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ETSI

European Telecommunications Standards Institute

ETSI Secretariat

Postal address: F-06921 Sophia Antipolis CEDEX - FRANCE
Office address: 650 Route des Lucioles - Sophia Antipolis - Valbonne - FRANCE
X.400: c=fr, a=atlas, p=etsi, s=secretariat - **Internet:** secretariat@etsi.fr

Tel.: +33 92 94 42 00 - Fax: +33 93 65 47 16

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Foreword

This European Telecommunication Standard (ETS) has been produced by the Radio Equipment and Systems (RES) Technical Committee of the European Telecommunications Standards Institute (ETSI).

This ETS is a multi-part standard and intended to comprise 11 Parts:

Part 1:	**"General network design".**
Part 2:	"Air Interface (AI)".
Part 3:	"Inter-working" (DE/RES-06004-3).
Part 4:	"Gateways" (DE/RES-06004-4).
Part 5:	"Terminal equipment interface" (DE/RES-06004-5).
Part 6:	"Line connected stations" (DE/RES-06004-6).
Part 7:	"Security" (DE/RES-06004-7).
Part 8:	"Management services", (DE/RES-06004-8).
Part 9:	"Performance objectives" (DE/RES-06004-9).
Part 10:	“SDL Model of the Air Interface” (DE/RES-06004-10).
Part11:	“PICS Proforma” (DE/RES-06004-11).

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1 Scope

This ETS applies to the TETRA Packet Data Optimised (PDO) radio air interface standard.

It establishes the TETRA general network design of the TETRA PDO standard. It specifies the technical realisation of the Connection Oriented Network Protocol (CONP) and Specific Connectionless Network Protocol (SCLNP) to provide the services on the network layer of the TETRA radio air interface.

It defines the packet mode reference points for the Mobile Station (MS), Line Station (LS) and Network Management Unit (NMU).

It specifies a model of the air interface protocol stack where the different functions of layers and sub-layers are described.

This ETS defines the registration, authentication, mode change signalling and an overview of the functions of the Mobile link Entity (MLE) including roaming and migrating.

It specifies the TETRA addressing and identities and their organisation in groups corresponding to the different functions.

The air interface protocol services, functions and interconnection protocol stacks are listed based on ISO/IEC 8473 [11] and ISO/IEC 8208 [9].

This ETS also gives guidance on priority in annex A, and Quality of Service (QoS) in annex B.

2 Normative references

This ETS incorporates by dated and undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this ETS only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

[1] CCITT Recommendation E.163 (1988): "Numbering Plan for the International Telephone Service".

[2] CCITT Recommendation E.164 (1988): "Numbering Plan for the ISDN Era".

[3] CCITT Recommendation E.212 (1988): "Identification Plan for Land Mobile Stations".

[4] CCITT Recommendation E.213 (1988): "Telephone and ISDN Numbering Plan for Land Mobile Stations in Public Land Mobile Networks (PLMN)".

[5] CCITT Recommendation X.121 (1988): "International Numbering Plan for Public Data Networks".

[6] CCITT Recommendation X.213: "Network Service Definition for Open System Interconnection for CCITT applications".

[7] ETR 086, Parts 1 to 3: "Radio Equipment and Systems (RES); Trans-European Trunked Radio (TETRA); Technical requirements specification".

[8] ETR 101: "European digital cellular telecommunications system (Phase 2); Quality of Service (GSM 02.08) ".

[9] ISO/IEC 8208: "Information technology - Data communications - X.25 Packet Layer Protocol for Data Terminal Equipment".

[10] ISO/IEC 8348: "Information technology - Open Systems Interconnection - Network Service Definition".

[11] ISO/IEC 8473: "Information technology - Protocol for providing the connectionless-mode network service: Protocol specification".

[12] ISO/IEC 8878: "Information technology - Telecommunications and information exchange between systems - Use of X.25 to provide the OSI Connection-mode Network Service".

[13] ECMA TR/44: "An architectural framework for private networks".

[14] ISO 8648: "Information processing systems - Open Systems Interconnection - Internal organisation of the Network Layer".

[15] ETS 300 392-1: "Radio Equipment and Systems (RES); Trans-European Trunked Radio (TETRA); Voice plus Data (V+D); Part 1: General network design".

[16] ETS 300 392-2: "Radio Equipment and Systems (RES); Trans-European Trunked Radio (TETRA); Voice plus Data (V+D); Part 2: Air Interface (AI)".

[17] ETS 300 393-2: "Radio Equipment and Systems (RES); Trans-European Trunked Radio (TETRA); Packet Data Optimized (PDO); Part 2: Air Interface (AI)".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of this ETS, the following definitions apply:

announced cell re-selection: Cell re-selection where MS-MLE informs the Switching and Management Infrastructure (SwMI) both in the old cell (leaving cell) and in the new cell (arriving cell) that cell change is performed. There are two types of announced cell re-selection relevant to PDO:

- type 2:
  - the MS-MLE knows the new cell before changing to it, but does not know the channel allocation on the new cell in advance;
- type 3:
  - the MS-MLE does not know the new cell before changing to it. The old cell is only informed by the MS-MLE that it want to change cell.

attached: A MS is said to be attached to a cell when the MS is registered on the cell. The MS may be in idle mode (i.e. not actively processing a transaction) or in traffic mode (i.e. actively processing a transaction in reception and/or in transmission). It is the Mobility Management (MM) which decides when a MS is said to be attached.

authentication: A function which allows the infrastructure to check that a MS is valid to operate in the system or which allows a MS to check that the infrastructure is valid to operate in.

background measurement: Measurement performed by the lower layers while maintaining current service toward the service users, i.e. MS-MLE.

bearer service: A type of telecommunication service that provides the capability for the transmission of signals between user-network interfaces.

bundle: A collection of Inter-TETRA Connections (ITCs) which utilises the same scenario over the Inter-System Interface (ISI).

cell re-selection: The act of changing the serving cell from an old cell to a new cell. The cell re-selection is performed by procedures located in MLE and in the MAC. When the re-selection is made and possible registration is performed, the MS is said to be attached to the cell.

cell-id: Characterized as the channel number of the main carrier on the cell.

constant delay service: A Network Service (NS) where the transit delay of the Network Service Data Units (NSDUs) between the network connection endpoints remains constant for the duration of the connection.

direct set-up signalling: A signalling procedure where immediate communication can take place between the calling and the called users without the alerting process and without an explicit response from the called user that he has answered.

external data transactions: A data transaction where only one of the parties, either the source or the destination, is in a TETRA network. The other party is in a non-TETRA network.

foreground measurement: Measurements performed by the lower layers while employing the whole capacity, e.g. no concurrent service is maintained.

functional group: A set of functions which may be needed in TETRA Land Mobile Network (TLMN) access arrangements. In a particular access arrangement, specific functions in a function group may but need not be present.

NOTE 1: Specific functions in a functional group may be performed in one or more pieces of equipment.

Grade of Service (GoS): Refers to certain traffic engineering variables which may be used to provide a measure of the adequacy of a NS under specified conditions.

home network: A network where a subscriber has a direct subscription. This means that a subscriber identity has been allocated in advance of any network access.

initial cell selection: The act of choosing a first serving cell to register in. The initial cell selection is performed by procedures located in MLE and in the Medium Access Control (MAC). When the cell selection is made and possible registration is performed, the MS is said to be attached to the cell.

internal data transactions: A data transaction where both the source (the calling party) and the destination (the called party) both lie in a TETRA network domain.

interrupted measurement: Measurements performed by the lower layers interrupting current services.

inter-TETRA data transaction: A data transaction where source and destination are in different TETRA networks.

Inter-TETRA Connections (ITCs): ITCs are provided by the InterVening Networks (IVNs) at the ISI and terminate at interfaces at C reference points. They may be grouped into bundles, each connecting to a specific type of IVN. Bundles, in turn, may comprise more than one interface between the SwMI and the IVN.

Inter-TETRA Links (ITLs): ITLs are provided by the Intervening Network Adaption (INA) and terminate at interfaces at the Q reference point in the ISI. An ITL is characterised by its ITL identity which corresponds to the instance of the Q reference point. The ITL comprises 1 DQ channel and a number of UQ channels each of them having certain channel characteristics.

InterVening Network (IVN): IVN is the network which is used to interconnect two TETRA SwMIs at the ISI. The network shall either be of the type:

- dedicated transmission system e.g. PCM;
- permanent circuit switched e.g. PSTN and ISDN;
- on-demand circuit switched e.g. PSTN and ISDN.

Inter-Working Unit (IWU): One or more items of equipment or a part of an item of equipment whose operation provides a network relay function, i.e. a real system that receives data from one correspondent network entity and forwards it to another correspondent network entity. Such equipment may be integrated into a real sub-network which is being interconnected.

intra-TETRA data transaction: A data transaction where both source and destination are in the same TETRA network sub-domain.

Location Area (LA): The area within radio coverage of a BS or group of BSs within which a MS is allowed to operate.

LXX-SAP: Any or all of the following Service Access Points (SAPs): LMM-SAP, LCO-SAP, LSCL-SAP.

migration: The act of changing to a new LA in a network, either with different Mobile Network Code (MNC) and/or Mobile Country Code (MCC) where the user does not have subscription, i.e. Individual TETRA Subscriber Identity (ITSI) for that network.

Mobile Network Identity (MNI): The identity that is broadcast by all TETRA BSs to uniquely identify the network.

Mobile Station (MS): A physical grouping that contains all of the mobile equipment that is used to obtain TETRA services. By definition, a MS contains at least one Mobile Radio Stack (MRS).

monitoring: The act of measuring the power of neighbour cells and calculating the path loss parameter C2 based upon information on neighbour cells broadcast by the serving cell (see ETS 300 393-2 [17], clause 10).

network: A collection of subscriber terminals interconnected through telecommunications devices.

Network SAP address (NSAP address): Addresses that belong to other (non-TETRA) addressing domains. These other domains include Integrated Services Digital Network (ISDN), Public Switched Telephone Network (PSTN) and Packet Data Network (PDN) domains.

nominal radio coverage area: The nominal radio coverage area is the geographical area over which the radio transmission performance exceeds a defined threshold.

NOTE 2: The boundary of the nominal radio coverage area is defined by a Bit Error Ratio (BER) contour as defined in ETS 300 393-2 [17], clause 6.

Quality of Service (QoS): Refers to certain characteristics of a Network Connection (NC) as observed between the NC endpoints which are attributable solely to the Network Service (NS) provider.

R0: The reference point within the Mobile Terminating Unit (MTU) that corresponds to the top of the MRS not including the routing. R0 acts as the NS boundary and exists in all MTUs.

R1: The reference point between packet mode Terminal Equipment (TE2) and the MTU (MTU2). There may be several alternative interface protocols at R1, including existing packet mode standards.

R2: The reference point at the TETRA air interface.

R4: The reference point for a character mode TE (TE3) connected to a Packet Assembler and Dis-assembler (PAD). There may be several alternative interface protocols at R4, including existing PDN standards.

R5: The reference point between the NMU and the TETRA network.

R6: The reference point between one TETRA network and another TETRA network.

R7: The reference point between one TETRA network and a non-TETRA packet data network

ranking: A procedural method of listing cells in descending order from the most suitable for communication to the least suitable for communication. The method comprises multiple calculations of C4 parameters and C3 parameters, defined in ETS 300 393-2 [17], clause 10. As inputs to the ranking procedure are:

- outputs from the monitor process (e.g. C2 parameters);

- outputs from the scanning process (e.g. C1 parameters);

- network parameters received in the MLE broadcast.

reference configuration: A conceptual configuration useful in identifying various possible physical access arrangements to a TLMN. Two concepts are used in defining reference configurations, i.e. reference points and functional groups.

NOTE 3: Physical interfaces that do not correspond to a reference point (e.g. transmission line interfaces) are not described in this ETS.

reference point: A conceptual point dividing functional groups. In a specific access arrangement, a reference point may correspond to a physical interface between pieces of equipment, or there need not be any physical interface corresponding to the reference point.

registration: The act of becoming an active and recognised TETRA user by exchange of ITSI with the SwMI.

relaying: This function enables a network entity to forward information received from one correspondent network entity to another correspondent network entity.

roaming: The act of changing LA within a network of the same MNC/MCC, and for which the user has a valid registration (i.e. ITSI).

routing: This function determines an appropriate route between network addresses.

scanning: The act of measuring the power of neighbour cells and calculate the path loss parameter C1 based upon the information on the neighbour cells broadcast by the neighbour cells themselves (see ETS 300 393-2 [17], clause 10).

Search Area (SA): An area comprising all LAs where a MS may search for service. The SA is considered to be defined at subscription. Some means of changing the SA during operation could be considered. However, the method of loading SA into the MS and to change it accordingly is outside the scope of this ETS.

segmentation: The act of generating two or more derived Packet Data Units (PDUs) from an initial or derived PDU.

service coverage area: The percentage of the nominal radio coverage area over which a specified grade of service and quality of service is maintained for a given service type.

NOTE 4: A particular service coverage area is specific to one service and one network.

serving cell: The cell that is currently proving service to the MS.

Short Subscriber Identity (SSI): The network specific portion of a TETRA Subscriber Identity (TSI). A SSI is only unique within one TETRA sub-domain (one TETRA network).

NOTE 5: There are four different types of SSI (refer to subclause 6.2.3):

a) Individual SSI (ISSI);
b) Group SSI (GSSI);
c) Alias SSI (ASSI);
d) Un-exchanged SSI (USSI).

sub-network: A collection of equipment and physical media which forms an autonomous whole and which can be used to interconnect real systems for purpose of communication. This ETS makes use of standard terms used in the International Organization for Standardization (ISO), in particular:

- logical channel;
- end system;
- access point;
- service primitive;
- Data Terminal Equipment (DTE).

surveillance: The process of monitoring the quality of the radio link to the serving cell.

TETRA Equipment Identity (TEI): An electronic serial number that is permanently embedded in the TETRA equipment. A TEI is embedded in both MSs (in the MTU) and in LSs (in the Network Termination (NT)).

TETRA Management Identity (TMI): The network address that allows the operator to address a particular MT or NT. TMIs are assigned to a particular piece of equipment by the network operator. TMIs are unique in all TETRA networks.

NOTE 6: The management entity has no functionality defined in this ETS.

TETRA Subscriber Identity (TSI): A global TETRA network address that is used to identify an individual or a group subscriber within the domain of all TETRA networks. A valid TSI refers to a TSI that has been allocated by the network where it is being used (see figure 18 for addressing domain).

TLC-SAP: Management SAP. The way of modelling layer-to-layer communication for management and control purpose.

unannounced cell re-selection: Cell re-selection where the MS-MLE does not inform the old cell (leaving cell) that it intend to change to a new cell. Only the new cell (arriving cell) is informed about the MS-MLE.

undeclared cell re-selection: Cell re-selection where the MS-MLE does not inform the old cell (leaving cell) nor the new cell (arriving cell) that cell change is performed.

variable delay service: A NS where the transit delay of the NSDUs between the Network Connection (NC) endpoints does not remain constant for the duration of the connection.

visited network: A network where a subscriber has an indirect subscription. This means that a valid subscriber identity is only allocated as part of the first network access.

3.2 Symbols

For the purposes of this ETS, the following symbol applies:

>> Possible physical interfaces.

3.3 Abbreviations

For the purposes of this ETS, the following abbreviations apply:

AI-n	Air Interface layer n
AP1	Access Point for bearer services at the S reference point
AP2	Access Point for bearer services at the R reference point
AP3	Access Point for teleservices
AS	Area Selection
ASSI	Alias Short Subscriber Identity
ATSI	Alias TETRA Subscriber Identity
BS	Base Station or Base Station (Cell)
CL	ConnectionLess
CO	Connection Oriented
COLP	COnnected Line identification Presentation
CONP	Connection Oriented Network Protocol
DSD	Destination Short Data
DSDA	Destination Short Data Agent
DSE	Dialogue Service Element
ESN	Electronic Serial Number
FAC	Final Assembly Code
GFT	Generic Functional Transport
GoS	Grade of Service
GSM	Global System for Mobile communication
GSSI	Group Short Subscriber Identity
GTSI	Group TETRA Subscriber Identity
IGSD	Incoming Gateway Short Data
INA	Intervening Network Adaption
ISD	Inter-system Short Data
ISDN	Integrated Services Digital Network
ISI	Inter-System Interface
ISSI	Individual Short Subscriber Identity
ITC	Inter-TETRA Connection
ITL	Inter-TETRA Links
ITSI	Individual TETRA Subscriber Identity
IVN	InterVening Network
LE	Late Entry
LLC	Logical Link Control
LLME	Lower Layer Management Entity
LMN	Land Mobile Network
LS	Line Station or Line-connected Station
MAC	Medium Access Control
MCC	Mobile Country Code
MLE	Mobile Link Entity
MM	Mobility Management
MNC	Mobile Network Code
MNI	Mobile Network Identity
MS	Mobile Station
MT	Mobile Termination (short form for MTU)
MT0	Mobile Termination type 0
MT2	Mobile Termination type 2
MTU	Mobile Termination Unit
NC	Network Connection
NS	Network Service
NSAP	Network Service Access Point
NSDU	Network Service Data Unit
NT	Network Termination
OGSD	Outgoing Gateway Short Data
OSD	Originating Short Data
OSDA	Originating Short Data Agent
OSI	Open Systems Interconnect
PC	Priority Call or Protocol Control
PDN	Packet Data Network

PDU	Protocol Data Unit
PPC	Pre-emptive Priority Call
PSTN	Public Switched Telephone Network
PTN	Private Telephonic Network
PVC	Permanent Virtual Circuit
QoS	Quality of Service
QSIG	Q interface Signalling protocol
R & R	Routing and Relaying
ROSE	Remote Operating Service Element
R_T	TETRA R reference point
SA	Search Area
SAP	Service Access Point
SCLNP	Specific ConnectionLess Network Protocol
SDP	Short Data Protocol
SDS	Short Data Service
SDU	Service Data Unit
SIM	Subscriber Identity Module
SMI	Short Management Identity
SNACP	Sub-Network Access Protocol
SNAF	Sub-Network Access Functions
SNDCP	Sub-Network Dependant Protocol
SNICP	Sub-Network Independent Protocol
S_T	TETRA S reference point
SwMI	TETRA Switching and Management Infrastructure
TAC	Type Approval Code
TA_T	TETRA Terminal Adapting functions
TC	Transfer of Control
TE	Terminal Equipment
TE1	TE presenting an ISDN interface
TE2	TE presenting a TETRA interface
TEI	TETRA Equipment Identity
TETRA	Trans-European Trunked RAdio
TL	Transmission Line
TLC1	TETRA Link layer Control No. 1
TMI	TETRA Management Identity
TN	Transit Network
TNSDS	Tetra Network Short Data Service
T_T	TETRA T reference point
Ud	TETRA Direct Mode air interface
Um	TETRA air interface
UPT	Universal Personal Telecommunications
USSI	Un-exchanged Short Subscriber Identity
V+D	Voice Plus Data
V.24T	Physical Layer Protocol over the R_T reference point
(V)ASSI	Visiting Short Subscriber Alias Identity or Visitor ASSI
(V)ATSI	Visiting TETRA Subscriber Alias Identity or Visitor ATSI
VC	Virtual Call
(V)GSSI	Visiting Short Subscriber Group Identity or Visitor GSSI
(V)GTSI	Visiting TETRA Subscriber Group Identity or Visitor GTSI

4 Packet mode reference points

4.1 Introduction

This clause gives the reference points for the TETRA PDO network, the MSs, the LSs and the NMU.

A set of examples of overall TETRA network configurations are described, together with all possible arrangements of the MS and the LS.

4.2 Physical interfaces

The physical interfaces for a TETRA PDO system are shown in figure 1. In this model each box represents a separate item of equipment (or group of equipment). Two important boundaries are shown in this diagram:

a) the Radio Packet Data Infrastructure (RPDI) boundary which shall correspond to the physical boundary of the infrastructure (e.g. the air interface);

b) the Radio Packet Data Network (RPDN) boundary which shall correspond to the network service boundary. The RPDN shall include a part of every MS.

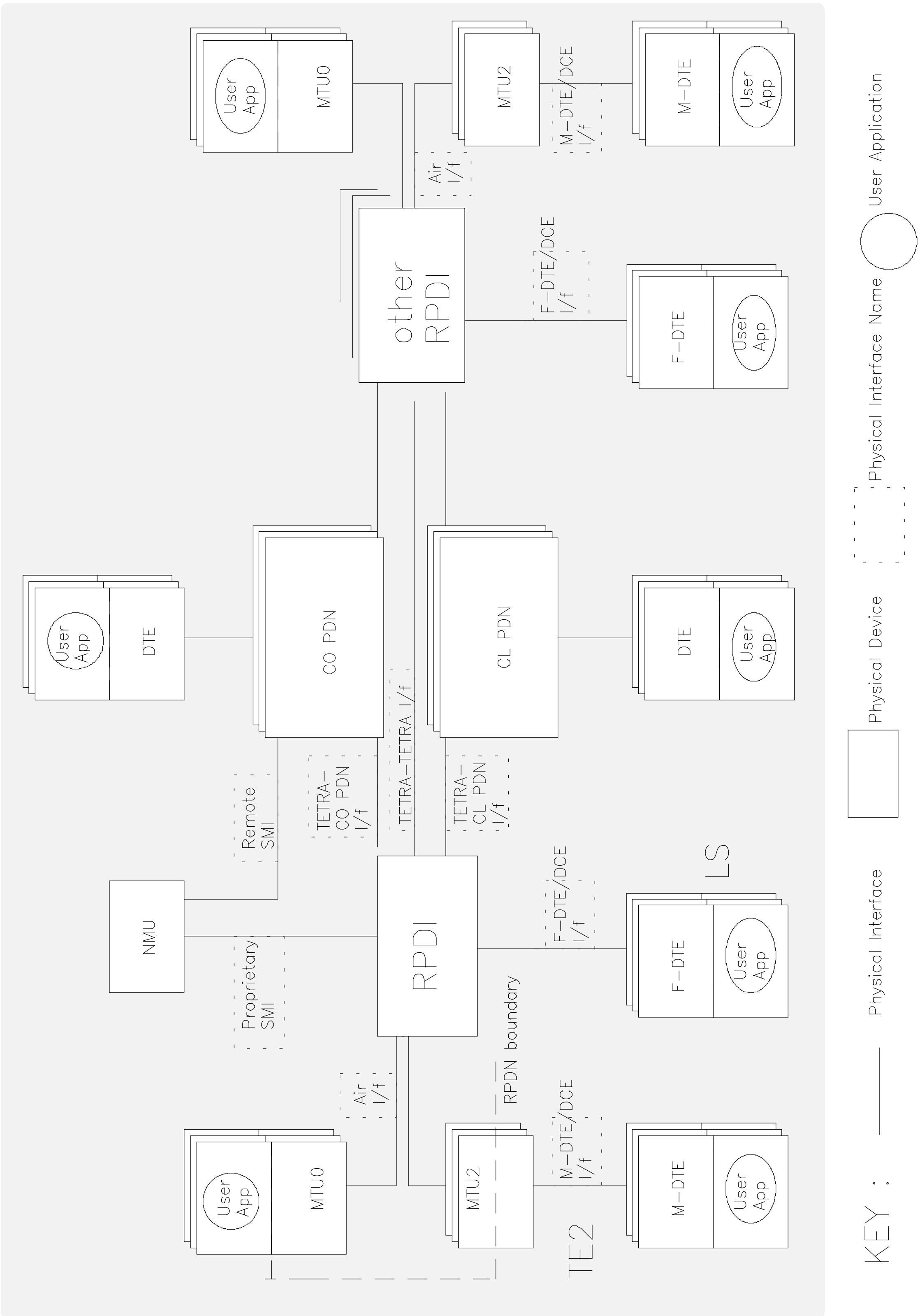


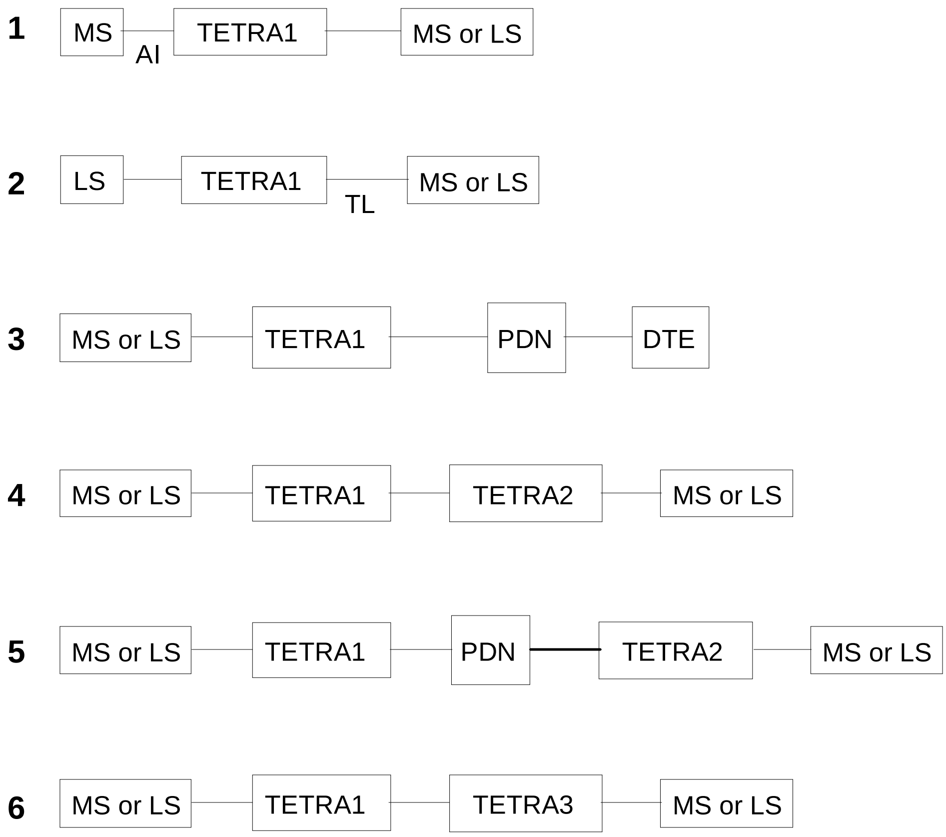
Figure 1: Physical interfaces reference model

4.3 Configurations

Figure 2 gives the basic configurations, figure 3 gives the specific configuration and figure 4 the NMU configuration. The PDN is assumed to handle connection and connectionless procedures.

4.3.1 Basic configurations

The different cases showing basic configurations are outlined in figure 2.



MS	Mobile Station
LS	Line Station
TL	Transmission Line
AI	Air Interface
DTE	Data Terminal Equipment
PDN	Public Data Network

TETRA1 and TETRA2 are PDO networks
TETRA3 is a Voice and Data network

Figure 2: Basic configurations

Case 1: a MS may be connected to another MS or to a LS through a TETRA network;

Case 2: a LS may be connected through the TETRA network to a MS or to another LS;

Case 3: a LS or MS may be connected through a TETRA network and one PDN to a fixed DTE;

Case 4: a MS or LS may be connected through two TETRA networks to another MS or LS;

Case 5: a MS or LS may be connected to a TETRA network interconnected to another TETRA packet via a PDN;

Case 6: a MS or LS may be connected through a TETRA PDO network and a TETRA V+D network to another MS or LS.

4.3.2 Specific configuration

A character mode LS shall be connected to a PAD in the TETRA network to a MS or LS (see figure 3).

Figure 3: Specific configuration

4.3.3 NMU configuration

The NMU configuration shall be connected to one or more TETRA networks. One or more of the connections may be achieved through a PDN (see figure 4).

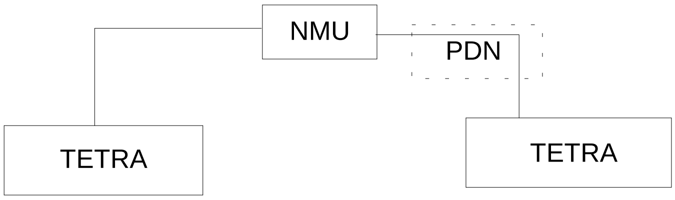


Figure 4: NMU configuration

4.4 Reference points

4.4.1 MS reference points

Figure 5 shows the alternative configurations for a MS. The reference points are shown for each configuration.

These configurations show a family of different MTUs (MTU0, MTU2 etc.). Each MTU shall be a physical entity, that contains all of the air interface stack. The TE shall support the application, the Man Machine Interface (MMI) to the user and the interface with the MTU. The MTU shall support the functions specific to the TETRA air interface and the interface to the terminal equipment.

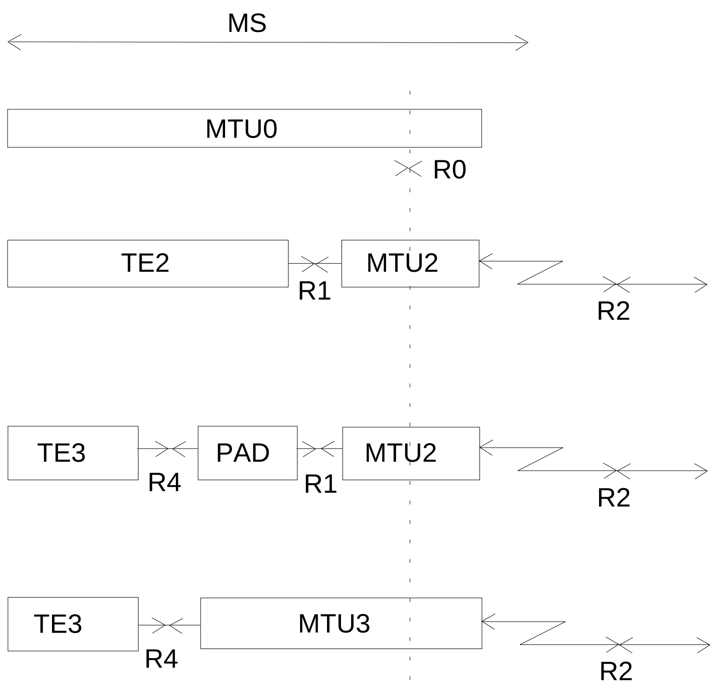
R0 shall be a reference point within the MTU. It shall correspond to the top of the MRS not including the routing. R0 shall be the network service boundary, and shall exist in all MTUs.

R1 shall be a reference point between packet mode TE (TE2) and the MTU2. There may be several alternative interface protocols at R1, including existing packet mode standards.

R2 shall be the reference point at the TETRA air interface.

R4 shall be the reference point for a character mode TE (TE3) connected to a PAD. There may be several alternative interface protocols at R4, including existing PDN standards.

The PAD may be a separate unit or may be physically integrated in the MTU, this integrated PAD is labelled MTU3.

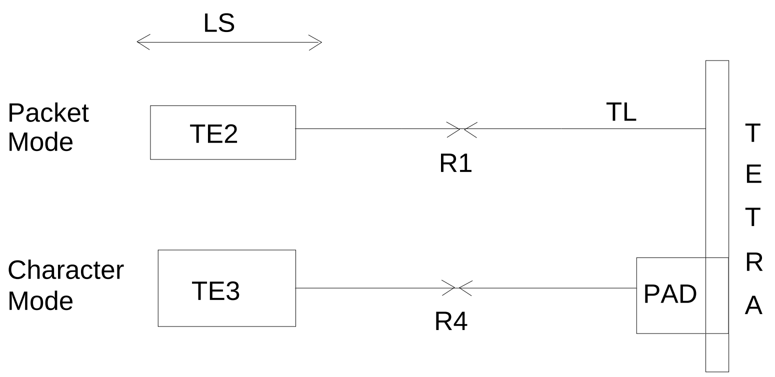


TE=	Terminal Equipment;
MTU=	Mobile Termination Unit;
RO/R1/R2/R4=	Reference points.

Figure 5: MS reference points

4.4.2 LS reference points

Figure 6 shows the LS reference point R1 for packet mode LSs. For character mode terminal the connection can be made via a PAD through the R4 reference point. For LSs both the R1 and the R4 interfaces should use existing PDN standards.



TL= Transmission Line

PAD= Packet Assembler/Disassembler

R1/R4= reference points

Figure 6: LS reference points

4.4.3 NMU reference point

Figure 7 shows R5 which shall be the reference point between the NMU and the TETRA network.

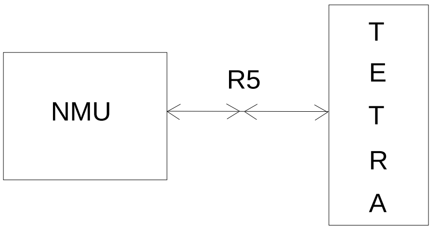


Figure 7: NMU reference point

4.4.4 TETRA to TETRA reference point

Figure 8 shows R6 which shall be the reference point between one TETRA network and another TETRA network.

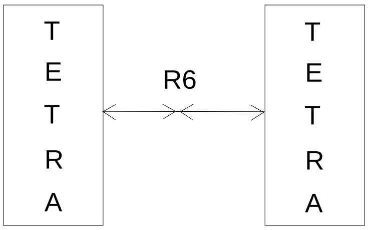


Figure 8: TETRA-to-TETRA reference point

Figure 9 shows the more general case of reference point R6, where the two TETRA networks are connected via a transparent transit network. R6 shall be the reference point between one TETRA network and the transparent transit network.

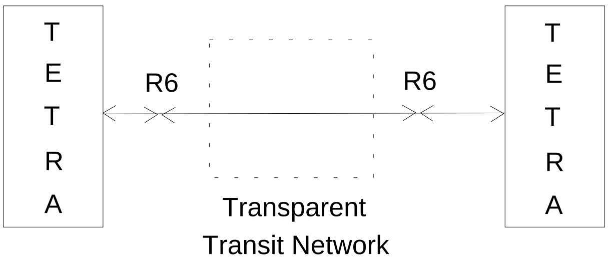


Figure 9: TETRA-to-TETRA reference point

4.4.5 TETRA to non-TETRA reference point

Figure 10 shows R7 which shall be the reference point between one TETRA network and a non-TETRA packet data network.

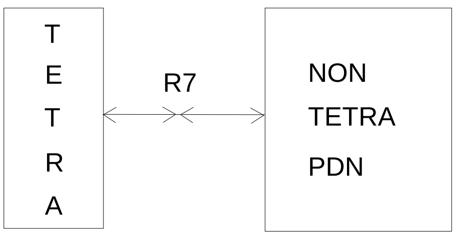


Figure 10: TETRA-to-non-TETRA reference point

4.5 Protocol stacks

4.5.1 Protocol stacks at R1 reference point

The protocol stacks (see figure 11) at the R1 interface shall be for operation over a line connection. These may be used for the interface between a TE2 and a MTU2, or to interface a packet mode LS.

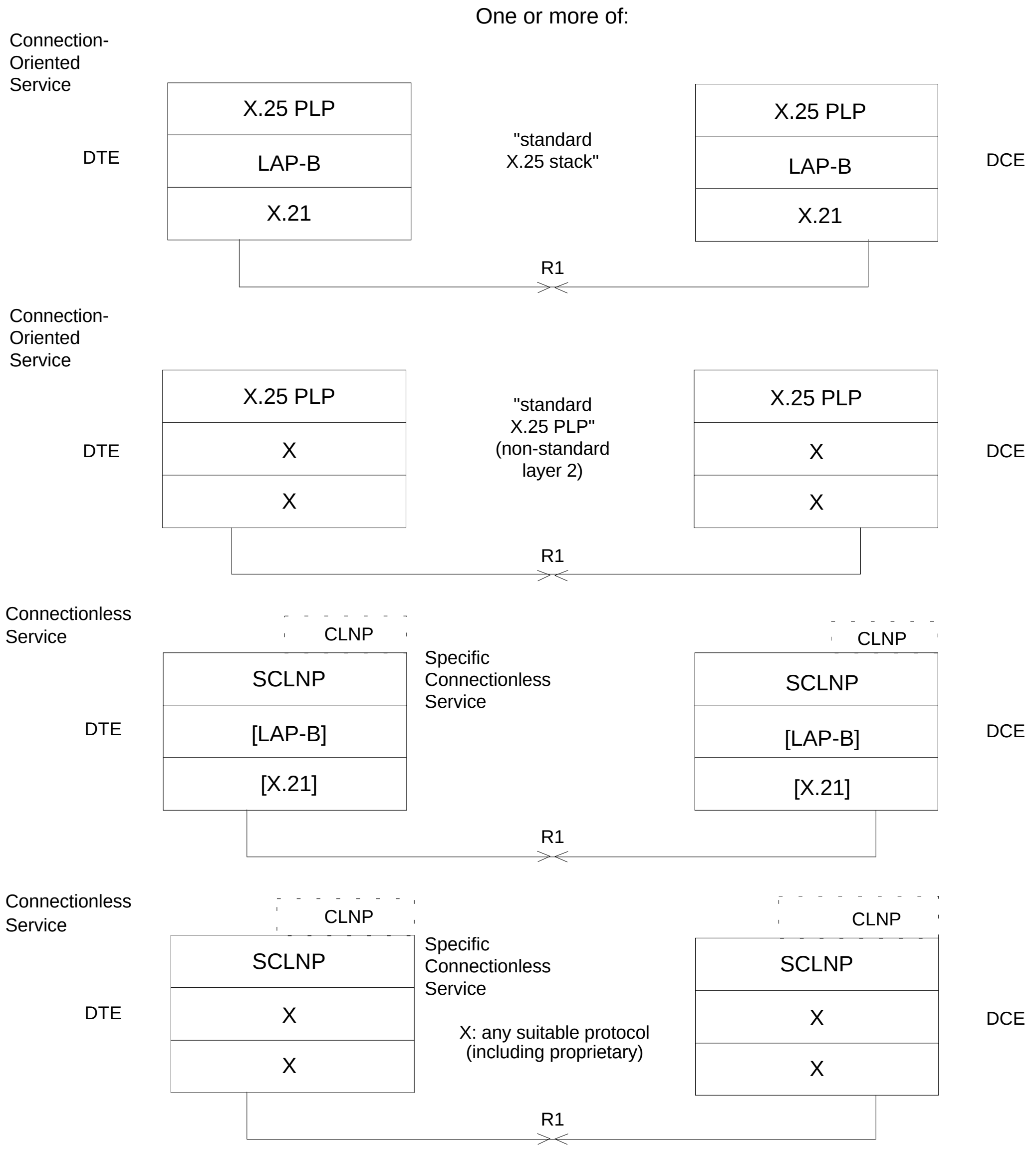


Figure 11: Protocol stacks at the R1 reference point

4.5.2 Protocol stacks at R2 reference point

These protocol stacks (see figure 12) shall be the TETRA air interface stack.

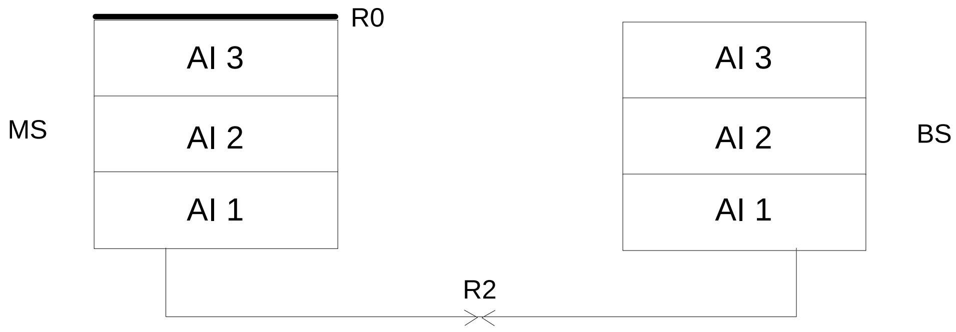


Figure 12: Protocol stacks at R2 reference point

4.5.3 Protocol stacks at R4 reference point

These protocol stacks (see figure 13) shall support character mode operation.

This is the character mode equivalent of the packet mode R1 reference.

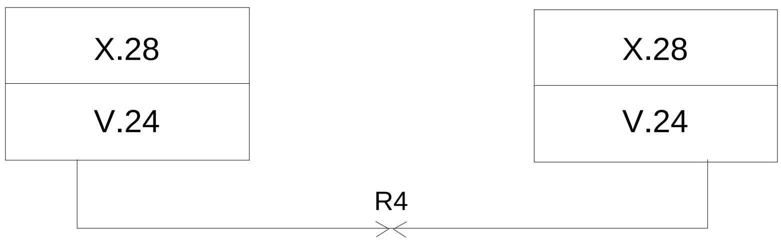


Figure 13: Protocol stacks at R4 reference point

4.5.4 Protocol stacks at R6 reference point

Each of the TETRA networks shall operate directly to the other TETRA network, independently whether there is a transparent transit network between them or not at the R6 reference point (see figure 14).

