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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 will consist of the following parts:

- Part 1: "General network design".**
- Part 2: "Air Interface (AI)".
- Part 3: "Inter-working - Basic Operation", (DE/RES-06001-3).
- Part 4: "Gateways for Basic Services", (DE/RES-06001-4).
- Part 5: "Terminal equipment interface", (DE/RES-06001-5).
- Part 6: "Line connected stations", (DE/RES-06001-6).
- Part 7: "Security".
- Part 8: "Management services", (DE/RES-06001-8).
- Part 9: "Performance objectives", (DE/RES-06001-9).
- Part 10: "Supplementary Services (SS) Stage 1".
- Part 11: "Supplementary Services (SS) Stage 2", (DE/RES-06001-11).
- Part 12: "Supplementary Services (SS) Stage 3", (DE/RES-06001-12).
- Part 13: "SDL Model of the Air Interface", (DE/RES-06001-13).
- Part 14: "PICS Proforma", (DE/RES-06001-14).
- Part 15: "Inter-working - Extended Operations", (DE/RES-06001-15).
- Part 16: "Gateways for Supplementary Services", (DE/RES-06001-16).

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1 Scope

This ETS defines the Trans-European Trunked Radio system (TETRA) supporting Voice plus Data (V+D). It specifies the air interface, the inter-working between TETRA systems and to other systems via gateways, the terminal equipment interface on the Mobile Station (MS), the connection of Line Stations (LSs) to the infrastructure, the security aspects in TETRA networks, the management services offered to the operator, the performance objectives, and the supplementary services that come in addition to the basic and tele-services.

This part of this ETS applies to the TETRA V+D radio air interface.

It establishes the TETRA general network design:

- it defines and specifies the circuit mode and packet mode reference points for the MS, LS and switching and management infrastructure;
- it defines and specifies a model of the air interface protocol stack where the different functions of layers and sublayers are listed based on ISO 8473 [13] and ISO 8208 [11] methodology;
- it defines and specifies the TETRA addressing and identities and their organisation in groups corresponding to the different functions;
- it defines and specifies the functions provided by the circuit mode teleservices used for speech and basic services used for data transfer;
- it defines and specifies the functions related to the management of the users' mobility across networks and inside a network including roaming and migration;
- it defines and specifies the functions related to the transport of short data messages as a service specific to TETRA;
- it defines and specifies the functions related to the support of connection oriented packet data service in TETRA;
- it defines and specifies the functions related to the support of connectionless packet data service in a way specific to TETRA;
- it defines and specifies the supplementary services that mainly extend the capabilities of the circuit mode basic and teleservices;
- in informative annexes, it illustrates the various possibilities of individual circuit mode call scenarios and provides guidance on priority concepts for packet data and circuit mode services and on the service quality.

NOTE: This part of this ETS may, by its nature as a general design statement, require updating when later parts of the ETS are completed (in order to avoid any non-alignment). If a discrepancy occurs between this part and any other part of this ETS, then the other part will take precedence. This part will be updated at a frequency consistent with maintaining the integrity of the ETS as a whole.

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 Blue Book): "Numbering Plan for the International Telephone Service".
- [2] CCITT Recommendation E.164 (1988 Blue Book): "Numbering Plan for the ISDN Era".

- [3] CCITT Recommendation E.212 (1988 Blue Book): "Identification Plan for Land Mobile Stations".
- [4] CCITT Recommendation E.213 (1988 Blue Book): "Telephone and ISDN Numbering Plan for Land Mobile Stations in Public Land Mobile Networks (PLMN)".
- [5] CCITT Recommendation I.130: "Method for the characterization of telecommunication services supported by an ISDN and network capabilities of an ISDN".
- [6] CCITT Recommendation I.411: "ISDN User-Network Interfaces - Reference Configurations".
- [7] CCITT Recommendation V.110: "Support of Data Terminal Equipments (DTEs) with V-series type Interfaces by an Integrated Services Digital Network (ISDN)".
- [8] CCITT Recommendation X.121 (1988): "International Numbering Plan for Public Data Networks".
- [9] CCITT Recommendation X.213: "Network Service Definition for Open System Interconnection for CCITT applications".
- [10] CCITT Recommendation X.219: "Remote Operations: Model, Notation and Service Definition".
- [11] ISO 8208: "X.25 packet level protocol for Data Terminal Equipment".
- [12] ISO 8348: "Information processing systems - Data communications-Network service definition".
- [13] ISO 8473: "Protocol for providing the connectionless mode network service".
- [14] ISO 8878: "Use of X.25 to provide the OSI connection mode network".
- [15] ECMA-165 PTN: "Generic Functional Protocol for the support of Supplementary Services".
- [16] ETR 086: "Radio Equipment and Systems (RES); Trans-European Trunked Radio (TETRA) systems; Technical requirements specification".
- [17] ETS 300 392-2: "Radio Equipment and Systems (RES); Trans-European Trunked Radio (TETRA); Voice plus Data (V+D); Part 2: Air interface".
- [18] prETS 300 392-10: "Radio Equipment and Systems (RES); Trans-European Trunked Radio (TETRA); Voice plus Data (V+D); Part 10: Supplementary services".

