error, timer expiry)	Iu-UP-Status-Indication(Error event)	Procedure control functions	
	Initialisation failure (Iu UP function error, repeated NACK)	Iu-UP-Status-Indication(Error event)	Procedure control functions	
	Rate control failure	Iu-UP-Status-Indication(Error event)	Procedure control functions	
	Error event failure	Iu-UP-Status-Indication(Error event)	Procedure control functions	

7 Communication Primitives for the Iu UP protocol layer

7.1 Modelling Principle

The principle illustrated by the figure below is used for modelling the primitives towards the protocol layer:

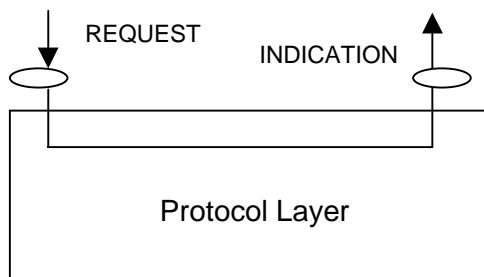


Figure 30: Modelling principle

7.2 Primitives towards the upper layers at the RNL SAP

7.2.1 General

The Iu UP protocol layer interacts with upper layers as illustrated in the figure above. The interactions with the upper layers are shown in terms of primitives where the primitives represent the logical exchange of information and control between the upper layer and the Iu UP protocol layer. They do not specify or constraint implementations.

The following primitives are defined:

- Iu-UP-DATA
- Iu-UP-STATUS
- Iu-UP-UNIT-DATA

Table 1: Iu UP protocol layer service primitives towards the upper layer at the RNL SAP

Primitive	Type	Parameters	Comments
Iu-UP-DATA	Request	Iu-UP-payload	
		Iu-UP-control	RFCI
	Indication	Iu-UP-payload	
Iu-UP-control		RFCI	
			FQC
Iu-UP-Status	Indication	Iu-UP-Procedure-Control	Error Cause, Error Distance
			Initialisation
			RFCI indicators, Downlink send intervals (when applicable)
			<i>Time Alignment (FFS Note 1)</i>
	Request	Iu-UP-Procedure-Control	Error Cause
			RFCI indicators, Downlink send intervals (when applicable)
Iu-UP-UNIT-DATA	Request	Iu-UP-payload	
	Indication	Iu-UP-payload	

Primitive usage is function of the mode of operation of the Iu UP protocol. The following table provides the association between Iu UP primitives towards the upper layers and the Iu UP mode of operation:

Table 2: Iu UP protocol layer service primitives related to the Iu UP mode of operation and function within the mode of operation

Primitive	Type	Mode of Operation
Iu-UP-DATA	Request	SMpSDU
	Indication	SMpSDU
Iu-UP-Status	Request	SMpSDU
	Indication	SMpSDU
Iu-UP-UNIT-DATA	Request	TrM
	Indication	TrM

7.2.2 Iu-UP-DATA-REQUEST

This primitive is used as a request from the upper layer Iu NAS Data Stream entity to send a RAB SDU on the established transport connection. This primitive also includes the RFCI of the payload information included in the primitive.

The Iu UP Frame protocol layer forms the Iu UP data frame, the Iu Data Stream DU being the payload of the Iu UP frame, and transfers the frame by means of the lower layer services.

7.2.3 Iu-UP-DATA-INDICATION

This primitive is used as an indication to the upper layer entity to pass the Iu NAS Data Stream User Plane information of a received Iu UP frame.

This primitive also includes the RFCI of the payload information included in the primitive.

At the RNL-SAP, this primitive may include an Frame Quality Classification indication.

This primitive may also include information aiming at informing the upper layers of a faulty situation that relates to the payload included in the primitive.

7.2.4 Iu-UP-STATUS-REQUEST

This primitive is used to pass down to the Iu UP, the rate control information necessary for changing the permitted rate(s) in the reverse direction over Iu. The rate control information consists of RFCI indicators and (when applicable) downlink send intervals.

This primitive is also used to report that a fault has been detected.

7.2.5 Iu-UP-STATUS-INDICATION

This primitive is used to report to the upper layer entity that a fault has been detected. The information concerning that fault is characterised by the Abnormal event information passed to the upper layer.

This primitive is also used in the context of the initialisation control procedure to pass to the upper Iu DS layer e.g. the RFC set and the associated RFCIs to be used in the communication phase.