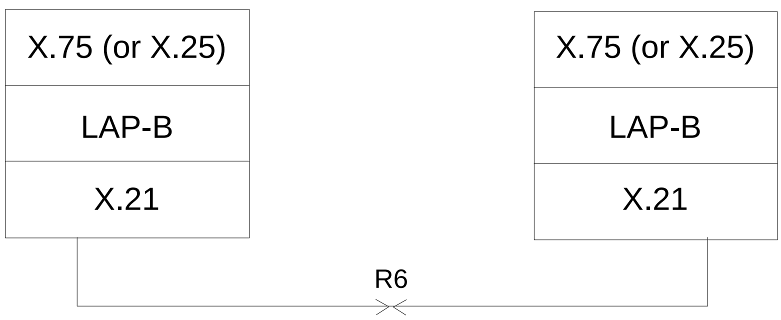


Figure 14: Protocol stacks at R6 reference point

5 Protocol architecture

5.1 Introduction

This clause gives a model where the different functions of the layers and sub-layers of the TETRA PDO network are described. This is based on the principles of layering (as used in the OSI reference model).

NOTE: The protocol stacks are used to define the functionality of the TETRA protocols for interfaces. The protocol stacks in this clause are normative when used to describe the functionality of interfaces, but these stacks and subdivision of protocol layers do not imply or restrict any implementation.

5.2 Functions

5.2.1 Layer 1 functions

Most of the layer 1 functions are common with the TETRA Voice plus Data (V+D) functions as described in ETS 300 392-2 [16], clauses 7 and 10 and ETS 300 393-2 [17], clauses 5, 6, 8 and 9. These functions are shown in figure 15, where the numbers indicate the relevant clauses in ETS 300 393-2 [17]. The layer 1 functions shall be:

a) burst related functions: (ETS 300 393-2 [17], clause 9):

  1) scrambling/de-scrambling (for colour code function);

  2) mapping of the training sequence onto "physical" bursts (and busy flag encoding, performed by means of two training sequences);

  3) mapping of the extended training sequence (and of the frequency correction sequence onto "physical" bursts).

b) modem functions: (ETS 300 393-2 [17], clause 5):

  1) modulation of a defined bit stream, at a requested time, with defined rate, transmit power and frequency, into an RF channel;

  2) demodulation of an RF channel into a bit stream (with or without soft decision information).

c) timing functions: (ETS 300 392-2 [16], clause 7):

  1) frequency-, bit-, burst-, synchronisation (and busy flag decoding, performed by means of two training sequences).

d) radio link control function: (ETS 300 392-2 [16], clause 10):

  1) Received Signal Strength Intensity (RSSI) measurement.

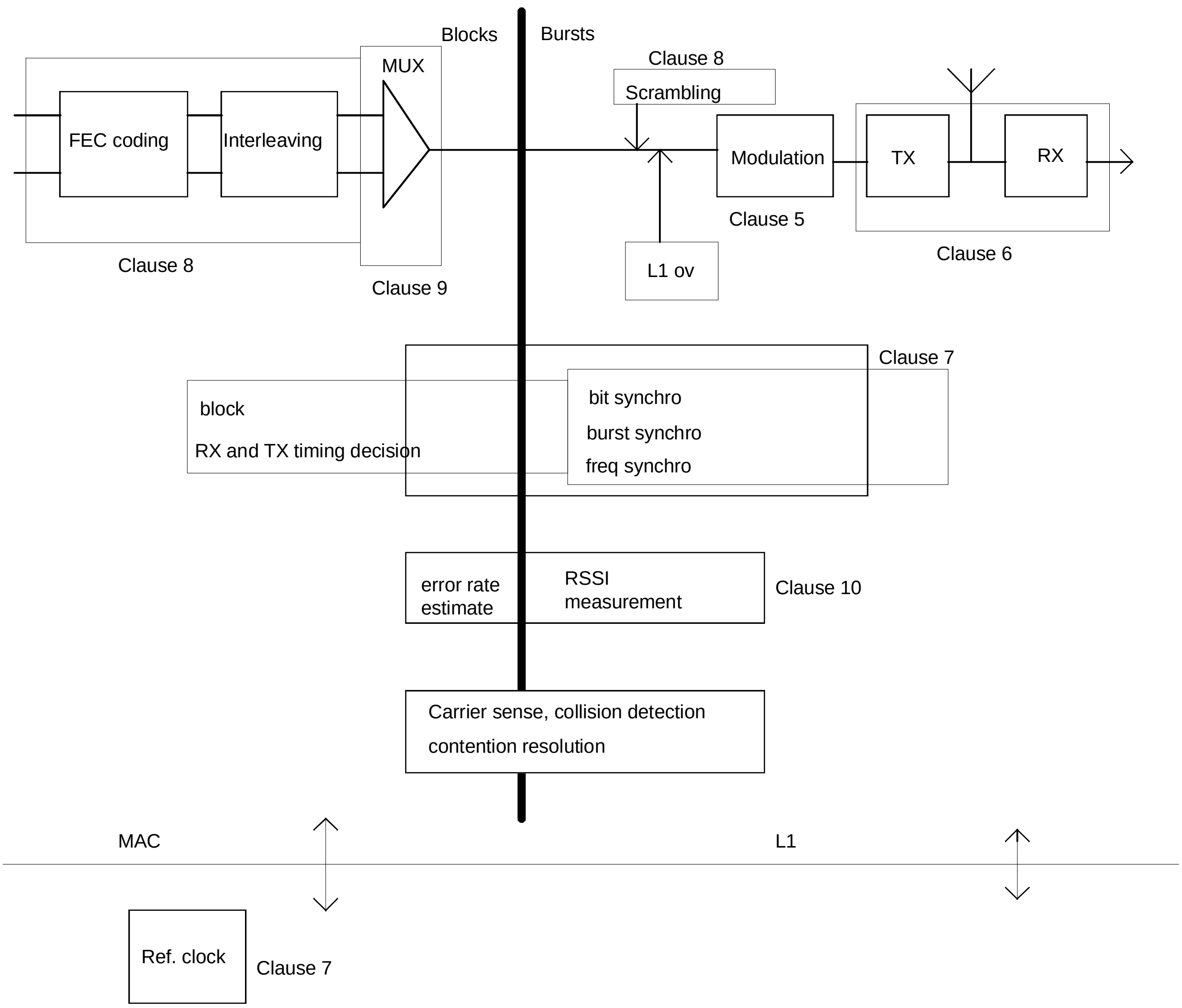


Figure 15: Identification of clauses in ETS 300 393-2 [17]

5.2.2 Layer 2 functions

The layer 2 is split into two sub-layers, the Logical Link Control (LLC) and the MAC sub-layers, and SAP and associated primitives are defined for this sub-layer boundary.

5.2.2.1 MAC functions (sub-layer 2.1)

The MAC sub-layer functions shall be as shown in figure 16 (see also ETS 300 393-2 [17], clause 22).

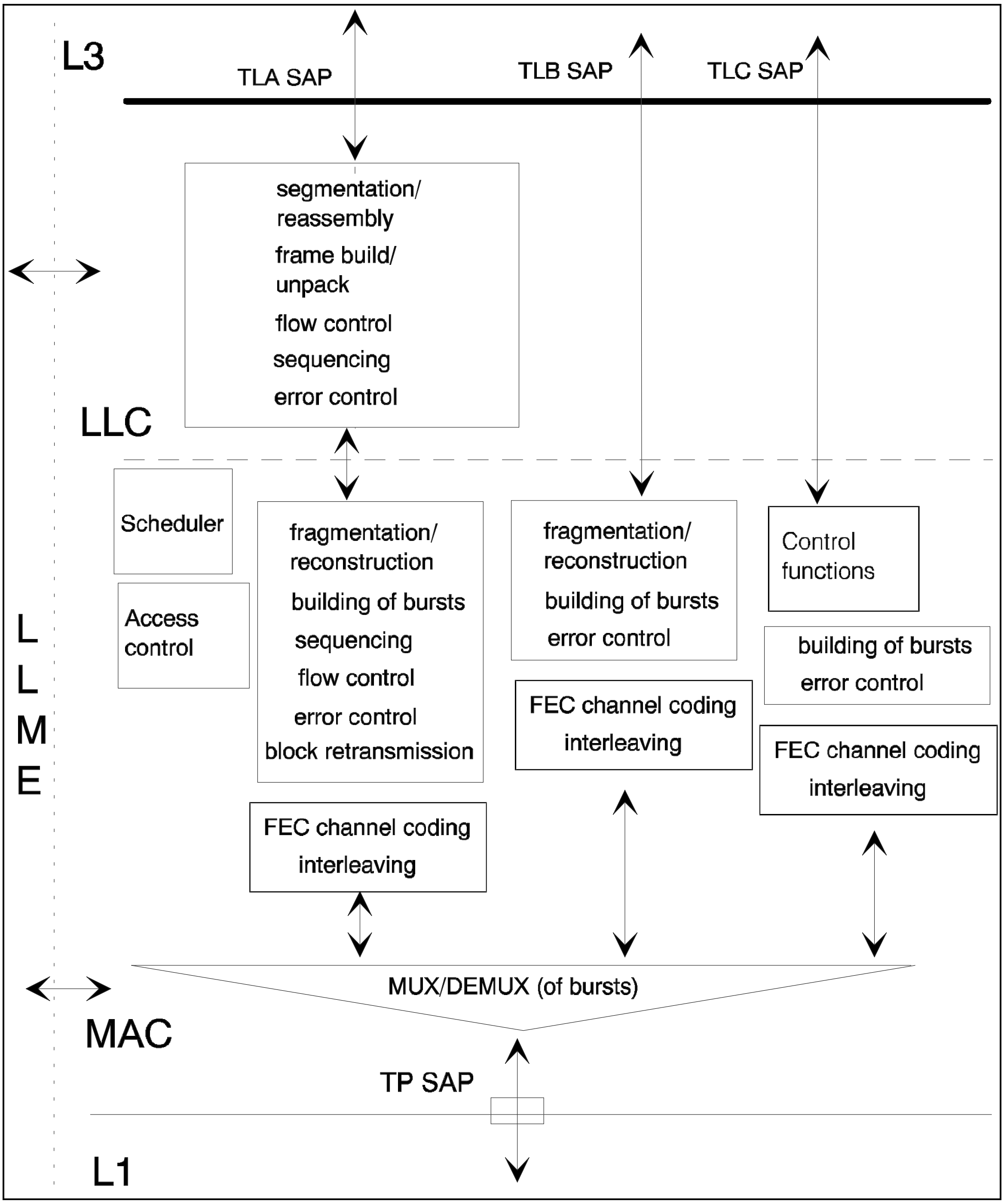


Figure 16: Layer 2 model for PDO

5.2.2.1.1 Transmit functions

The MAC transmit functions shall be as listed below:

- accept frames from LLC and fragment into blocks if they exceed the maximum block length allowed;
- build bursts by adding presiding block:
  - a burst can correspond to a complete frame or part of one frame;
  - a burst can include retransmitted blocks;
- MAC CRC computing;
- re-transmission of blocks (ARQ);
- coding and Forward Error Correction (FEC);
- interleaving;
- multiplexing of bursts;
- submitting data to physical layer for transmission;
- access control (digital sense; collision detection; etc.);
- downlink burst addressing;
- battery saving/wake up (downlink only).

5.2.2.1.2 Receive functions

The MAC receive functions shall be as listed below:

- synchronisation;
- extracting data in blocks from bursts on specified uplinks;
- de-multiplexing;
- de-interleaving;
- decoding and Forward Error Correction (FEC);
- computing Cyclic Redundancy Check (CRC);
- passing decoded data in blocks assembled in frames to LLC sub-layer;
- acknowledgement of blocks;
- access control;
- uplink burst addressing;

battery saving/wake up (downlink only).

5.2.2.2 LLC functions (sub-layer 2.2)

Three SAPs are defined, the TLA-SAP for data transfer, the TLB-SAP for system broadcast information and the TLC-SAP for control functions (see figure 16).

The LLC functions shall be as follows (see ETS 300 393-2 [17], clause 21):

- segmentation and/or assembly of layer 3 packets when they exceed the maximum length allowed;
- flow control of frames (only in the case where an acknowledged transfer is applicable);
- sequencing control of frames to maintain the sequential order of frames across the data link connection;
- multiplexing and/or de-multiplexing of frames;
- error control and detection that provides the means to recognise transmission errors;
- establishment and release of data links requested by layer 3 (only reset of sequence numbers).

Following the generic layer architecture defined by the European Computer Manufacturers Association (ECMA) reference model (see ECMA TR/44 [13]) results in the model given in table 1. The LLC only corresponds to functions associated with TLA-SAP of the layer 2 for data transfer. The TLB-SAP and TLC-SAP are not included in table 1.

C(i), B(i), A(i) refers to functional groups as defined in ECMA TR/44 [13], referring respectively to individual Control functions (C(i)), Information Fan-in Fan-out functions (B(i) and Common control functions (A(i).

DT, CL refer to data transfer in connection mode and connectionless data transfer, this separation is required because the coding of the address fan-in fan-out fields is usually different.

Table 1: Functions provided by the data link layer at the TLA SAP

Sub-layer	Code	LLC	MAC	Combined
Segmenting/ re-assembly	C5	o	o	o
Sequencing	C4	o	o	o
Splitting	C3	-	-	-
Flow control	C2	o (acknowledge) - (unacknowledged)	-	- or o
Error control	C1	o	o	o
Connection qualification	B3	-	-	-
Remote SAP processing	B2	o	o	o
Local SAP processing	B1	o	o	o
Protocol version identification	A5	-	-	-
DT/CL discrimination	A4	-	o	o
Error detection	A3	o	o	o
PDU delimiting	A2	-	o	o
Protocol identification	A1	-	-	-

Key: o: applicable, -: not applicable.

5.2.3 Layer 3 functions

The following functions shall be part of layer 3:

a) sub-layer 3.2:

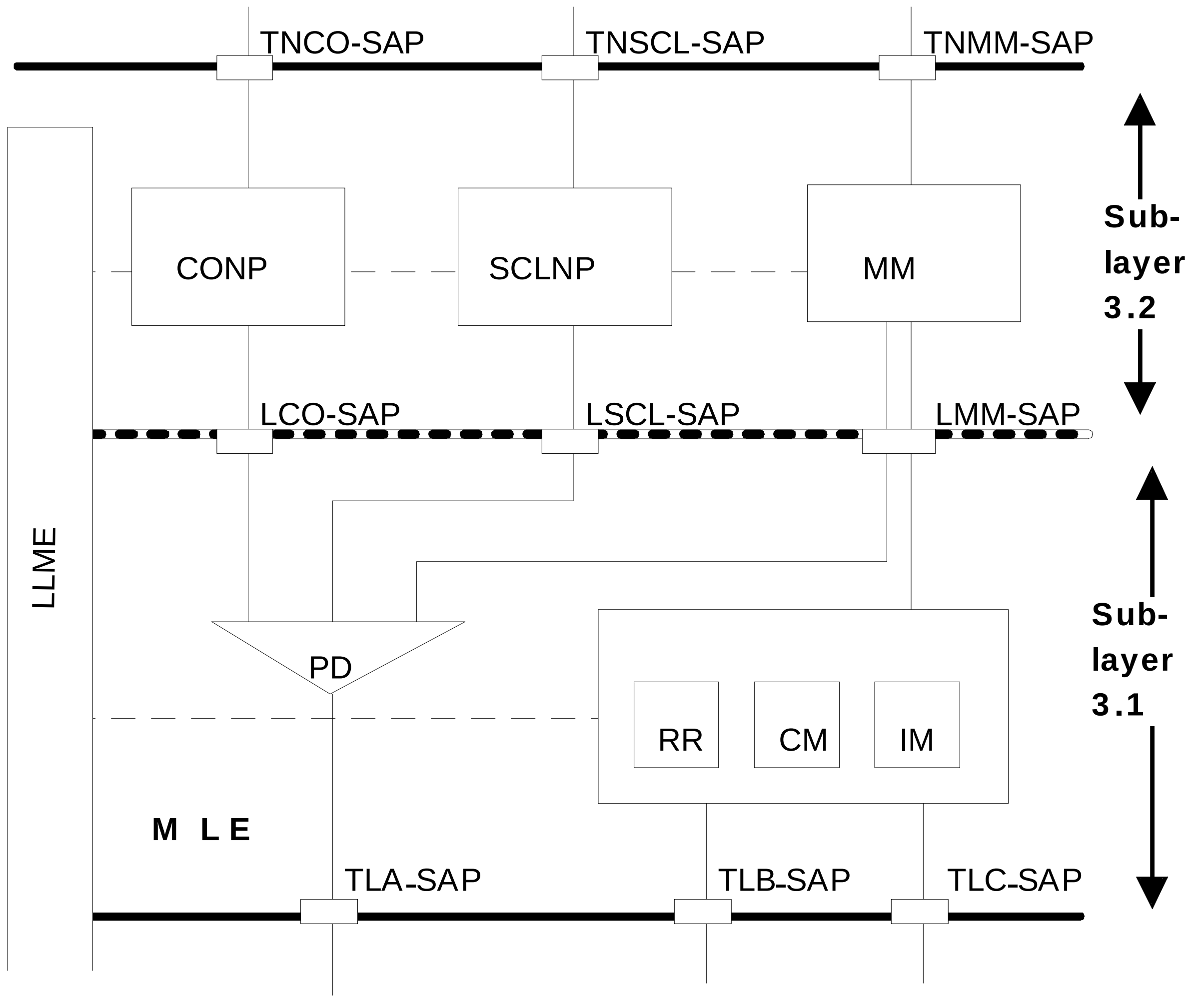
1) Mobility Management (MM), (see clause 7);

2) Connection Oriented Network Protocol (CONP), (see ETS 300 393-2 [17], clause 15);

3) Specific ConnectionLess Network Protocol (SCLNP), (see ETS 300 393-2 [17], clause 25);

b) sub-layer 3.1:

1) MLE ,(see ETS 300 393-2 [17], clause 18).



PD = Protocol Discriminator;
RR = Radio Resource;
CM = Connection Management;
IM = Identity Management.

Figure 17: Layer 3 model

5.2.3.1 Connection Oriented Network Protocol (CONP)

The CONP (see ETS 300 393-2 [17], clause 15) shall perform the standard procedures, formats and facilities at the packet layer for data terminal equipment operating in conformance with the ISO standard referred to in ETS 300 393-2 [17], clause 12.

The CONP services shall be accessed at the TNCO SAP. The CONP protocol shall open a connection, transfer the data, close the connection and also perform a reset operation when required by the application. It can handle multiple independent transactions (multiple virtual circuits). In the MS CONP uses the services offered by the MLE of layer 3.

The services offered by CONP shall be:

- connection establishment;
- transfer of user data;
- disconnection;
- reset;
- expedited data.

5.2.3.2 Specific ConnectionLess Network Protocol (SCLNP)

The SCLNP (see ETS 300 393-2 [17], clause 25) shall offer a connectionless service that includes specific TETRA facilities. The SCLNP services shall be offered to the application at the TNSCL-SAP, these include data transfer with local or remote replies depending on the facility requested. In the MS SCLNP uses the services offered by the MLE sub-layer of layer 3.

The SCLNP functions depend on its role, i.e. whether it is a send, a receive or a forwarding system. The main data transfer functions shall be:

- PDU composition/decomposition;
- routing forwarding of PDUs.

The SCLNP facilities shall include delivery disposition, priority, multicast, area selection, packet signature, time stamp, packet storage, sub-addressing. Some of these facilities may vary according to implementation options.

5.2.3.3 Mobility functions

The mobility functions shall be split into two groups of sub-functions:

- functions associated with radio resources in the MLE; and
- functions associated with mobility management in the MM entity.

5.2.3.3.1 MM

The MM services shall be offered to the application through the TNMM-SAP (see clause 7). The functions performed shall be:

- registration at roaming;
- registration at migration;
- network initiated authentication;
- user attach/detach;
- disable/enable;
- authentication;
- location updating;
- network selection.

5.2.3.3.2 MLE

The MLE shall be the layer 3 sub-layer that performs Protocol Discrimination (PD), logical channel selection, the Radio Resource (RR) handling, the Connection Management (CM) and the Identity Management (IM) (see ETS 300 393-2 [17], clause 18).

The procedures related to radio resources shall manage the common transmission resources, such as the physical channels and the data link connections. They shall establish, maintain and release the MLE connections between the MS and the BS. They shall perform cell selection and re-selection, measurement reports, re-establishment (handover), and broadcast of adjacent cell information.

The services provided to the upper layer shall be:

- establishment and release of a MLE connection;
- cell selection and re-selection on the MS side;
- transfer of messages on the data link layer connection;
- indication of temporary unavailability of transmission;
- handover to maintain the MLE connection;
- broadcast system information.

The identity management procedures manage all of the subscriber identities (ITSI, ISSI, GTSI, GSSI, ASSI and TMI).

5.2.3.4 Point-to-multipoint services

There are two types of point-to-multipoint service:

- user multicast (requested by the user); and
- system broadcast (issued by the infrastructure in the direction BS to MS).

User multicast is a facility that is requested by the user application and is handled by the specific connectionless protocol with specific primitives. This service shall be routed via the layer 2 TLA-SAP.

System broadcast contains messages issued by the protocol entities like radio resource management. It is not a specific functional entity by itself but it is included in the MLE. This service shall be routed via the layer 2 TLB-SAP.

6 Addressing and identities

6.1 Introduction

This clause defines the TETRA addresses and identities that shall be used by all TETRA equipment.

The identities are organised into the following groups, corresponding to the different functions of the addresses and identities:

- TETRA Subscriber Identities (TSI);
- Short Subscriber Identities (SSI);
- TETRA Management Identities (TMI);
- Network layer SAP addresses (NSAP);
- TETRA Equipment Identities (TEI);

- Mobile Network Identity (MNI).

TETRA addresses and identities are designed to support the following objectives:

a) to allow a large number of networks (and network operators) to co-exist, and for each network to support a large number of subscribers;

b) to be able to uniquely identify any subscriber in any network;

c) to allow the use of shortened identities for intra-TETRA data transactions to reduce the signalling information in the set-up messages;

d) to support efficient roaming and migration of subscribers.

The main TETRA identities are the subscriber identities. A key difference between TETRA and public mobile networks is the existence of group identities. As far as possible, group identities within TETRA shall be treated identically to individual identities, in particular group and individual identities shall have the same structure and shall be allocated from the same TETRA identities space.

Nonetheless, the individual subscriber identities shall have a special role to provide a unique identification of terminal users because an individual subscriber identity can only refer to one mobile (or fixed) termination. By contrast, a group subscriber identity can refer to several mobile (or fixed) terminations.

The subscriber identities may be transferable, and may be removed from the equipment by the user. An additional non-transferable management identity shall therefore be defined to allow a termination to be addressed independently from the subscribers.

NOTE: Fleet addressing is outside the scope of this ETS.

The different addressing domains relevant to TETRA are shown in figure 18. The TETRA domain is shown as intersecting three other domains (PSTN, ISDN and PDN). This indicates that a given individual TETRA subscriber address may be associated with one address in each of these public domains.

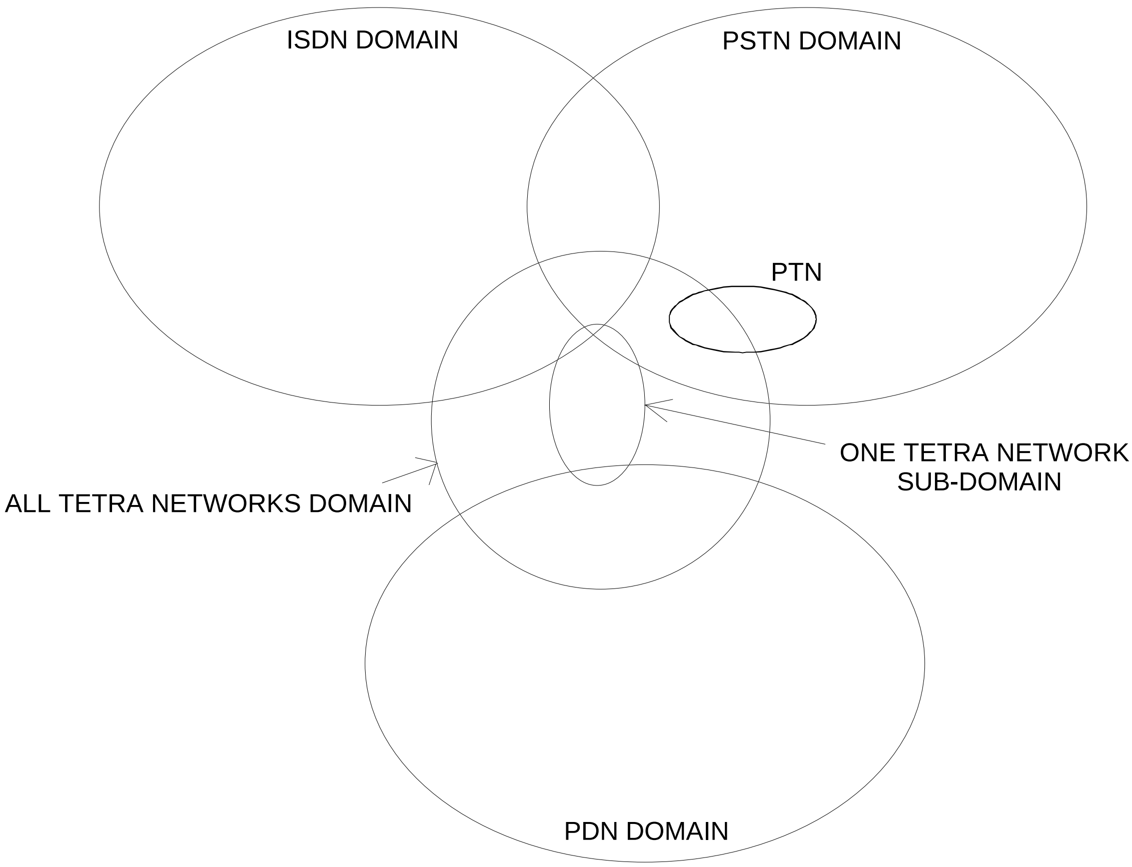


Figure 18: Addressing domains within TETRA

Within the TETRA domain, the TETRA identities can have different roles. The relationship between the different TETRA identities and the other addresses is shown in figure 19.

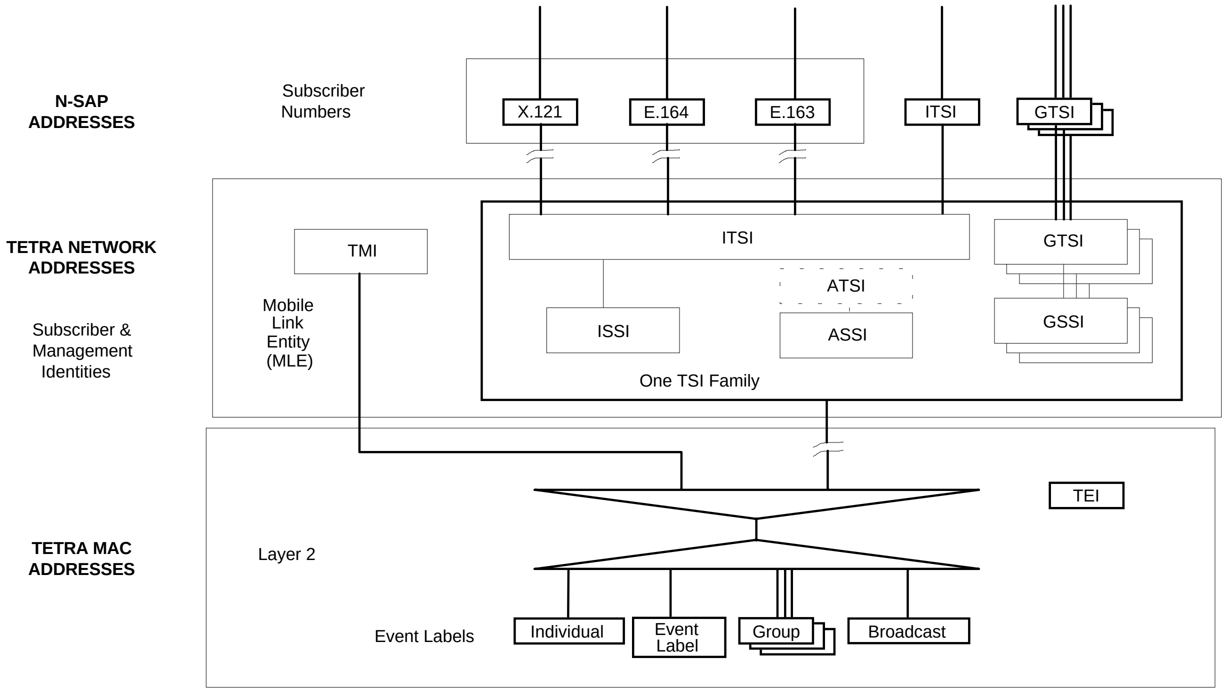


Figure 19: Relationship between TETRA addresses

The use of addresses in TETRA set-up messages and other messages are described in subclause 6.8.

6.2 Subscriber identities

6.2.1 General

Subscriber identities (TSI or SSI) shall exist in two sizes:

- TETRA Subscriber Identity (TSI), 48 bits long;
- Short Subscriber Identity (SSI), 24 bits long.

The SSI shall be a truncation of the TSI.

Each TSI shall be unique across the complete TETRA domain (i.e. all TETRA networks) but each SSI shall only be unique in one TETRA sub-domain (i.e. one TETRA network).

NOTE: These subscriber identities do not necessarily correspond to "chargeable subscribers". The definition of "chargeable subscribers" is outside the scope of this ETS.

6.2.2 TSI

Each MS or LS shall contain at least one family of TSIs. Each family shall contain one ITSI and may also have one ATSI and several GTSIs:

One TSI family:

- 1 x Individual TSI (ITSI);
- 1 x Alias TSI (ATSI);
- N x Group TSI (GTSI).

This TSI family shall be valid for a home TETRA network. Likewise, one or several visitors TSI families may also coexist with the home TSI family but shall have a slightly different composition: they shall not contain a visiting equivalent to the individual identities, i.e. no (V)ITSI. The binding between home and visitors TSI families is out of the scope of this ETS. The lifetime of these addresses is an operator option, but the visitors TSI family shall be deleted at de-registration.

In visited networks, an alias address shall be provided by the SwMI. Other MS shall continue to use the (home) individual address to access MS in visited networks.

The following will only consider the requirements for a single family. A single termination may contain more than one TSI family, and in this case each family shall meet these requirements independently of the other families.

TSIs shall be allocated by the network operators. A valid TSI shall refer to a TSI that has been allocated by the network where it is being used. A MS or LS shall possess at least one valid ITSI before it can be used. Special procedures are defined to allow a migrating subscriber to attach to a visited network and to "exchange" an existing ITSI for a valid TSI for that visited network. This exchanged TSI shall be known as a visitors ATSI or (V)ATSI, and this new (V)ATSI should be allocated when the migrating visitor first contacts the visited network.

A valid ITSI shall be required in order to support the air interface addressing procedures. Refer to subclauses 6.2.6 and 6.8.

NOTE 1: Subject to inter-operator agreements, the functionality of a (V)ATSI may be identical to the ITSI (i.e. a migrating subscriber may be offered an equivalent service to the non-migrating subscriber).

To support secure network operations, an ATSI may be allocated in addition to the ITSI. There shall only be one ATSI per ITSI and the ITSI-ATSI pairing shall only be known to the network operator. The ATSI cannot be derived from a knowledge of the ITSI, and a given subscriber shall only be known to other subscribers by his ITSI.

Because the ATSI shall not be available to other users, the network operator may change the value of the ATSI at frequent intervals without notifying any of the other users. Infrastructure routing tables are assumed to operate using the public ITSI.

If a valid ATSI is available for a given network, this shall be used in place of the ITSI as described in subclauses 6.2.6 and 6.8.

The ATSI does not replace the ITSI. The ITSI shall remain available (by definition) and can still be used if required.

To support group addressing, one (or more) GTSI shall be allocated in addition to the ITSI. There may be several GTSI per ITSI and the same GTSI may be associated to several ITSIs. The binding between the GTSI and the ITSI is outside the scope of this ETS, and a given group subscriber shall only be known to other subscribers by his GTSI.

NOTE 2: There is no group equivalent of the ATSI.

The ATSI and the GTSIs may be either pre-allocated (like ITSIs) or may be allocated dynamically by the network using standard TETRA procedures as part of normal operation. (V)ASSIs and (V)GSSIs may also be exchanged by the visited network (like in the home network).

NOTE 3: No standard procedures are defined for the dynamic allocation of ITSIs.

The method(s) of TSI installation are described in subclause 6.2.8.

6.2.3 SSI

The SSI is the network specific part of the TSI. SSIs shall be unique within a given TETRA sub-domain (i.e. a given network). The same SSI may be used in many TETRA sub-domains.

An Individual Short Subscriber Identity (ISSI) shall be formed from an ITSI by removing the MCC and the MNC. Likewise, a GTSI shall be truncated to a Group Short Subscriber Identity (GSSI).

Valid values for an SSI shall correspond to the valid types of ITSI as follows:

- ISSI = SSI from ITSI;
- ASSI = SSI from ATSI (see note);
- GSSI = SSI from GTSI;
- USSI = SSI from a foreign ITSI (see note).

If an ASSI is available, this shall be used in place of the ISSI. For more details, refer to subclauses 6.2.6 and 6.8. The ASSI does not replace the ISSI. The ISSI shall remain available (by definition) and may still be used by the infrastructure if required. The ISSI may also be used by the MS if for example the ASSI assignment expires.

NOTE: There is no group equivalent of the ASSI.

Most MS operations should use the valid home (or visitor) values of SSI. However, an Un-exchanged SSI (USSI) shall also be defined to support migration. This non-valid SSI, based on the home ISSI, shall be used instead. The USSI shall be formed by using a "foreign" ISSI as defined in subclause 6.7. Additional rules for the use of SSIs are defined in subclause 6.7.

The USSI enables a MS to register with the visited network. As part of this registration, the USSI shall normally be exchanged for a valid ASSI. Group SSI may also be exchanged at the same time. A special flag in the messages shall indicate when an USSI is used.

6.2.4 Composition of subscriber identities

10 bits	14 bits	24 bits
Mobile Country Code (MCC)	Mobile Network Code (MNC)	network specific Short Subscriber Identity (SSI)

Figure 20: Contents of TSI

TSI identities shall have a fixed length structure that is based on the identity structures defined in CCITT Recommendation E.212 [3].

The partitioning of the address space between ITSIs, ATSIs and GTSIs shall only be known inside the relevant sub-domain. Outside of this sub-domain ITSI, ATSI and GTSI cannot be distinguished.

The ASSI shall be unique for the whole sub-domain (the whole network). The relationship between a given ASSI and the corresponding ITSI is not defined in this ETS.

6.2.5 Allocation principles for subscriber identities

MCC shall use 10 bits to encode the 3 decimal digit value of the country code as defined in CCITT Recommendation X.121 [5], annex D.

EXAMPLE: France has the country code 208 Decimal;

This is coded as 00 1101 0000 Binary (0D0 hexadecimal).

The undefined binary codes (decimal values 1 000 to 1 023) are reserved and shall not be used.

MNC shall be allocated possibly by the national administration for each country. A unique MNC shall be allocated to each operator using binary code on 14 bits.

The SSIs (i.e. ISSI, ASSI or GSSI) shall be allocated by the network operator.

NOTE: The ISSI assignment is expected to be a long term assignment, but the ASSI and GSSI assignments are expected to be more dynamic. It is the responsibility of the network operator to ensure that all of these identities are allocated uniquely at all times.

6.2.6 Use of subscriber identities

Subscriber identities shall be used for two distinct roles:

- as a lower layer address (MAC address) for the air interface as described in subclause 6.7 (SSI);
- as a network routing address (TSI).

The MM and the SCLNP shall use subscriber identities as network routing addresses. This may include both source and destination addresses.

The SCLNP destination address shall be either:

1) an ISSI or GSSI for intra-TETRA data transactions; if available, an ASSI shall be used by the SwMI. i.e. destination in the same TETRA network as the source; or

2) an ITSI or GTSI for inter-TETRA data transactions; if available, an ATSI shall be used by the SwMI. i.e. destination in a different TETRA network to the source.

NOTE: The use of a SSI as the destination address is provided to allow the use of a short set-up message for intra-TETRA data transactions.

The source address shall be either:

a) an ISSI or ASSI for intra-TETRA data transactions, i.e. source in its home TETRA network; or

b) an ITSI (downlink and inter-system interface) or (V)ASSI (uplink) for inter-TETRA data transactions, i.e. source not in its home TETRA.

If an ASSI is available, this shall be used in preference to the ISSI for the source address by a MS and for the destination address by the SwMI when appropriate.

6.2.7 NSAP addresses

In some cases NSAP addresses shall be used as the source and destination addresses instead of using subscriber addresses. This alternative shall apply to the following cases:

a) in all CONP packets. These shall contain both a source and destination address based on CCITT Recommendation X.121 [5];

b) by an external protocol, such as ISO CLNP or Internet IP.

NOTE: These external protocols are assumed to be converged onto SCLNP.

In the case of the CONP protocol, the NSAP address shall be allocated by the TETRA network operator, and it shall be bound to a valid ITSI as defined in subclause 6.4. Binding to a group TSI is not supported. The SSI shall continue to be used as the lower layer address, but any combination of ITSI and NSAP may be used as a network routing address within the infrastructure.

In all other cases (where the NSAP address is not allocated by the TETRA network operator) the binding of NSAP addresses to ITSIs is not be defined in this ETS.

6.2.8 Installation of TSIs

TSIs may be installed by several alternative mechanisms.

ITSIs or GTSI may be installed as follows:

a) by the dealer (i.e. not usually changed by the user);

b) by inserting a "smart card";

c) by the user entering a login code via a local MS/LS application.

NOTE 1: These mechanisms are only provided as examples. No methods of installation are defined in this ETS.

In addition GTSIs (but not ITSIs) may also be allocated (downloaded) over the air interface to allow dynamic groups and to enable the user to automatically "collect" his GTSIs by registering the ITSI (e.g. when replacing faulty equipment or when "logging-in" to a new MS).

Visitors to a TETRA network shall initially register using their permanent (home) (H)ITSI according to the procedure described in ETS 300 393-2 [17], clause 15. If this migration is accepted, the network shall allocate a temporary visitors (V)ATSI (and possibly visitors (V)GTSIs) using spare TSI addresses (allocated from the sub-domain of the visited network). The visitor shall then use the (V)ASSI as his source address for all subsequent messages in this visited network.

NOTE 2: Allocations of (V)ASSIs to visitors are temporary, and it is assumed that the network will subsequently wish to re-allocate them to another migrating subscriber. The network operator should create suitable mechanisms to avoid duplicate allocations.

6.3 TETRA Management Identity (TMI)

6.3.1 General

The TMI is defined as a non-transferable network (layer 3) identity. The TMI shall be allocated to a termination before it can be used, and it cannot be exchanged dynamically or transferred between terminations by the user.

The TMI shall be allocated by the network operator and should be installed in the termination prior to delivery to the customer.

The TMI shall only be used as an address by the internal network management functions using a specific set of management messages. These management messages, and therefore the TMI address space, should be inaccessible to normal network users.

6.3.2 Composition of management identities

The composition of the TMI shall be identical to the TSI as described in subclause 6.2.4. The MCC and MNC fields shall have the same values as the corresponding TSI. However, the TMI identities should be allocated from a separate address space, i.e. the management address space. TMI shall be composed of Mobile Network Identity (MNI = MCC+MNC), and Short Management Identity (SMI) (see also subclause 6.6).

10 bits	14 bits	24 bits
Mobile Country Code (MCC)	Mobile Network Code (MNC)	Network specific Short Management Identity (SMI)

NOTE: The SMI part of a TMI may be numerically equal to the SSI part of a TSI, but the TMI and TSI identities remain distinct because they relate to different families of messages. The SMI is also a valid layer 2 address.

Figure 21: Contents of TMI

A visitors TMI shall not be allocated to a migrating station. The TMI shall only be allocated by the home network.

6.3.3 Use of management identities

The TMI shall only be used to support management functions such as defined in the MLE (see ETS 300 393-3 [17], clause 17). The TMI shall not be used for messages to or from any other than the network management entities. These management functions may include both standardised and non-standardised functions.

NOTE: Secure networks may restrict the use of the TMI. It possible that they may allow no TMI functions at all.

6.4 Network layer SAP addresses (NSAP)

6.4.1 General

NSAP addresses are an additional method of addressing that may be used to provide direct compatibility with external (non-TETRA) networks.

The mapping between NSAP addresses and a TETRA terminal is described as "binding". This binding may take place when an NSAP address is allocated to a particular TETRA Mobile (MT) or to an independent source of identity such as a Subscriber Identity Module (SIM) card. This binding is described as static. Alternatively, the association may be flexible so that the association may be changed by either the network operator or the user. This is dynamic binding.