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 SwMI both in the old cell (leaving cell) and in the new cell (arriving cell) that cell change is performed. There are three types of announced cell re-selection:

- type 1:
 - the MS-MLE knows the new cell and the traffic channel allocations on the cell before deciding to leave its serving cell;

- 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 wants to change cell.

attached: A MS is said to be attached to a cell when the MS is camped and 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 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 ITCs which utilises the same scenario over the inter system interface.

call: A complete information exchange between two or more parties.

call transaction: All of the events associated with one continuous transmission of information during a call (including control signalling). A call consists of one or more call transactions.

NOTE 1: In a half-duplex call, the call consists of a sequence of unidirectional transactions.

camped: A MS is said to be camped on a cell when the MS is synchronized on the cell BS and has decoded the Broadcast Network CHannel (BNCH) of the cell. The synchronization procedure is performed by the MAC and the interpretation of the network information from the BNCH (V+D) is performed by a procedure in the MLE. It is the MLE which decides when a MS is said to be camped on a cell.

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 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 calls: A call 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 (LMN) access arrangements. In a particular access arrangement, specific functions in a function group may but need not be present.

NOTE 2: 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 Network Service (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 MAC. When the cell selection is made and possible registration is performed, the MS is said to be attached to the cell.

internal calls: A call 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 call: A call where source and destination are in different TETRA networks.

Inter-TETRA Connections (ITCs): ITCs are provided by the InterVening Networks (IVNs) at the Inter-System Interface (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 TETRA 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 one (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 may be of the following types:

- 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: One or more items of equipment or a part of an item of equipment whose operation provides a network relay function; that is 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 call: A call where both source and destination are in the same TETRA network sub-domain.

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

LXX SAP: Any or all of the following SAPs: LCMC SAP, LCO SAP, LSCL SAP.

message trunking: A method of traffic channel organisation where each traffic channel is permanently allocated for the complete duration of the call, which may include several separate call transactions (several pressel activations by separate terminals). The channel is only de-allocated if the call is (explicitly) released or if a time-out expires (see also transmission trunking, quasi-transmission trunking).

migration: The act of changing to a new LA in a network (either with different MNC and/or MCC) where the user does not have subscription (ITSI) for that network.

Mobile Network Identity (MNI): The identity that is broadcast by all TETRA base stations 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 C_2 based upon information on neighbour cells broadcast by the serving cell (see ETS 300 392-2 [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 ISDN, PSTN and PDN domains.

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

NOTE 3: The boundary of the nominal radio coverage area is defined by a Bit Error Ratio (BER) contour as defined in ETS 300 392-2 [17], clause 6.

on/off hook signalling: A signalling procedure which includes an alerting process to the called user. The calling user should wait for an explicit response from the called user that he has answered before the call can be set-up.

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.

quasi-transmission trunking: A method of traffic channel organisation where each traffic channel is allocated for the each call transaction (while the pressel is activated) and in addition the channel de-allocation is delayed for a short period at the end of the transaction (after the pressel release). During this "channel hold-time", the channel allocation may be re-used for a new call transaction that is part of the same call. A delayed channel de-allocation procedure will apply at the end of each transaction.

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 network service 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 terminal equipment (TE3) connected to a Packet Assembler and Disassembler (PAD). There may be several alternative interface protocols at R4, including existing PDN standards.

R5: The reference point between the Network Management Unit (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.

R10: A logical reference point equivalent to R0.

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 C_4 parameters and C_3 parameters, defined in ETS 300 392-2 [17], clause 10. As inputs to the ranking procedure are:

- outputs from the monitor process (e.g. C_2 parameters);
- outputs from the scanning process (e.g. C_1 parameters);
- network parameters received in the MLE broadcast.

reference configuration: A conceptual configuration useful in identifying various possible physical access arrangements to a TETRA LMN.