This primitive is used to indicate to the upper layers the set of permitted rate(s) in the reverse direction over Iu. The set of permitted rate(s) is represented by RFCI indicators and (when applicable) downlink send intervals.

This primitive is also used to indicate when a frame has been dropped as a result of frame quality classification handling.

NOTE 1: Time Alignment is FFS.

7.2.6 Iu-UP-UNIT-DATA-REQUEST

This primitive is used as a request from the upper layer to send an Iu UP payload on the established transport connection.

The Iu UP protocol layer transfers the Iu Data Stream DU by means of the lower layer services without adding any protocol header overhead.

7.2.7 Iu-UP-UNIT-DATA-INDICATION

This primitive is used as an indication to the upper layer entity to pass the Iu UP payload.

7.3 Primitives towards the transport layers at TNL SAP

7.3.1 General

Access to the Transport network Layer is performed through a generic SAP: TNL-SAP.

When the Transport Network upper layer consists of AAL2, the TNL SAP maps onto the AAL-SAP through which communication is performed using specific AAL primitives.

When the Transport Network upper layer consists of GTP-U, the TNL SAP maps onto the GTP-U SAP through which communication is performed using generic primitives.

The choice of communication, specific or generic, through the TNL SAP is fixed by the Radio Network Layer control plane logic. This choice is based on the requirements placed by e.g. the RAB characteristics, the CN domain requesting the RAB establishment or other operator's choice.

7.3.2 ATM/AAL2 based Transport layer

7.3.2.1 General

When the Iu UP protocol layer uses the services of an ATM/AAL2 transport, it uses an established AAL2 connection for transferring frames between the peer TNL-SAPs at both end of the Iu User plane access points. The Transport Network Control Plane over Iu handles the signalling to establish and release the AAL2 call connections.

7.3.2.2 AAL2 Service Primitives used by the Iu UP protocol

AAL2 services and primitives used at the Service Access Point from the AAL2 layer are shown in the following table:

Table 3: AAL2 primitives and parameters

Primitive	Type	Parameters	Comments
SSSAR-UNITDATA	Request	SSSAR-INFO	
		SSSAR-UII	Not used (Note 1)
SSSAR-UNITDATA	Indication	SSSAR-INFO	
		SSSAR-UII	Not used (Note 1)

NOTE 1: The setting of this field is set to not used i.e. decimal value 26 according to [8].

The primitives of table 3 are the standard primitives of [5]. These primitives are intended to be used in the Iu UP.

7.3.3 GTP-U based Transport Layer

7.3.3.1 General

When the Iu UP protocol layer uses the services of a GTP-U transport, it uses an established GTP-U tunnel for transferring frames between the GTP-U tunnel endpoints at both end of the Iu User plane access points. The RANAP Control Plane signalling over Iu handles the signalling to establish and release the GTP-U tunnels.

7.3.3.2 Generic Service Primitives used by the Iu UP protocol

Generic primitives are used at the GTP-U SAP. They are shown in the following table:

Table 4: Generic primitives and parameters to and from GTP-U layer

Primitive	Type	Parameters	Comments
Iu-UP-UNITDATA	Request	Iu-UP-payload	
Iu-UP-UNITDATA	Indication	Iu-UP-payload	

8 Evolution of Iu UP Protocol

8.1 Principles for Protocol Evolution

8.1.1 Unknown field value

The Iu UP protocol may be evolved by taking into use field values that have been specified to be reserved for future use or have been specified as spare values. When a UP protocol entity receives an unknown field value, it can react differently depending whether the unknown value is reserved for future use or if it is a spare value. The following

principles are recommended for receiver reactions :

- If a spare value is used by the sender, but not understood by the receiver, there should be a default action for the receiver. This default action should be defined on a field basis.
- If a value that is reserved for future use is used by the sender, but not understood by the receiver, the value should be rejected by the receiver. This should be done by sending a Negative Acknowledgement to the peer entity, if possible. Otherwise an Error Event should be generated in order to inform the upper layers and the peer entity.
- A received Error Event message shall not trigger another Error Event message back to the sender, even though e.g. the Cause value in the received Error Event message would not be understood.

In the following the recommended actions of the receiver are handled field by field when an unknown field value is received.

PDU Type

Value range: {0-1 in use, 2-13 reserved for future use, 14 in use, 15 reserved for future use}.