6.4.2 Static binding

Procedures for static binding are the responsibility of the administration of a particular network and are outside the scope of this ETS.

6.4.3 Dynamic binding

6.4.3.1 General

The TETRA network shall treat NSAP addresses as "user numbers" that are associated with the TE. A "binding" process is defined whereby a NSAP addresses becomes temporarily associated with one MT or one NT.

All NSAP addresses shall conform to the one of the existing international standards, e.g. CCITT Recommendations E.163 [1], E.164 [2] or X.121 [5] or to a standard private numbering plan. None of these standards provides support for group addressing and therefore a NSAP address shall not be bound to a GTSI.

NSAP addresses shall be used to address external users (destination NSAP) and for external users to address TETRA users.

NOTE: It is assumed that GTSI binding to an NSAP address is possible at the gateway.

6.4.3.2 Structure and contents of NSAP addresses

The structure and contents of the NSAP is defined by the appropriate numbering plan:

NSAP = CCITT Recommendation E.163 [1]; or

CCITT Recommendation E.164 [2]; or

CCITT Recommendation X.121 [5].

6.4.3.3 Use of NSAP addresses

Each network operator may allocate NSAP addresses in addition to TSIs.

Standard NSAP addresses shall be used for the CONP to support direct inter-working to existing fixed networks (see subclause 6.2.7).

NSAP addresses may also be used as part of external protocols.

6.4.3.4 Binding of NSAP addresses

In order to receive data transactions, a NSAP address shall be temporarily bound (attached) to one ITSI. This binding may be changed by the user and/or by the network manager at any time. Ideally a user should be able to bind an NSAP address to a new ITSI by simply unplugging the TE and plugging it into the new MT (or NT).

Alternatively, a network operator can create the binding over the air interface.

NSAP address binding requires a set of binding protocols. TE binding shall be reported to the MTU with a TE protocol. MTU binding shall be reported to the infrastructure using the MM registration procedures, and every change of binding shall be reported with a new registration. LS address binding may follow the same rules.

NOTE: User changes are assumed to correspond to the attachment of new TE.

6.5 TETRA Equipment Identity (TEI)

6.5.1 General

The TEI uniquely identifies one piece of TETRA equipment, either one MT or one NT.

The TEI shall be allocated by the equipment manufacturer. One manufacturer may supply several networks, and therefore the TEI shall not be specific to one network.

6.5.2 Contents of TEI

6 digits	2 digits	6 digits	1 digit
Type Approval Code (TAC)	Final Assembly Code (FAC)	Electronic Serial Number (ESN)	Spare (SPR)

Figure 22: Contents of TEI

TEI digits shall only use the decimal digits "0" - "9" inclusive.

6.5.3 Allocation principles for TEI

Type Approval Code (TAC) shall be allocated by a central body.

Final Assembly Code (FAC) shall identify the manufacturer and place of final assembly. These shall be also allocated by a central body.

Electronic Serial Number (ESN) shall be an individual serial number that uniquely identifies each equipment within each TAC+FAC. ESN shall be allocated by manufacturers in sequential order.

6.5.4 Use of TEI

TEI shall be used to support TETRA security functions e.g. MS enable and disable as described in ETR 086 [24].

6.6 Mobile Network Identity (MNI)

6.6.1 Contents of Mobile Network Identity (MNI)

10 bits	14 bits
Mobile Country Code (MCC)	Mobile Network Code (MNC)

Figure 23: Contents of MNI

The MCC and MNC are the same as the MCC and MNC fields used in the ITSI and TMI identities. The coding for these fields is defined in subclause 6.2.5.

NOTE: Additional operator information may be included as part of the system broadcast information.

6.7 Layer 2 addresses and labels

6.7.1 Overview

The following subclauses shall only apply to MTs. Layer 2 addressing for LSs is outside the scope of this ETS.

In the lower layers of the air interface, the primary layer 2 addresses shall be based on the SSIs as defined in subclause 6.2.3. This use of subscriber identities requires a subscriber identity to be allocated to all terminations before they can access the network.

The following subclauses describe additional layer 2 addressing functions. These additional functions are divided as follows:

- event labelling, using information bits that are part of the message content;

- scrambling labelling, using a scrambling technique, not part of the message content.

6.7.2 Event labelling

As an example, an event label may be used to identify all of the separate transmission events that belong to one or more transactions. These labels shall be cell specific to a particular channel (i.e. they may not be unique outside that cell) and they may be used to label both traffic events and control events.

The shortest duration of one label shall be one transaction, but the same label may be used for more than one transaction.

NOTE: An event label may be unique for a complete cell, or for part of a cell, e.g. specific to one carrier, or to one slot on one carrier.

In addition to providing a cell specific reference for each event, the event labels may also be used to define control groups by each BS. These ad-hoc groups may be used by each BS to control e.g. priorities (random access) and battery saving.

6.7.3 Scrambling label

The scrambling label functions are defined to ensure that transmissions on a given channel are only received by the intended endpoints. Scrambling labels shall contain an infrastructure endpoint identification. This scrambling label shall consist of the MNI from layer 3 and a cell number (colour code) from layer 2. This BS identity shall be geographically unique.

NOTE: The cell number can only provide protection against co-channel interference when all co-channel sites belong to the same operator. The operator should allocate a different cell number for all co-channel cells (for reasonable cluster sizes). However, the co-channel sites may belong to different operators, and this level of co-operation cannot be assumed. Therefore the MNI is also required.

6.7.4 Use and implementation of layer 2 addresses

6.7.4.1 General requirement

A scrambling label shall be used as part of every transmission event for both signalling and traffic, except for the downlink synchronisation channel where the unscrambled scrambling label shall be located. In addition to this, event labelling may also appear. However, there are some exceptions to this general requirement as described in the following subclauses.

The scrambling label shall be used for all downlink transmissions except for the V+D downlink synchronisation channel where the unscrambled scrambling label shall be located.

The scrambling label shall be used for all uplink station transmissions. Un-reserved uplink transmissions shall also include an individual subscriber identity (either the ISSI, the ASSI or the USSI).

6.7.4.2 Implementation of event labels

Event labelling identities shall be either:

a) an SMI, ISSI, USSI, GSSI or ASSI (i.e. the SSI may serve a dual role of MS identification as layer 2 and layer 3 address, 24 bits);

b) an event label, which is a local layer 2 temporary address that replaces an SMI, ISSI, GSSI or ASSI. It is specific to one channel and is valid for a specified time. call reference that is specific to one cell site (or part of a cell site) and valid at least for one transaction. The size of the event label shall be 10 bits.

6.7.4.3 Implementation of scrambling labels

The scrambling label shall be generated as an algorithmic combination of an network specific cell number and the essential part of the MNI (i.e. the MCC+MNC elements only). These identities shall be used as the "seed" for the colour code scrambling function with every transmission or reception as described in ETS 300 393-2 [17], clause 8.

NOTE: At the receive side, there is assumed to be no extraction of the scrambling label. An erroneous reception would only be detected by the normal channel coding as a decoding failure. This means that the receiver need not distinguish between different errors (e.g. errors due to noise, fading, Doppler or errors due to a co-channel interferer).

6.7.5 Labelling of packet channels

All MAC PDUs shall contain a SSI or a locally allocated event label. Event labels shall be used for all data transfers that require multiple bursts.

NOTE: The first burst of a data transfer will usually include the ISSI or ASSI. Therefore the event label offers no advantage for data transfers that only occupy a single burst.

Event labels may be used for any MAC PDU (both user data and control).

6.7.5.1 Use of identities for uplink data transfers

Uplink PDUs shall only be addressed with a SSI. The SSI used for uplink MAC PDUs shall be either:

a) the ISSI or ASSI value that has been allocated by this network. For migrating MSs this will be the visitors (V)ASSI; or

b) an Un-exchanged Short Subscriber Identity (USSI).

The type of SSI in use shall be indicated in the MAC PDU.

An ASSI or ISSI shall be used if one is available and the ASSI shall be used in preference to an ISSI if both are available. An USSI shall only be used if no valid value is available.

NOTE: An USSI is only used for the first access to a new (visited) TETRA network. This is followed by an identity exchange to obtain a (V)ASSI.

When required, the USSI shall be generated by the MS by copying an existing home ISSI (i.e. an ISSI allocated by a home network).

6.7.5.2 Use of identities for downlink data transfers

Downlink PDUs may be addressed with either a SSI or a SMI.

The SSI used for downlink MAC PDUs shall be:

a) an ISSI; or

b) an ASSI; or

c) a GSSI; or

d) the USSI used by the MS in the initial registration request.

These alternative SSIs shall not be distinguished in the downlink MAC PDUs.

The MS shall respond to all valid addresses on the downlink (all values of ISSI, ASSI, GSSI and SMI). In particular in the home TETRA network, it shall respond to a valid ISSI even if an ASSI is available for that family.

6.7.6 System information broadcast

Broadcast MAC PDUs (e.g. control messages) shall be un-addressed (i.e. they shall not contain any SSI address). These un-addressed messages shall be implicitly addressed to all MSs.

6.7.7 Reserved value of group address for user information broadcast

A specific SSI shall be reserved for broadcasting information to all MSs in a TETRA network. The content of the 24 bits shall be all ones (1). To broadcast information over the whole TETRA domain, a special TSI shall be obtained by adding a MNI containing all ones (1) to the previously defined SSI. Partial user broadcast shall be obtained by combining different MNI and SSI.

This reserved address defines a group to which all MSs shall belong, e.g. it may be used as the distribution address for S-CLNP data transactions. It may also be used by the SwMI for sending broadcast signalling messages.

6.8 Use of individual addresses

The use of TETRA addresses (notably the ITSI and ISSI) for the air interface is outlined in the following subclauses.

6.8.1 Air interface addressing functions

The address functions for all layers are summarised in table 2.

NOTE: Table 2 only considers address related functions. Refer to the protocol architecture in clause 5 for details of other functions.

Table 2: Addressing functions per layer

Layer	Protocol	Addresses used	Address function
3	CONP	No TETRA addresses	End-to-end routing
		(X.121 source + destination)	
3	SCLNP	ITSI/ISSI	End-to-end routing
3	MLE	ISSI	internal endpoint routing
			address management
2	LLC	SSI	Virtual frame address (PDO)
2	MAC	SSI and/ or	Uplink burst addressing
		Event label	Battery saving/wake-up (PDO)
			Battery saving (V+D)
			Downlink filtering
1	PHL	Scrambling label	Scrambling

The overview through all layers of the functions related to the addresses is illustrated in figure 24.

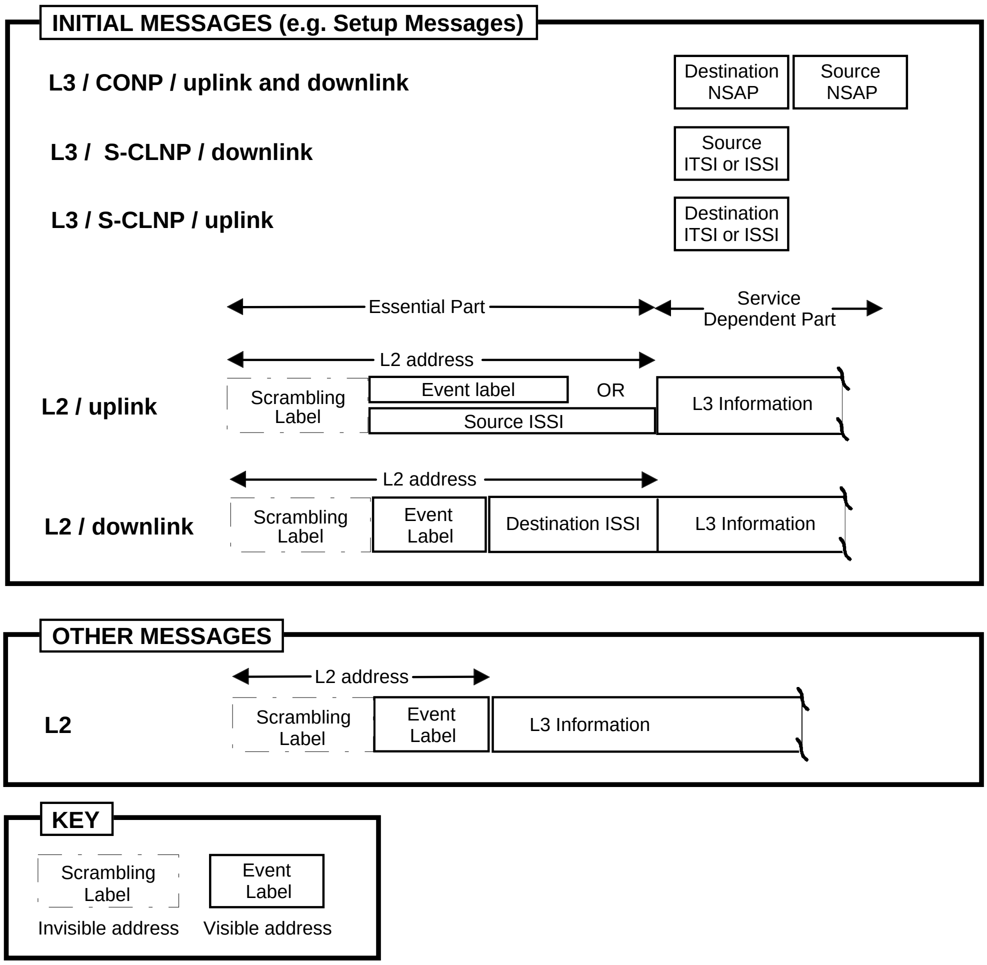


Figure 24: Message addressing for initial messages

6.8.2 Address placement in primitives and PDUs

6.8.2.1 Use of ISSI at layer 2

The placing of the SSI addresses into primitives and PDUs is shown in figure 25. Although the SSI is a layer 3 address, it shall also be used in the air interface layer 2.

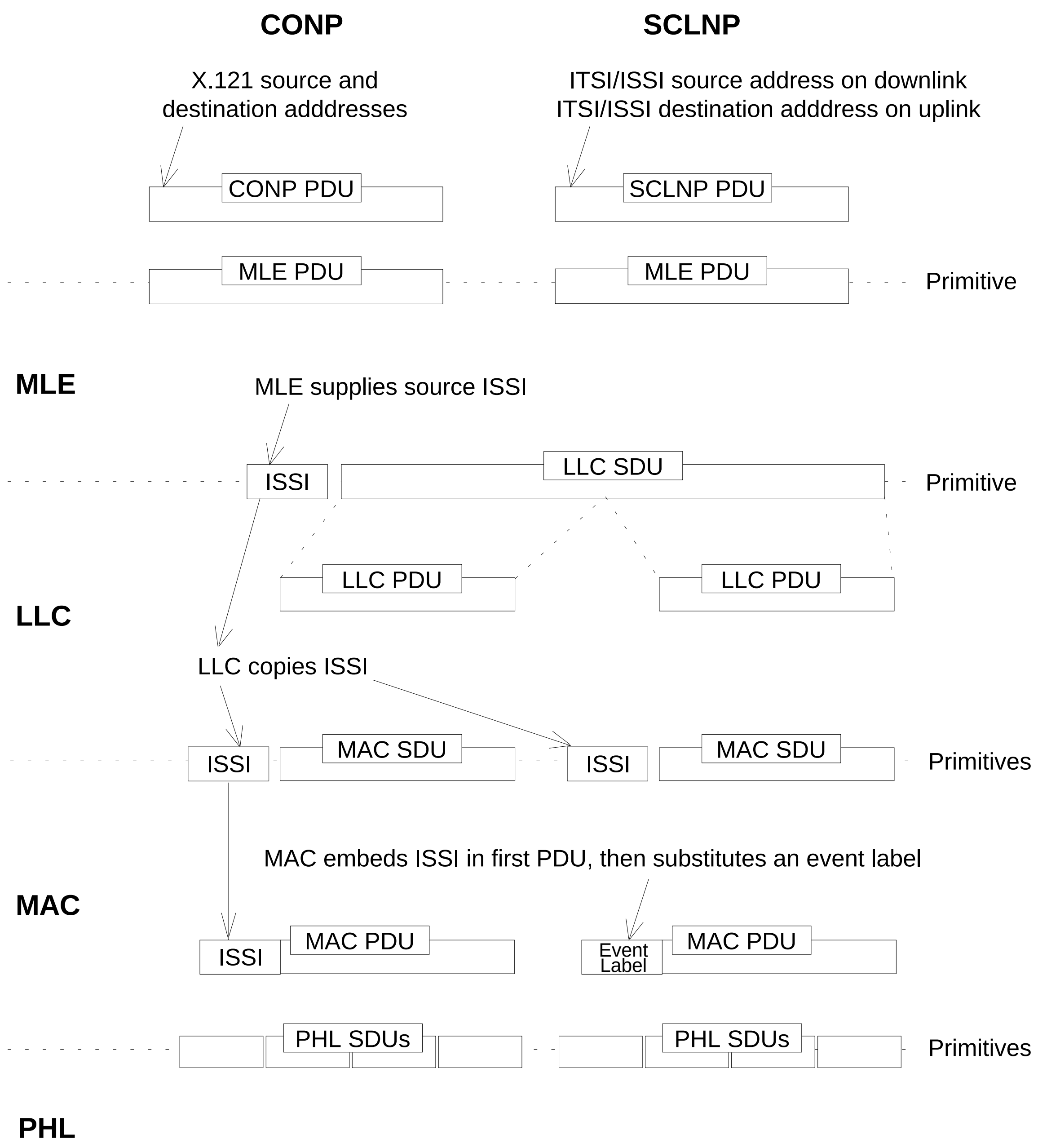


Figure 25: PDO air interface addressing

The relevant SSI address shall be supplied to layer 2 by the MLE. It shall appear in the layer 2 primitives as a separate parameter; i.e. it shall remain visible down to the MAC layer. This SSI address shall only be "invisible" at the physical layer.

This SSI parameter shall be the SOURCE SSI in request primitives (i.e. at the sending side) and shall be the DESTINATION SSI in the indication primitives (i.e. at the receiving side).

In all cases, the SSI shall be the value allocated by the current network. For a migrating terminal this shall be the (V)ASSI allocated by the visited system (see subclause 6.7).

The SSI mentioned as the source address shall not be a group address (GSSI), except in the case of the layer 2 group presence indication.

At the sending side, the MAC layer may place the source SSI into any suitable uplink PDUs unless an event label has been assigned. The MAC may choose to only send the ISSI in the first burst. It may then substitute an event label at any time, and may then use this event label to label future MAC bursts for the same ISSI.

At the receiving side the MAC layer may have received the destination ISSI at any time (e.g. in a previous message) and may only receive an event label in a particular burst. Nonetheless, it shall always provide the destination ISSI as a parameter in each indicate primitive (i.e. convert any event labels to the associated ISSI).

6.8.2.2 Use of ITSI/ISSI at layer 3

6.8.2.2.1 Use of ITSI/ISSI by SCLNP

The ITSI and ISSI addresses shall be used as the routing address for all SCLNP packets, where the PDU routing shall be defined by the source and destination ITSI (or ISSI).

The ISSI shall be used for all intra-TETRA data transactions. The ITSI shall be used for inter-TETRA data transactions. As usual, alias identities shall replace individual addresses if appropriate.

When migrating, the SCLNP shall retain its home network (H)ITSI, and data transactions to this subscriber should continue to use the (H)ITSI as the layer 3 destination address. The visitors (V)ASSI shall be used for all air interface PDUs in the visited network, and translation between the home (H)ITSI and the visitors (V)ASSI shall be performed by the visited network.

NOTE: The (V)ASSI is a temporary exchanged address, and the association to a given subscriber may be changed at any time by the visited network.

The SCLNP packet header over the air interface is designed to be as short as possible. As a result, three different PDUs have been defined for SCLNP as described in ETS 300 393-2 [17], clause 14:

- S1_DT PDU: Used on the uplink. Contains only DESTINATION ITSI (or ISSI);
- S2_DT PDU: Used on the downlink. Contains only SOURCE ITSI (or ISSI);
- S3_DT PDU: Used for inter-system inter-working. Contains both DESTINATION and SOURCE ITSI.

There shall only be one address field in the uplink and downlink PDUs to remove the duplication with the MAC layer address (the other ISSI address shall appear in the layer 2 primitives as described above). These air interface PDUs shall use shortened ISSI addresses (instead of the full ITSI) for addressing within one TETRA sub-domain.

The infrastructure shall convert between these different PDUs as required.

6.8.3 Routing principles

6.8.3.1 Routing of intra-TETRA data transactions (within one TETRA network)

Within one TETRA network, packet routing may use NSAP or SSI.

SSI alone should be sufficient for intra-TETRA routing, however, dual addresses (SSI and NSAP) may be used for all intra-network routing as an operator choice.

Dual addressing shall be used for CONP data transactions: both the X.121 (NSAP) address and the ITSI shall be allocated by the TETRA network operator.

6.8.3.2 Routing of inter-TETRA data transactions (between two TETRA networks)

Between two TETRA networks, packet routing may use NSAP or TSI.

TSI alone should be sufficient, however, dual addresses (TSI and NSAP) may be used as an operator choice in packet mode services.

6.8.3.3 Routing of external data transactions (to/from non-TETRA networks)

External to a TETRA network routing shall only use NSAP addresses.

The ISSI (or ASSI) shall still appear in the set-up packet for initial access to support the TETRA procedures.

6.8.4 Address and identity comparison

TETRA addresses and identities are compared in table 3 to the ones used in other systems.

Table 3: Comparison of addresses and identities between TETRA and other systems

TETRA	GSM	NA7/ UPT	Notes
ITSI	IMSI		
GTSI			4
ISSI	MSIN	Personal Identity	1, 2, 3
ASSI	TMSI		
GSSI			4
TMI	IMEI	Terminal Identity	2, 3
TEI			
NSAP	MS-ISDN or X.25	Personal or Terminal Number	3

NOTE 1: See CCITT Recommendation E.212 [3].
NOTE 2: Both the ITSI and the IMSI may be removable (transferable) identities. The TMI, the TEI and the IMEI are not removable.
NOTE 3: NA7/ UPT makes an important distinction between Identities and Numbers.
NOTE 4: Only TETRA recognises group addressing.

7 Mobility Management (MM) in MS

7.1 Introduction

This clause deals with the network signalling aspects of registration, authentication, energy economy mode change signalling and enable/disable signalling.

7.2 Overview of MM relations and procedures

Figures 26 and 27 show the MM relations, stimulations and procedures on the MS side. The distinction between the MS MM and RPDI MM entities are presented in the scenarios.

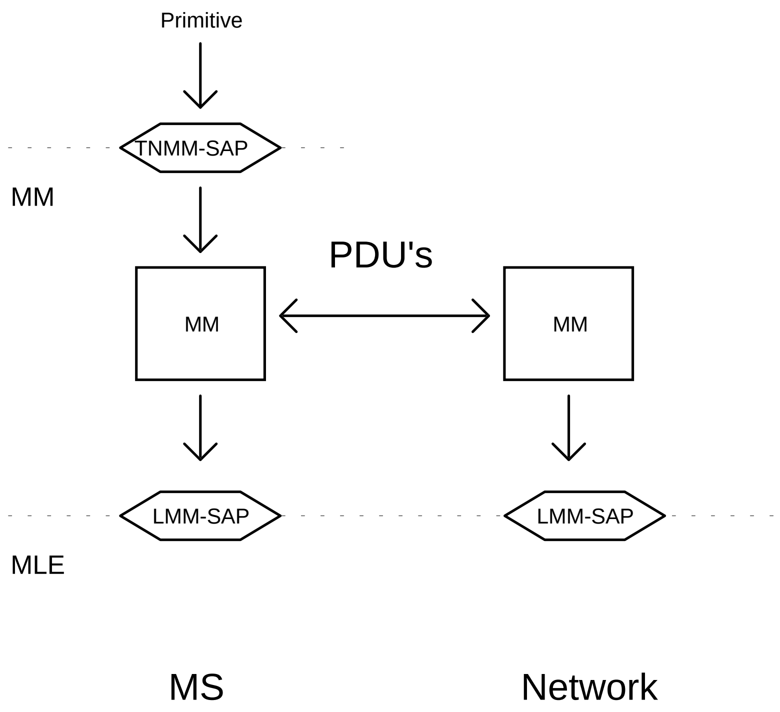


Figure 26: Mobility management relation

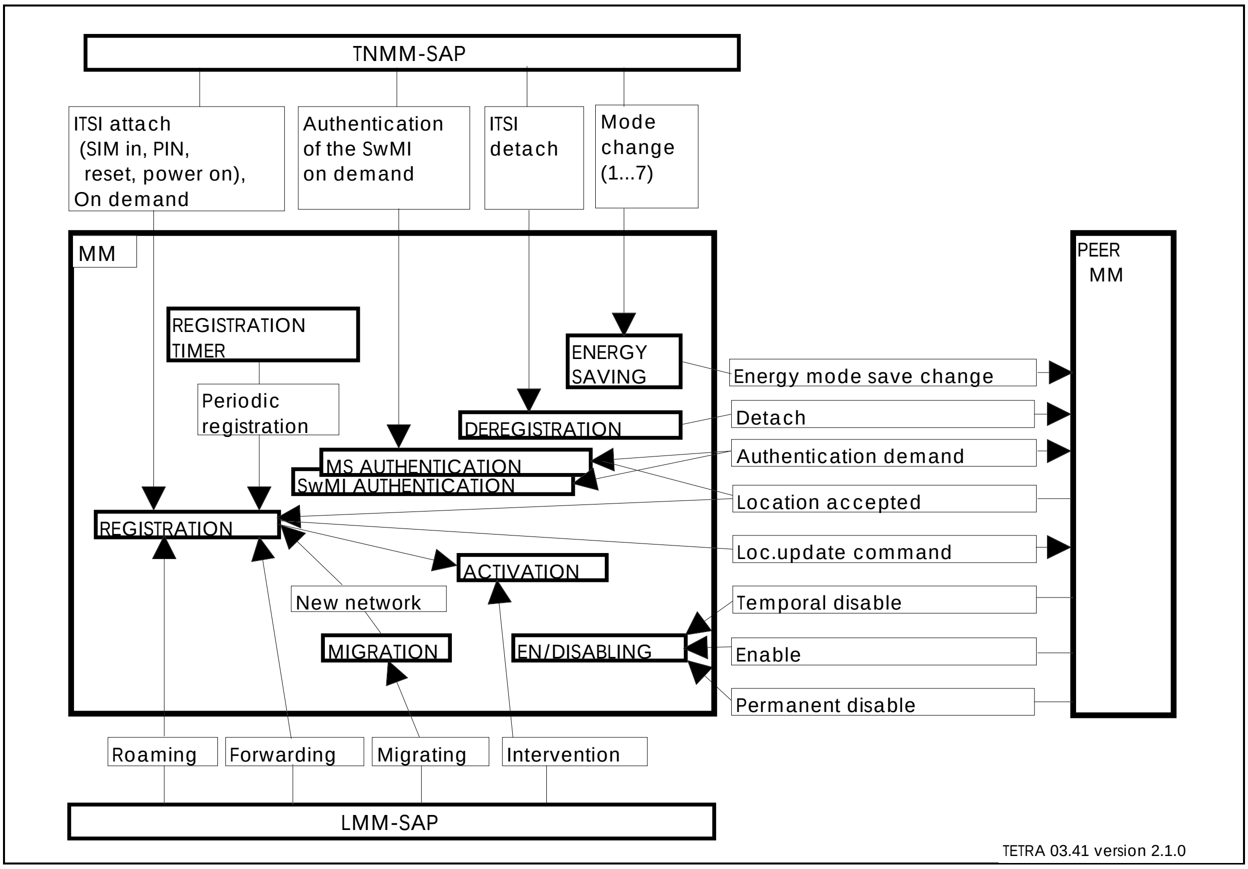


Figure 27: MM stimulations (thin boxes) and procedures (thick boxes)

7.3 Stimulation of MM

7.3.1 Stimulation through TNMM-SAP

- **ITSI attach:** when an ITSI is attached after previously having been detached, this shall be reported to the MM. An ITSI may be attached by a registration request or at subscription.

  Examples of events that should cause an ITSI attach are:

  - entering of a SIM-card containing the ITSI into the MS;
  - invoke an application, possibly by means of a PIN-code;
  - "reset button";
  - power up.

- **ITSI detach:** when a ITSI is detached after previously having been attached, this shall be reported to the MM. The way an ITSI is detached can be in a number of different ways. It shall be reported to the MM via the TNMM-SAP by a primitive request.

  Examples of events that should cause an ITSI detach are:

  - removal of the SIM-card containing the ITSI from the MS;
  - invoke an application, possibly by means of a PIN-code;
  - power down.

- **registration on demand:** registration may be requested by the user to force the registration and/or the authentication procedure. It shall be reported to the MM via the TNMM-SAP by a primitive request with cause "registration on demand";

- **network authentication on demand:** authentication shall be requested by the user to force an authentication of the TETRA infrastructure (BS). The authentication may be invoked by an "authentication button";

- **energy economy mode change:** the change of an energy saving scheme shall be requested by the user. It shall be reported to the mobility management peer in the infrastructure.

7.3.2 Stimulation through LMM-SAP

Stimulations through the LMM-SAP are defined in ETS 300 393-2 [17], clause 18 and may be any of the following:

- **intervention:** whenever the MM is required to take over control of the roaming or migration process either by performing registration/authentication or by performing activation;

- **roaming:** the change of a LA within the TETRA network may require registration;

- **forwarding:** the change of a LA within the TETRA network while still using the previous LA shall require registration;

- **migrating:** the change of a LA from one TETRA network to another one shall require registration.

7.3.3 Stimulation through peer MM

Stimulation through peer MM shall be achieved by sending PDU (messages) between the peer entities.

- **location update command:** the peer MM shall be able to force registration by the message <Location update command>;
- **location acceptance:** the peer MM may accept a location registration of a MS or refuse it;
- **network initiated user authentication:** the peer MM shall be able to start an authentication independent of registration by means of the message <Authentication Demand>;
- **temporary disable:** the peer MM shall be able to temporary disable a MS by sending the <Disable> message;
- **enable:** the peer MM shall be able to enable a MS temporary disabled by sending the <Enable> message;
- **permanent disable:** the peer MM shall be able to permanently disable a MS by sending the <Disable> message.

7.3.4 Other stimulation

- **periodic registration:** registration may be ordered to be performed periodically when a timer expires. The value of the timer shall be stored in the MS data base.

7.4 Outputs from MM

7.4.1 Output through TNMM-SAP

- **registration and authentication result:** the result of the registration and authentication procedures shall be reported via the TNMM-SAP by indication and confirm primitives:
  - for a successful registration/authentication;
  - for an unsuccessful authentication;
  - for an unsuccessful registration or successful detach;
  - for disabling/enabling.
- **temporary disabled:** the order to temporary disable the MS shall be reported via the TNMM-SAP by a primitive indication with cause "temporary";
- **temporary enabled:** the order to temporary enable the MS shall be reported via the TNMM-SAP by a primitive indication;
- **permanently disabled:** the order to permanently disable the MS shall be reported via the TNMM-SAP by a primitive indication> with cause "permanently".

7.4.2 Outputs through LMM-SAP

Outputs from the LMM-SAP are defined in ETS 300 393-2 [17], clause 17.

- **MM activates MLE:** MM shall control the LAs wherein the MS may search for service in by activating the MLE.

7.4.3 Output to peer MM

The messages to the MM peer entity shall be any of the following:

- **authentication demand:** when using the MS invoked authentication a message <authentication demand> shall be sent to the infrastructure;

- **authentication reply:** when using the network initiated authentication a message <authentication reply> shall be sent to the infrastructure;

- **ITSI detach:** when the ITSI detach is reported to the MM by a request, and the operator option of ITSI detach report is invoked, a message <ITSI detach> shall be sent to the peer MM;

- **location update demand:** MS shall request the infrastructure to update the location information of the MS with a message <location update demand>;

- **status:** MS shall report the energy saving mode to the infrastructure with a message <status>.

7.5 Data base requirement

The identified data base requirements in the MS for MM use are:

- **authentication parameters:** the keys for authentication parameters shall be stored in the data base;

- **ITSI detach report:** it shall be stored in the MS data base if ITSI detach shall be reported to MM in the infrastructure or not;

- **the search area:** the total area in which the MS may search for service.

7.6 MM procedures

7.6.1 Registration

Location registration procedures in MS should be chosen by the network operator.

7.6.1.1 Registration at roaming

7.6.1.1.1 Implicit registration

A network can be run so that no registration is needed. To keep track of where the MSs are situated, implicit registration should be used. This registration should be performed when a MS is sending or is responding to for example a call control message.

7.6.1.1.2 Multiple registration

Multiple registration is when a MS keeps its registration (for a finite or infinite time period) to a LA when it moves to, and registers in, a new LA. Effectively, the current registered area is enlarged. Multiple registration can also be pre-arranged by operator arrangement. However, the function is not considered in this ETS.

7.6.1.1.3 Registration procedure

The process shall start in the MS when another LA is preferred or when the MS is activated. The message <Location Update Demand> shall be sent to the infrastructure (see figure 28). The ISSI shall be used as sender identity. The data base should be interrogated. If the request is granted, and if authentication is not performed together with the registration, the message <Location Update Accept> shall be returned.

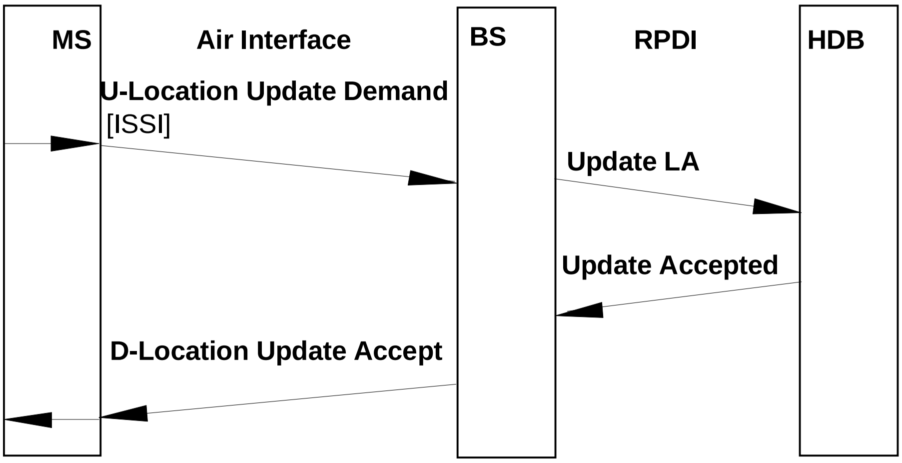


Figure 28: Registration at accepted roaming, with no authentication nor identity exchange

In the <Location Update Accept> message all LAs the MS may use without re-registering shall be included together with an indication of how long these LAs are valid. The MS may be registered in more than one LA.

If the registration is not granted for some reason, e.g. overload, network failure or MS access deny, the message <Location Update Reject> shall be returned with the cause for the reject (see figure 29).

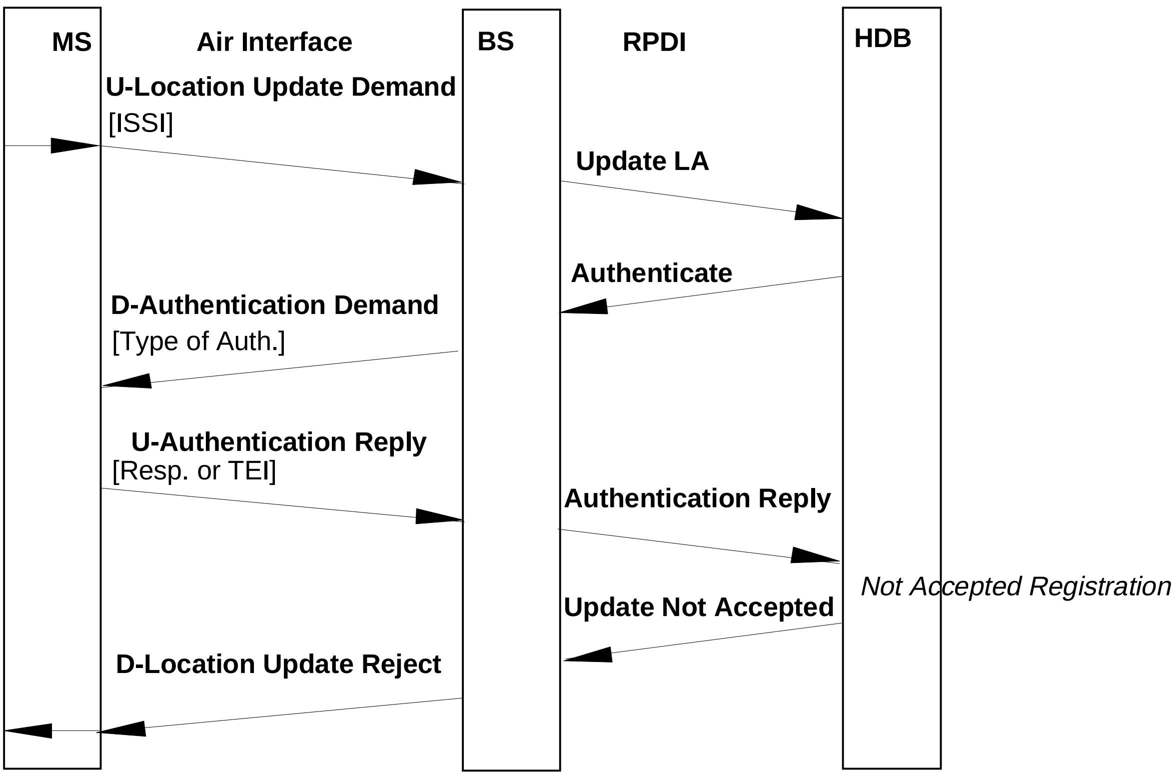


Figure 29: Registration at not accepted roaming, with authentication and no identity exchange

7.6.1.1.4 Registration with authentication

The network initiated authentication process (see subclause 7.6.2.1.) may be included in the registration process (see figure 30).

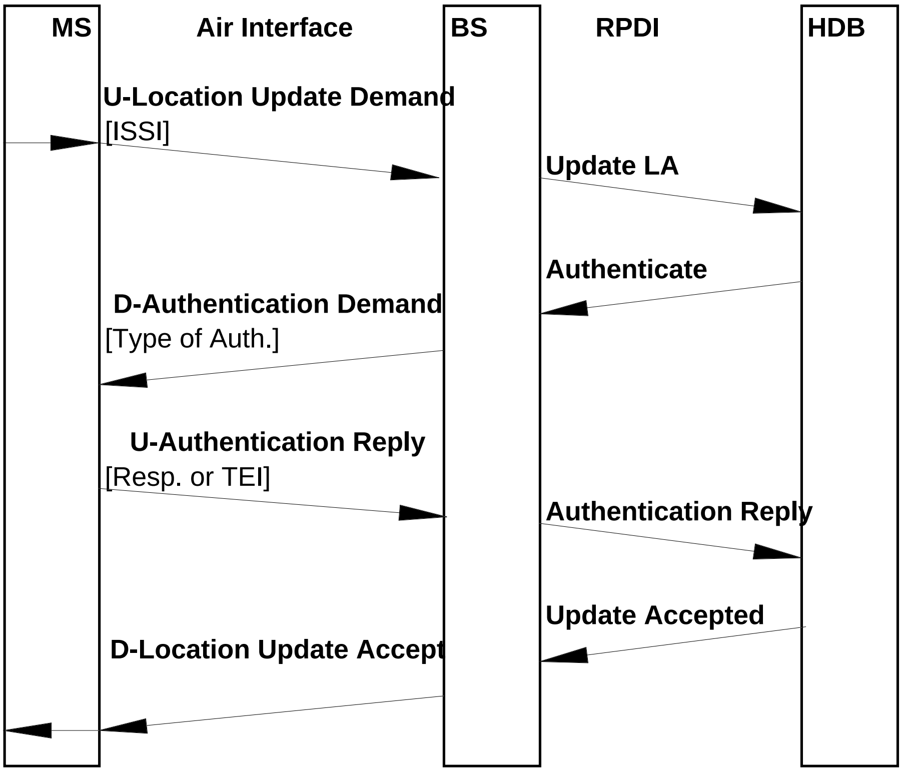


Figure 30: Registration at accepted roaming, with authentication and no identity exchange

7.6.1.1.5 Registration with identity exchange

When the message <Location Update Demand> is sent to the infrastructure (see figure 30), an ASSI shall be used for sender identity, if available. This ASSI should be translated in the infrastructure to the correct ITSI to gain access to the correct entry in the data base. The first time the identity exchange is carried out, it shall be the ISSI which is used in the <Location Update Demand>. The infrastructure may then return the new identity in form of an ASSI. This new identity should now be used hereafter (see figure 31).