Two concepts are used in defining reference configurations:

- reference points; and
- functional groups.

NOTE 4: Physical interfaces that do not correspond to a reference point will not be described in the TETRA 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. Physical interfaces that do not correspond to a reference point (e.g. transmission line interfaces) will not be the subject of TETRA LMN interface recommendations.

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 (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 C_1 based upon the information on the neighbour cells broadcasted by the neighbour cells themselves (see ETS 300 392-2 [17], clause 10).

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

segmentation: The act of generating two or more derived 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 5: A particular service coverage area is specific to one service and one network.

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

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

NOTE 6: There are four different types of SSI (see subclause 7.2.3):

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

sub-network: A collection of equipment's and physical media which forms an autonomous whole and which can be used to interconnect real systems for purpose of communication.

supplementary service: A service which modifies or supplements a bearer service or a teleservice. A supplementary service cannot be offered to a customer as a stand-alone service. It should be offered in combination with a bearer service or a teleservice.

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 MT) and in LSs (in the NT).

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

NOTE 7: The management entity has no functionality 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 25 for addressing domain).

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

transmission trunking: A method of traffic channel organisation where each traffic channel is individually allocated for each call transaction (for each activation of the pressel). The channel is immediately de-allocated at the end of the call transaction, subject to unavoidable protocol delays (see also message trunking, quasi-transmission trunking).

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 Network Service (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.

This ETS also makes use of the standard terms used in ISO in particular:

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

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
AL	Ambience Listening
AoC	Advice of Charge
AP	Access Priority
AP1	Access Point for Bearer Services at S reference point
AP2	Access Point for Bearer Services at R reference point
AP3	Access Point for Teleservices
AS	Area Selection
ASSI	Alias Short Subscriber Identity
ATSI	Alias TETRA Subscriber Identity
BIC	Barring of Incoming Calls
BOC	Barring of Outgoing Calls
BS	Base Station or Base Station (Cell)
CAD	Call Authorized by Dispatcher
CC	Call Control
CCBS	Call Completion to Busy Subscriber
CCNR	Call Completion on No Reply
CFB	Call Forwarding on Busy
CFNRc	Call Forwarding on Mobile Subscriber Not Reachable
CFNRy	Call Forwarding on No Reply
CFU	Call Forwarding Unconditional
CL	ConnectionLess
CLIP	Calling Line Identification Presentation
CLIR	Calling/connected Line Identification Restriction
CMCE	Circuit Mode Control Entity
CO	Connection Oriented
COLP	COnnected Line identification Presentation
CONP	Connection Oriented Network Protocol
CR	Call Report
CRT	Call Retention
CW	Call Waiting
DGNA	Dynamic Group Number Assignment
DL	Discreet Listening
DSD	Destination Short Data
DSDA	Destination Short Data Agent
DSE	Dialogue Service Element
ESN	Electronic Serial Number
FAC	Final Assembly Code
GoS	Grade of Service
GSM	Global System for Mobile communications
GSSI	Group Short Subscriber Identity
GTSI	Group TETRA Subscriber Identity
HOLD	Call HOLD
IC	Include Call
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
LMN	Land Mobile Network
LS	Line Station or Line-connected Station
LSC	List Search Call
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
ROSE	Remote Operating Service Element
R _T	TETRA R reference point
SA	Search Area
SAP	Service Access Point
S-CLNP	Specific ConnectionLess Network Protocol
SDP	Short Data Protocol
SDS	Short Data Service
SDU	Service Data Unit
SIM	Subscriber Identity Module
SMI	Short Management Identity
SNA	Short Number Addressing
SNACP	Sub-Network Access Protocol
SNAF	Sub-Network Access Functions
SNDCP	Sub-Network Dependant Protocol
SNICP	Sub-Network Independent Protocol
SS	Supplementary Service
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
TNP1	TETRA Network Protocol No. 1
TNP2	TETRA Network Protocol No. 2
TNP3	TETRA Network Protocol No. 3
TNP4	TETRA Network Protocol No. 4
TNSDS	TETRA Network Short Data Service
TPI	Talking Party Identification

T _T	TETRA T reference point
U _d	TETRA Direct Mode air interface
U _m	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 Circuit mode reference points

4.1 Introduction

This clause is based on the principle of reference configurations presented in CCITT Recommendation I.411 [6].