Recommended action if reserved values used: Generate Error Event, i.e. the upper layers and the peer entity are informed about the error event with Cause : Unknown PDU Type.

FQC

Value range: {0-1 in use, 2-3 spare}.

Recommended action if spare values used: Ignore the field and pass it onwards.

ACK/NACK

Value range: {0-2 in use, 3 reserved}.

Proposed action if reserved values used: Generate an Error Event, i.e. the upper layers and the peer entity are informed about the error event with Cause : Unknown reserved value.

Procedure Indicator

Value range: {0-3 in use, 4-15 reserved}.

Recommended action if reserved values used: Generate an Error Event, i.e. the upper layers and the peer entity are informed about the error event with Cause : Unknown procedure

Cause Indicator

Value range: {0 reserved, 1, 16 in use, 2-15 and 17-255 spare}.

Recommended action if reserved values used: Generate Error Event, i.e. the upper layers and the peer entity are informed about the error event with Cause : Unknown reserved value.

Recommended action if spare values used: Ignore the field and pass it onwards.

8.1.2 Adding a new field to an existing frame

If there is a need to add a new field to an existing procedure, the following principles shall be applied:

- The PDU type defines the header mask. Therefore, a new field shall not be added to the header part of an existing frame and possible spare bits in the header shall not be taken into use since these would be violations of the header mask.
- The Procedure Indicator shall define the fields that should be in a control frame.
- There shall be only one Procedure Indicator for each procedure.
- If a new field needs to be introduced to an existing procedure (i.e. existing procedure that is defined in an existing UP version), the new field shall not be *added* to the payload part. Instead, the new field may be

introduced by placing it to a spare field in the payload part of the frame, if possible.

- However, if a new field needs to be introduced to an existing procedure, but spare fields(s) in the payload part cannot be used to introduce the new field, then a new procedure shall be created and hence a new Procedure Indicator value shall be allocated for the new procedure.
- To enable simple protocol evolution, when a new Procedure Indicator will be introduced, the new frame shall include both the new fields and the fields of the old frame.
- When an implementation receives an unknown Procedure Indicator it may use the Error Event message with Cause: Unknown procedure to report this. This indicates to the sender that the procedure was not understood and it may try with an older procedure.

8.1.3 Adding a new PDU type

In the future, the Iu UP protocol may evolve so that there is a need to add a new PDU type. The criteria for introducing a new PDU type could be e.g.:

- The Procedure Indicators may run out and there is a need to have more.
- There is a need to change the header mask, e.g. the Frame Number field may need to be increased or the CRC field needs to be modified.

While the PDU type 14 is reserved for future PDU type extensions, there may be 'subtypes' under PDU type 14 in the future and there also may be new procedures in these 'subtypes'.

Thus it has to be ensured that if the same Procedure Indicator value is used under several PDU types, it should be made clear e.g. in the Error Event cause element, which PDU type it concerns.

8.1.4 Protocol version handling

In the future, new versions of the Iu UP protocol may be introduced. A reason for a new version of the protocol could be, e.g.

- The earlier introduced new features or functions are required to be mandatory in the new version.
- Due to technical development, the new version of the protocol could be totally different (and incompatible) from the earlier version.

The following principles shall be applied to version handling of Iu UP protocol:

- It shall be possible to introduce additional modes of operation.
- It shall be possible to evolve the operation modes independently of each other.
- There shall be independent version numbers for each mode of operation.
- The mode of operation of an Iu UP protocol instance is decided by the CN, but the version of the mode shall be negotiated between the CN and UTRAN during RAB Assignment and Relocation Resource Allocation procedures.
- The version number of a UP operation mode may change or be unchanged between different releases.
- When the protocol is evolved it shall be made clear in the specification, which features belong to which versions.
- A new version may be an evolution (i.e. compatible) of the old version or the new version may be totally different from the old version.

Annex A (Informative): Illustration of usage of RFCI for AMR speech RAB

This annex contains information related to usage of RFCIs in the context of AMR speech RAB.

The following figure illustrates the RFCI allocation and flow throughout the UTRAN.