The authentication process may be included as described in subclause 7.6.1.1.4.

If the demanded authentication and registration are granted, a new ASSI may be sent to the MS. This new ASSI shall be used in subsequent communications with the network.

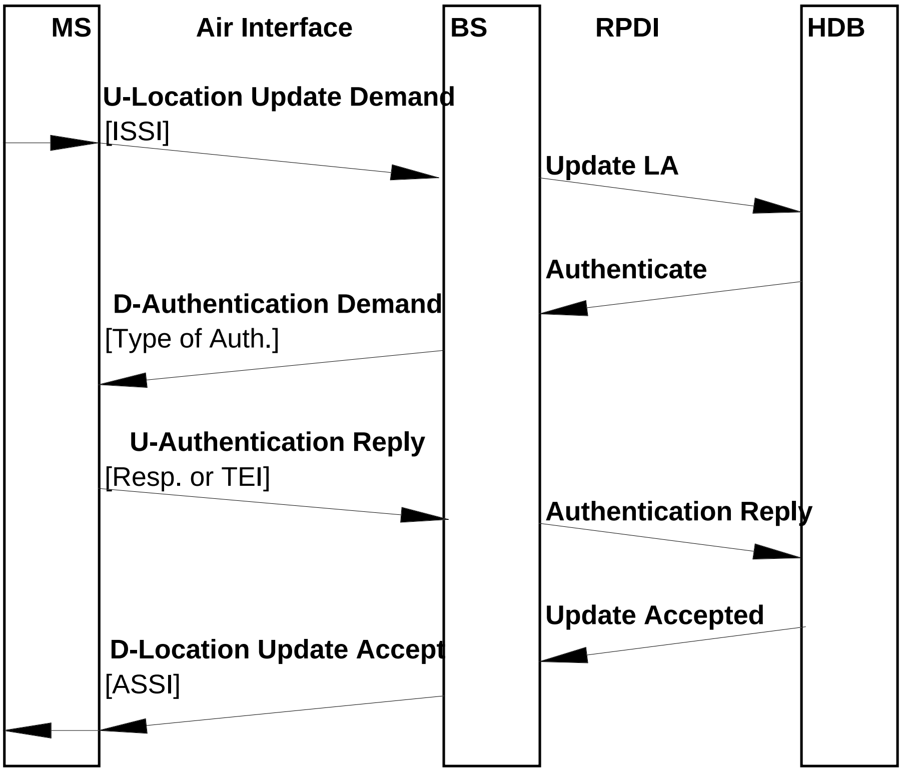


Figure 31: Registration at accepted roaming, with authentication and first identity exchange

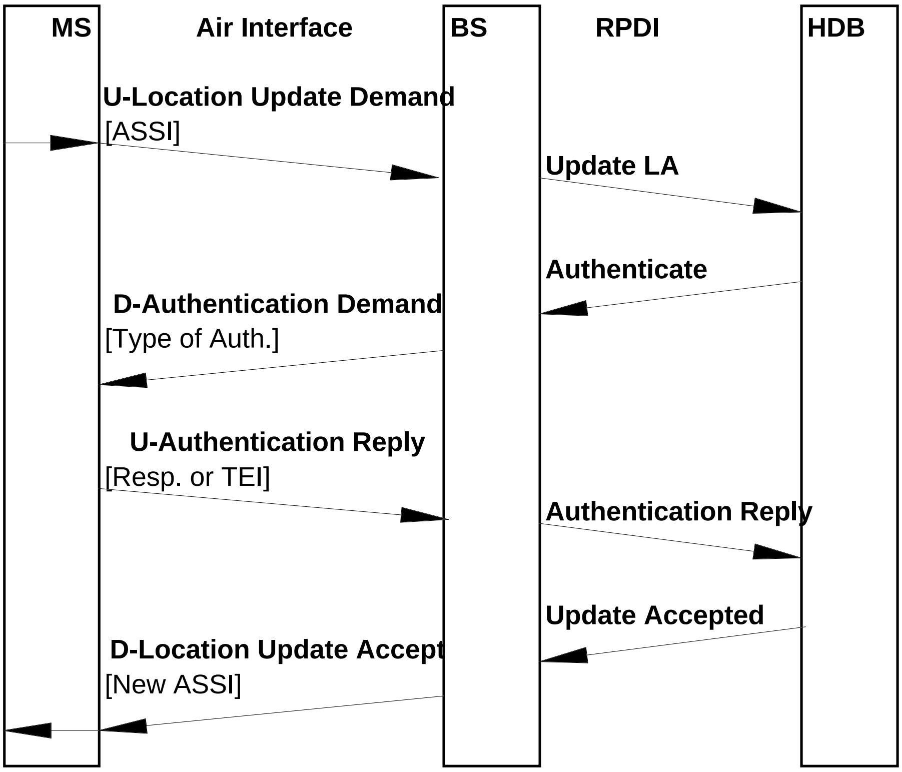


Figure 32: Registration at accepted roaming, with authentication and subsequent identity exchange

7.6.1.2 Registration at migration

7.6.1.2.1 Registration with identity exchange

When roaming, the process shall start in the MS when another LA in another network is preferred or when the MS is activated. The message <Location Update Demand> shall be sent to the infrastructure (see figure 33). In this case, the USSI shall be used for sender identity.

The <Location Update Demand> using the USSI shall contain the full ITSI as parameter (see figure 33). No <Location Update Proceeding> message should be needed.

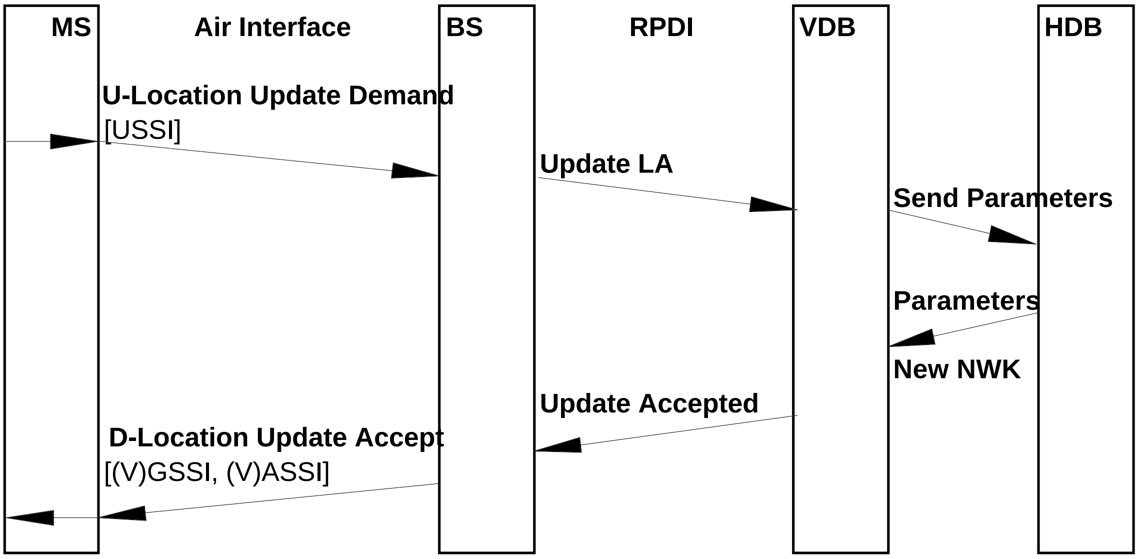


Figure 33: Registration at accepted migration, with identity exchange and no authentication

The visited infrastructure and possibly also the home infrastructure shall identify the ITSI. After this identification procedure, the MS should have an entry in the Visited Data Base (VDB) which should mirror the Home Data Base (HDB) as closely as possible.

After registration is accepted, the HDB shall be updated. This update may include services not supported by the visited TETRA. Any entry in another VDB should be erased by the home system.

Furthermore, after accepted registration, the <Location Update Accept> message including new (V)GSSIs and (V)ASSI parameters shall be sent to the MS. These new (V)GSSIs and (V)ASSI shall be used in subsequent communications with the network. Subsequent changes of LA in the same visited system shall be regarded as roaming, not migration.

7.6.1.2.2 Registration with authentication

The USSI shall be used during all the message exchanges and until a (V)ASSI has been assigned after <Location Update Accept> (see figure 34).

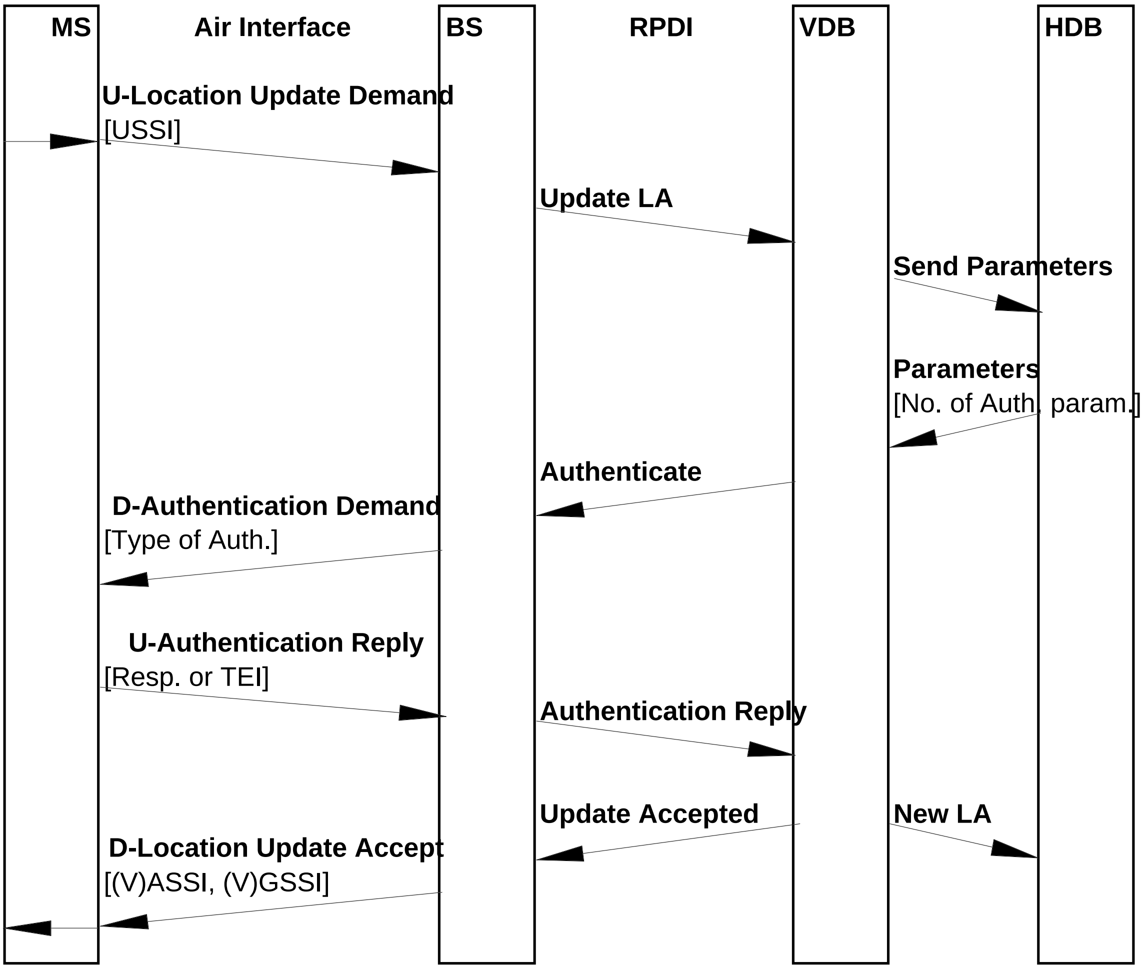


Figure 34: Registration at accepted migration, with identity exchange and authentication (PDO)

If authentication and registration are granted new (V)ASSI and (V)GSSIs shall be sent to the MS. These new (V)ASSI and (V)GSSIs shall be used in subsequent communications with the network.

7.6.1.3 Network initiated registration

The network shall be able to force the MS to initiate a location update procedure. This shall be activated by the <Location Update Command> message (see figure 35).

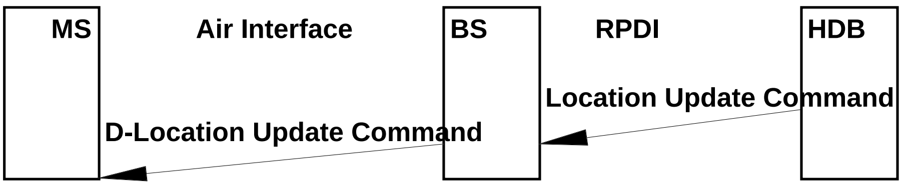


Figure 35: Network initiated registration

7.6.2 Authentication

Authentication mechanisms to be used in TETRA PDO STET will be described in Part 7.

7.6.2.1 Network initiated authentication

It is possible for the network to authenticate a MS without any previous MS initiated registration. This is done by sending the message <Authentication Demand> (see figure 36).

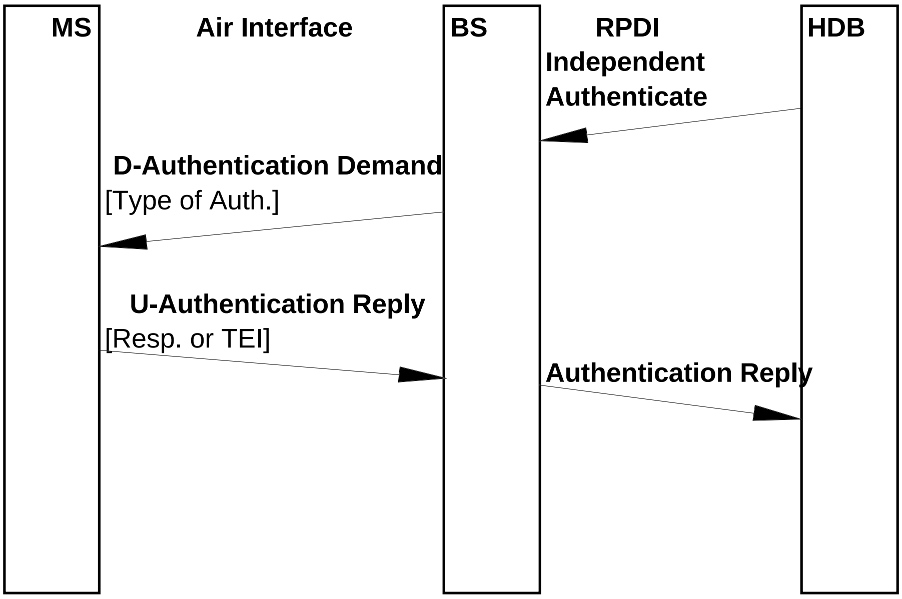


Figure 36: Independent authentication initiated by the network

If the C/R method is selected, the network sends the challenge number to the MS in the <Authentication Demand> message and the MS calculates the response and returns it to the network in the <Authentication Reply> message.

If the TEI method is selected, the MS calculates a 32 bits number based on a pre-defined encryption key and the TEI and returns the number in the <Authentication Reply> message.

If the authentication is not granted due to incorrect response, an <Authentication Reject> message is returned (see figure 37).

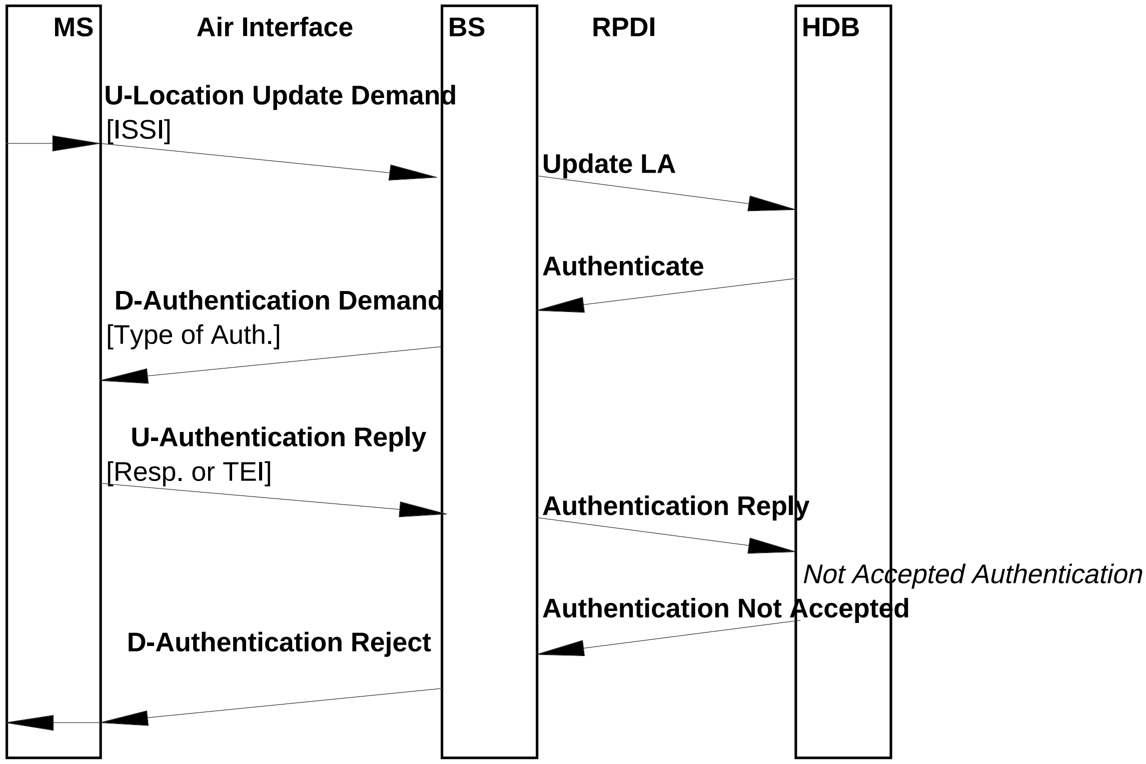


Figure 37: Registration at not accepted authentication, with authentication and no identity exchange

In the <Location Update Accept> message, all LAs the MS may use without re-registering is included together with an indication of how long these LAs are valid.

7.6.2.2 MS initiated authentication

It is possible also for a MS to start the authentication by sending the message <Authentication demand> to the infrastructure (see figure 38).

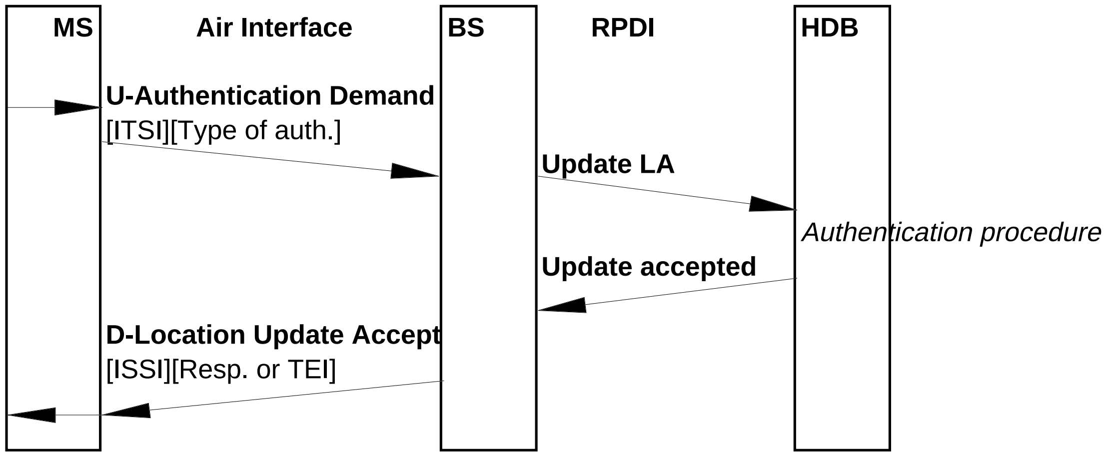


Figure 38: Authentication initiated by the MS

If the C/R method is selected, the MS sends the challenge number to the infrastructure in the <Authentication Demand> message and the infrastructure calculates the response and returns it to the MS in the <Location Update Accept> message.

If the TEI method is selected, the infrastructure calculates a 32 bits number based on a pre-defined encryption key and the TEI and returns the number in the <Location Update Accept> message.

The MS will not accept the network if an incorrect response in the <Location Update Accept> message is returned.

In the <Location Update Accept> message, all LAs the MS may use without re-registering are included together with an indication of how long these LAs are valid.

7.6.3 De-registration

The ITSIs and GTSIs may be stored in a card or as an application. If this identity is removed or the MS is powered down, as an operator option, an <ITSI Detach> message shall be sent to the infrastructure (see figure 39).

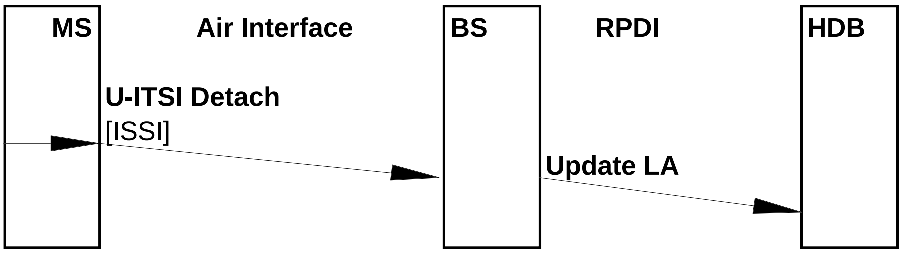


Figure 39: De-registration (ITSI detach)

7.6.4 Periodic registration

Registration of the MS to the network can be initiated periodically by an internal MS timer, the procedure shall be the same as described in subclause 7.6.1 and associated subclauses.

7.6.5 Disable/enable

7.6.5.1 Temporary disable

It may be possible, as an operator option, to temporarily disable an MS (see figure 40). The MS shall on receipt of the message <Disable with parameter "Temporary"> be prohibited from sending any further messages than MM messages over the air interface. This state shall remain until the message <Enable> is received. It is an operator option if an accepted authentication should be performed before the disable order is executed.

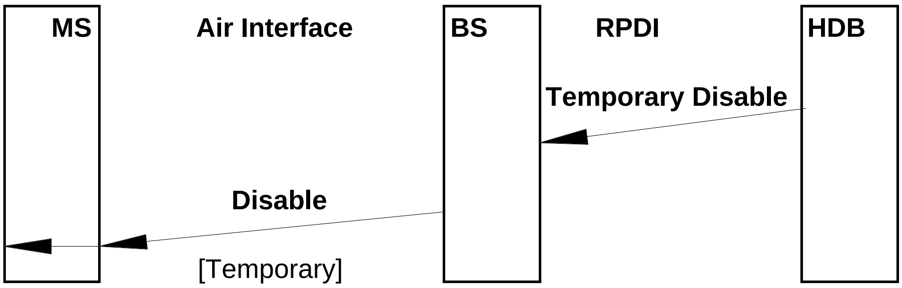


Figure 40: Temporary disabling a MS

7.6.5.2 Temporary enable

The message <Enable> shall be used to change an earlier "Temporary" <Disable> message (see figure 41).

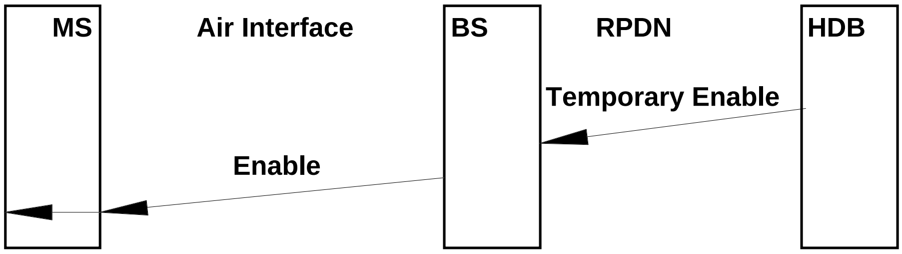


Figure 41: Temporary enabling a MS

7.6.5.3 Permanently disable

As an operator option, an MS may be dialled permanently (see figure 42). The MS shall on receipt of the message <Disable with parameter "Permanently"> be prohibited from sending and receiving any further messages than MM messages over the air interface. This state shall remain until the MS has been re-activated in an operator authorised service centre. It is an operator option if an accepted authentication shall be performed before the disable order is executed.

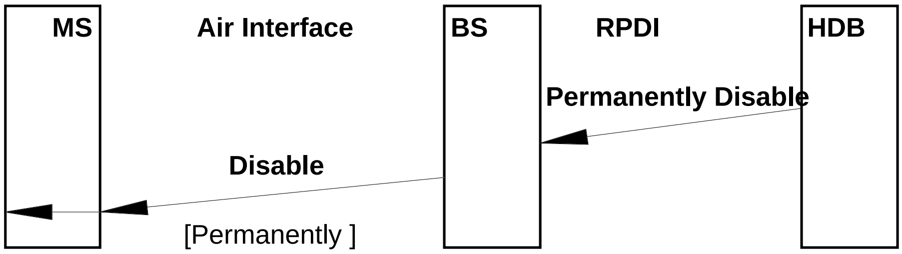


Figure 42: Permanently disabling a MS

7.6.6 Energy economy mode change

The mode changes for MS energy saving mode shall be reported to the infrastructure, either in normal registration or as a separate action. One of the eight different energy saving schemes (including <No energy> saving) shall be reported.

7.7 Downloading of group identities

The downloading of group identities shall be performed by the MM entity.

7.7.1 Add group identity

When the infrastructure wants to add one or more group identities to the ITSI family in the MS, a <Group Identity Command> message shall be sent to the MS with the command "add list" (see figure 43). The MS either accepts the complete list or rejects whole list. The accept or reject shall be sent to the infrastructure in a <Group Identity Acknowledge> message.

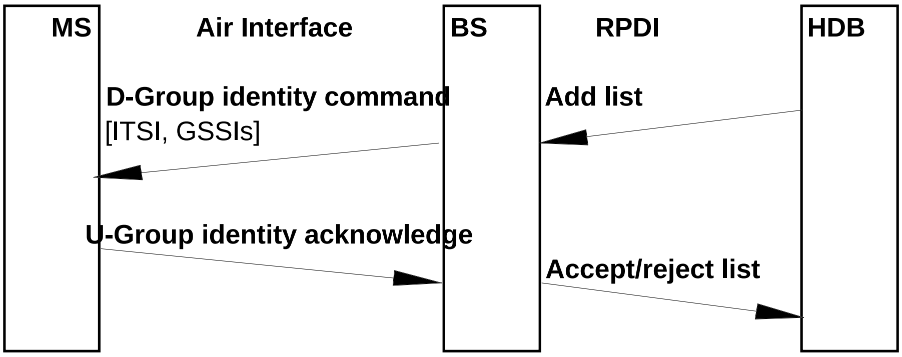


Figure 43: Network group identity (GSSI) download

7.7.2 Delete group identity

When the infrastructure wants to delete one or more group identities in the ITSI family of the MS, a <Group Identity Command> message shall be sent to the MS with the command "delete list" (see figure 44). The MS shall then delete all GSSIs that can be found in the ITSI family and an acceptance of the command shall be sent to the infrastructure in a <Group Identity Acknowledge> message.

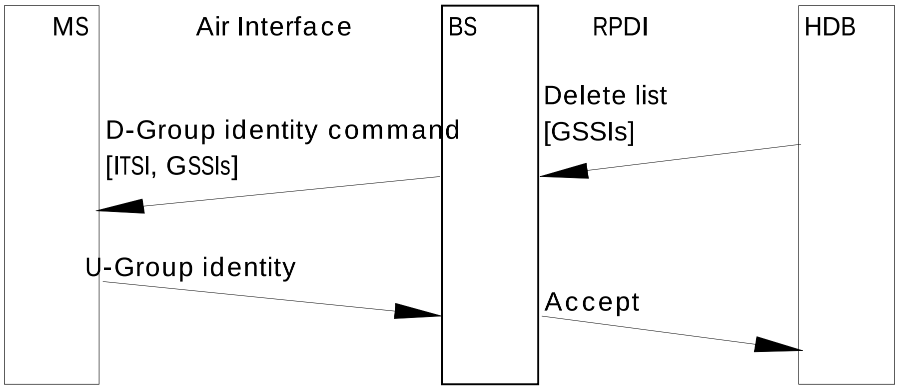


Figure 44: Deletion of a list of group identities (GSSI) by the network

7.7.3 Delete all group identities

When the infrastructure wants to delete all group identities in a ITSI family of the MS, a <Group Identity Command> message shall be sent to the MS with the command "delete all" (see figure 45). The MS shall then delete all GSSI that belong to the ITSI family and an acceptance of the command shall be sent to the infrastructure in a <Group Identity Acknowledge> message.

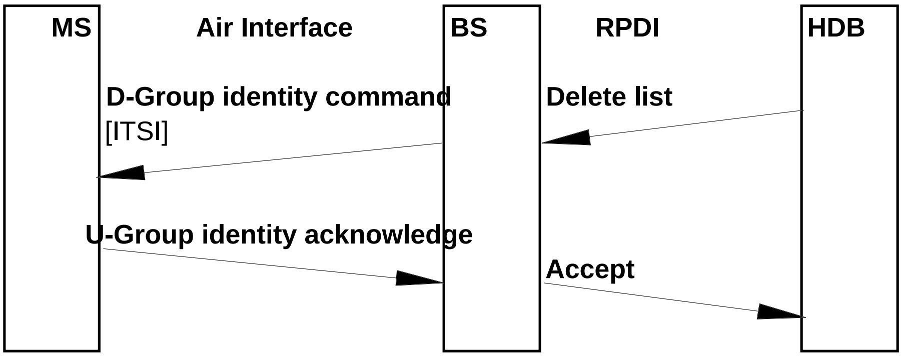


Figure 45: Deletion of all group identities (GSSI) by the network

7.7.4 Report group identities

When the infrastructure wants a report on the current group identities belonging to the ITSI family of the MS, a <Group Identity Command> message shall be sent to the MS with the command "report" (see figure 46). The MS shall then respond with a complete (or partial) list of GSSIs in the requested ITSI family. The list shall be sent to the infrastructure in a <Group Identity Acknowledge> message.

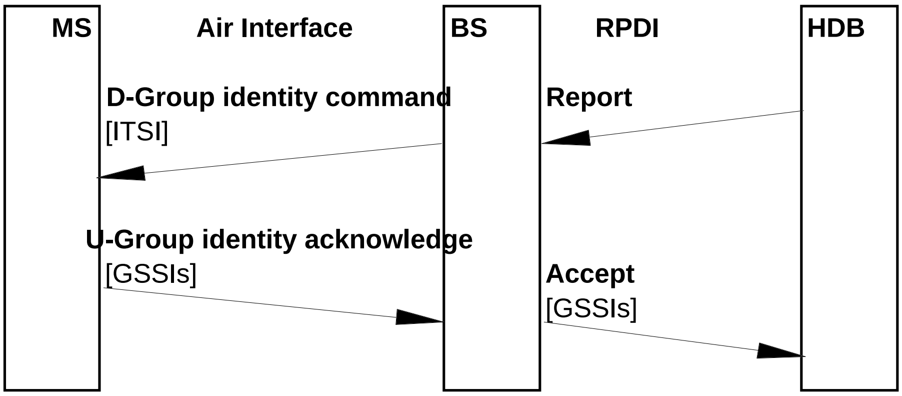


Figure 46: Reporting current group identities (GSSI) to the network

7.8 Exception conditions

7.8.1 Undisciplined de-registration

Prior to changing the ITSI of a subscriber, the "old" ITSI shall be detached. Failure to do so results in two identical ITSIs operating in the TETRA network. This may cause an undesirable disturbance to the operation.

8 MLE mobility scenarios and functionalities

8.1 Introduction

This clause deals with the functions which may be performed by the MLE sub-layer during mobility scenarios, both when roaming and migrating.

8.2 Overview

When a MS moves from cell to cell, the higher layer entities in the protocol stack may experience some interruption in the TETRA services. The MLE may perform certain functions which reduce the interruption caused by cell re-selection.

These functions may be applied either to assist the MM of the MS, e.g. to keep track of the movements of the MS, or the functions may be applied to recover MLE connections between a MS and the RPDI during cell re-selection. The functions may also assist the recovery of communications (i.e. call restoration) during the cell re-selection, but the specific communication recovery procedures are outside the scope of this ETS. The MLE connection recovery and the assistance of communication recovery may also be relevant after a temporary loss of coverage within the same cell.

This clause gives then a description of the functions and the different levels of capability that the MLE protocol shall support within TETRA. It gives also an overview of the different stimuli known to the MLE, including the MLE PDUs. The clause describes how these stimuli may be used by the MLE to support the MLE mobility functions.

8.3 MLE responsibilities

MS-MLE shall be responsible for the following:

- manage the scanning for suitable cells using the relevant location areas and the cell selection/re-selection procedures for the MLE;
- manage the monitoring of neighbour cells by instructing the lower layers. The function may help the scanning process in ranking the cells;
- manage the surveillance of the serving cell by instructing the lower layers to provide quality information, when attached to the cell;
- manage the undeclared cell re-selection;
- invite MM entity intervention if no service is found, whereby guidance is received containing information on new location areas;
- invite MM entity intervention if a suitable cell is outside registered area, whereby MM is envisaged to perform the registering procedure.

RPDI-MLE and MS-MLE shall be responsible for the following:

a) manage the announced cell re-selection;

b) manage the unannounced cell re-selection;

c) advise the higher layer 3 entities of the potential of errors arising from a break in the MLE connection while attaching to another cell. The advisory is only supported by the MLE if higher layers have asked for a MLE connection;

d) advise the higher layer 3 entities when a existing MLE connection has been terminated due to a lower layer failure;

e) advise the higher layer 3 entities by the time MLE service is required, that due to ongoing cell re-selection service is not available;

f) exchange network information via network information broadcast, this information is used by the initial cell selection and cell re-selection procedures.

The MLE in the MS or RPDI may support a number of levels of TETRA system capability for the assistance of communications recovery or attachment recovery both with and without MLE connection. These are summarised in the following list:

1) initial cell selection;
2) announced cell re-selection type 2 by roaming;
3) announced cell re-selection type 3 by roaming;
4) unannounced cell re-selection by roaming;
5) undeclared cell re-selection by roaming;
6) announced cell re-selection type 2 by migrating;
7) announced cell re-selection type 3 by migrating;
8) unannounced cell re-selection by migration;
9) undeclared cell re-selection by migration;
10) no MLE recovery.

8.4 MS-MLE model

In the scenarios that follow, the LSCL SAP is taken as an example of an LXX SAP. The services offered to the LSCL SAP during the scenarios that follow may be the same as for the other LXX SAPs (see figure 47).

NOTE: The layer-to-layer primitives shown on the RPDI side in the following scenarios are only informative and shown for the description of the model.

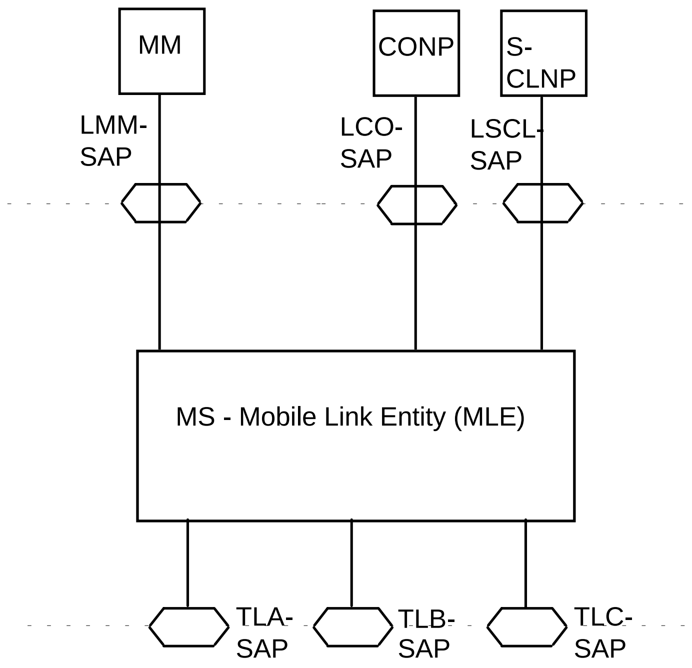


Figure 47: SAPs offered to the MS MLE

8.5 MLE functionalities

The overall mobility functionalities as outlined in figure 47 can be broken down into different sub-functions. Each of these sub-functions are described by an individual scenario. These are:

1) monitoring of neighbour cells (MS - side);

2) scanning of neighbour cells (MS - side);

3) MM Activation of MLE (MS - side);

4) open up MLE services (RPDI/MS - side);

5) closing MLE services (RPDI/MS - side);

6) changing to the serving cell (MS - side);

7) surveillance of the serving cell (MS - side);

8) inviting MM intervention when no service is found (MS - side);

9) inviting MM intervention when found LA is outside RA (MS - side);

10) set-up MAC broadcast (RPDI - side);

11) initiating MLE broadcast (RPDI - side);

12) MM registering (MS - side);

13) announce old cell and to-to-channel (MS/RPDI - side);

14) announce old cell (MS/RPDI - side);

15) announce new cell and successful restoration (MS/RPDI - side);

16) announce new cell and restoration failure (MS/RPDI - side);

17) path lost to the serving cell (MS - side).

8.5.1 Monitoring of neighbour cells (Scenario 1)

Monitoring of the neighbour cells is started by issuing a TL-MONITOR-LIST request primitive from the MS-MLE to the lower layers at the TLC-SAP. Before starting the monitoring, the MS-MLE should have received a <D-BROADCAST> PDU containing information of neighbour cells. The parameters to the TL-MONITOR-LIST request primitive are a list of cell-ids and the corresponding broadcast information from the <D-BROADCAST> PDU. The lower layers shall then be instructed to perform power measurements and path loss calculations concurrently with other services. The measurement method is outlined in ETS 300 393-2 [17], clause 10 and the monitor function is described in ETS 300 393-2 [17], clause 22 . When a measurement on one neighbour cell is finished, the result should be passed up to the MS-MLE in a TL-MONITOR indication primitive. The path loss result C2 for the concerned cell should be passed as a parameter. Based upon the individual C2 results from each of the neighbour cells, the MS-MLE should build a ranking list. The scenario is outlined in figure 48.

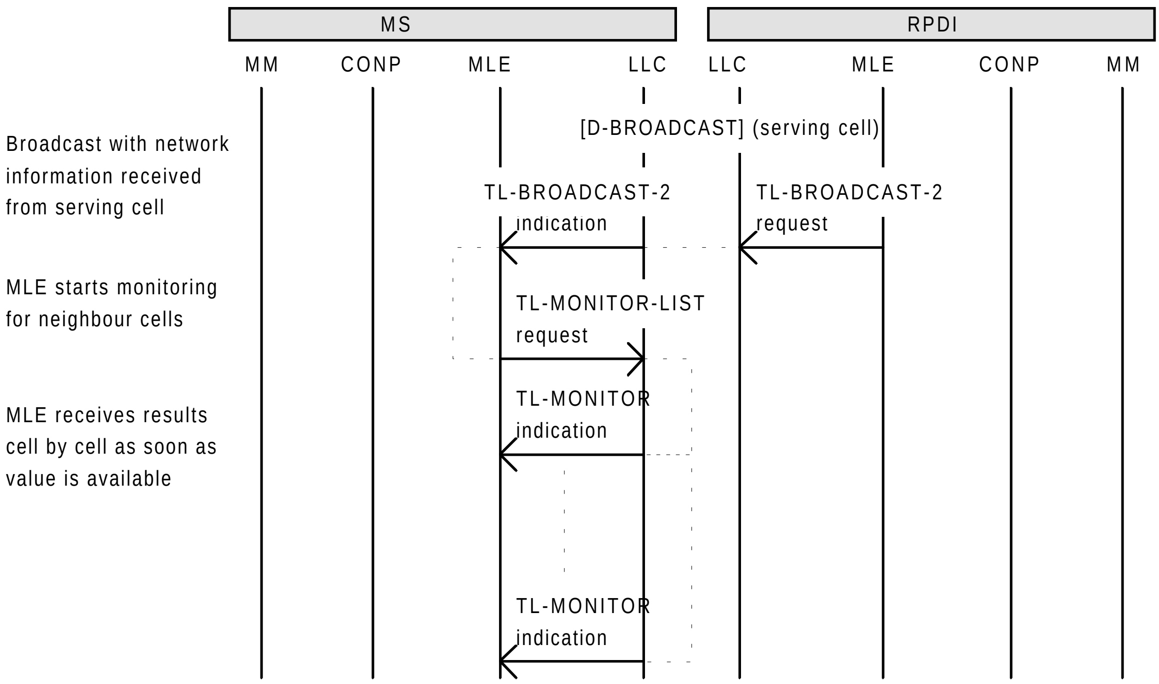


Figure 48: Monitoring of neighbour cells (Scenario 1)

8.5.2 Scanning of neighbour cells (Scenario 2)

The scanning procedure seen from the MS-MLE may be a procedure in several steps employing a scanning list. This list can be built using various inputs such as:

- the result from the ranking of the neighbour cells performed by the monitoring sub function;

- a stored cell list;

- the result of the MLE-ACTIVATE request primitive;

- preference for certain cells.