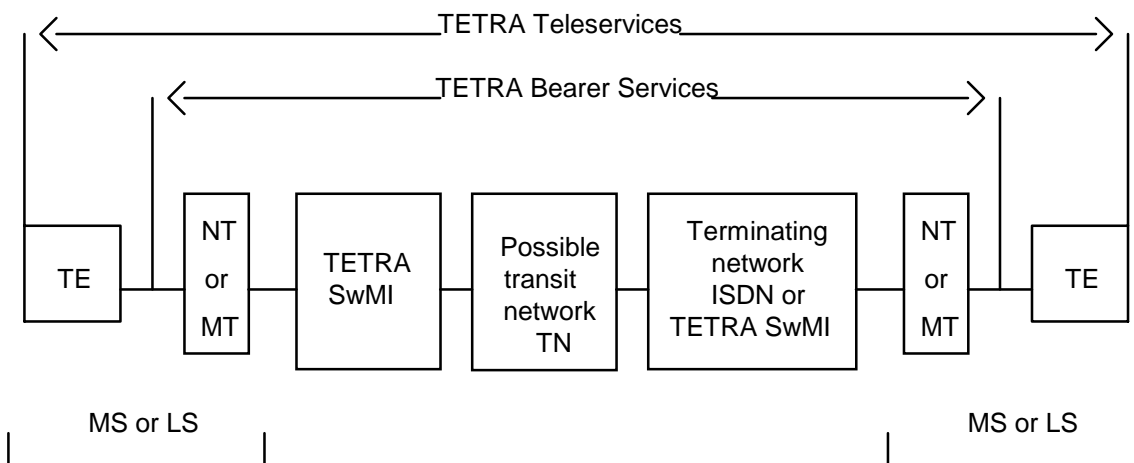
The TETRA LMN supports various speech and data services. This clause defines the general reference configuration and the circuit mode reference points for TETRA MSs, LSs, and the inter system interface. An overview of circuit mode services and examples of protocol configurations are described in clause 8.

In order to enable data services in the TETRA LMN there is a need to connect different Terminal Equipment (TE) to a Mobile Termination (MT) or a Network Termination (NT).

4.2 Reference configuration

A general TETRA LMN configuration may comprise MSs or LSs which are connected to a terminating network. The terminating network may be a TETRA network (TETRA SwMI) or an ISDN network. A Transit Network (TN) shall be used for communication between different terminating networks. A MS shall include a MT and may include a TE. A LS shall include a TE and a NT.

A TETRA LMN can offer various telecommunication services at different Service Access Points (SAPs). The general TETRA LMN, and the access for teleservices and bearer services supported by a TETRA LMN is shown in figure 1.



NOTE: The terminating network may include a TETRA LMN, either the originating one or another one.

Figure 1: Bearer services and teleservices supported by a TETRA LMN

4.2.1 Configuration examples of TETRA LMNs

General configuration examples of TETRA LMNs using one or more TETRA SwMI are shown in figure 2. Figure 3 shows the direct mode connection between MSs.