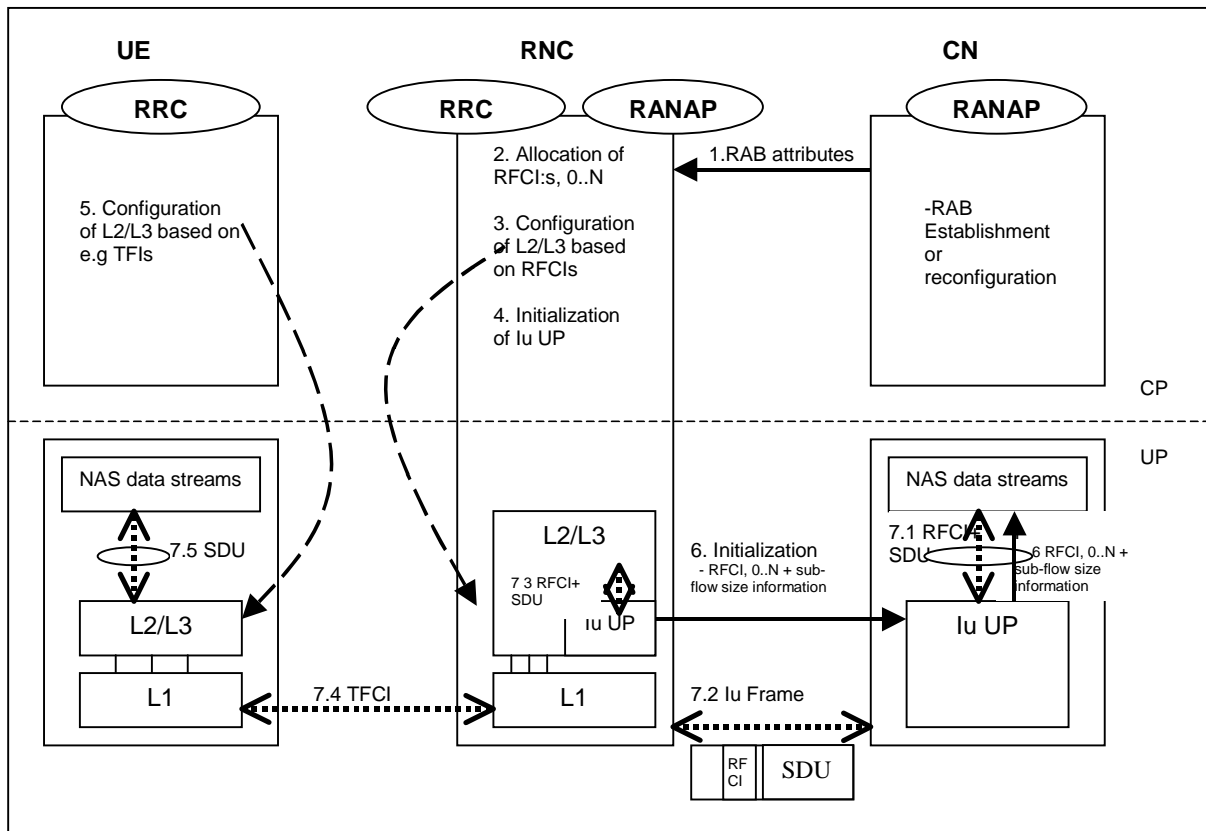


Figure A.1

1. **RAB Attributes:** at RAB establishment or reconfiguration, the SDU size information parameter is passed to UTRAN. The SDU information is organised per BER i.e. RAB sub Flow. For instance, 12.2 kbits/s AMR codec is passed as RAB sub flow 1 SDU size: 81 bits –class A bits-, RAB sub flow 2 SDU size: 103 –class B bits-, as RAB sub flow 3 SDU size: 60 –class C-, which makes one RAB sub Flow Combination. This is done for all rates (i.e. all codec modes, DTX also if included). The Iu UP is used in support mode for predefined SDU size.
2. **Allocation of RFCIs:** the RNC dynamically allocates an identification (RFCI) to each permitted/possible combinations it can offer. E.g. for 12.2 kbits/s, the RNC allocates RFCI 3 (according to the example table 2)
3. **Configuration of L2/3 based on RFCIs:** RFCIs are used to configure the L2/3. RLC is used transparently. MAC configures its co-ordinated DCHs with the RFCIs and associate one RFCI to one TFI
4. **Initialisation of Iu UP:** the RNC reports the permitted combinations it can offer to the transcoder using an inband Iu initialisation frame containing the RFCIs and associated RAB sub Flow sizes.
5. **Configuration of L2/3 based on e.g. TFIs:** idem as 3. L2/3 may use e.g. TFI to communicate with the Codec about the RAB sub-Flow structure of the SDU received or to be sent.
6. **RFCIs+ SDU size information:** the RFCIs and associated RAB sub Flow sizes are received within the Iu initialisation frame are passed to the Codec for configuration.
7. **Example of DL frame transfer:**
 - 7.1. The Codec encodes a 12.2 kbits/s frame. It sends down to the Iu UP and SDU with an associated RFCI equals to 3 (in this example)
 - 7.2. The Iu UP packs a frame with a header containing an RFCI set to value 3, and the payload made of the SDU received from the Codec.
 - 7.3. The Iu UP passes to L2/3, the Iu frame payload (the Codec SDU) and the RFCI. The L2/3 uses this RFCI to break the Iu frame onto the co-ordinated DCHs corresponding to the different bits protection classes. The corresponding TFI is selected.
 - 7.4. The radio frame is sent with the TFCI chosen by MAC
 - 7.5. The L2/3 receives the SDUs on the co-ordinated DCHs, combined them back and uses e.g. the TFCI to indicate to the codec the structure of the received frame.