The scanning is started by issuing a TL-SCAN request primitive from the MS-MLE to the lower layers at the TLC-SAP. Each scan shall be performed on only one neighbour cell. The parameters sent in the primitive are apart from a scanning list element, the measurement method to be utilised at the lower layers. The measurement methods applied to the scanning may be:

- foreground measurements; or
- background measurements; or
- interrupted measurements.

The measurement method is described in ETS 300 393-2 [17], clause 10. Based upon the TL-SCAN request primitive parameters, the lower layers should be instructed to perform power measurements and to synchronise and read the information from the SYNC broadcast and the SYSINFO broadcast. When the lower layers have finalised their task, a TL-SCAN confirm primitive should be issued to the MS-MLE. Information about the scanned cell should be returned as parameters including the calculated path loss C1.

From now on, the path loss parameter C1 shall be returned in a TL-SCAN-REPORT indication primitive every time the monitor process (scenario 1, figure 48) has retrieved the power measurement. The MS-MLE may now choose to continue the scanning process or wait to see whether the scanned cell increases its C1 parameter.

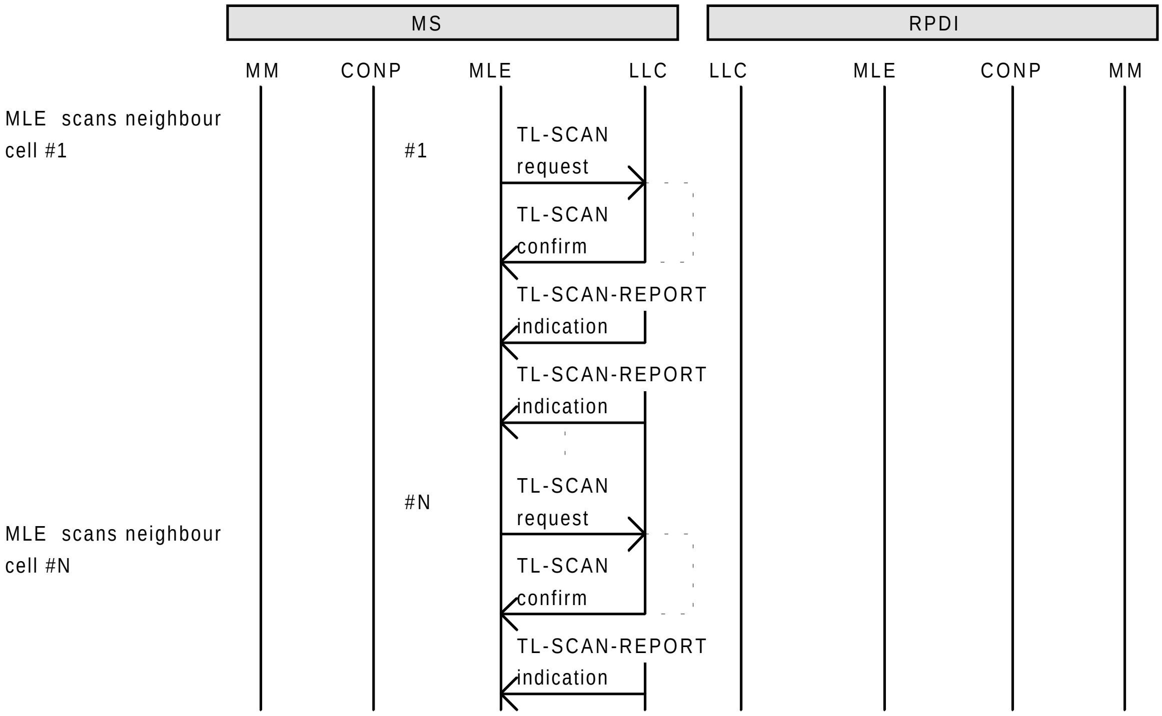


Figure 49: Scanning of neighbour cells (Scenario 2)

8.5.3 MM activation of the MS-MLE (Scenario 3)

Activation of the MS-MLE should be performed by the MM entity. The activation process should be started by the MM issuing a MLE-ACTIVATE request primitive to the MS-MLE. The location areas containing the cell-ID in which the MM empowers the MS-MLE to search for service in should be passed as parameters to the primitive. The cell-ID may be the preferred cells for the location areas.

The MS-MLE then should start scanning procedure according to subclause 8.5.2. and when a suitable cell is found, the selection procedure according to subclause should be applied. The measurement method, given as parameter to the lower layers in the TL-SCAN request primitive, should be foreground measurement. The method is described in clause 10.

NOTE: The activation of the MS-MLE may start with monitoring according to scenario 1 (see figure 48). Since it is an initial monitoring, the broadcast parameters on neighbour cells may not be known to the MS-MLE and therefore default values should in this case be assigned.

When the activation process has finished, the MS-MLE should informs the MM about the result in a MLE-ACTIVATE confirm primitive. The result may either be that no suitable cells could be found or that the MS is now camped on the cell. In both cases, the MS-MLE should wait for intervention from the MM.

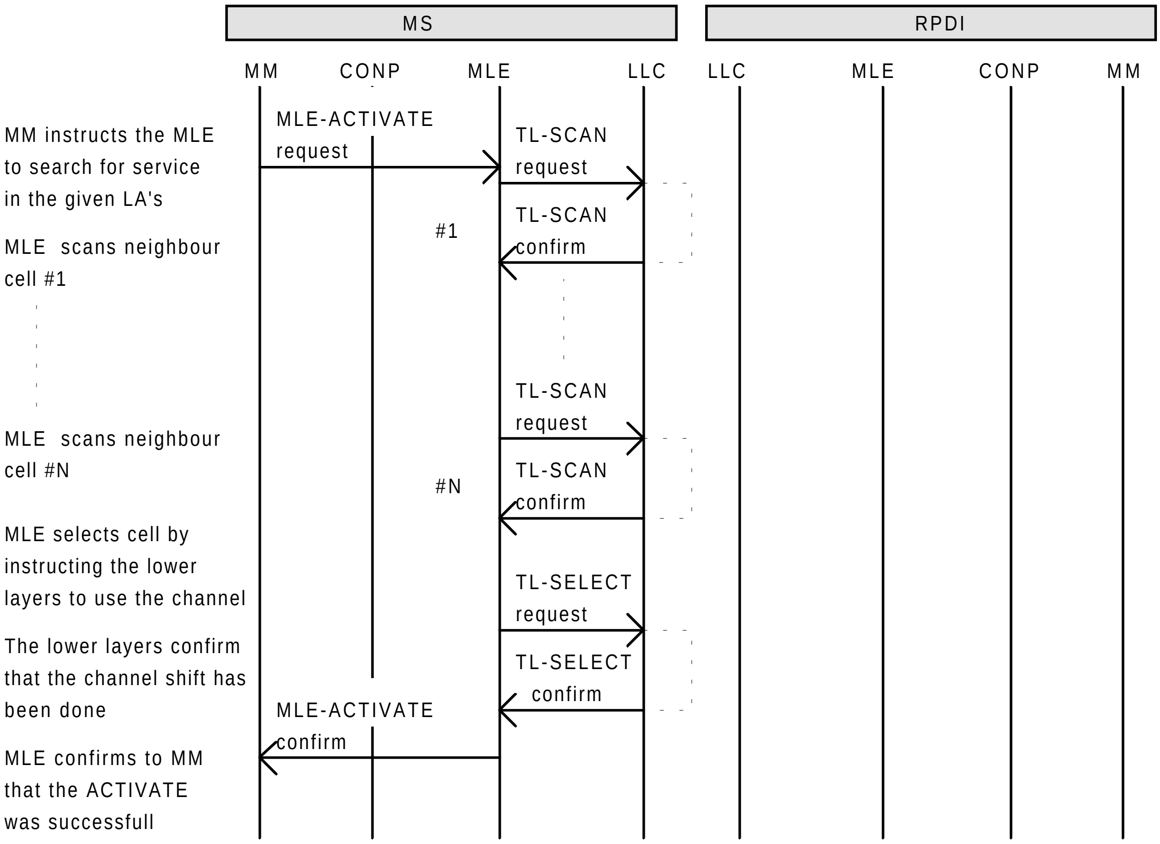


Figure 50: MM activation of the MS-MLE (Scenario 3)

8.5.4 Open up MLE service (Scenario 4)

The MM should decide when to open up for MLE services. When the MM issues an MLE-OPEN request primitive to the MLE this opens up the MLE services both in the MS and in the RPDI. In order to synchronise the events, signalling between the MM entities in the MS and in the RPDI shall take place before the employment of the "open-up-MLE-service" function. After reception of the MLE-OPEN request primitive, the MS-MLE and the RPDI-MLE should issue a MLE-OPEN indication primitive to their service users, e.g. CONP and SCLNP. After this sub-function is performed, the MLE service users should have access to the communication resources.

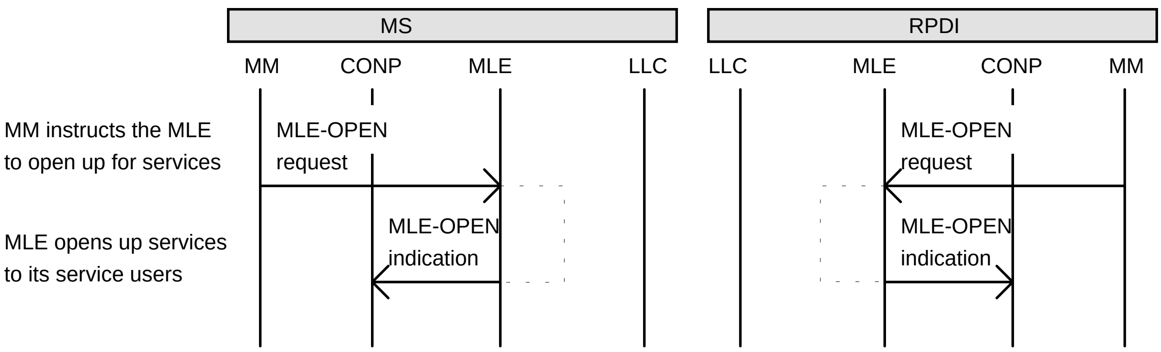


Figure 51: Open up MLE services (Scenario 4)

8.5.5 Close of MLE service (Scenario 5)

The MM should decide when to close for MLE services. When the MM issues an MLE-CLOSE request primitive to the MLE this closes MLE services both in the MS and in the RPDI. In order to synchronise the events, signalling between the MM entities in the MS and in the RPDI can take place before the employment of the "close-of-MLE-service" function. After reception of the MLE-CLOSE request primitive, the MS-MLE and the RPDI-MLE should issue a MLE-CLOSE indication primitive to their service users, e.g. CONP and SCLNP. After this sub-function is performed, only the MM entity shall have access to the communication resources. All other MLE SAPs shall be closed.

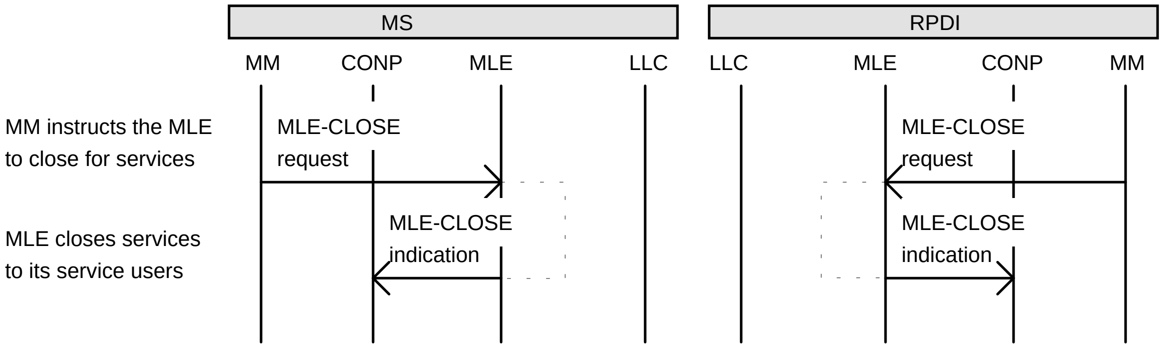


Figure 52: Close of MLE services (Scenario 5)

8.5.6 Changing to serving cell (Scenario 6)

When MS-MLE decides to change to another cell, it should issue a TL-SELECT request primitive to the lower layers. The cell-ID (channel number) and some rules for surveillance of the serving cell should be provided as parameters. The lower layers should immediately change to the identified cell and start the survey. The TL-SELECT confirm primitive should be sent back to the MS-MLE indicating whether the selection has been successful or not.

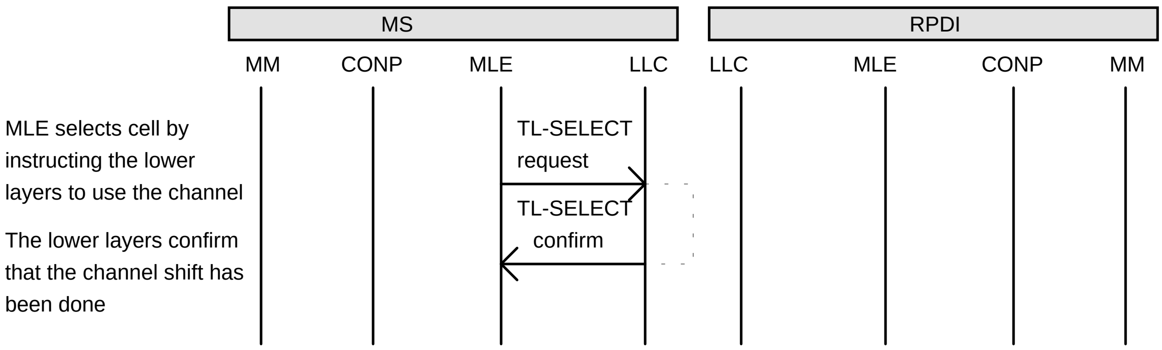


Figure 53: Changing to serving cell (Scenario 6)

8.5.7 Surveillance of the serving cell (Scenario 7)

The MS-MLE should start surveillance of its serving cell when selection of the cell is performed by utilising the TL-SELECT request/confirm primitives. From now on, the MS-MLE should receive TL-MEASUREMENT indication primitives containing quality information from the lower layers and network broadcasts from the RPDI-MLE. The quality parameters in the TL-MEASUREMENT indication primitives should also contain the calculated path loss C1 (refer to ETS 300 393-2 [17], clause 10) and may as well contain message error rate, indication of random access failure and re-transmission failure on the LLC link. The <D-BROADCAST> PDU from the serving cell should contain information about neighbour cells and may as well contain network information related to the serving cell.

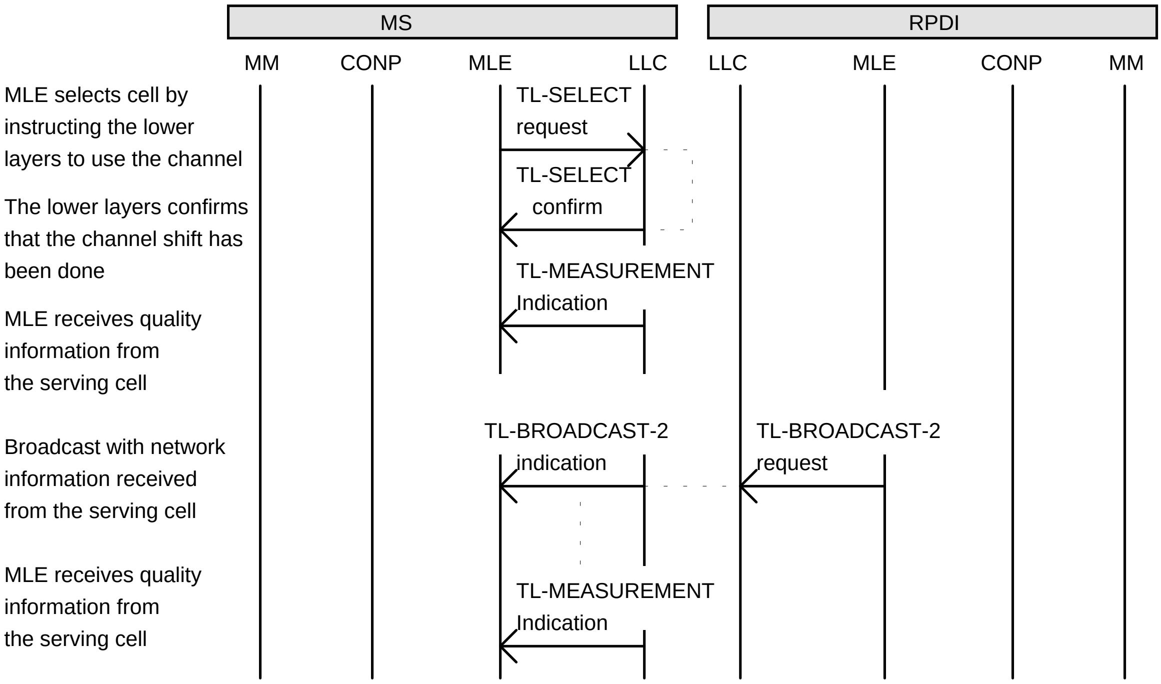


Figure 54: Surveillance of the serving cell (Scenario 7)

8.5.8 Inviting MM intervention

8.5.8.1 No service can be found (Scenario 8)

After scanning or due to sudden loss of radio contact, the MS-MLE may invite MM entity intervention in order to receive instructions for new location areas. When the MS-MLE cannot obtain service using its current understanding of the network, it should send a MLE-ACTIVATE indication primitive to the MM entity with parameters containing information about the reason why to invite MM entity. The parameters may be the current location area, the current serving cell and some other network parameters which MS-MLE has obtained via the network broadcast.

After sending of the MLE-ACTIVATE indication primitive, the MM should proceed with a normal MLE activation as described in subclause 8.5.3.

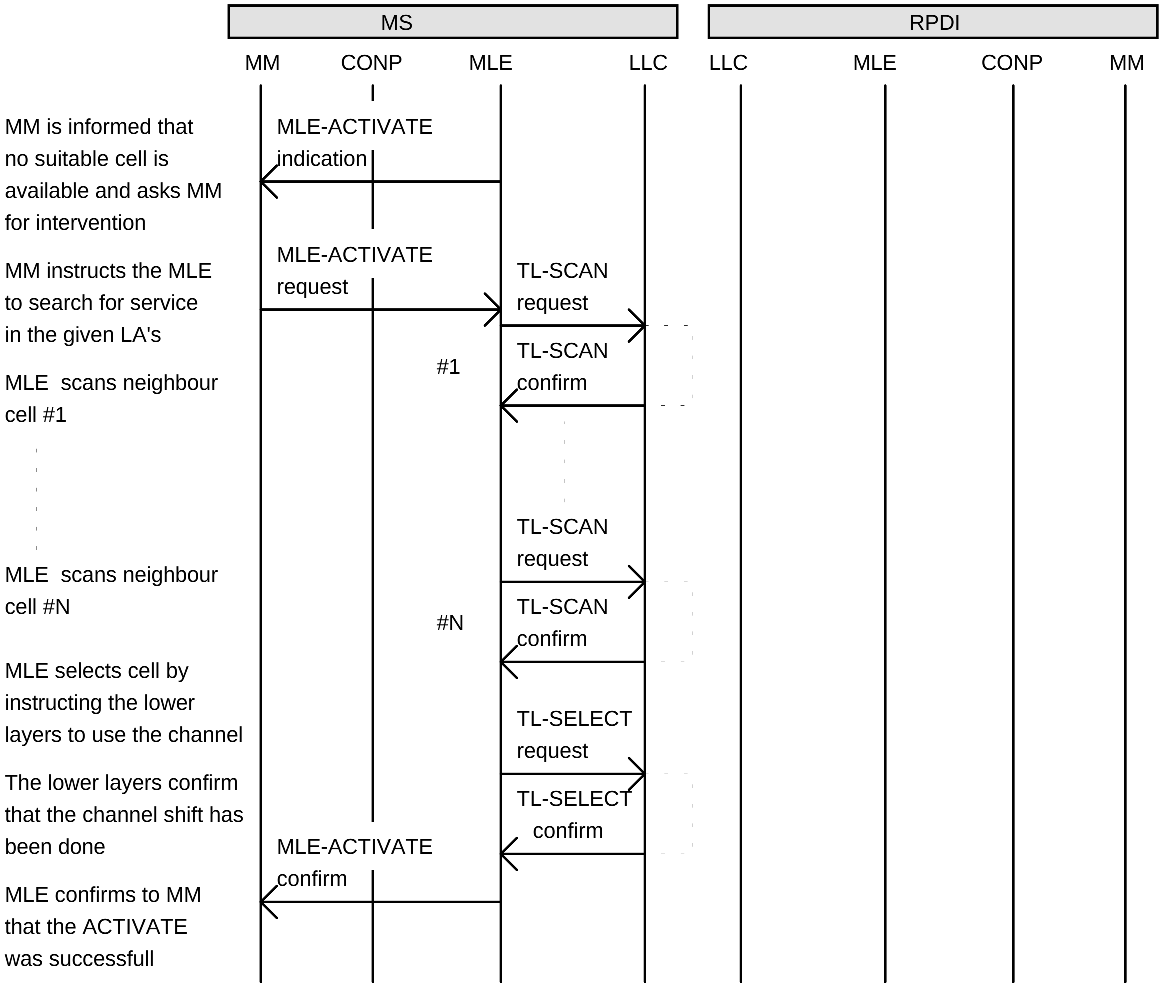


Figure 55: Inviting MM intervention - no service can be found (Scenario 8)

8.5.8.2 LA found outside RA (Scenario 9)

When MS-MLE finds a cell in a location area which is outside the current registered area, it should invite MM entity intervention. As soon as the MS-MLE has discovered that the obtained location area is outside the registered area, it should send a MLE-LINK indication primitive to the MM entity. The new location area in which the MS-MLE wants the MM to register in should be provided as a parameter. Then the MM register procedure should take place as described in subclause 8.5.11. When the MM is satisfied with the new location area, it should send a MLE-UPDATE request primitive to the MS-MLE with the new registered area in which the MS-MLE is empowered to search for service.

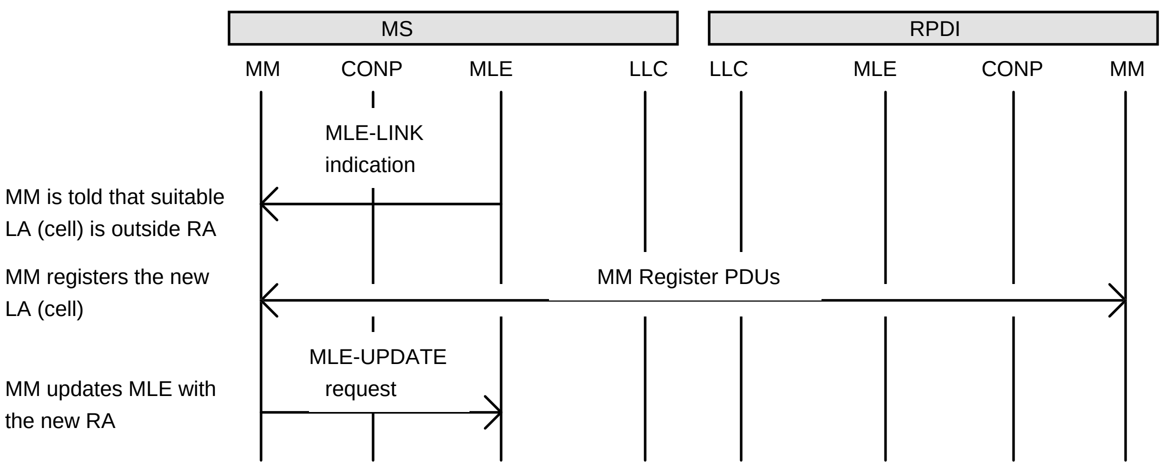


Figure 56: Inviting MM intervention - LA outside RA (Scenario 9)

8.5.9 Set-up of MAC broadcast (SYNC + SYSINFO) (Scenario 10)

The MS-MLE can receive information about its serving cell and its neighbour cells via the SYSINFO broadcast and the SYNC broadcast. The decoding of the broadcasts shall be undertaken by the lower layers in the MS and should be passed on to the MS-MLE via the survey sub-function (see subclause 8.5.7.) and the scanning sub-function (see subclause 8.5.2). The RPDI-MLE should provide network information to the lower layers for broadcasting by issuing a TL-SYNC request primitive and a TL-SYSINFO request primitive.

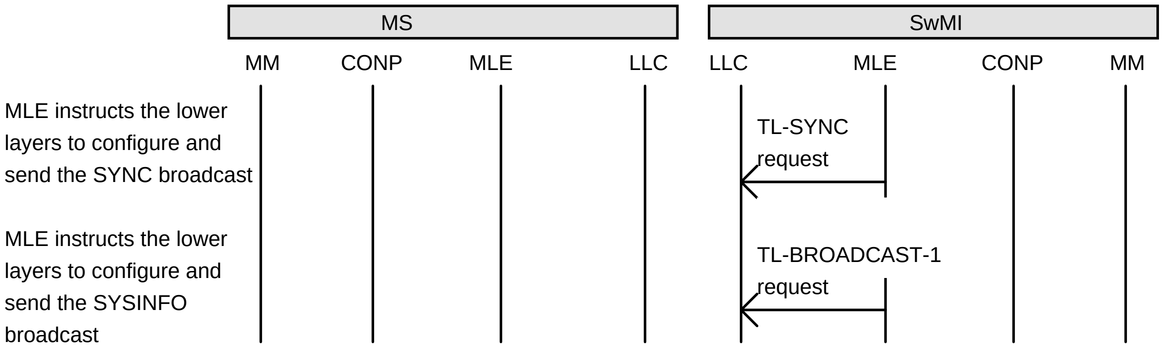


Figure 57: Set-up of MAC broadcast (Scenario 10)

8.5.10 Set-up of MLE broadcast (NETWORK) (Scenario 11)

The MS-MLE can receive network information from the RPDI-MLE when attached to a cell. The broadcast may contains information about neighbour cells. The broadcast shall be sent in a <D-BROADCAST> PDU which is triggered by a TL-BROADCAST request primitive to the lower layers in the RPDI. The MS-MLE should receive the PDU in a TL-BROADCAST indication primitive.

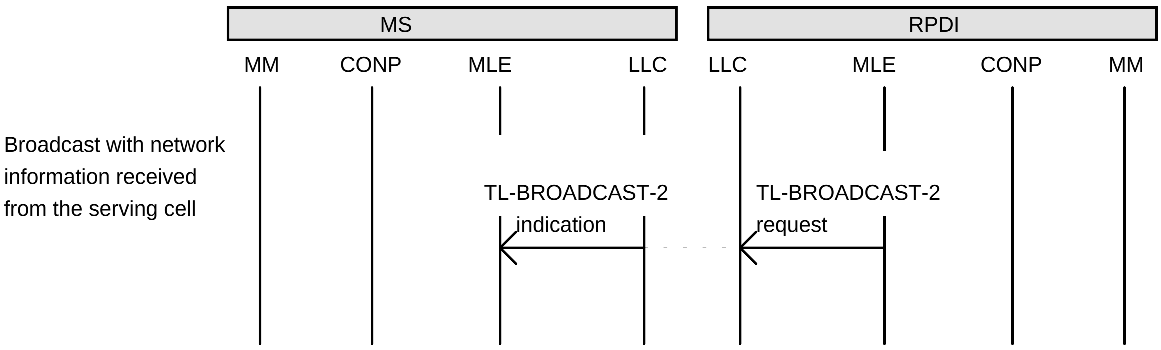


Figure 58: Set-up of MLE broadcast (Scenario 11)

8.5.11 MM registering (Scenario 12)

The MM entity may register without being triggered from the MS-MLE. When these procedures are applied (see clause 7) and when the MM is satisfied with the registering, the MS-MLE should receive a MLE-UPDATE request primitive with the new registered area. The MS-MLE shall be empowered to search for service in the new registered area.

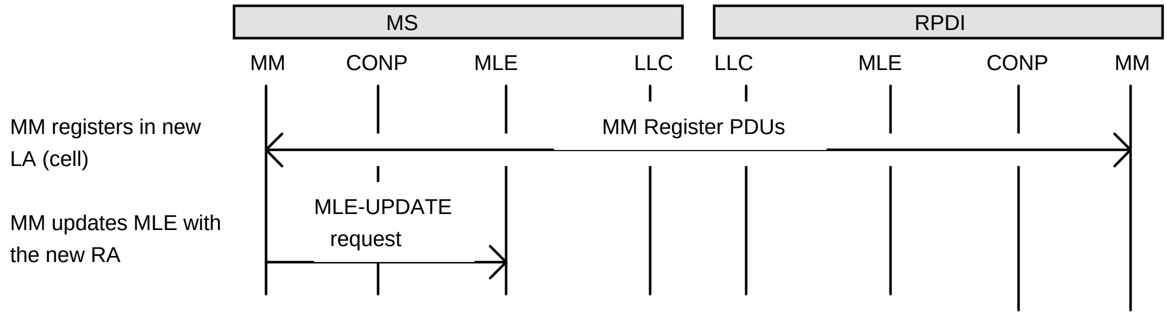


Figure 59: MM registering (Scenario 12)

8.5.12 Announce old cell and go-to-channel (Scenario 13)

There is no scenario 13 applicable for TETRA PDO.

8.5.13 Announce old cell (Scenario 14)

Before announcing the RPDI-MLE, the MS-MLE shall issue a MLE-BREAK indication to the CONP entity.

The MS-MLE shall then issue a <U-PREPARE CELL> PDU. This shall inform the RPDI-MLE that the MS intends to move to the new cell. The identity of the new cell may or may not be in the <U-PREPARE CELL> PDU. On receipt of the <U-PREPARE CELL> PDU, the RPDI-MLE should issue a MLE-BREAK indication primitive to the CONP entity.

If the RPDI is not able to support the MLE recovery procedure, the RPDI-MLE shall issue a <D-PREPARE CELL FAIL> PDU.

The RPDI MLE should then issue a <D-NEW CELL> PDU in response to the <U-PREPARE CELL> PDU. This <D-NEW CELL> PDU shall indicate that the MS may change to the new cell, but does not have access to a configuration of logical channels which would enable the MS to continue any ongoing communications. Instead, the MS shall begin communications in the new cell using the common control channels.

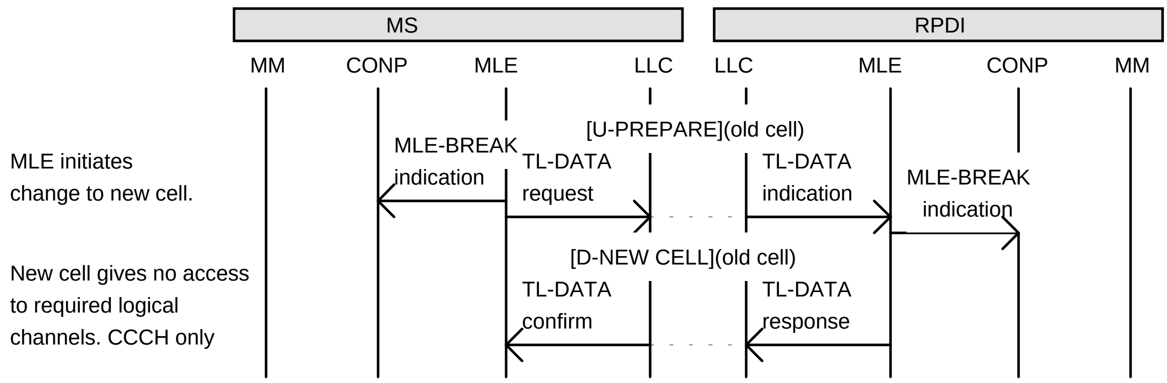


Figure 60: Announce old cell (Scenario 14)

8.5.14 Announce new cell and successful restoration (Scenario 15)

The MS-MLE shall send a <U-RESTORE> PDU to the RPDI using the new cell. This shall indicate to the RPDI-MLE that the old cell is no longer being used by the MS. All further communications should be passed through the new cell. The RPDI-MLE should issue a MLE-RESUME indication primitive to the CONP, indicating that the MLE connection now has been restored and the continuous service is now available again.

The CONP information may be different in the new cell from that of the previous cell. The CONP in the RPDI may send an SDU to the RPDI-MLE for transmission. The RPDI-MLE should piggyback a <D-RESTORE ACKNOWLEDGE> PDU on to the CONP-generated SDU. If no SDU is received from the CONP, the RPDI-MLE shall still issue a <D-RESTORE ACKNOWLEDGE> PDU.

On receipt of the <D-RESTORE ACKNOWLEDGE> PDU, the MS-MLE shall issue a MLE-RESUME indication to the CONP entity.

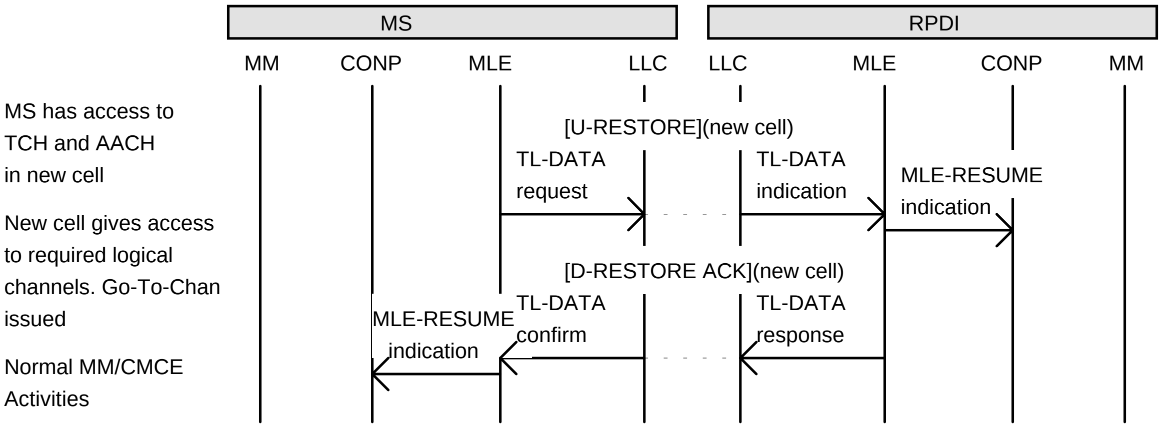


Figure 61: Announce new cell and successful restoration (Scenario 15)

8.5.15 Announce new cell and restoration failure (Scenario 16)

The MS-MLE shall send a <U-RESTORE> PDU to the RPDI using the new cell. This shall indicate to the RPDI-MLE that the old cell is no longer being used by the MS. All further communications should be passed through the new cell.

If the RPDI-MLE is unable to restore the connection to the MS in the new cell, the RPDI-MLE should respond to the <U-RESTORE> PDU with a <D-RESTORE FAIL> PDU. After a <D-RESTORE FAIL> PDU has been issued, both the MS and RPDI MLEs shall issue a MLE-REOPEN indication primitive to the CONP entity.

NOTE: It is now up to the CONP entity to cater for the restoration of the MLE connection by setting up a new one. It is also the responsibility of the CONP to restart its own services. The procedure for this is outside the scope of this ETS.

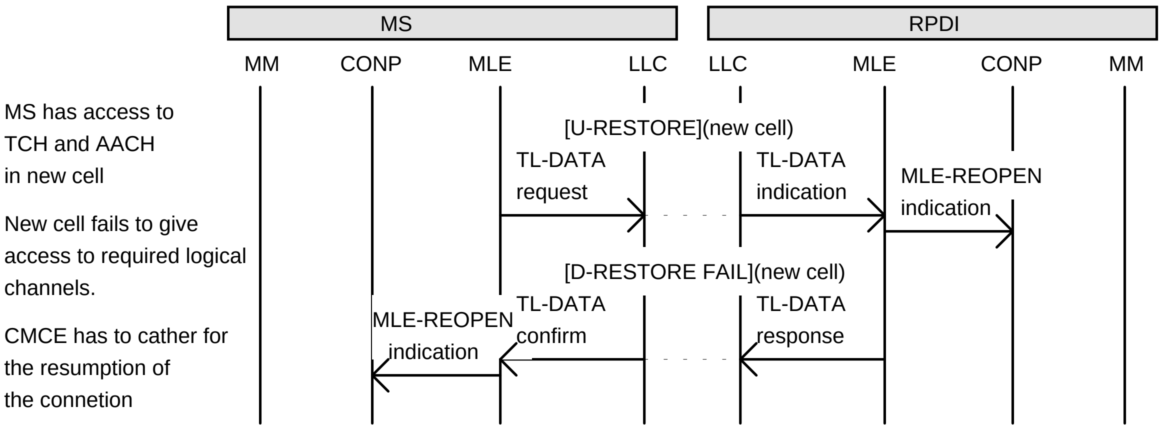


Figure 62: Announce new cell and restoration failure (Scenario 16)

8.5.16 Path lost to the serving cell (Scenario 17)

When the path is lost to the serving cell (e.g. the MAC layer has failed to obtain the SYNC and the SYSINFO broadcast for a certain time), the MS-MLE should be informed by a TL-REPORT indication primitive. The parameters to the primitive should contain the cause of the path loss.

If MLE-connection services have been invoked in the MLE by service users, these shall be informed by a MLE-BREAK indication.

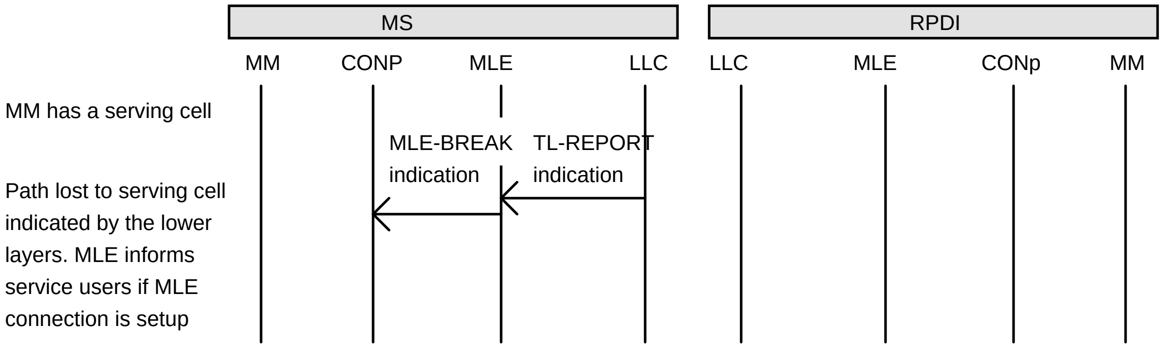


Figure 63: Path lost to the serving cell (Scenario 17)

8.6 Initial cell selection

While moving from cell to cell, the MS shall use cell re-selection. However, the very first time a MS wants to be attached to a cell, i.e. the first time where registration is performed after for instance power up, it shall employ the initial cell selection procedures.

Initial cell selection in the MS-MLE comprises special procedures due to the fact, that both leaving cell and location area are unknown. The initial location areas and preferred cells shall be given to the MS-MLE by the MM before starting scanning after a suitable cell. The measurement procedures themselves are outside the scope of MS-MLE and should be performed by the MAC. Thus the procedures used for initial cell selection may be different to the procedures used at cell re-selection.

When a MS attaches to the RPDI by using initial cell selection, any recovery of MLE connections shall not be applicable. Therefore a initial cell selection is only valid for the LMM SAP and other upper layer 3 SAPs should in principle be closed for communication.

8.6.1 MLE functions as viewed at the LMM SAP

Until MM starts the scanning process, the MS-MLE should be in a NULL state and not able to communicate with anyone. MM should start the selection process by activating the MS-MLE as outlined in scenario 3 (see figure 50).

The MM intervention performed after the activation may be registration and authentication in the new cell. If these procedures are successful, the MS shall be attached to the cell. The MM shall inform the MS-MLE about the new registered area by a MLE-UPDATE request primitive. Finally the MM shall open up the services as described in scenario 4 (see figure 51).

NOTE: The MM intervention may also be another activation of the MS-MLE via a new MLE-ACTIVATE request primitive. The parameters may then contain a different set of location areas. The initial cell selection procedure should now start all over again.

8.6.2 MLE functions.

The MS-MLE shall use scanning when initial cell selection is performed. The procedure in scenario 2 (see figure 49) may then apply. If a suitable cell can be obtained amongst the scanned cells, the MS-MLE shall select this cell (see scenario 3, figure 50).