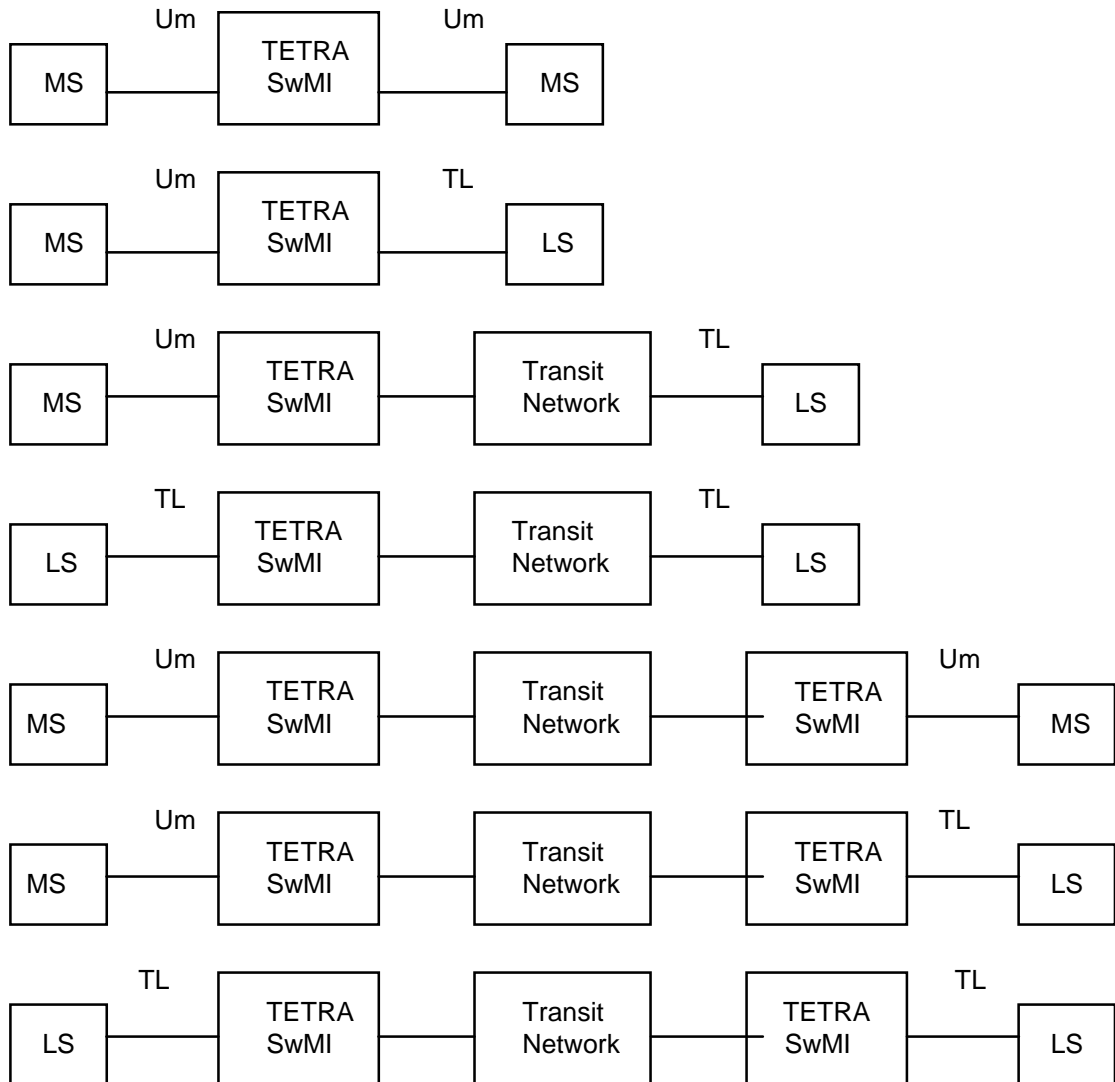


Figure 2: TETRA LMN configuration examples using a TETRA SwMI

The examples shown in figure 2 are not exhaustive, but only illustrate possible network configurations.

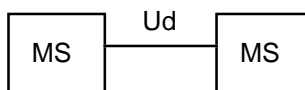


Figure 3: MS connected to MS via direct mode interface

4.3 TETRA LMN access

4.3.1 MS access

A MS shall include a MT and may include a TE. The MS access to services supported by a TETRA LMN is shown in figure 4.

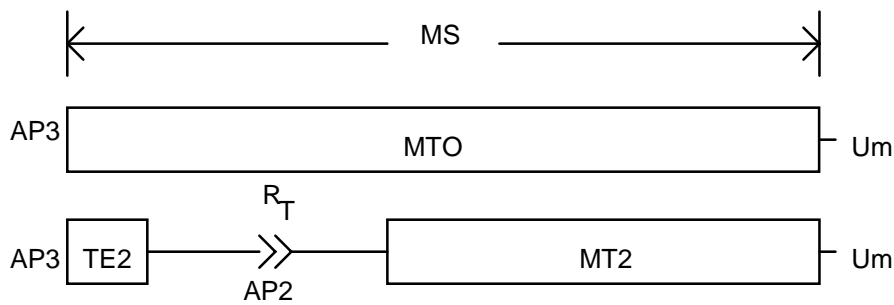


Figure 4: MS access to a TETRA LMN

4.3.1.1 MS functional groups

The mobile termination functional group, MT, shall support the following general functions:

- air interface termination (Um);
- radio channel management;
- Mobility Management (MM);
- speech and data encoding/decoding;
- error protection/correction for all information (speech, signalling, user data) sent across the radio path;
- flow control and mapping of signalling and user data;
- rate adaption between user data and radio channel rate;
- support of TE.

There are two types of MT defined:

- MT0 shall include functions belonging to the functional group MT, with support of non-standard terminal interfaces that provide TE functionality;
- MT2 shall include functions belonging to the functional group MT, with a terminal interface that complies with a TETRA recommended interface.