The following table shows RAB sub-flow SDU sizes for a RAB with variable source rate as they are signalled in RAB assignment request in RANAP.

Table A.1: Example of SDU sizes for AMR with DTX

RAB sub-flows			Total size of bits/RAB sub-flows combination	Source rate
RAB sub-Flow 1	RAB sub-Flow 2	RAB sub-Flow 3		
39	56	0	95	Source rate 1
49	54	0	103	Source rate 2
55	63	0	118	Source rate 3
55	79	0	134	Source rate 4
61	87	0	148	Source rate 5
75	84	0	159	Source rate 6
65	99	40	204	Source rate 7
81	103	60	244	Source rate 8
39	0	0	39	Source rate 9
⋮	⋮	⋮	⋮	⋮
0	0	0	0	Source rate M

NOTE 1: In the table above the greyed area shows what is signalled in RANAP RAB establishment request.

NOTE 2: In the table above the number of sub-flows is informative only.

SRNC allocates one or more possible/available RAB sub-flow combination(s) and generates RAB sub-flow combination set. RAB sub-flow combination number is dynamically generated by SRNC. This RAB sub-flow combination set is signalled towards CN with user plane signalling as described in [1]. The signalling towards UE is to be defined by TSG-RAN WG2.

RAB sub-flow combination set

A RAB sub-flow combination indicator, RFCI, indicates which RAB sub flow combination will be used for the Iu user frames. In the communication phase the RFCI is included in the user frame, and the RFCI state the structure of the user frame.

Table A.2 below exemplifies the allocation of 4 different RAB sub-flows combinations for 3 sub-flows and generating of RAB sub-flows combination set.

Table A.2: Example of Allocation of RAB sub-flows combination indicator

	RFCI (RAB sub-Flow Combination Indicator)	RAB sub-Flow 1	RAB sub-flow 2	RAB sub-flow 3	Total	Source rate
RAB sub-flows combination set	0	0	0	0	0	Source rate 1
	1	39	0	0	39	Source rate 2
	2	39	56	0	95	Source rate 3
	3	81	103	60	244	Source rate 4

NOTE: In the table above the greyed area shows the part that is sent in the initialisation procedure in Iu UP. This is what constitutes the RAB subflow combination set.

Annex B (Informative): Illustration of protocol states in the Iu UP

This annex contains information related to possible protocol states for operation of the Iu UP. This annex does not constraint implementation and is for illustration purposes only.

The state model is common for both ends of the Iu UP so that the protocol machines are operating symmetrically. This approach is taken to facilitate state description for all cases including TFO and TrFO.

Note: Primitive Iu-UP-CONFIG-Req is used by upper layers to configure the Iu UP protocol layer. It is used in this annex for illustrative purposes and therefore it is not defined in chapter 7.

B.1 Protocol state model for transparent mode

The following figure illustrates the state model for transparent mode Iu UP instances. A transparent mode instance can be in one of following states.