If no suitable cell is found, the MM entity may be invited for intervention. However, if the cell is found to be suitable for communication, the MM entity should register the MS.

The initial cell selection shall be completed by opening up the service SAPs towards the MLE service users (see scenario 4, figure 51).

Now the MS-MLE may prepare the monitoring of neighbour cells (see scenario 1, figure 48).

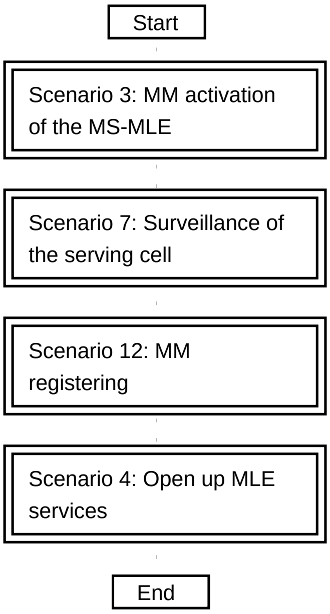


Figure 64: Initial cell selection

8.7 Cell re-selection by roaming

After the initial cell selection, further change of cells should be made using cell re-selection procedures. While moving within the same network, cell re-selection procedures for roaming shall be applied. The network procedures are defined in the MLE.

When the MS is migrating instead of roaming it means that the cell re-selection shall be performed choosing a cell in another TETRA infrastructure (RPDI).

In principle, the procedures described for roaming are also applicable for migration with a few exceptions:

- MM shall open up a communication path to a new functional entity if MM intervention is required;

- MS shall inform the RPDI about the cell re-selection. It is assumed that migration shall lead to a change in location area.

8.7.1 Announced cell re-selection

When an MLE connection has been established, it means that MLE has some responsibilities during cell re-selection. These responsibilities are depending on the choice of the type of re-selection procedure. There may be two different types of announced cell sub-functions for assistance of this overall procedure in PDO:

- type-2;

- type-3.

8.7.1.1 Announced cell re-selection (type-2)

The announced type-2 cell re-selection requires only that the MS-MLE knows the new cell in advance. The MS does not receive any knowledge of the channel organisation on the new cell before making the decision to change cell.

NOTE: The reason to utilise this type-2 announcement may be because the RPDI is not able to issue a go-to-channel in the present serving cell, or the network information cannot be provided via the present serving cell or an announced type-1 cell re-selection procedure is not applicable to the RPDI.

Figure 65 shows the scenarios sequence for the announced type-2 cell re-selection.

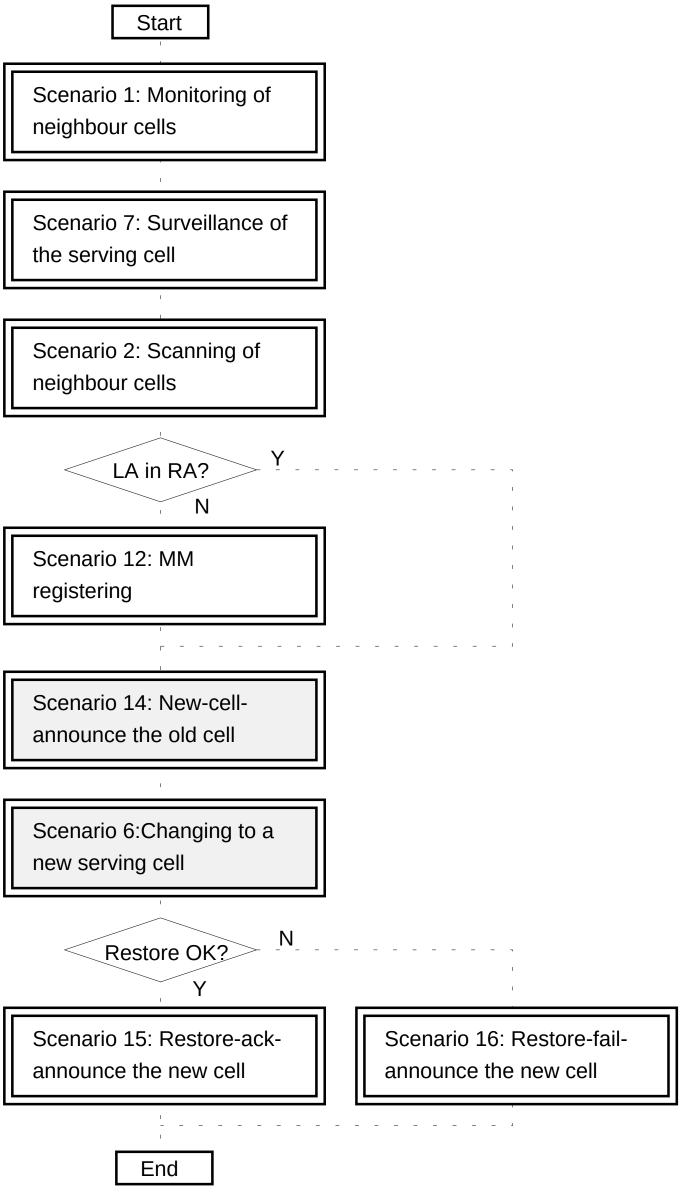


Figure 65: Announced type-2 cell re-selection

8.7.1.2 Announced cell re-selection (type-3)

The announced type-3 cell re-selection implies that the MS-MLE does not know the new cell beforehand, i.e. before MS makes the decision to change cell. The announcement of the old cell is then only an information stating that the MS leaves the cell and services may be interrupted for a while.

8.7.1.2.1 MLE functions

The MS-MLE shall check the quality information available for the serving cell and the neighbour cells. This quality information should be provided by the lower layers according to scenario 1 and scenario 7 (see figures 48 and 54). When the MS-MLE decides to change to the new cell, it shall perform the new-cell announcement before the scanning scenario 2 (see figure 49) is started. When a suitable cell is found, the MS-MLE shall change to the new serving cell according to scenario 6 (see figure 53).

Invitation of MM by MS-MLE depends on whether the new cell (location area) is within the current registered area. If MM intervention is needed, MM registering scenario 12 (see figure 59) shall be applied.

Figure 66 shows the scenario sequence for the announced type-3 cell re-selection.

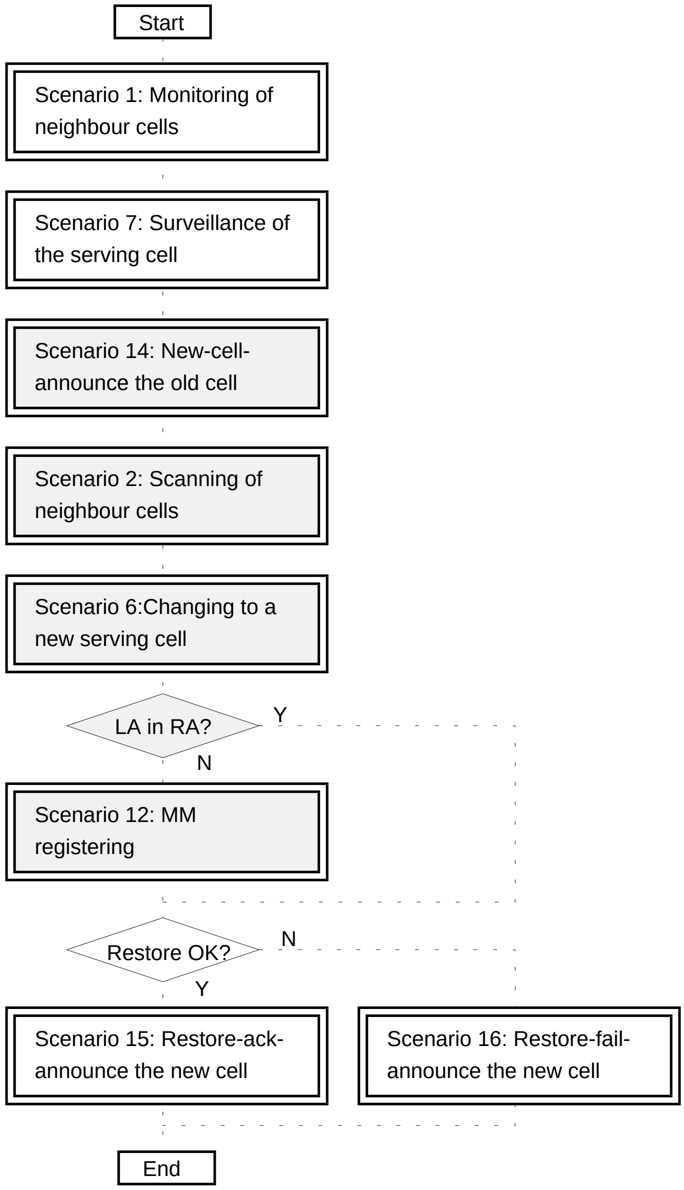


Figure 66: Announced type-3 cell re-selection

8.7.2 Unannounced cell re-selection

In these scenarios, the MS-MLE shall not inform the present serving cell of the intention to change cell. The reason may be that the MS has lost the path or there may be no time to inform the serving cell beforehand.

NOTE: It may also be part of normal operation that the MS does not inform its serving cell when it decides to change cell.

The scenario sequence shown in figure 67 is for the unannounced cell re-selection.

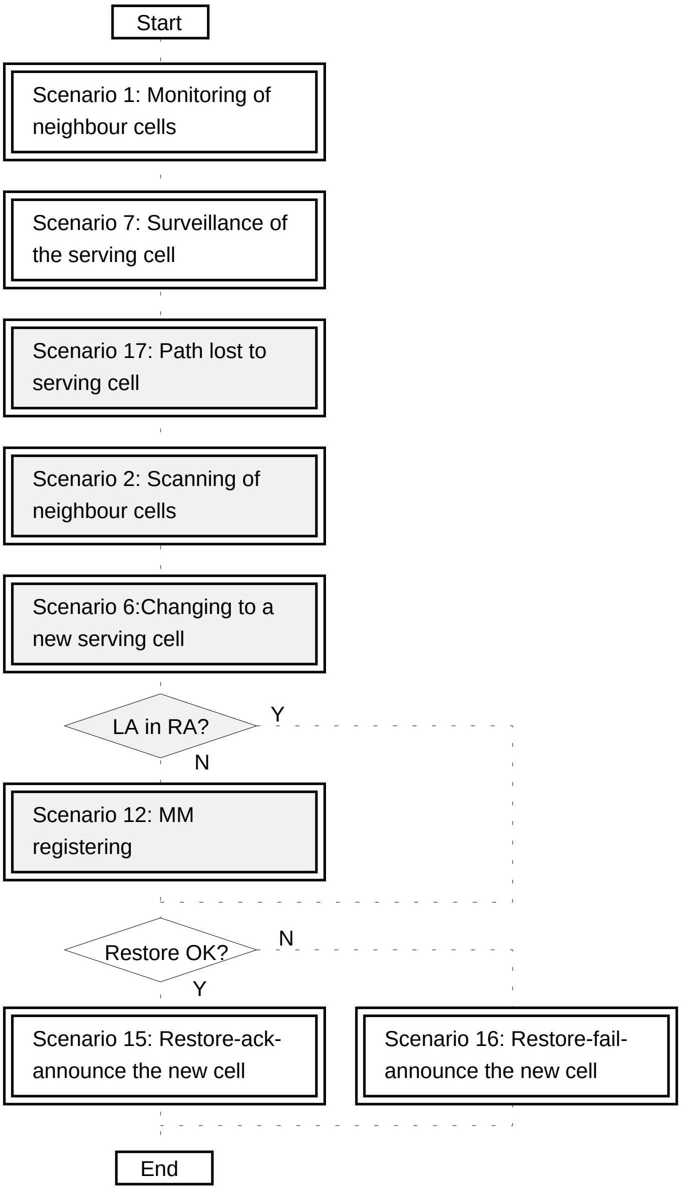


Figure 67: Unannounced cell re-selection

8.7.3 Undeclared cell re-selection

When no MLE connection is present, the MS-MLE shall not have any obligation towards its service users and it shall not declare the cell change to neither the serving cell or to the new cell. The MS-MLE is empowered to move freely within the registered area without contacting the RPDI.

8.7.3.1 MLE functions as viewed at the LMM SAP

The MM shall be invited to make intervention if the MS-MLE finds that a new cell during the scanning scenario 2 (see figure 49) is outside the current registered area. Scenario 12 (see figure 59) may then apply according to the scenario sequence in figure 68.

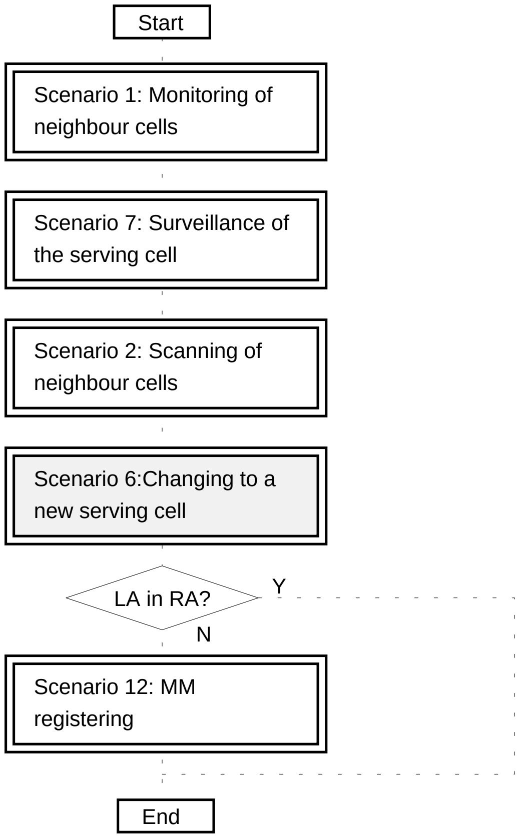


Figure 68: Undeclared cell re-selection.

8.8 MLE service requests during cell re-selection

If the MLE service users request service while the MLE is performing cell re-selection, they should be informed about the current situation by the MLE. If service is not available, the scenario in figure 69 may apply.

8.8.1 Undeclared cell re-selection

The information provided by the MLE informs the service users that service is temporarily not available. The information should be provided in a MLE-REPORT indication primitive with the cause = "service not available".

NOTE: The normal case when this information is provided is during undeclared cell re-selection; however, the procedure may also be applicable towards service users that do not employ MLE connections.

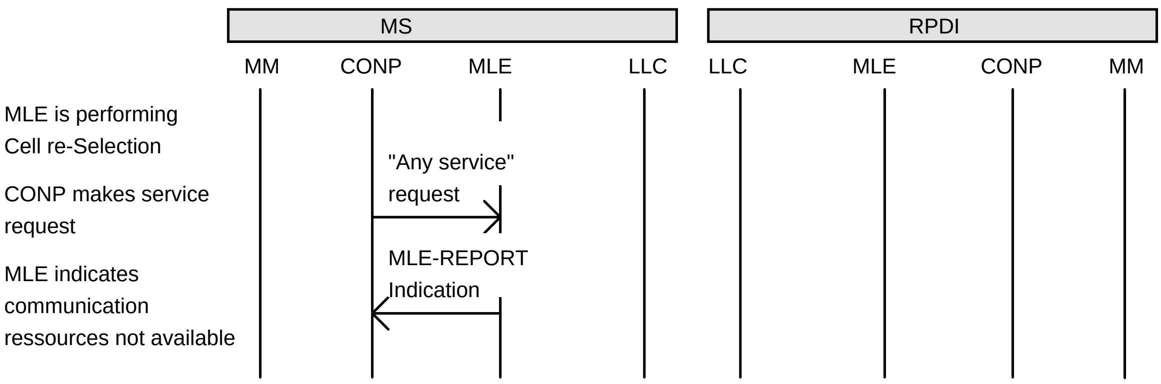


Figure 69: Service requests during undeclared cell re-selection

8.9 No MLE recovery

It is not a mandatory requirement for the MLE to perform any recovery functions on cell re-selection.

At the LMM-SAP, the MS-MLE shall issue a MLE-LINK indication primitive or a MLE-ACTIVATE indication if MM intervention is required.

9 Technical realisation of TETRA connection mode CONP

9.1 Introduction

This clause specifies the technical realisation of the protocol which is intended to provide the connection mode CONP service on the network layer of the air interface. This clause describes:

- the protocol services and functions; and

- the primitives and sequences for the transmission of data and control information on the air interface.

9.2 Overview of the protocol

9.2.1 Internal organisation of the network layer and ISO

The architectural organisation of the network layer is described in clause 5. This protocol shall be used in the connection mode where figure 70 gives the layer 3 organisation concerned with CONP.

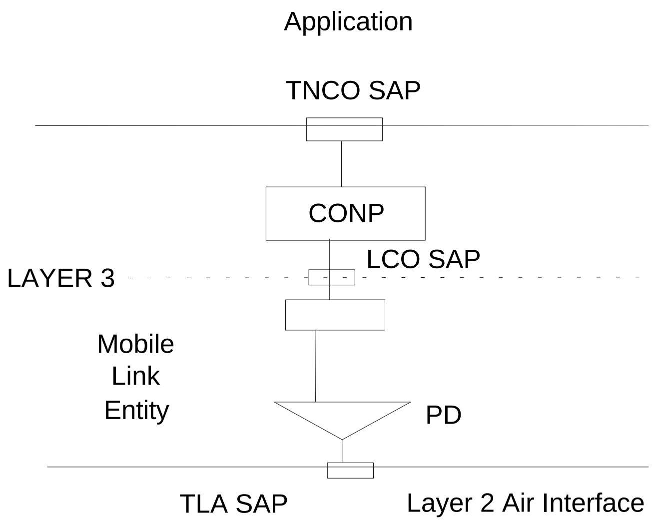


Figure 70: Layer 3 stack on the air interface

TETRA CONP shall be based on three ISO documents:

- the network service definition ISO/IEC 8348 [10] defining:
    - the primitives, actions and events of the service;
    - the parameters associated with each primitive action and event;
    - the interrelationship and sequences of events and actions;
- the use of X.25 to provide the OSI connection mode network service ISO/IEC 8878 [12]:
    - proposing CONP primitives;
    - mapping between the CONP primitives and the X.25 packets and procedures.

- the X.25 packet layer protocol ISO/IEC 8208 [9] defining:
  - procedures for virtual calls and permanent virtual circuits;
  - formats and fields of packets associated with these procedures;
  - procedures and formats for optional user facilities and DTE facilities.

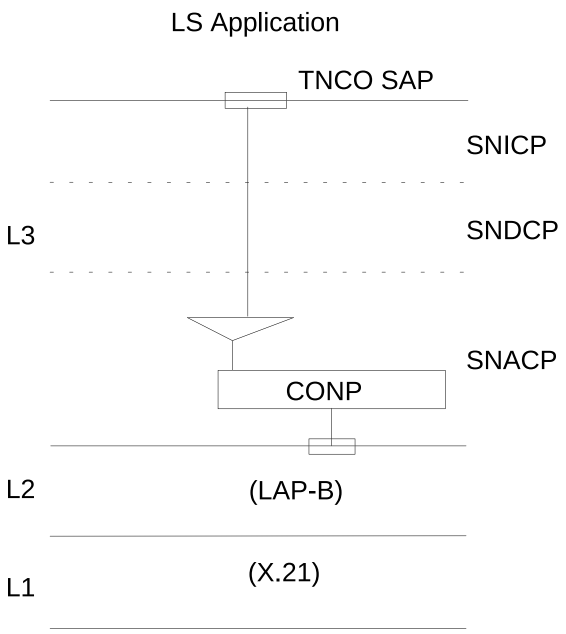


Figure 71: LS protocol stack

TETRA CONP shall offer services conforming to ISO/IEC 8348 [10] with an agreed mapping, to and/or from the packet layer protocol elements. This mapping of the connection mode network service shall be based on ISO/IEC 8878 [12], and the protocol shall be based on ISO/IEC 8208 [9] (see figure 72). This is described in:

- ETS 300 393-2 [17], clause 11, which is the TETRA delta clause defining the connection mode network service at the TNCO SAP, and in particular the service primitives based on ISO/IEC 8348 [10] and ISO/IEC 8878 [12];

- ETS 300 393-2 [17], clause 12, which is the TETRA delta clause defining the connection mode network protocol, and in particular the packets formats and procedures based on ISO/IEC 8208 [9].

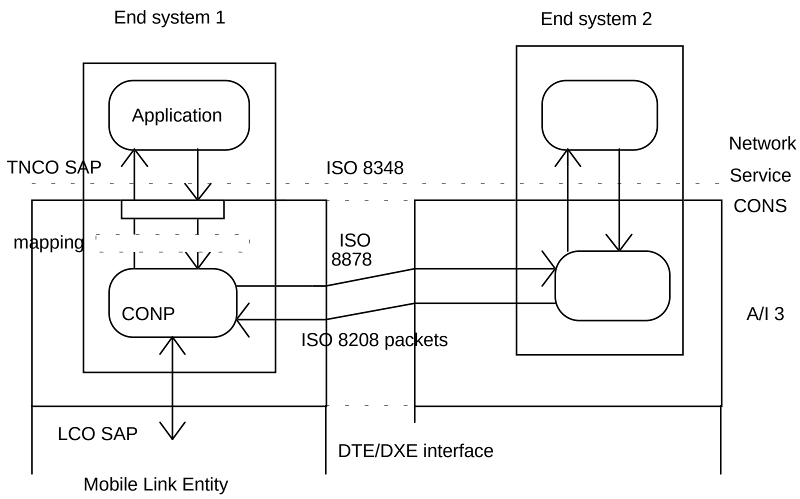


Figure 72: CONP and ISO

9.2.2 End-to-end protocol

The ISO references which apply at the SAPs are mandatory or are assumed but not mandatory as follows:

- at the R0 reference point the ISO/IEC 8348 [10] (plus delta ETS 300 393-2 [17], clause 11) mandatory primitives shall apply;

- at the R2 reference point the ISO/IEC 8208 [9] (plus delta ETS 300 393-2 [17], clause 12) mandatory protocol shall apply;

This protocol is designed to accommodate variability where the underlying protocol can be the MLE, see ETS 300 393-2 [17], clause 18, on the MS or BS side or a TETRA specific layer 2 (or LAPB) on the LS side (see figures 70 and 71).

9.3 Handover and mobility

Mobility implies situations where the MS changes from one BS to another during a slow handover without releasing the established virtual call. Then a set of data, e.g. state variables, packets sequence numbers, have to be exchanged by the TETRA infrastructure in order to keep the data sequence, avoid redundancies or loss of packets.

9.4 Packet through layer 3 in connection mode

Figure 73 shows the data structure from the application to the layer 2 through CONP and the MLE.

The user data or message is eventually split into packets and the Packet Header (PH) shall correspond to the ISO/IEC 8208 [9] packet header.

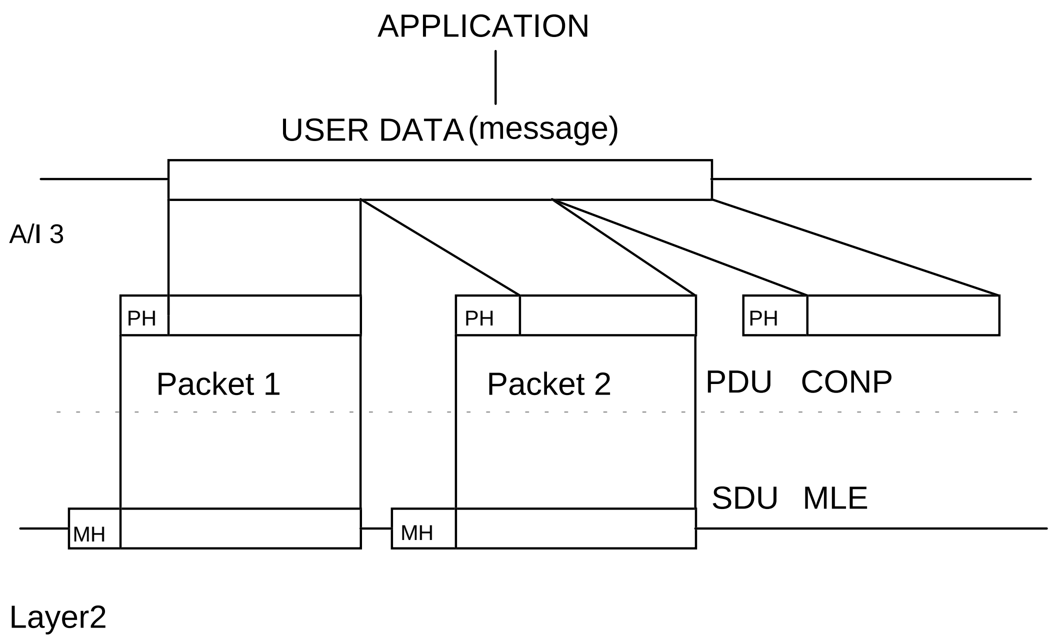


Figure 73: Data in CONP

9.5 Interconnection

The figures 74 to 82 position CONP in the protocol stack on the different nodes of the TETRA networks. The references points defined in clause 4 are also shown on the figures.

On figure 74 there is no direct connection between the two end systems which are the TE, TETRA and the MTU2 act as a real sub-network. The MTU2 acts as an inter-working unit.

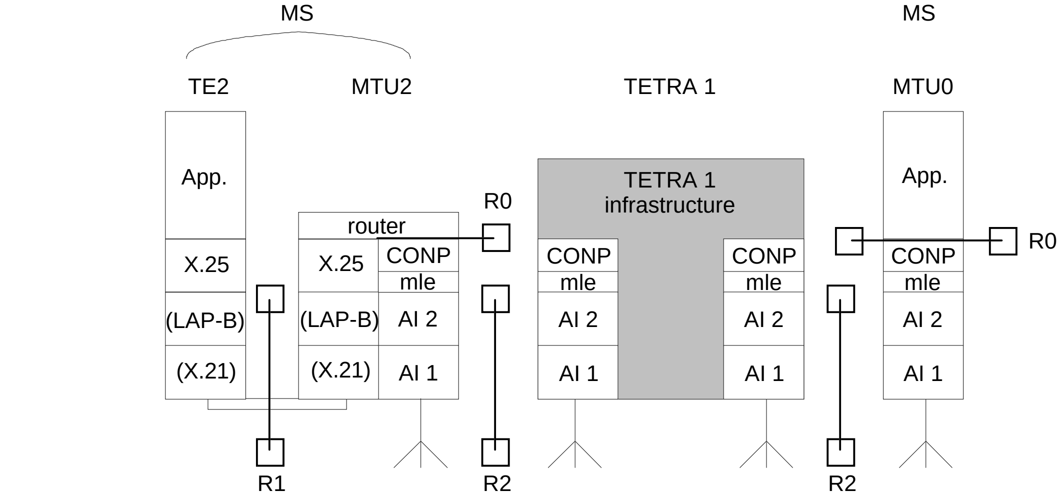


Figure 74: MS to MS through one TETRA network

Figure 75 represents the case of the LS with an example of possible layer 2/1 (LAPB-X.21)

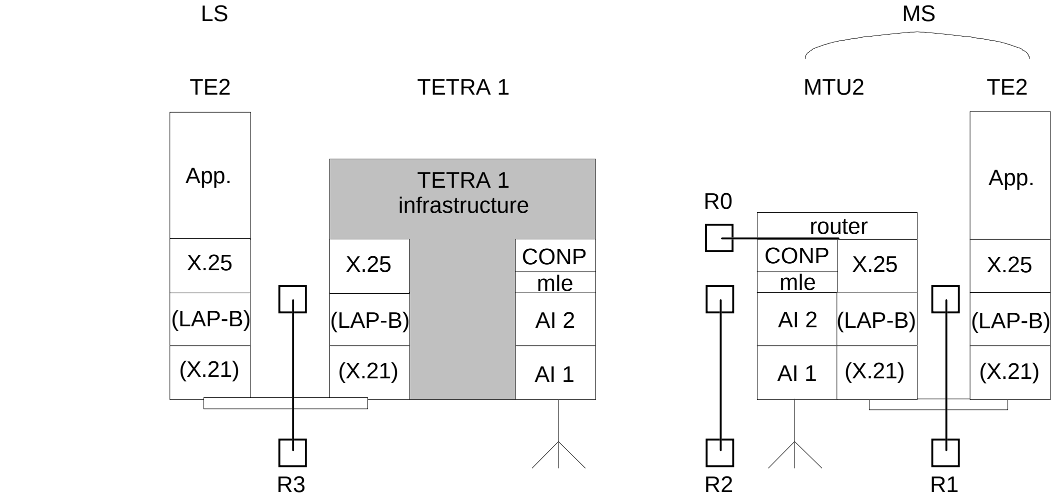
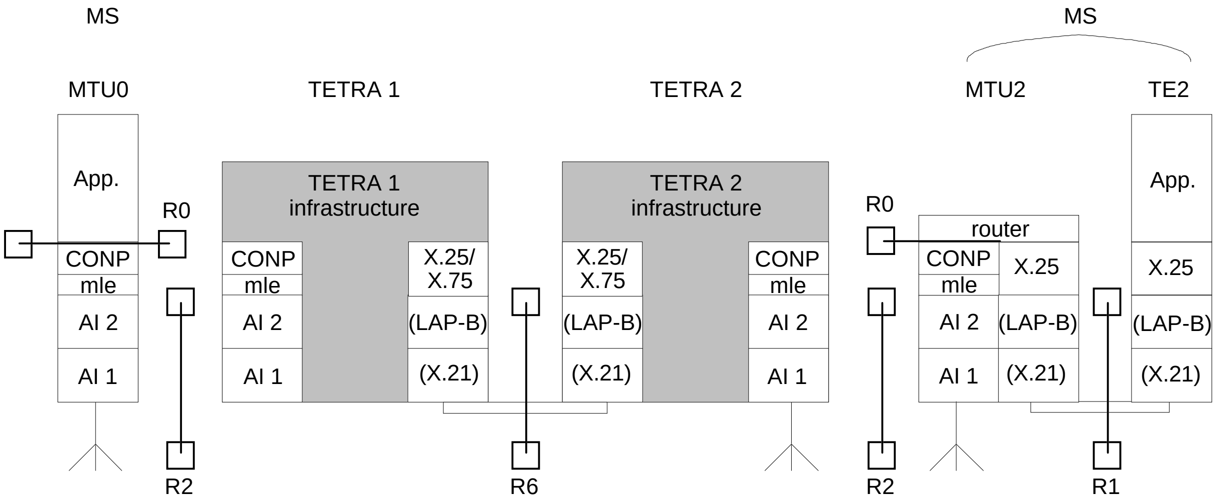


Figure 75: LS to MS through one TETRA network

Figure 76 represents the case of a two TETRA networks interconnected through an X.25 or X.75 protocol.



NOTE: Inter-system inter-working can be either X.75 or X.25 (DTE-DTE) interconnection.

Figure 76: MS to MS through two TETRA networks

Figure 77 represents the case of two TETRA networks connected through an X.25 PDN using X.25 or X.75 protocol.

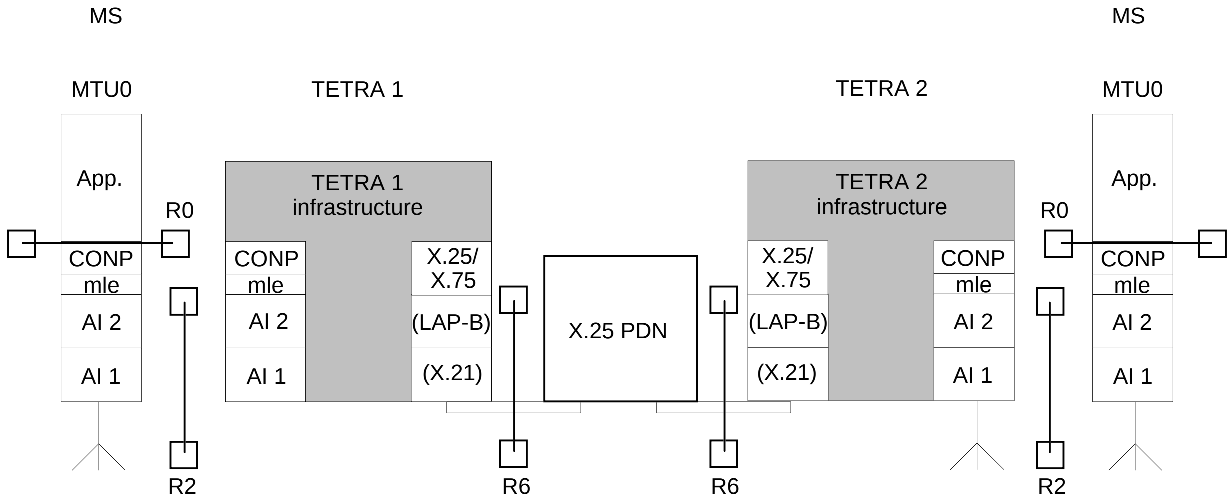


Figure 77: MS to MS through two TETRA networks and one X.25 PDN

Figure 78 represents the case of a TETRA PDO network connected to a V+D network through an X.25 or X.75 protocol.

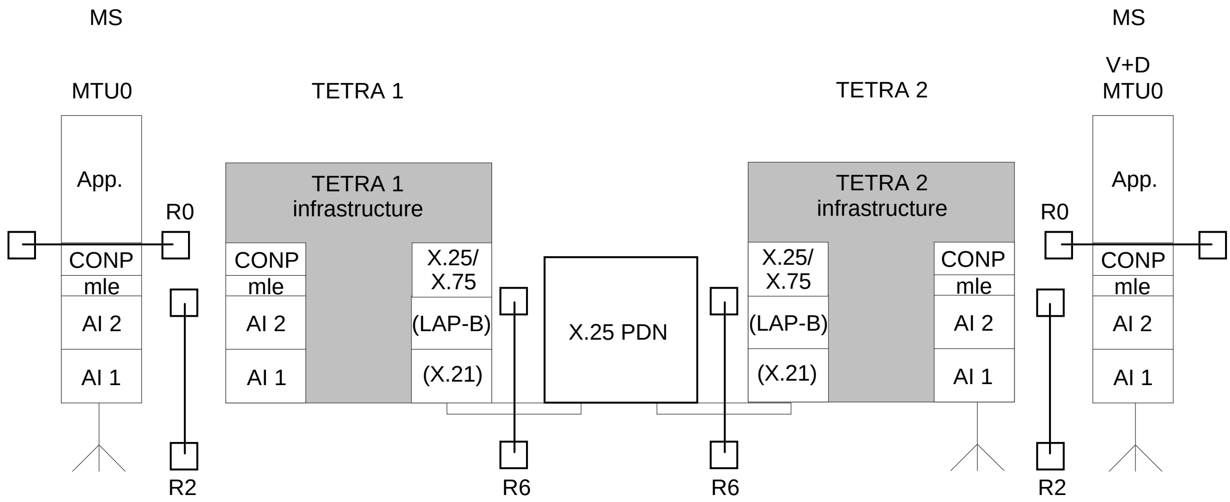


Figure 78: MS in a PDO network to MS in a V+D network through two TETRA networks via one X.25 PDN

Figure 79 represents MS to DTE through TETRA network and X.25 PDN.

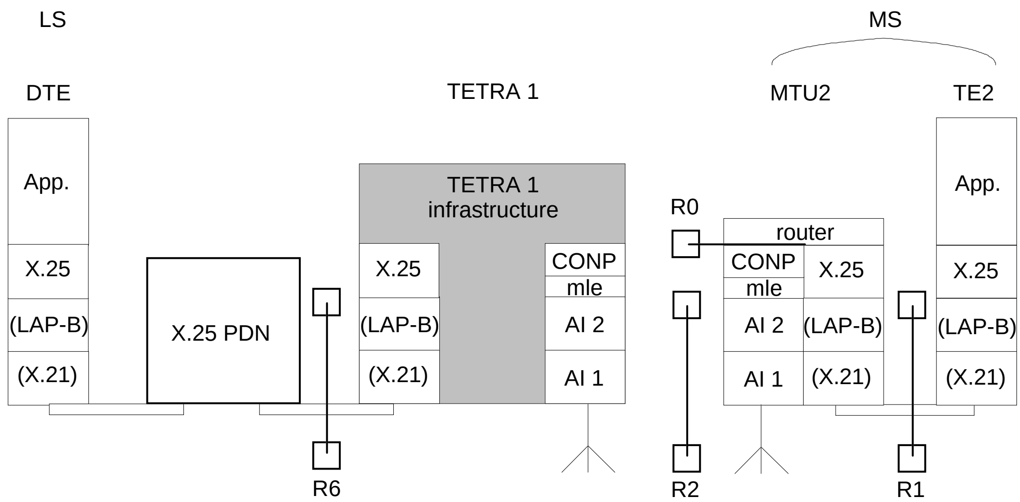


Figure 79: MS to standard DTE through one TETRA network and one X.25 PDN

Figure 80 represents the case of a character mode MS with integrated PAD and character mode LS connected via PSTN.

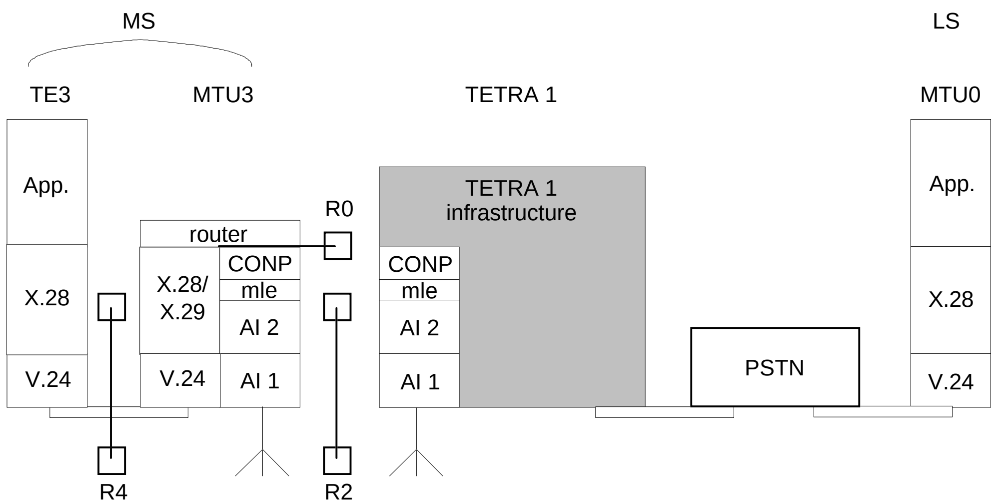


Figure 80: Character mode MS with integrated PAD (MTU3) connected to a character mode LS via PSTN

Figure 81 represents a character mode MS with discrete PAD.

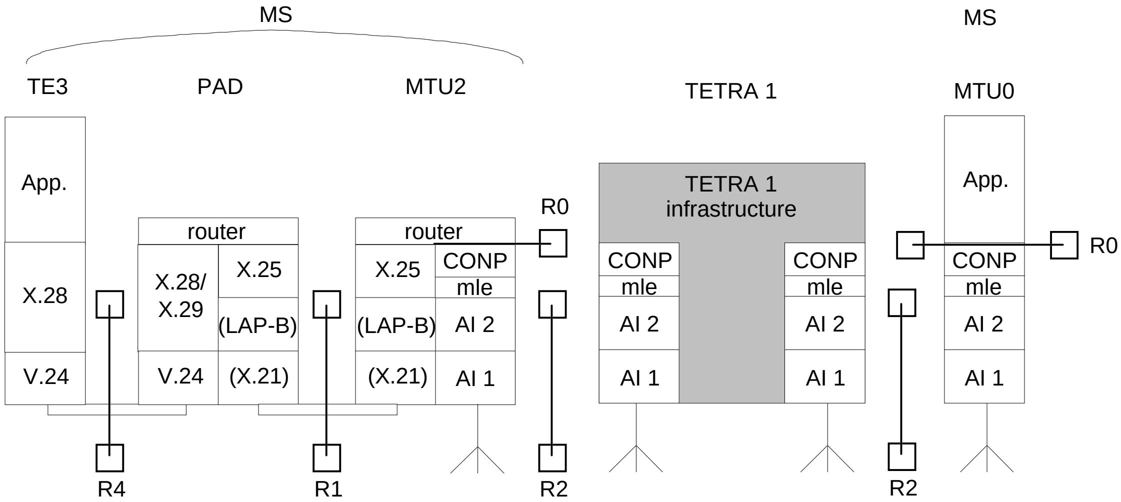


Figure 81: Character mode MS with discrete PAD

Figure 82 represents the connection of the NMU to local and remote TETRA.