The terminal equipment functional group, TE, shall support Man Machine Interface (MMI) to the user (access point AP3) and shall support a TETRA terminal interface to MT2 functional group (access point AP2).

There is one type of TE defined:

- TE2 represents an asynchronous (start/stop) serial TETRA specific CCITT Recommendation V. series interface.

4.3.1.2 MS access points and reference points

The R_T reference point shall define the boundary between the TE2 and MT2 functional groups. AP2 shall be the access point for TETRA bearer services at this reference point.

4.3.2 LS access

The LS shall comprise the functional groups NT, Terminal Adapting (TA) function and TE. The LS access to services supported by a TETRA LMN is shown in figure 5.

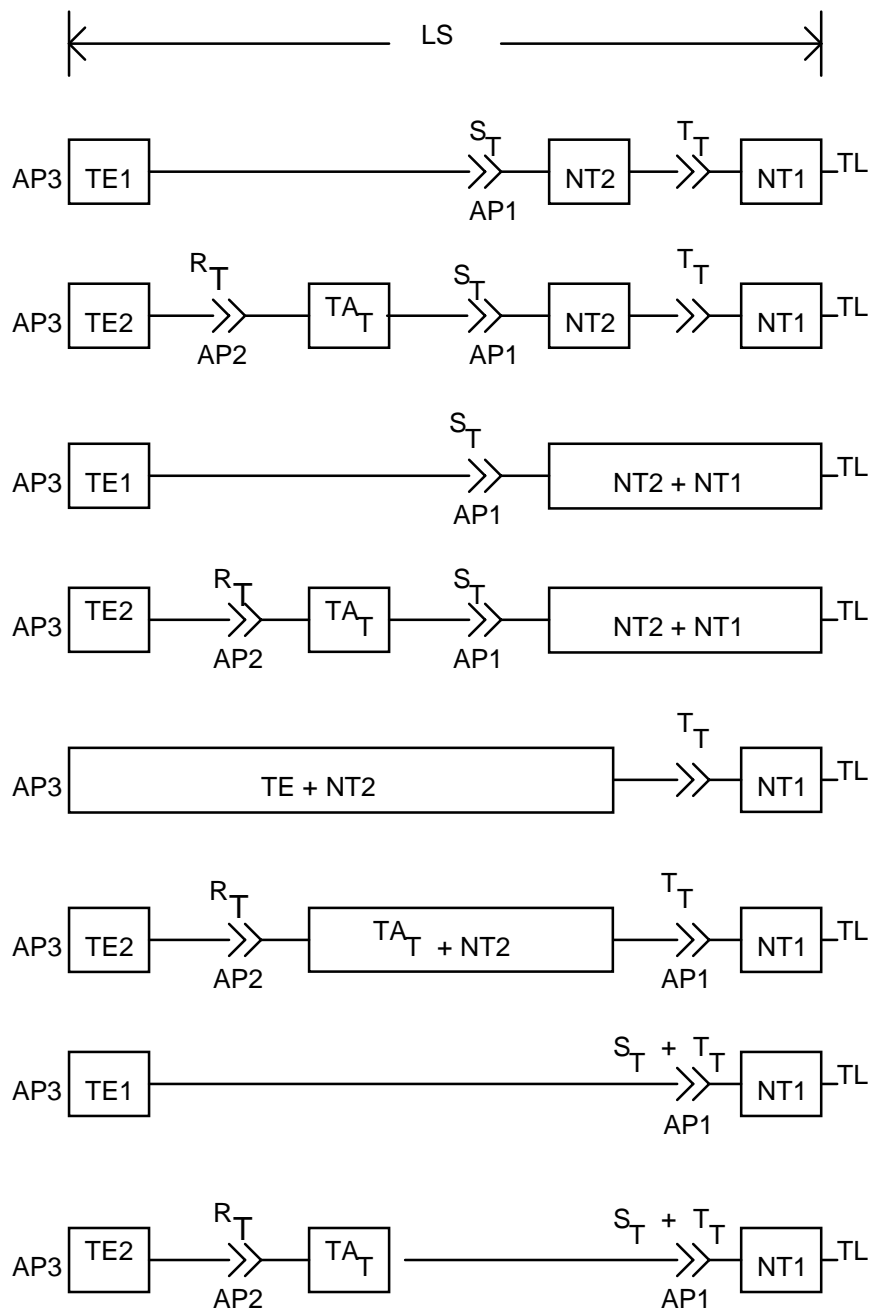


Figure 5: LS access to services supported by a TETRA LMN

4.3.2.1 LS functional groups

The Network Termination functional group, (NT), shall support the functions defined by CCITT Recommendation I.411 [6].