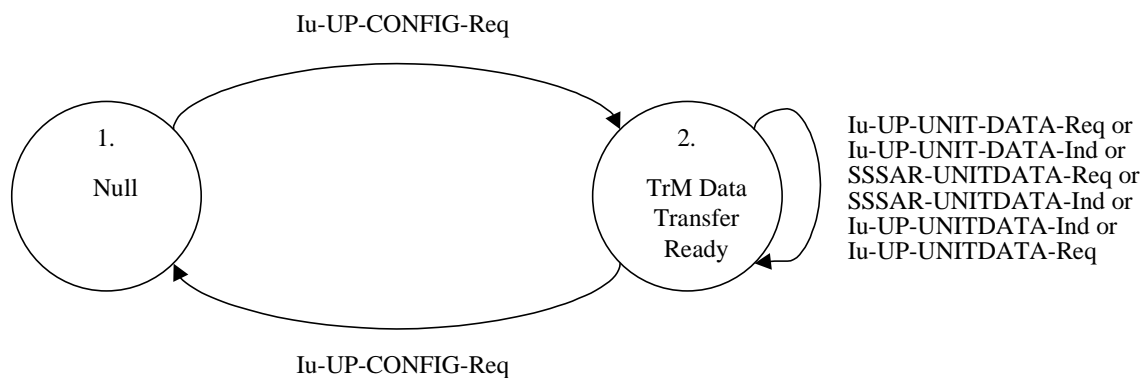


Figure: Protocol state model for transparent mode.

B.1.1 Null State

In the null state the Iu UP instance does not exist and therefore it is not possible to transfer any data through it.

Upon reception of a Iu-UP-CONFIG-Req from higher layer the Iu UP instance is created and transparent mode data transfer ready state is entered. The mode information is received either through RANAP signalling or directly in the CN node. In the Iu-UP-CONFIG-Req e.g. the following information will be indicated:

- Transparent mode.

B.1.2 Transparent Mode Data Transfer Ready State

In the transparent mode data transfer ready state, transparent mode data can be exchanged between the entities.

Upon reception of Iu-UP-CONFIG-Req indicating release from higher layer, the Iu UP instance is terminated and the null state is entered.

B.2 Protocol state model for support mode for predefined SDU sizes

The following figure illustrates the state model for support mode Iu UP instances. A support mode instance can be in one of the following states.