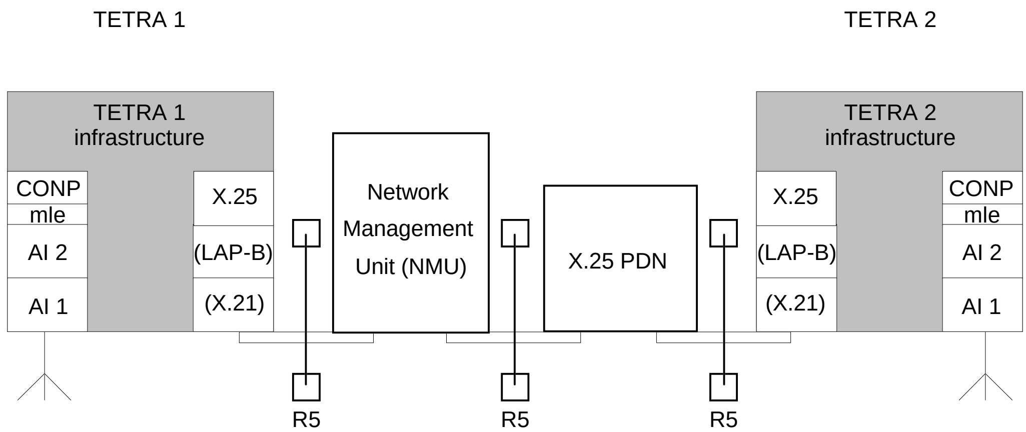


Figure 82: NMU connected to a local and a remote TETRA

9.6 Addresses

See clause 6.

9.7 Lower layer service used

It is intended that CONP shall be capable of operating over:

a) the MLE, ETS 300 393-2 [17], clause 17, (figure 70) in a MS or BS environment; and

b) a link layer protocol as shown in figure 71.

The service primitives at the LCO-SAP are defined in ETS 300 393-2 [17], clause 18.

In particular the MLE should mask CONP from mobility impacts like re-establishment of the link.

9.8 Services produced by the protocol

The protocol shall provide the connection mode network service at the TNCO SAP to the upper layer (see ISO/IEC 8878 [12] and ETS 300 393-2 [17], clause 11).

The services offered are:

- connection establishment;
- transfer of user data without acknowledgement;
- transfer of user data with acknowledgement;
- disconnection;
- reset;
- expedited data.

9.9 Primitive definition

The primitives and sequence of primitives (see figure 72) at the TNCO SAP are defined in ETS 300 393-2 [17] and these map to the corresponding packets with the fields corresponding to the primitives parameters.

9.10 Protocol functions

CONP shall provide the following functions:

- segmentation/assembly of user data into packets;
- PDU composition and decomposition;
- data transfer;
- flow control;
- interrupt transfer allowing to send and receive a small amount of information independent of the data stream;
- error control with the ability to detect packet layer errors;
- multiplexing with the ability to support multiple communications;
- reset and restart to reinitialise communication paths in the event that packet layer errors are encountered.

9.11 Structure and encoding of the PDUs

The PDUs shall be packets with a packet header as defined in the ISO/IEC 8208 delta, ETS 300 393-2 [17], clause 12, with the following types:

- call set-up and call clearing packets;

  data and interrupt packets;
- flow control packets;
- reset packets;
- restart packets.

The packet header shall contain at least the following standard information:

a) general format identifier;

b) logical channel identifier;

c) packet type identifier;

d) additional fields like sequence numbers, user data (see ISO/IEC 8208 [9]).

10 Technical realisation of TETRA Specific ConnectionLess Network Service (SCLNS)

10.1 Introduction

This clause specifies the technical realisation of the protocol which is intended to provide the specific connectionless mode service on the network layer of the air interface:

- the protocol functions;

- primitives and sequences for the specific connectionless transmission of data and control information on the air interface;

- the PDUs list for the transmission of data and control information.

10.2 Overview of the protocol

10.2.1 Internal organisation of the network layer

The architectural organisation of the network layer is described in clause 5. This protocol shall be used in the access protocol role (SNACP) as described in ISO 8648 [14]. Figure 83 gives the layer 3 organisation concerned with SCLNS where the MLE is the Mobile Link Entity (or network link entity) ETS 300 393-2 [17], clause 17.

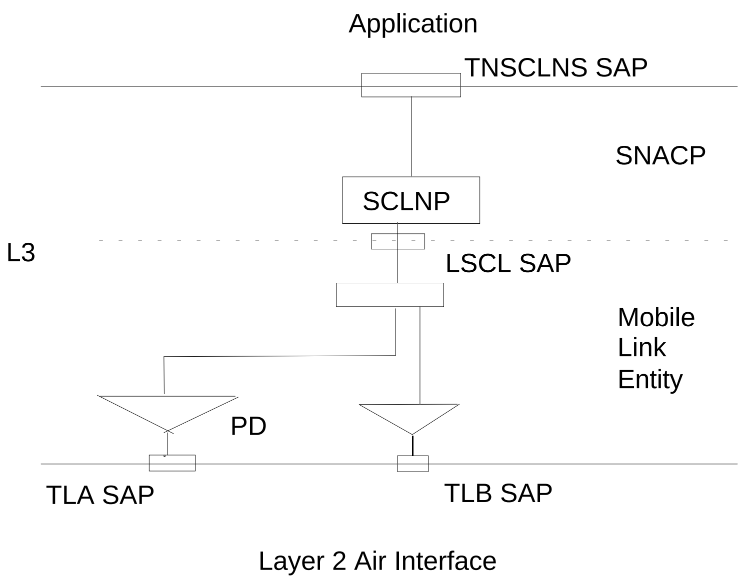


Figure 83: Layer 3 SCLNP protocol stack on the air interface

This protocol shall be designed to accommodate variability where the underlying protocol can be the MLE on the MS (figure 83) or a sub-network dependant sub-layer (SNDCP) for convergence as described in figure 84. It shall also offer services to support a user application implementation of CLNP (figure 84).

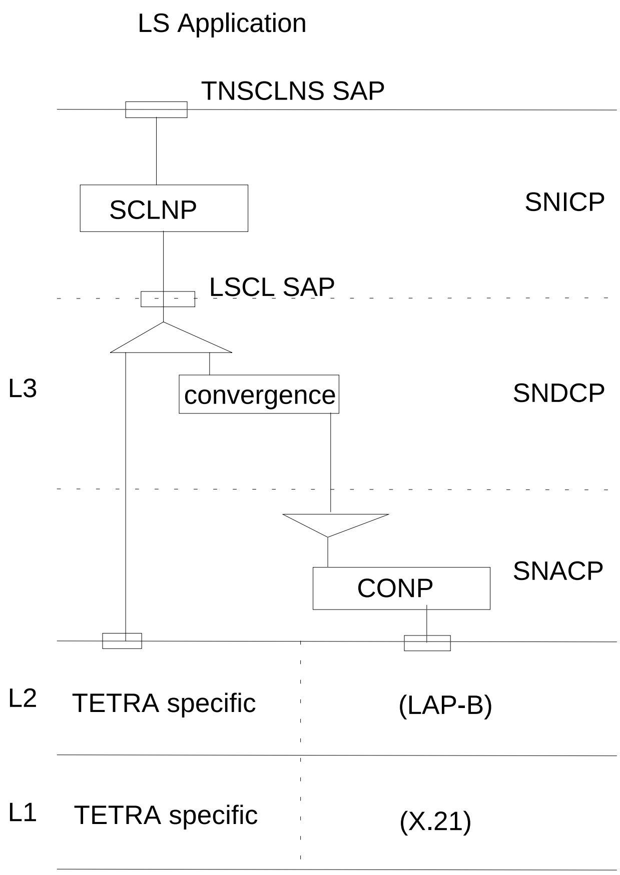


Figure 84: LS protocol stack

In order to optimise the protocol two versions are created, one corresponding to a full version with the TETRA specific facilities and one without any facilities called the slim version.

10.2.2 Interconnection

The figures 85 to 90 position the SCLNP in the protocol stack on the different nodes of the TETRA networks. The reference points (clause 4) are also shown on the figures.

Figure 85 gives the MS to MS interconnection through a TETRA network.

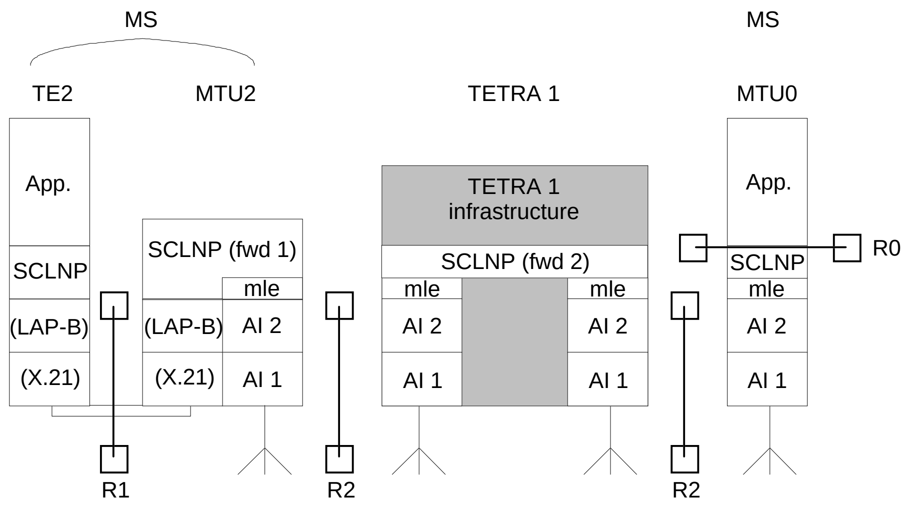


Figure 85: MS to MS through one TETRA network

Figure 86 gives the LS connection where different possibilities are offered as the layer 2 and layer 1 can be TETRA specific or existing standards (figure 83) where:

- **case 1:** SCLNP accesses through a CONP access protocol with the SNDCP convergence asking for a virtual circuit to be established in the connection mode (see table 4);

- **case 2:** direct access of SCLNP to layer 2 which can be in that case a specific TETRA layer 2 (see table 4).

Table 4: Possibilities of access to SCLNP

	case 1	**case 2**
SNICP	SCLNP	SCLNP
SNDCP	CONV	NULL
SNACP	CONP	NULL

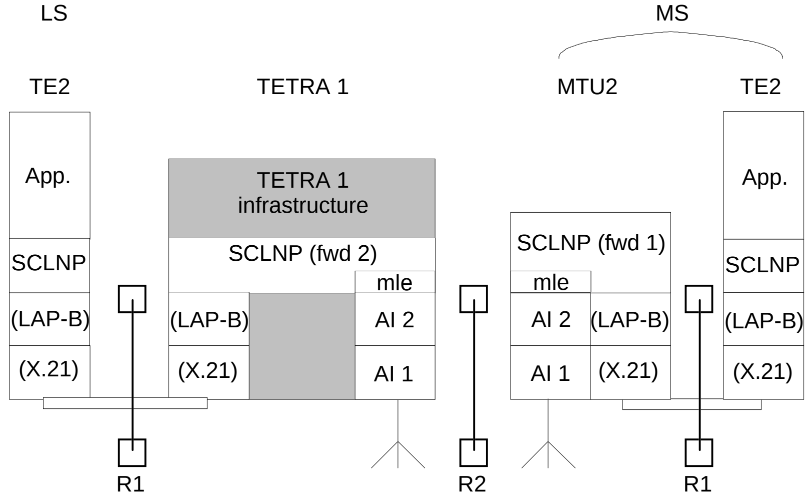


Figure 86: LS to MS through one TETRA network

Figure 87 shows the interconnection of two TETRA networks where TETRA1 adds an X.75 header to the specific connectionless packet and sends it via an X.25 protocol to the network in a connection mode.

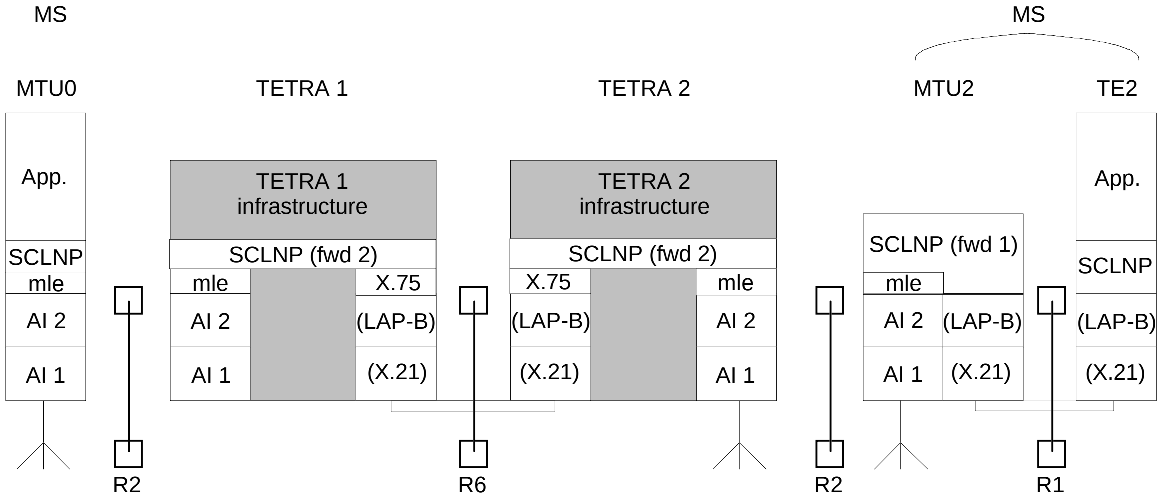


Figure 87: MS to MS through two TETRA networks

Figure 88 shows the case of two TETRA networks interconnected through a CLPDN.

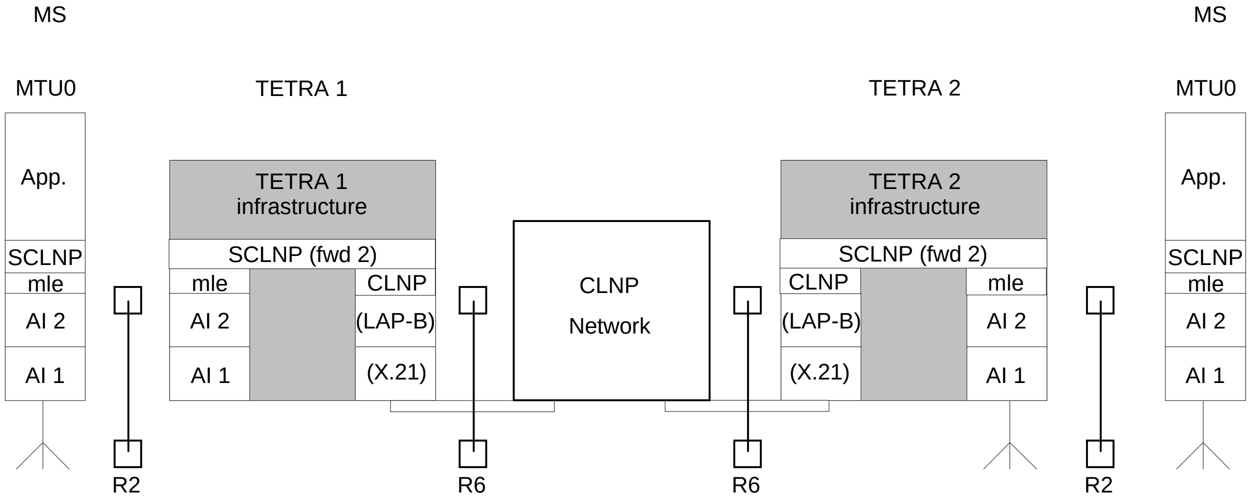


Figure 88: MS to MS through two TETRA networks and one CLPDN

Figure 89 is the case of an intermediate X.25 PDN where the specific connectionless packet is put in an X.25 packet on a virtual circuit.

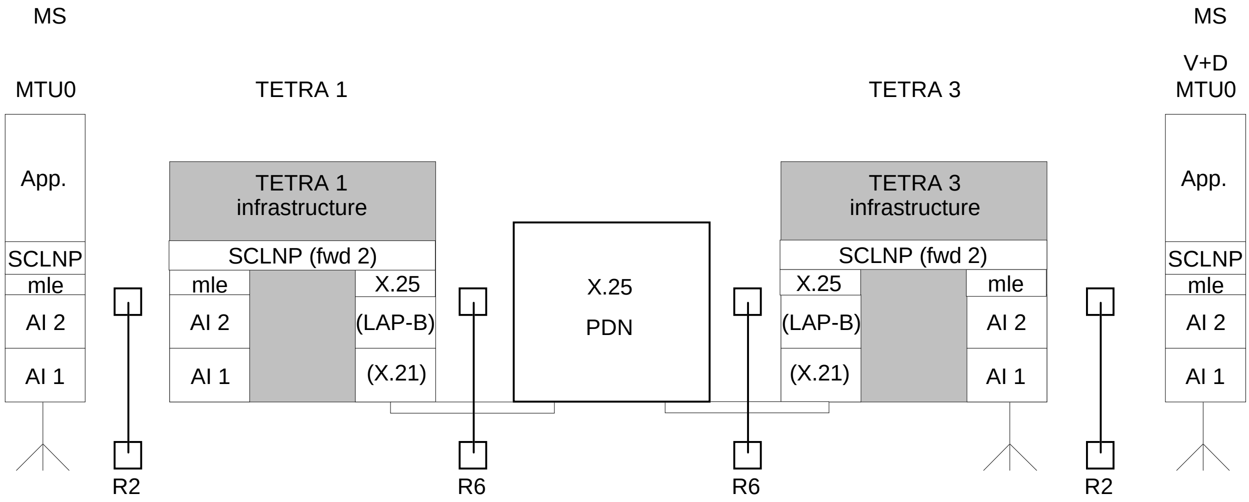


Figure 89: MS in a PDO network to MS in a V+D network through two TETRA networks via one X.25 PDN

Figure 90 shows the case of a MS sending and receiving data from an application on a host <DTE> through an X.25 PDN. The SCLNS is built on a CONS protocol where the specific connectionless packet is sent in a X.25 packet over a virtual circuit.

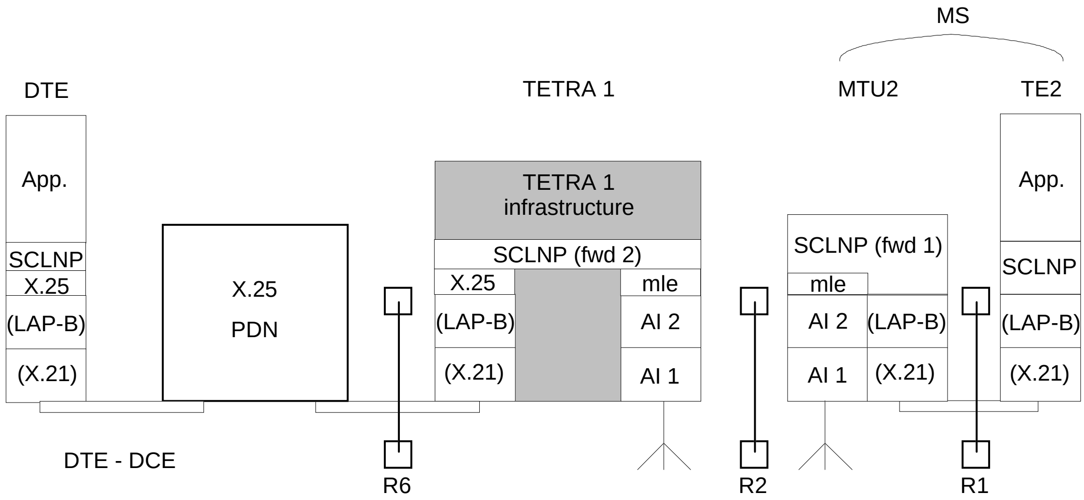


Figure 90: MS to standard DTE through one TETRA network and one X.25 PDN

10.2.3 Addresses

The source address and destination address shall be TETRA addresses described in clause 6.

Two length of addresses shall be allowed:

- 3 octets (SSI); or
- 6 octets (TSI);

named short and long addresses which allow reducing the header length inside PDUs.

10.3 Lower layer service used

It is intended that SCLNS shall be capable of operating over:

a) the MLE (see ETS 300 393-2 [17], clause 17) (see figure 83) in a MS or BS environment; or

b) a sub-network dependent sub-layer protocol.

The access point shall be the LSCL-SAP.

The MLE offers services for the establishment and release of a layer 2 connection which may be used by the SCLNP entity.

The service primitives shall be:

- MLE-CLOSE indication to indicate that access to the MM link has been removed;
- MLE-OPEN indication to inform that access to the link is available;
- MLE-DATA request to send control data;
- MLE-DATA indication to indicate the arrival of control data;
- MLE-DATA confirm for confirmation;
- MLE-BREAK indication to inform that the current link is no longer available.

The underlying protocol on a LS shall be either a sub-network dependant sub-layer which ensures convergence to CONP or directly layer 2 (see figure 84).

10.4 Services provided by the protocol

The protocol shall provide the specific connectionless mode network service at the SCLNS SAP to the user application.

Two services shall offer the full version with the TETRA specific facilities and the slim version without the facilities.

NOTE: CLNP is intended to be carried by the slim version.

10.4.1 Full version

The services offered shall be:

- send and receive user data without connection establishment;
- confirmation of uplink success to transfer data:
  - this service allows the sender of uplink data to know that his data has reached the infrastructure, by means of a confirmation report;
- delivery report:
  - this service informs the sender that his data has been delivered to the remote destination.

10.4.2 Slim version

The services offered shall send and receive user data without connection establishment as for the full version.

10.5 Primitives definition

The set of primitives to offer the services described concerns the data transmission (see ETS 300 393-2 [17], clause 14.

10.5.1 Data transmission group

The request and indication primitives at the SCLNP SAP for data transmission shall be:

- TN-UNITDATA request (parameters);
- TN-UNITDATA indication (parameters).

The parameters are described in ETS 300 393-2 [17], clause 14.

These primitives are common to full and slim versions to send and receive data.

Confirmation of the uplink success (or failure) to transfer the data to the infrastructure, (a local infrastructure immediate answer) shall be reported by:

- TN-UNITDATA confirm (parameters).

The parameters are described in ETS 300 393-2 [17], clause 13.

Delivery of the user data shall be reported by:

- TN-DELIVERY indication (parameters).

The parameters are described in ETS 300 393-2 [17], clause 13.

10.5.2 Protocol sequences

Figure 91 shows the layer 3 protocol sequence on the MS side.

Figure 92 shows the protocol sequence at layer 3 MS-BS for point to point with delivery disposition.

Figure 93 is the multipoint case with delivery disposition.

Figure 94 shows the inter TETRA case.

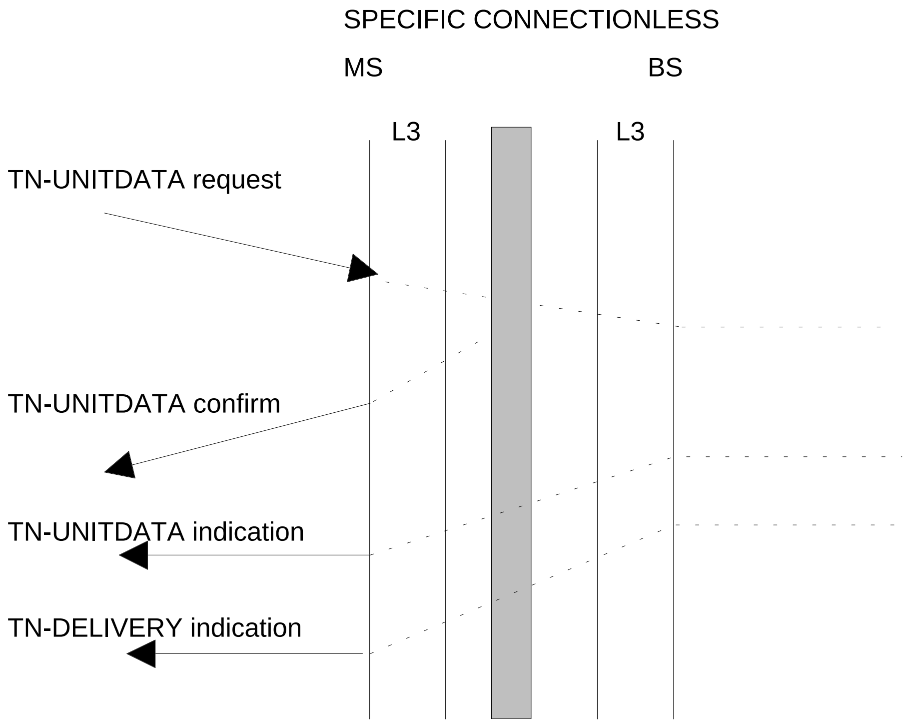


Figure 91: Network layer service primitives sequences specific connectionless at TNSCLNS SAP

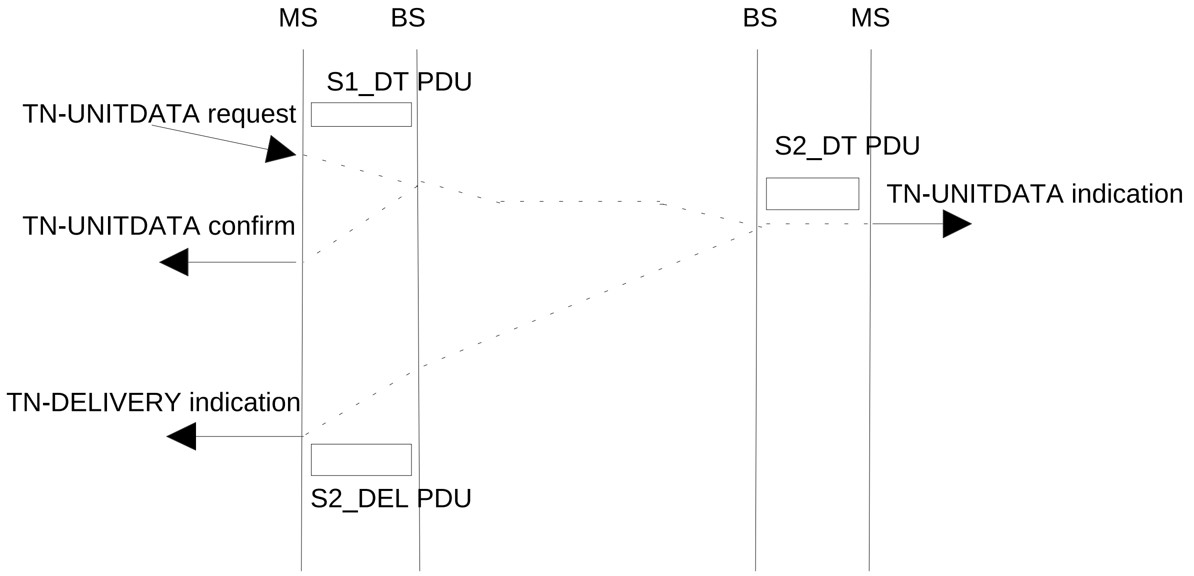


Figure 92: Point-to-point SCLNS

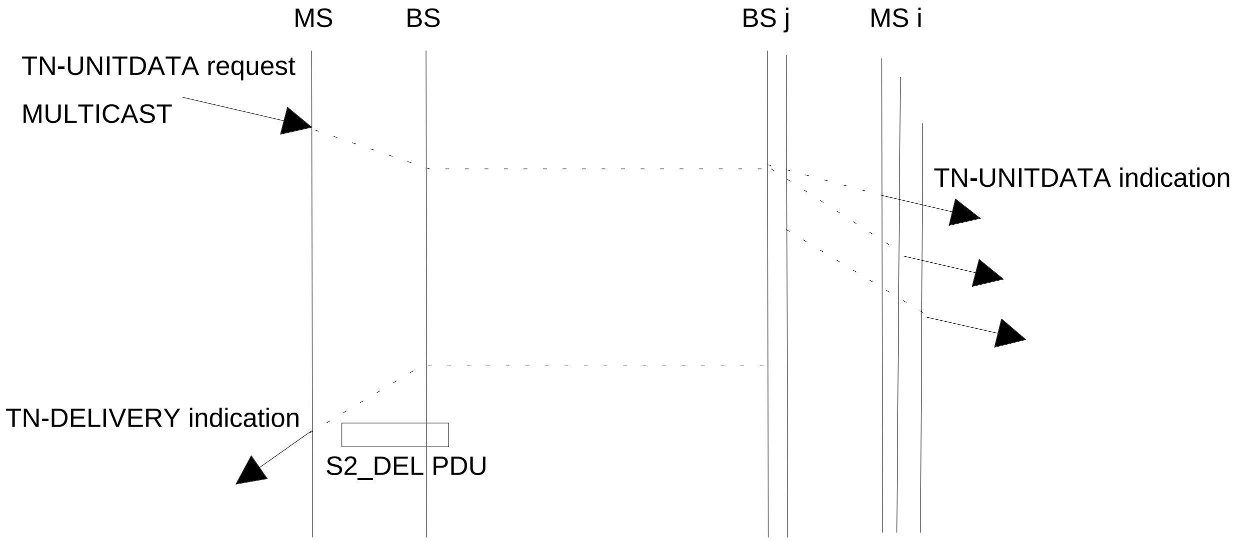


Figure 93: Multipoint case

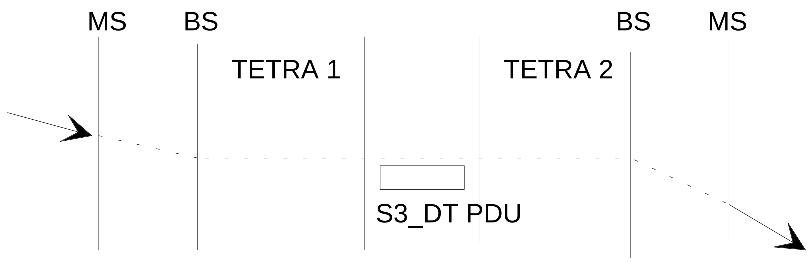
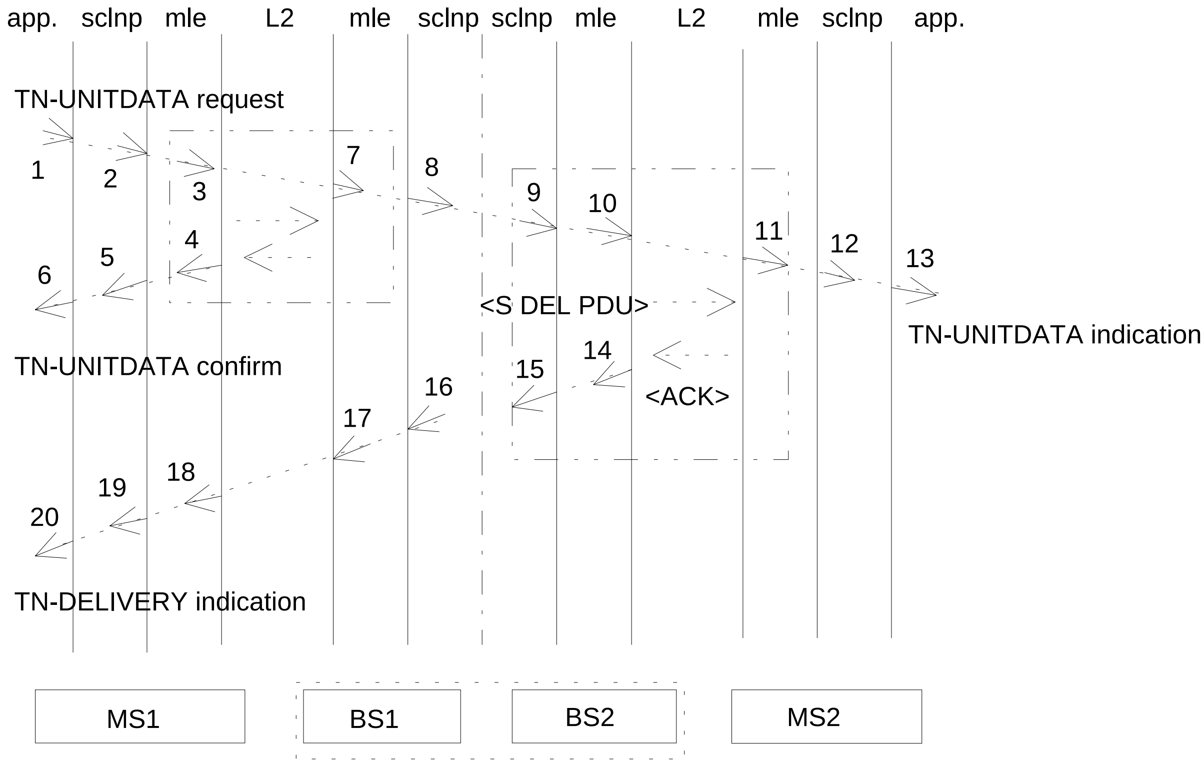


Figure 94: Inter-TETRA case

Figures 95, 96 and 97 detail a scenario involving confirmation of successful transfer to the infrastructure by a TN-UNITDATA confirm, a status transfer within a layer 2 acknowledge after this status has been pre-set, a delivery indication to the sender.

In the report indication scenario (figure 96) the layer 2 acknowledge sent by the infrastructure and associated with the successful uplink transfer of data shall correspond to a TL-DATA confirm primitive at the MS MLE boundary which shall become a TN-UNITDATA confirm at the MS application boundary.



1) TN-UNITDATA request (send data);
2) MLE-DATA request;
3) TL-DATA request;
4) TL-DATA confirm (confirm of transfer to infrastructure);
5) MLE-DATA confirm;
6) TN-UNITDATA confirm;
7) TL-DATA indication;
8) MLE-DATA indication;
9) MLE-DATA request;
10) TL-DATA request;
11) TL-DATA indication;
12) MLE-DATA indication;
13) TN-UNITDATA indication (data delivered to application);
14) TL-DATA confirm;
15) MLE-DATA confirm;
16) MLE-DATA request;
17) TL-DATA request;
18) TL-DATA indication;
19) MLE-DATA indication;
20) TN-DELIVERY indication.

Figure 95: End-to-end scenario, involving confirmation and delivery confirmation

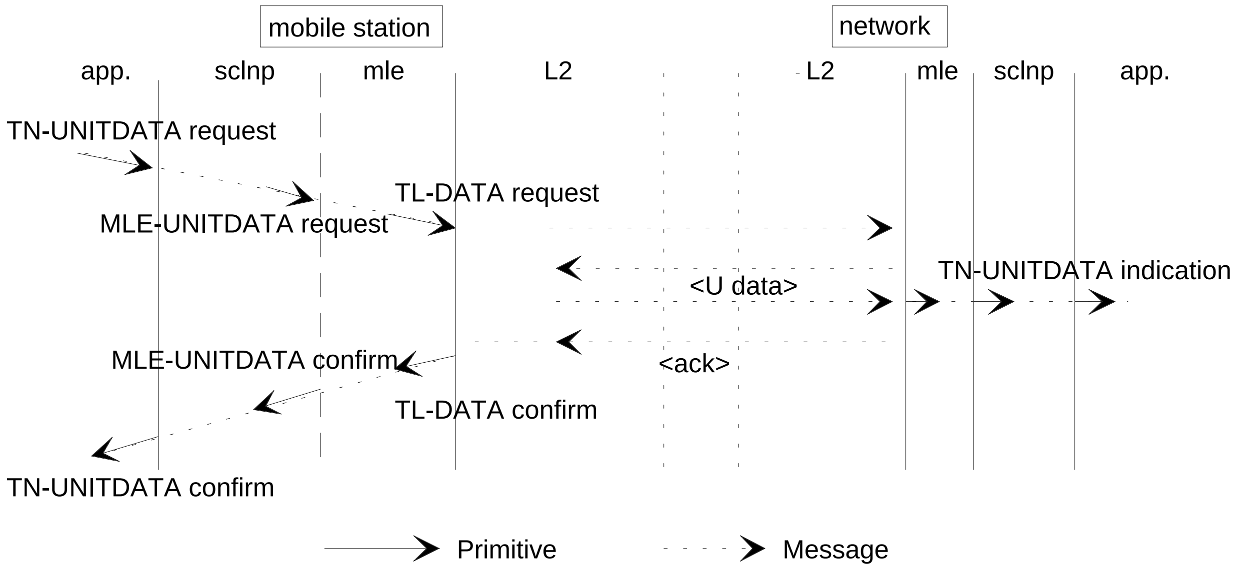


Figure 96: Report indication scenario

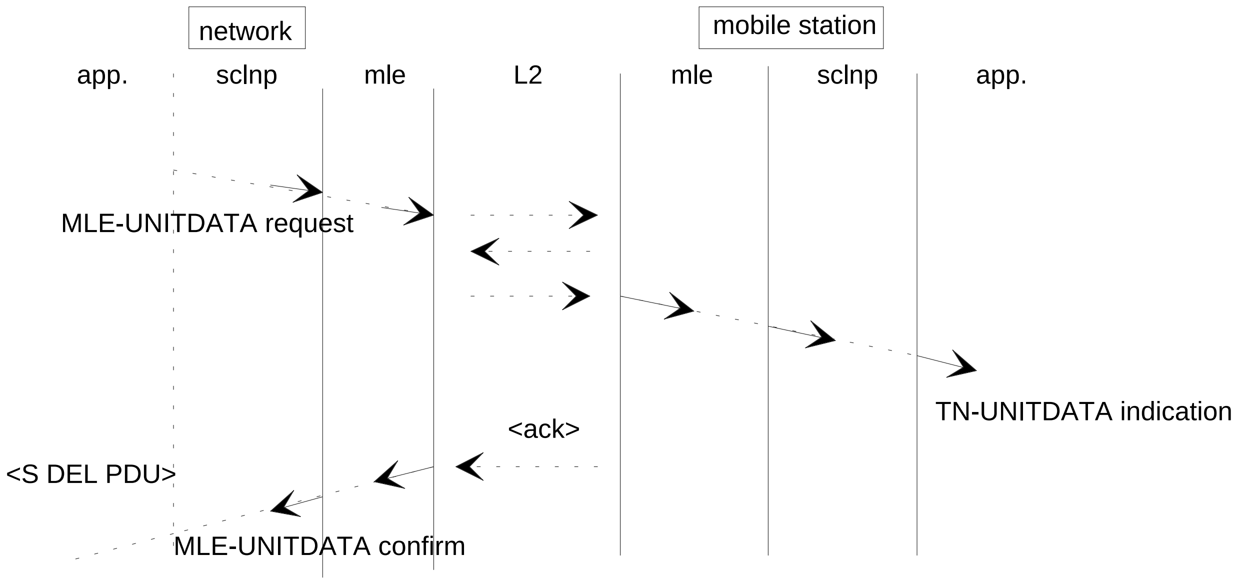


Figure 97: Delivery indication scenario

10.6 Protocol functions

The SCLNP may provide different functions depending where it is located: on a send system type, a forward or a receive system type. The forward system type is on the MTU or on the infrastructure, see ETS 300 393-2 [17], clause 14.

The functions shall be:

- PDU composition/decomposition;
- routing/forwarding/discarding of PDU;
- error reporting;
- facility handling.

10.7 Structure and encoding of the PDUs

To optimise the size of the packet header several options shall be offered:

- short or long addressing;
- a slim PDU which contains no facilities field compared to the full version.

Different PDUs are defined for each interface. On the air interface the uplink PDU can be different from the same type downlink PDU.

The structure and encoding of the PDUs are described in ETS 300 393-2 [17], clause 14. Figures 92, 93 and 94 show the types of PDUs uplink and downlink.

The different types of PDUs shall be S1 meaning uplink, S2 meaning downlink and S3 meaning inter-system interface:

- S1_DT_PDU Uplink data PDU;
- S2_DT_PDU Downlink data PDU;
- S3_DT_PDU which is the inter TETRA data only PDU;
- S2_DEL_PDU which is the downlink delivery PDU;
- S3_DEL_PDU which is the inter TETRA delivery PDU.

Annex A (normative): Priority functions for packet mode services

A.1 Introduction

This annex describes the different meanings and uses of priority functions in this ETS.

A.2 Priority and OSI layers

A.2.1 Exchange of priority information with other protocol entities

The layers in the air interface protocol stack can exchange priority information with the following entities:

- the layer above;
- the layer below;
- the peer entity;
- the lower layer management entity.

This arrangement is shown schematically in figure A.1.

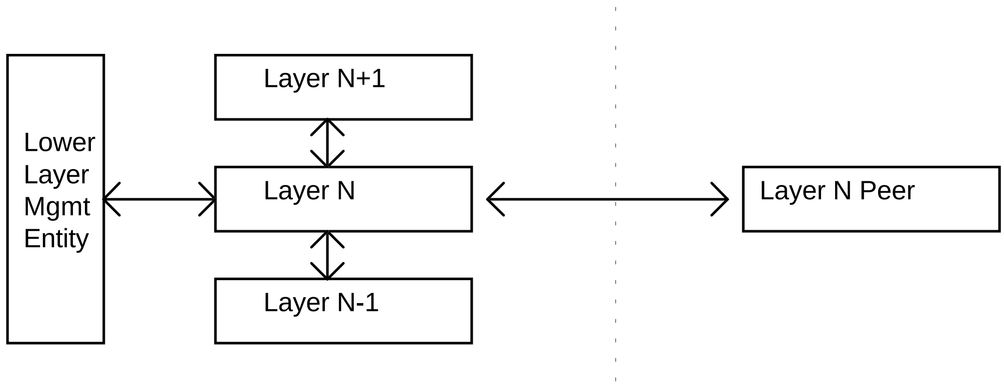


Figure A.1: Sources and destinations of priority information

A.2.2 Passing of priority information

A.2.2.1 Encoding of priority in PDUs

Priority information may be passed directly between peer entities by encoding fields in PDUs which are exchanged between the peer entities.