There are two types of NT defined:

- NT1 shall include functions belonging to the functional group NT, with support of functions specific to the Transmission Line (TL) interface, and may support an interface to NT2 functional group;
- NT2 shall include functions belonging to the functional group NT, with support of more than one network terminations, and may support an interface to TE1 functional groups or TETRA TA functional groups (access point AP1).

The Terminal Equipment functional group (TE) shall support man machine interface to the user (access point AP3) and may support a TETRA interface to TETRA TA functional groups (access point AP2) or may support an ISDN interface to NT functional groups (access point AP1).

There are two types of TE defined:

- TE1 represents an ISDN interface;
- TE2 represents an asynchronous (start/stop) serial TETRA specific CCITT V. series interface.

The Terminal Adapting functional group (TA) supports the following general functions as defined by CCITT Recommendation V.110 [7]:

- asynchronous (CCITT V. series) to synchronous (ISDN) conversion;
- rate adaption;
- flow control.

There is one type of TA defined:

- TA_T represents a TETRA specific terminal adapter which shall include the functions belonging to the functional group TA, with support of an interface to TE2 functional group and an interface to NT2 functional group.

4.3.2.2 LS access points and reference points

The R_T reference point shall define the boundary between the TE2 and TA_T functional groups. AP2 shall be the access point for TETRA bearer services at this reference point.

The S_T reference point shall define the boundary between the TE1 or TA_T and NT2 functional groups. AP1 shall be the access point for TETRA bearer services at this reference point.

The T_T reference point shall define the boundary between NT2 and NT1 functional groups.

4.3.3 Inter System Interface (ISI) access

The functional groups and reference points of an ISI are shown in figure 6.

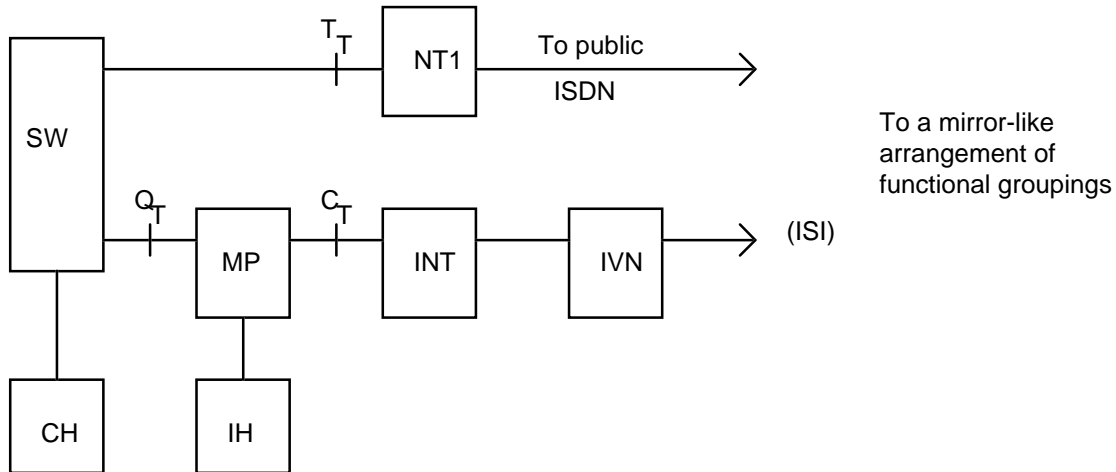


Figure 6: ISI reference points

4.3.3.1 ISI functional groups

The Call Handling (CH) functional grouping shall provide signalling and call handling functions. Signalling information shall be sent and received, via the SWitching (SW) functional grouping, to and from call handling functions within the TE functional grouping, peer CH functional groupings within other SwMIs, and call handling functions within public ISDNs.

The Inter-network protocol Handling (IH) functional grouping shall provide signalling and connection handling functions for the control, where possible, of inter-SwMI connections provided by the IVN functional grouping. Signalling information shall be sent and received, via the Mapping (MP) functional grouping, to and from call handling functions within the IVN functional grouping.

The SwMI system manager functions should co-ordinate IH and CH functional groupings.

The IVN functional grouping shall support communication between SwMIs. Where inter-SwMI connections are controllable by the SwMI, the IVN functional grouping shall include call handling functions.