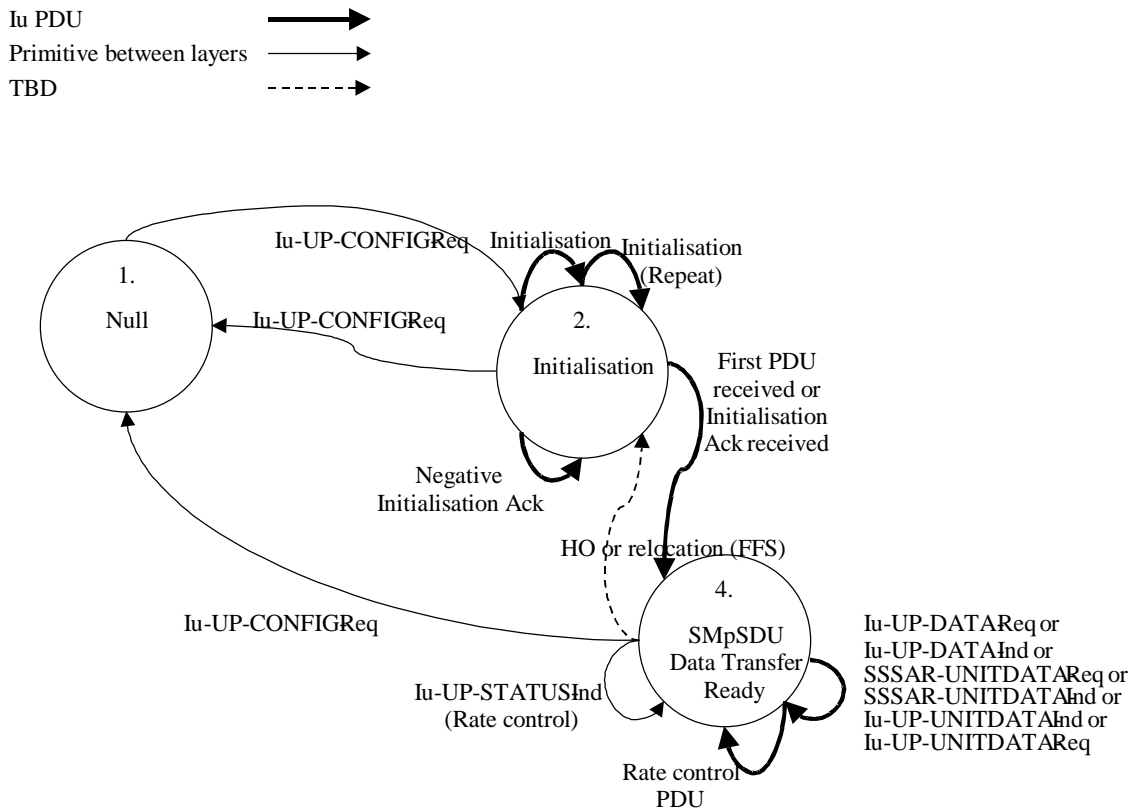


Figure: Protocol state model for support mode.

B.2.1 Null State

In the null state the Iu UP instance does not exist and therefore it is not possible to transfer any data through it.

Upon reception of a *Iu-UP-CONFIG-Req* from higher layer the Iu UP instance is created and initialisation state is entered. In the *Iu-UP-CONFIG-Req* e.g. the following information could be indicated:

- Support mode for predefined SDU sizes;
- Time alignment (FFS);
- Indication of delivery of erroneous SDUs;
- Periodicity.

B.2.2 Initialisation State

In the initialisation state the instance exchanges initialisation information with its peer Iu UP instance.

Upon reception of *Iu-UP-CONFIG-Req* indicating release from higher layer, the Iu UP instance is terminated and the null state is entered.

Upon sending or receiving of an initialisation frame the Iu UP instance remains in the Initialisation state. The sending side starts a supervision timer T_{INIT} . The receiving side acknowledges the initialisation frame with a positive acknowledgement or a negative acknowledgement. The Iu UP remains in initialisation state.

Upon reception of an initialisation acknowledgement frame, the supervision timer T_{INIT} is stopped and the Iu UP instance enters SMpSDU data transfer ready state.

Upon reception of a first PDU after sending a positive acknowledgement, the Iu UP instance enters SMpSDU data transfer ready state.

Upon reception of an initialisation negative acknowledgement frame (INIT NACK) initialisation frame can be repeated n times.

If after n repetitions, the initialisation procedure is unsuccessfully terminated (due to n negative acknowledgements or timer expires) the Error event procedure is used to report the Initialisation failure and the Iu UP instance remains in the initialisation state.

B.2.3 Support Mode Data Transfer Ready State

In the support mode data transfer ready state, support mode data can be exchanged between the peer Iu UP instances.

Upon reception of Iu-UP-DATA-Request from the upper layer or SSSAR-UNITDATA-Indication or Iu-UP-UNITDATA-Indication from TNL layer, appropriate user data transfer procedures are performed. Iu UP instance remains in the SMpSDU data transfer ready state.

Upon sending of Iu-UP-DATA- Indication or SSSAR-UNITDATA-Request or Iu-UP-UNITDATA-Request the Iu UP instance remains in the SMpSDU data transfer ready state.

Upon sending or receiving of a rate control PDU the Iu UP instance remains in the SMpSDU data transfer ready state.

Upon sending of a Iu-UP-STATUS-Indication (rate control) the Iu UP instance remains in the SMpSDU data transfer ready state.

Upon reception of Iu-UP-CONFIG-Req from higher layer the Iu UP instance is terminated and the null state is entered.

Upon detection of a protocol fault, Iu-UP-STATUS-Indication is sent to upper layer an error event frame may be sent over Iu UP.

TBD event (FFS): In case of handover or relocation, initialisation procedures may have to be performed and Iu UP instance may have to enter the initialisation state.

Annex C (Informative): Open Issues of the Iu UP

This annex contains information related to open issues left in the Iu UP protocol.

- 1) Handling of Abnormal Event and Error Handling;
- 2) Timing over Iu, including Time Alignment.

Annex D (informative): Change History

Change history					
TSG RAN#	Version	CR	Tdoc RAN	New Version	Subject/Comment
RAN_05	-	-	-	3.0.0	Approved at TSG RAN #5 and placed under Change Control
RAN_06	3.0.0	-	RP-99748	3.1.0	Approved at TSG RAN #6
RAN_06	3.0.0	-	RP-99749	3.1.0	Approved at TSG RAN #6
RAN_06	3.0.0	-	RP-99750	3.1.0	Approved at TSG RAN #6

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History

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