Priority information is passed between the following peer entities:

- layer 3/CONP;
- layer 3/S-CLNP;
- layer 2/random access and data transfer procedures.

A.2.2.2 Encoding of priority in primitives

Priority information may be passed between a protocol entity and another entity in the same protocol stack as a parameter to a primitive.

Priority information is passed between the following layers:

- user application to layer 3 (TETRA network service boundary);
- layer 3 to layer 2.

A.2.3 Framework for priorities

This subclause describes priorities using the following concepts:

- priority functions; and
- priority parameters.

Priority functions are defined as functions which are dependant on one or more priority parameters.

A priority parameter is a TETRA concept. A priority parameter shall be classified in priority levels by the assignment of a specific value.

Each priority parameter shall be agreed for a period of time, e.g. related to a subscription, and may apply per event, e.g. may be defined separately by the service user for each packet submission, as shown in table A.1.

Table A.1: Priority parameters

Ref.	Description	Subscription related	Applies per packet
7.1	Subscriber Class	Yes	Yes
7.2	NC Quality of Service	Yes	Yes
7.3	SCLNP priority facility	No	Yes
7.4	CONP expedited data	Yes	Yes
7.5	Mobile Network Identity	Yes	No
7.6	Cell service level	No	No
7.7	Message type	No	No
7.8	Message length	No	No
7.9	Emergency call	No	Yes

Table A.2: Priority functions

Ref.	Description
8.1	Air interface access procedures (layer 2)
8.2	System broadcast
8.3	MTU queue management
8.4	Infrastructure queue management

A.2.4 Priority parameters

A.2.4.1 Subscriber class

A.2.4.1.1 Description

The subscriber class is a network priority parameter that is associated with the Individual ITSI at subscription (see clause 6 for a description of the ITSI).

The main role of the subscriber class is to control access to the network. The network operator can use the subscriber class parameter to regulate network access. It may be used to reserve network resources for certain classes of subscriber.

NOTE: This type of network access control is not intended for use in normal operation, but is intended for abnormal conditions such as emergency situations or when one of two co-located TETRA networks is malfunctioning.

A.2.4.1.2 Defining subscriber class

The subscriber class may be defined in different ways:

a) by the network operator who modifies the TETRA data base that contains the ITSI subscriber class associations. The updated subscriber class can then be downloaded to the MS at the same time as the ITSI;

b) by introducing a removable file (SIM) which carries the subscriber information and in particular the subscriber class plus the ITSI;

c) by being predefined in the MS.

In the case where the subscriber class is assigned or changed by the network operator it shall be downloaded to the MS or sent with the first downlink message.

In the case where the subscriber class is defined by a removable file (a SIM) this information has to be sent to the network by the MS for information and storage. This can be done at the first registration. The information shall also be stored by the MTU itself to support the layer 2 access procedures.

In the case where the subscriber class is predefined in the MS, it is sent to the infrastructure on the first uplink message.

A.2.4.1.3 Values of subscriber class

All subscribers (all ITSIs) may be assigned to one out of 10 randomly allocated mobile populations referred by subscriber class 0 to 9. This information should be stored internally by the MS or on the removable file (SIM) of the MS.

In addition, subscribers may be members of one or more out of 6 special categories, access classes 10 to 15. These may be allocated to specific priority users as follows:

class 10:	Network operator defined;
class 11:	Network operator defined;
class 12:	Network operator defined;
class 13:	Public transport (railways, etc.);
class 14:	Emergency services (police, fire, ambulance);
class 15:	TETRA network staff.

NOTE: This enumeration is not meant as a priority sequence.

A.2.4.2 Network Connection (NC) priority

A.2.4.2.1 Definition

Refer also to annex B and to ETS 300 393-2 [17], clause 14.

The quality of service parameters include a Network Connection (NC) priority. This specifies independently the relative importance of an NC with respect to the following (see annex B):

- type A - priority to gain a NC;

- type B - priority to keep a NC;

- type C - priority of data on the NC.

NC priority QoS parameters of type A and B together define the order in which the NCs are broken to recover resources if necessary. The NS provider shall accept new requests for NCs with a high priority, i.e. type A parameter, if it can, even if NCs with a lower priority, i.e. type B parameter, are released to do so.

NC priority QoS parameter type C defines the order in which NCs have their QoS degraded. The NCs with a high priority type C shall have their requests serviced within the required QoS first and remaining resources are then used to satisfy requests on lower priority NCs.

NC priority is not wholly negotiable. The negotiation is limited to a NS user being able to request the service at one of three levels as perceived by the user that are mapped to one of the ranked levels of priority as defined in subclause A.1.6.2.2. If the absolute level chosen is acceptable to the NS provider the call can proceed.

A.2.4.3 SCLNP priority facility

Refer also to annex B and to ETS 300 393-2 [17], clause 13.

At least two levels of priority should be provided for all SCLNP packets sent from a MS. Higher priority packets should be transmitted ahead of lower priority packets.

Two additional higher levels of priority may be provided for defined high priority classes of MS.

This facility is assumed to be mapped into queuing priority at the air interface. It may also be mapped into layer 2 access priority, e.g. the use of the access channels may be restricted to high priority messages.

The CLNP protocol, ISO/IEC 8473 [11], includes a priority parameter. The parameter indicates the relative priority of the PDU, a PDU with a numerically higher priority value should be processed preferentially with respect to other PDUs with numerically lower priority values, i.e. parameter in the option part header.

This CLNP priority may be mapped to one or more of the SCLNP priority facilities.

A.2.4.4 CONP expedited data

Expedited data is an interrupt procedure that allows a DTE to transmit data to a remote DTE without following the flow control procedures applying to data packets. The initiation of the interrupt procedure and the generation of the data are controlled by a higher layer entity.

For a given Virtual Call (VC) or Permanent Virtual Circuit (PVC) an interrupt packet is delivered at, or before, the point in the stream of data packets at which the interrupt was generated. It shall be processed as soon as it is received.

Expedited data negotiation is an optional facility in the call request packet to indicate it wishes to use expedited data transfer procedures. The interrupt packet shall be used and passed transparently and unaltered directly through the network.

A typical example is a transaction abort.

A.2.4.5 Mobile Network Identity (MNI)

Refer also to clause 6.

The MNI comprises the MCC plus the MNC. These correspond to the network part of the ITSI. The MNI uniquely identifies a network and this identity shall be broadcast by all BSs.

The scanning list for cell selection and re-selection in the MS can be classified by MNI. The preferred network for attachment should correspond to the operator where the subscription has been taken.

A.2.4.6 Cell service level

Refer also to ETS 300 393-2 [17], clauses 10 and 18.

The cell service level parameter can be used to avoid overload on particular BSs of the network. A different value can be defined for every cell and this value together with the values for each of the adjacent cells can be broadcast.

For example, a BS may broadcast its current traffic loading and the loading of the adjacent BSs. A MS that wishes to access the network may use this information to choose the best BS for its needs.

This parameter should provide a range of at least 4 levels. If there are two cells which meet all the other criteria for selection then the cell with the highest level should be used.

A.2.4.7 Message type

The message type parameter is a general parameter that applies to all messages. This includes a user messages (CONP and SCLNP) as well a system control messages and broadcast messages.

Control messages and broadcast messages can be issued by different protocol layers. On the air interface control messages can be generated by both layers 2 and 3 in both directions (uplink or downlink).

The layer 3 messages include:

- layer 3 user packets like CONP and SCLNP;
- layer 3 system control messages like mobility management messages, MLE messages;
- layer 3 broadcast messages like system information.

The layer 2 messages include:

- layer 2 system control messages like access request;
- layer 2 broadcast messages like wake up.

The priorities of these messages can vary depending of the type, for example a broadcast message can be urgent, a system control message may need to be quickly synchronised with a corresponding response.

A.2.4.8 Message length

There should be no explicit priority parameter based on message length.

Priority of user messages should only be defined using the QoS parameters defined in subclauses A.1.4.2 to A.1.4.4.

A.2.4.9 Emergency calls

Emergency calls should be provided as the highest priority for the specific connectionless service, see ETS 300 393-2 [17], clause 13. This should only be available in the full SCLNP protocol.

A.2.5 Priority functions

A.2.5.1 Layer 2 access priority (air interface only)

A.2.5.1.1 General

The access priority function is contained in the MAC layer random access procedures. This random access applies to uplink access, and the "rights of access" are controlled by the BS on a local basis.

Under normal operation, random access control can be used to offer different grades of service to different groups of users but in general, all users would have at least some possibility to access the system.

Under overload conditions access restrictions may be imposed, whereby certain groups of users are denied access altogether. This may be a short term restriction, e.g. load shedding using layer 2 access restrictions, or may be longer term. In the case of a long term restriction, the system broadcast function should be used to announce the restriction (see subclause A.1.5.2).

A.2.5.1.2 Address restrictions

Layer 2 access may be restricted to specific groups of subscribers by defining an address mask. Using wild cards, or "don't care", values an address mask can be used to define any size of group from a single subscriber up to all subscribers.

The effects of address masking are determined by the address allocation strategy of the operator, but two distinct techniques are noted:

- random address grouping;
- structured address grouping.

Random address grouping typically uses a mask of the least significant bits of the address. The resulting group is random, assuming that the TSI addresses have been allocated sequentially to new users.

Structured address grouping uses a mask that is aligned to a pre-defined address structure. This can be used to provide network specific groupings such as "fleet grouping" or "closed user groups".

No address structures are defined in the standard. However, an operator may structure the TSI addressing sub-domain in any convenient manner, and the network specific field (the SSI) may be structured to support fleet addressing or closed used groups or many other groupings.

As an example, one possible technique to manage fleets is described below:

1) the operator may define a "fleet address" field as (say) the most significant 8-bits of the 24 bit SSI;

2) the operator assigns specific "fleet number" values to all of his users, and may assign the TSI according to this rule. Thus all SSI belonging to fleet number "W" will have the value "W" in the "fleet address" field;

3) the operator can then control access to each fleet by using the structured address grouping to define a mask for the "fleet address" field.

A.2.5.2 System broadcast functions

A.2.5.2.1 Summary

The system broadcast function refers to the layer 3 function that is used to broadcast system information to all MSs. This information is available to MSs both before and after they have registered.

The system information which is broadcast by all BSs should include the list of authorised subscriber classes (see subclause A.1.4.1), including an indication of whether emergency data calls are allowed for all MS or only to the special classes.

The system broadcast information may also be used to restrict access to other groups of users, e.g. address groups, or to certain types of message. As noted in subclause A.1.5.1, this should only be used when these restrictions are in existence for a long period of time.

A.2.5.2.2 Network access control

Network access control uses the subscriber class parameter defined in subclause A.1.4.1.

A.2.5.3 MTU queue management

The MTU queuing priority can be influenced by several parameters as defined in subclause A.1.6.

MTU queue management is assumed to relate to the packet multiplexing that is located in the LLC sub-layer, where LLC frames are multiplexed, and/or in the MAC sub layer, where the bursts are multiplexed. As a working assumption the transmission of a burst or a LLC frame is not interrupted by a shorter one but shorter LLC frames than a fixed threshold could get higher priority.

A.2.5.4 Infrastructure queue management

Queue management in the infrastructure is outside the scope of this ETS.

The parameters that may be used to influence infrastructure queues are defined in subclause A.1.6.

A.2.6 Relationship between parameters and functions

A.2.6.1 Summary table

The following table shows the impact of the different priority parameters (as described in subclause A.1.4) on the functions described in subclause A.1.5.

Table A.3: Summary of relationship between parameters and functions

	Layer 2 access	Queuing in MTU	Queuing in infrastructure	System broadcast
Subscriber class	yes(2)	no	no	yes
QoS: NC priority	yes(1)	yes	yes	no
SCLNP: priority facility	yes(1)	yes	yes	no
CONP: expedited data	yes(1)	yes	yes	no
Mobile Network Identity	no	no	no	yes(3)
Cell service level	no	no	no	yes(3)
Message type	yes(1)	yes	yes	no
Message length	no	no	no	no
Emergency call	yes(1)	yes	yes	no

NOTE 1: These priorities should be translated to an range of access priorities and/or queuing priorities that is handled internally in layer 2, (see subclause A.1.6.2).

NOTE 2: Subscriber class may be used in abnormal situations to bar MSs from making calls.

NOTE 3: Network ID and cell service level may also affect priority related to the MS scanning algorithm, and extraction of system information.

A.2.6.2 Mapping of priority parameters at layer 2

A.2.6.2.1 Overview

The different priority parameters that influence access priority at layer 2 should be aligned into a smaller number of functional elements.

A total of three elements is proposed:

- address element;
- subscriber class element (note);
- ranked element.

NOTE: The subscriber class is not intended for normal control. It is included here in order to enforce the network access control contained in the system broadcast function (see subclause A.1.5.2).

The address element and the subscriber class elements are mapped directly from the ITSI and the subscriber class. Both of these elements are assumed to contain no implied sequence: all values have equal priority.

The ranked element is a composite priority element that defines a small number of levels. This element is expected to be the main control element in normal operation. This has a more complex mapping as defined in the following subclause.

A.2.6.2.2 Mapping of the ranked element

The ranked element should provide a defined mapping for several different priority parameters.

The proposed mapping is:

- level 1 (low):

  - NC priority level 1 (CONP QoS parameter);
  - low priority of SCLNP packet;
  - system message: ack, etc.;

- level 2 (medium):

  - NC priority level 2 (CONP QoS parameter);
  - medium priority of SCLNP packet;
  - CONP expedited data;
  - system broadcast message;

- level 3 (high):

  - high priority of SCLNP packet;
  - NC priority level 3 (CONP QoS parameter);
  - system message;

- level 4 (emergency):

  - emergency priority of SCLNP packet.

Annex B (informative): Quality of Service (QoS)

B.1 Introduction

This annex is largely based on ISO/IEC 8348 [10] (which is equivalent to CCITT Recommendation X.213 [6]). These two documents have the same clause numbering.

Some clauses have been shortened, where it was felt that the information was of lower importance, and readers should therefore refer back to these source documents for more details if required.

Some parts of this annex have been specially drafted for TETRA. These subclauses are clearly marked as not having any equivalent in ISO/IEC 8348 [10] or CCITT Recommendation X.213 [6].

This annex describes the network connection QoS parameters that will be required for services in TETRA.

The annexes define a number of parameter values based on what is likely to be achievable.

The QoS refers to those characteristics that are observed between the network connection endpoints. The paper is largely based on ISO/IEC 8348 [10] and CCITT Recommendation X.213 [6], but has been modified to suit the requirements of TETRA. Additionally ETR 101 [8] has been used to provide a more user oriented definition or a more radio oriented definition.

B.1.1 Quality of network service

See ISO/IEC 8348 [10] or CCITT Recommendation X.213 [6], clause 10.

Quality of network service refers to certain characteristics of a Network Connection (NC) as observed between the NC endpoints. QoS describes aspects of an NC which are attributable solely to the Network Service (NS) provider; it can only be properly determined in the absence of NS user behaviour, which is beyond the control of the NS provider, that specifically constrains or impairs the performance of the network service.

A value of QoS applies to an entire NC. When determined or measured at both ends of an NC, the QoS observed by the NS user at the two ends of the NC is the same. This is true even in the case of an NC spanning several sub-networks where each sub-network offers different services.

The term “Quality of Service” also refers to certain characteristics of a network connectionless mode transmission as observed between a pair of NSAPs. QoS describes aspects of a network connectionless mode transmission which are attributable solely to the Network Service (NS) provider; it can only be properly determined in the absence of NS user behaviour, which is beyond the control of the NS provider, that specifically constrains or impairs the performance of the network service.

Whether the view of the QoS during each instance of the use of the network connectionless-mode transmission is the same to each NS user associated with the service depends on the nature of their association and the type of information concerning the nature of the service that is made available to the NS user(s) by the NS provider prior to the invocation of the service.

B.1.2 Determination of quality of network service

See ISO/IEC 8348 [10] or CCITT Recommendation X.213 [6], clause 10.1.

Quality of network service is described by means of QoS parameters. The definition of each of these QoS parameters specifies the way in which the QoS parameters value is measured or determined, making reference, where appropriate, to primitive events of the NS.

Information about the QoS is exchanged among the NS provider and NS users in terms of QoS parameters.

B.1.2.1 Connection oriented quality of network service

Connection oriented QoS parameters can be classified as:

1) those which are conveyed between peer NS users by means of the NS during the establishment phase of an NC. As part of this conveyance a three-party negotiation may take place among the NS users and the NS provider, for the purpose of agreeing upon a particular QoS parameter value;

2) those values which are not conveyed, i.e. they are purely requested by the NS user from the NS provider. For these QoS parameters, however, information about the values which is useful to the NS provider and each NS user may be made known by local means.

The connection oriented NS QoS parameters are defined in subclause B.1.4.

B.1.2.2 Connectionless quality of network service

A basic characteristic of a connectionless-mode service is that no peer-to-peer negotiation of the QoS for a transmission takes place at the time that the service is accessed. No dynamic association is set up between the parties involved as during a NC establishment; thus, characteristics of the service to be provided during the transfer are not negotiated on a peer-to-peer basis. An a priori agreement is assumed to exist between the NS users and the NS provider concerning those parameters, formats and options that affect the transfer of data.

The NS QoS parameters associated with each network connectionless-mode transmission are described in subclause B.1.4.17.

B.1.3 QoS negotiation and non-negotiation

See ISO/IEC 8348 [10] or CCITT Recommendation X.213 [6], clause 12.2.7.

QoS parameters may be negotiated or non-negotiated. The negotiation is between the NS users and the NS provider. Non-negotiated parameters apply to both directions of data transfer. Negotiated parameters may be different for each direction of data transfer. Negotiation takes the form of a QoS parameter set, where each parameter has a set of "sub-parameters" defined from the following possibilities:

a) a target value which is the QoS value desired by the calling user;

b) the lowest quality acceptable value which is the lowest QoS value agreeable to the calling user;

c) an available value which is the QoS value that the network is willing to provide;

d) a selected value which is the QoS value to which the called user agrees.

B.1.4 QoS parameter set for connection oriented services

B.1.4.1 Summary

See ISO/IEC 8348 [10] or CCITT Recommendation X.213 [6], subclause 10.2.

The connection oriented QoS parameters may be classified as:

a) QoS parameters which express network service performance;

b) QoS parameters which express other network service characteristics.

Tables B.1 and B.2 summarise the QoS parameters.

Table B.1: Classification of performance QoS-parameters

Phase	Performance Criterion	
	Speed	**Accuracy/Reliability**
NC establishment	NC establishment delay	NC establishment failure probability
Data transfer	Throughput Transit delay	Residual error rate NC resilience Transfer failure probability
NC release	NC release delay	NC release failure probability

Table B.2: QoS-parameters not associated with performance

NC protection **NC priority** **Maximum acceptable cost** **NC resilience**

B.1.4.2 NC establishment delay

See ISO/IEC 8348 [10] or CCITT Recommendation X.213 [6], subclause 10.2.1.

NC establishment delay is the maximum acceptable delay between a TN-CONNECT request and the corresponding TN-CONNECT confirm primitive.

B.1.4.3 NC establishment failure probability

See ISO/IEC 8348 [10] or CCITT Recommendation X.213 [6], subclause 10.2.2.

NC establishment failure probability is the ratio of total NC establishment failures to total NC establishment attempts in a measurement sample.

NC establishment failure is defined to occur when a requested NC is not established within the maximum acceptable time period as a result of NS provider behaviour such as misconnection, NC refusal, or excessive delay. NC establishment attempts which fail as a result of NS user behaviour such as error, NC refusal, or excessive delay are excluded in calculating NC establishment failure probability.

NOTE: This parameter is defined in terms of establishment failure as reported at the network layer service boundary. Certain lower layer failures may not contribute to this failure probability, e.g. if the protocol includes automatic recovery procedures.

B.1.4.4 Throughput (User information transfer rate)

B.1.4.4.1 Throughput for constant delay services

See ISO/IEC 8348 [10] or CCITT Recommendation X.213 [6], subclause 10.2.3.

Throughput is defined, for each direction of transfer, as the maximum rate the NS provider can continuously sustain, when unconstrained by flow control applied by the receiving NS user.

Given a sequence of n NSDUs, where n is greater than or equal to 2, throughput is defined to be the smaller of:

a) the number of NS-user data octets contained in the last (n-1) NSDUs divided by the time between the first and last TN-DATA requests in the sequence;

b) the number of NS-user data octets contained in the last (n-1) NSDUs divided by the time between the first and last TN-DATA indications in the sequence.

Successful transfer of the octets in a transmitted NSDU is defined to occur when the octets are delivered to the intended receiving NS user(s) without error, in the proper sequence, prior to release of the NC by the receiving NS user.

Throughput is specified separately for each direction of transfer. Each throughput specification will specify both the desired "target" value and the minimum acceptable value, i.e. the "lowest quality acceptable", for the NC.

B.1.4.4.2 Throughput for variable delay services

Throughput for variable delay services differs from the constant delay case due to the existence of automatic re-transmission protocols.

NOTE 1: This parameter does not appear in ISO/IEC 8348 [10] or CCITT Recommendation X.213 [6].

Throughput for variable delay services defines the average user data rate that can be achieved over the relevant service coverage area. This average throughput should be expected to reduce for operation outside the stated coverage area.

NOTE 2: The actual throughput that is achieved may be further reduced by certain user protocols, e.g. synchronous modems. The stated figure will only be achieved with ideal user protocols.

B.1.4.5 Transit delay

B.1.4.5.1 Transit delay for constant delay services

See ISO/IEC 8348 [10] or CCITT Recommendation X.213 [6], subclause 10.2.4.

Transit delay is the elapsed time between a TN-DATA request and the corresponding TN-DATA indication. Elapsed time values are calculated only on NSDUs that are successfully transferred.

Successful transfer of an NSDU is defined to occur when the NSDU is transferred from the sending NS user to the intended receiving NS user without error, in the proper sequence, prior to release of the NC by the receiving NS user.

Specification of transit delay will define a pair of values: the desired "target" value and the maximum acceptable value, i.e. the "lowest quality acceptable". The specified values will be averages and will be based on an NSDU size of 128 octets.

The pair of transit delay values specified for an NC applies to both directions of transfer. That is, the transit delay in each direction is expected to be no worse than that specified.

B.1.4.5.2 Transit delay for variable delay services

Transit delay for variable delay services can vary due to the existence of automatic re-transmission protocols.

NOTE: This parameter does not appear in ISO/IEC 8348 [10] or CCITT Recommendation X.213 [6].

Transit delay for variable delay services refers to the delay that will apply under ideal conditions, when no automatic re-transmissions have occurred. Any automatic re-transmissions will increase this delay.

B.1.4.6 Residual Error Rate (RER)

See ISO/IEC 8348 [10] or CCITT Recommendation X.213 [6], subclause 10.2.5.

The RER is the ratio of total incorrect, lost and duplicate NSDUs to total NSDUs transferred across the NS boundary during a measurement period. The RER may be represented by the following formula;

$$RER = \frac{N(e) + N(l) + N(x)}{N}$$

where:

- N is the total number of NSDUs transferred;
- N(e) is the number of incorrect NSDUs received;
- N(l) is the number of NSDUs lost;
- N(x) is the number of extra NSDUs received.

B.1.4.7 Transfer failure probability

See ISO/IEC 8348 [10] or CCITT Recommendation X.213 [6], subclause 10.2.6.

Transfer failure probability is the ratio of total transfer failures to total transfer samples during a performance measurement.

A transfer sample is a discrete observation of NS provide performance in transferring NSDUs between a specified sending and receiving user. A transfer sample begins on input of a selected NSDU at the sending NS user boundary, and continues until the outcome of a given number of NSDU transfer requests has been determined. A transfer sample should normally correspond to the duration of an individual NC.

A transfer failure is a transfer sample in which the observed performance is worse than a specified minimum acceptable level. Transfer failures are identified by comparing the measured values for performance parameters with specified failure thresholds. The three supported performance parameters are throughput, transit delay and residual error rate.

In systems where QoS is reliably monitored by the NS provider, transfer failure probability can be estimated by the probability of an NS provider invoked TN-DISCONNECT during a transfer sample.

B.1.4.8 NC resilience

See ISO/IEC 8348 [10] or CCITT Recommendation X.213 [6], subclause 10.2.7.

NC resilience parameters specify the probability of:

a) an NS provider invoked NC release, i.e., issuance of an TN-DISCONNECT indication with no prior TN-DISCONNECT request; and

b) an NS provider invoked reset, i.e. issuance of a TN-RESET indication with no prior TN-RESET request;

during a specified time interval on an established NC.

B.1.4.9 NC release delay

B.1.4.9.1 NC release delay at the peer user

See ISO/IEC 8348 [10] or CCITT Recommendation X.213 [6], subclause 10.2.8.

NC release delay at the peer user is the maximum acceptable delay between an NS user invoked TN-DISCONNECT request and the successful release of the NC at the peer NS user. NS release delay does not apply in cases where NC release is invoked by the NS provider.

Issuance of a TN-DISCONNECT request by either NS user starts the counting of the NC release delay for the other NS user. Successful NC release is signalled to the NS user not initiating the TN-DISCONNECT request by a TN-DISCONNECT indication.

B.1.4.9.2 NC release delay at the invoking user

NC release delay at the invoking user is the maximum acceptable delay between an NS user invoked TN-DISCONNECT request and the successful acknowledgement of the release of the NC at that same NS user. NS release delay does not apply in cases where NC release is invoked by the NS provider.

NOTE: This parameter does not appear in ISO/IEC 8348 [10] or CCITT Recommendation X.213 [6].

Issuance of a TN-DISCONNECT request by either NS user starts the counting of the NC release delay for the other NS user. Successful NC release is signalled to the NS user initiating the TN-DISCONNECT request by a TN-DISCONNECT confirmation.

B.1.4.10 NC release failure probability

See ISO/IEC 8348 [10] or CCITT Recommendation X.213 [6], subclause 10.2.9.

NC release failure probability is the ratio of total NC release requests resulting in NC release failure to total NC release requests included in a measurement sample. NC release failure probability is normally specified independently for each NS user.

A release failure is defined to occur, for a particular NS user, if that user does not receive a TN-DISCONNECT indication within the specified maximum NC release delay of the NS user issuing the TN-DISCONNECT request, given that the former NS user has not issued a TN-DISCONNECT request.

This is only specified as a network performance figure.

B.1.4.11 NC protection

See ISO/IEC 8348 [10] or CCITT Recommendation X.213 [6], subclause 10.2.10.

NC protection is the extent to which an NS provider attempts to prevent unauthorised masquerading or monitoring or manipulation of NS-user-data. NC protection for an NC is specified by selecting any combination of the following features:

a) confidentiality of an entire NSDU sequence on the NC;

b) detection of modification, deletion, replay, or insertion of data within the NSDU sequence on an NC;

c) peer entity authentication. The NS user may request that the NS provider should confirm the identity of the remote NSAP such that there is protection against masquerading T-entities;

d) authentication of the origin of an NSDU such that there is protection against the unauthorised insertion or replay of the NSDU;

e) authentication of the NS provider to guard against masquerading entities.

B.1.4.12 NC priority

See ISO/IEC 8348 [10] or CCITT Recommendation X.213 [6], subclause 10.2.11.

NC priority specified independently the relative importance of an NC with respect to the following:

a) priority to gain an NC;

b) priority to keep an NC;

c) priority of data on the NC.

NC priority QoS-parameters a) and b) together define the order in which the NCs are broken to recover resources if necessary. The NS provider shall accept new requests for NCs with a high priority type a) if it can, even if NCs with a lower priority b) are released to do so.

NC priority QoS-parameter c) defines the order in which NCs have their QoS degraded. The NCs with a high priority c) shall have their requests serviced within the required QoS first and remaining resources shall then be used to satisfy requests on lower priority NCs.

See annex A for more details on priority.

B.1.4.13 Maximum acceptable cost

See ISO/IEC 8348 [10] or CCITT Recommendation X.213 [6], subclause 10.2.12.

The maximum acceptable cost QoS-parameter specifies the maximum acceptable cost for an NC. The cost may be specified in absolute or relative cost units. The cost of an NC is composed of communications and end-system resource costs.

B.1.4.14 Air interface parameters

These definitions are adapted from ETR 101 [8]. These parameters do not appear in ISO/IEC 8348 [10] or CCITT Recommendation X.213 [6]. Therefore they are only applicable to circuit-mode services.

B.1.4.14.1 Call restoration success rate

The call restoration success rate is the probability of a call restoration being successful within a defined service coverage area. A successful call restoration is defined to occur when all established calls are maintained.

B.1.4.15 Connection oriented QoS negotiation

The initial negotiation between NS user and NS provider utilises the QoS-parameter set field in the TN-CONNECT request message. This will contain both "target" and "lower quality acceptable" values. The NS provider will send the QoS-parameter set with the "available" values in the TN-CONNECT confirm message. Where negotiation involves the called party, the TN-CONNECT indication message includes the "target" and "lower quality acceptable" values that are agreeable to the NS provider, and the calling NS user. The TN-CONNECT response includes the "selected" value. The "selected" value is transmitted to the calling user in the TN-CONNECT confirm message.

B.1.4.16 QoS parameter set for connectionless services

B.1.4.16.1 Summary

Connectionless QoS parameters can be classified as:

1) those which are fixed in advance: either fixed characteristics of the network, i.e. non-negotiable, or negotiated in advance of the packet submission;

2) those which are requested at the time of packet submission, i.e. they are purely requested by the NS user from the NS provider on a per-packet basis.

The QoS parameters can be further classified as:

a) QoS parameters which express network service performance;

b) QoS parameters which express other network service characteristics.

The following tables summarise the connectionless QoS parameters:

Table B.3: Classification of performance QoS-parameters

Phase	Performance criterion	
	Speed	Accuracy/reliability
Data transfer	Transit delay	Residual error probability

Table B.4: QoS-parameters not associated with performance

Protection from unauthorised access
Cost determinants
Priority

B.1.4.16.2 Transit delay

See ISO/IEC 8348/Addendum 1 [10], subclause 10.3.1.

Connectionless packet transit delay is the elapsed time between a TN-UNITDATA request and the corresponding TN-UNITDATA indication. Elapsed time values are calculated only on NSDUs that are successfully transferred.

Successful transfer of an NSDU is defined to occur when the NSDU from the sending NS user is delivered to the intended receiving NS user without error.

Transit delay should be specified independently for each network connectionless-mode transmission. Transit delay defines the value expected for the completion of the transmission of a particular NSDU. Its specification should be based on an average NSDU size. It should be determined by the NS provider and made known to the NS user prior to the invocation of the service.

Transit delay for an individual NSDU may be greatly increased if local interface flow control is exercised at either the transmitting or receiving service provider to service user interface. Occurrences of local interface flow control should be excluded in calculating transit delay values.

B.1.4.16.3 Protection from unauthorised access

See ISO/IEC 8348/Addendum 1 [10], subclause 10.3.2.

The extent to which a NS provider attempts to prevent unauthorised monitoring or manipulation of NS user-originated information is specified qualitatively by selecting one of four options:

a) no protection features;

b) protection against passive monitoring;

c) protection against modification, replay, addition and deletion; and

d) both (b) and (c).

B.1.4.16.4 Cost determinants

See ISO/IEC 8348/Addendum 1 [10], subclause 10.3.3.

A class of parameter values and options may exist which provide a NS user with:

a) the ability to indicate to the NS provider that it should choose, for example, the least expensive means available to it, even in situations where this may not be the most expedient means; or

b) the ability to specify maximum acceptable cost.

The cost may be specified in absolute or relative cost units. The cost of a network connectionless mode transmission is composed of communications and end system costs.

B.1.4.16.5 Residual error probability

See ISO/IEC 8348/Addendum 1 [10], subclause 10.3.4.

Residual error probability describes the likelihood that a particular NSDU will be lost, duplicated, or delivered incorrectly. This probability is estimated as the ratio of lost, duplicated, or incorrectly delivered NSDUs to the total NSDUs transmitted by an NS provider during a measurement period.

An incorrectly delivered NSDU is one in which the user data are delivered in a corrupted condition, or the user data are delivered to an incorrect NSAP.

Lost data includes all NSDUs which are discarded by the NS provider due to congestion, transmission error, or some other error. NSDUs which are lost due to error by the NS user are not included.

B.1.4.16.6 Priority

See ISO/IEC 8348/Addendum 1 [10], subclause 10.3.5.

This parameter allows the NS user to specify the relative priority of an NSDU in relation to any other NSDUs acted upon by the NS service provider. An NSDU of higher priority is serviced by the NS provider before one of lower priority. The priority information is conveyed to the receiving NS user.

This parameter specifies the relative importance of network connectionless-mode transmission with respect to:

a) the order in which NSDUs are to have their quality of service degraded, if necessary; and

b) the order in which NSDUs are to be discarded to recover resources, if necessary.

This parameter has meaning only in the context of some management entity or structure able to judge relative importance. The number of priority levels is limited to 15.

B.1.4.17 Connectionless QoS negotiation

Not applicable.

B.1.4.18 Applicability of QoS parameters to TETRA services

Table B.5: Applicability of connection oriented QoS-parameters

	CONS
NC establishment delay	n
NC establishment failure probability	s
Throughput	N
Transit delay	n
Residual error rate	n
Transfer failure prob.	s
NC resilience	s
NC release delay	s
NC release failure prob.	s
NC protection	N note 1
NC priority	n note 2
Maximum acceptable cost	n note 1
NOTE 1: May not be implemented on all systems. NOTE 2: The negotiation only uses a limited set of parameters (see subclause B.1.4.12).	

Key:

n negotiable only between NS user and NS provider;

N negotiable between NS users (calling and called) and NS provider;

s network performance figure.

Table B.6: Applicability of connectionless QoS-parameters

	S-CLNS
Transit delay	x
Protection from unauthorised access	x
Cost determinants	x
Residual error probability	x
Priority	x

Key:

x not applicable/not specified.

Annex C (informative): ISO ConnectionLess Network Service (CLNP)

The ISO connectionless network service (ISO-CLNS) may be supported by TETRA by introducing a Sub-Network Dependent Convergence Sub-layer (SNDCP) in the network layer as shown in figure C.1. In this arrangement ISO-CLNP should act as a Sub-Network Independent Protocol (SNICP) and the TETRA specific connectionless protocol (TETRA-SCLNP) should act as a Sub-Network Access Protocol (SNACP).

This arrangement should be based on the internal organisation of the network layer as described in ISO 8648 [14].

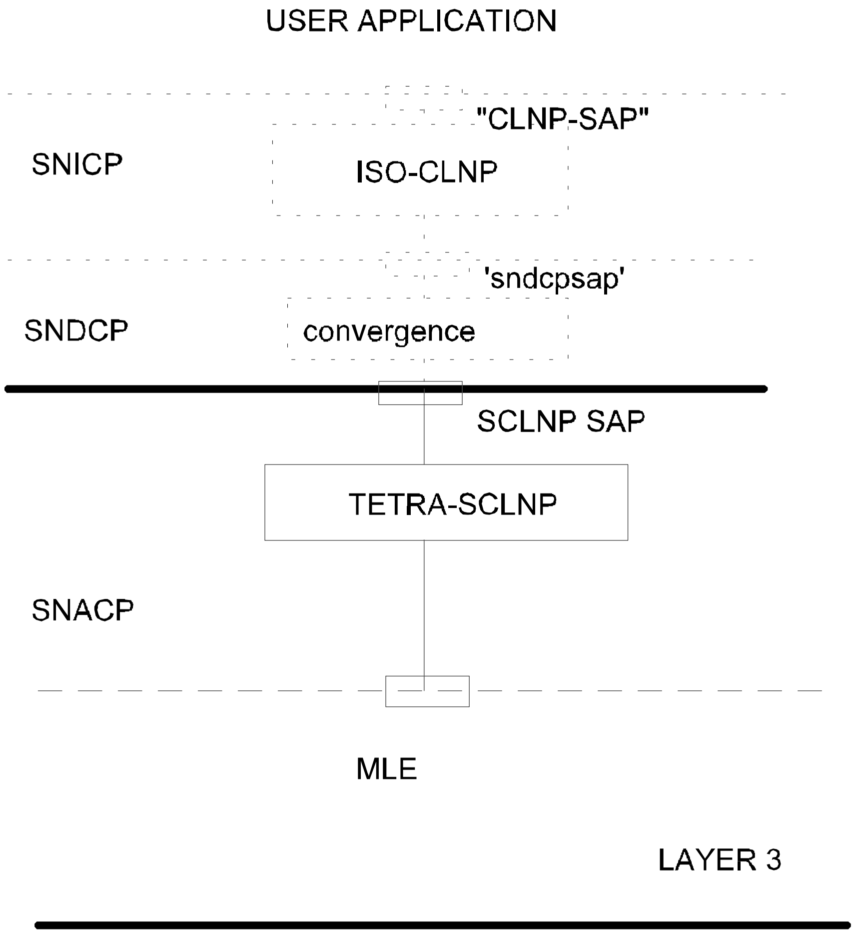


Figure C.1: Support of ISO-CLNP with TETRA-SCLNS

Annex D (informative): Internet-connectionless Protocol (Internet-IP)

The Internet-IP may be supported by TETRA by introducing a Sub-Network Dependent Convergence sub-layer (SNDCP) in the network layer as shown in figure D.1. In this arrangement IP should act as a Sub-Network Independent Protocol (SNICP) and the TETRA specific connectionless protocol (TETRA-SCLNP) should act as a Sub-Network Access Protocol (SNACP).

This arrangement should be based on the internal organisation of the network layer as described in ISO 8648 [14].

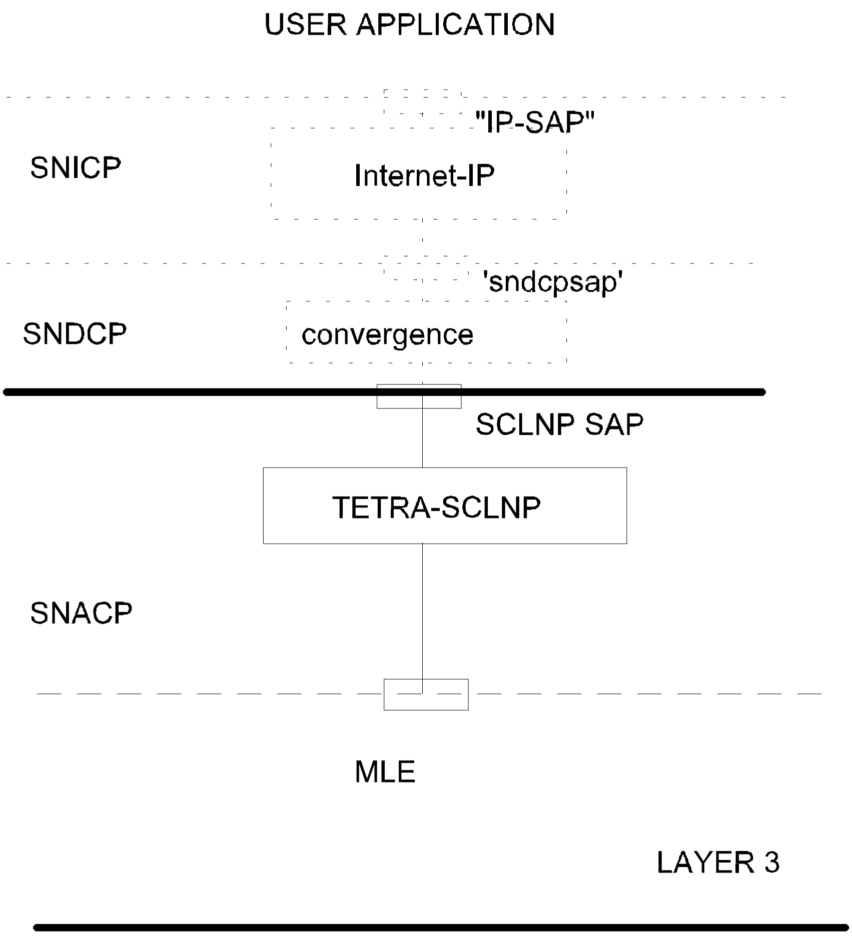


Figure D.1: Support of Internet-IP with TETRA-SCLNS

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