The INT functional grouping shall provide transmission functions and, if applicable, layer 1 signalling functions between the MP and the IVN functional groupings. In the case where the real network is an ISDN, the INT shall be equal to an NT1 functional grouping.

The MP functional grouping shall provide the functions necessary for mapping of user and signalling information between the INT and the SW functional groupings. It shall also map signalling information for inter-SwMI connection control between the INT and the IH functional groupings.

The NT1 functional grouping shall be as defined in CCITT Recommendation I.411 [6].

The SW functional grouping shall provide switching functions for user and signalling information. User information shall be switched between base termination (not shown), MP and NT1 functional groupings. Signalling information shall be switched between CH and base termination (not shown), between CH and MP, and between CH and NT1 functional groupings.

4.3.3.2 ISI reference points

The C_T reference point shall define the boundary between the MP and the INT functional groupings. In the case where the intervening network is a public ISDN, the C_T reference point shall coincide with the T_T reference point.

The Q_T reference point shall define the boundary between the SW and the MP functional groupings.

The T_T reference point shall define the boundary between the SW and the NT1 functional groupings. It shall indicate the point of inter-working between the TETRA and public ISDN capabilities.

4.3.3.3 The significance of the C_T and Q_T reference points

The interconnection of SwMIs between TETRA shall be achieved by using services of an intervening network, which shall be terminated at each end by the INT functional grouping. A number of different scenarios can be identified for the interconnection of SwMIs, depending on the intervening network and the bearer service which it provides, e.g. dedicated transmission system, permanent or demand bearer services of a public ISDN or other network. Consequently the nature of the interface at the C_T reference point may vary.

At the Q_T reference point, however, the nature of the intervening network and bearer service should not be visible. Although physical interfaces should not normally exist at the Q_T reference point, conceptual inter-SwMI protocols which are independent of the interconnection scenario can be specified for the Q_T reference point. These protocols should be visible and indirectly testable at the C_T reference point.

The MP functional grouping shall provide mapping between a scenario-independent conceptual interface at Q_T and a scenario-dependent real interface at C_T , for example:

- mapping of conceptual B and D channels at Q_T onto real channels or time-slots at C_T ;
- conversion between scenario-independent signalling protocols at Q_T and scenario-dependent signalling at C_T .

4.3.4 Location of TETRA functionality

In the MS, the TETRA functionality shall reside in the MT0 terminal or in the TE2 terminal together with the MT2 mobile termination.

In the LS, the TETRA functionality shall reside in the TE1 terminal or in the TE2 terminal together with the Terminal Adapter for TETRA (TA_T).

4.3.5 TETRA terminals

The AP1 access point at S_T reference point may be used by both TETRA terminal equipment, TE1 and TE2. TE2 shall be connected to AP1 via R_T reference point on access point AP2 and terminal adapting function TA_T . The TETRA terminals connected to AP1 access point are shown in figure 7.

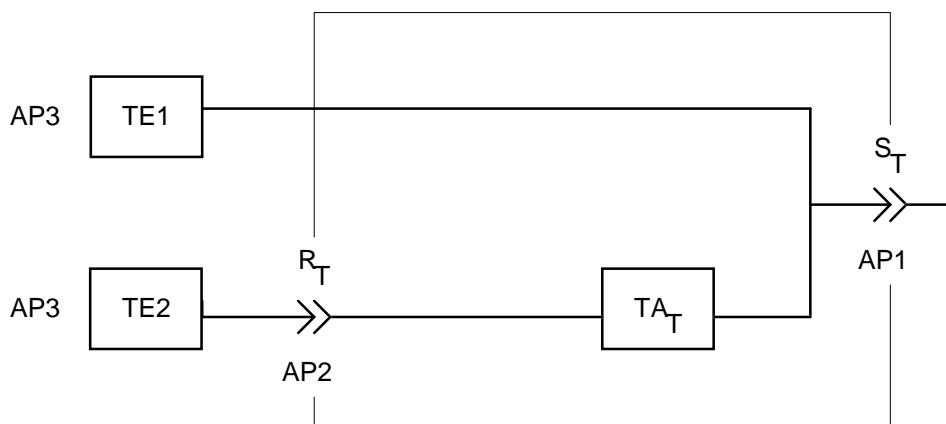


Figure 7: TETRA terminals connected to AP1

The Um or Ud access point may be used by the mobile termination MT0 or the terminal equipment TE2. TE2 shall be connected to Um or Ud via R_T reference point on access point AP2 and mobile termination MT2. The TETRA terminals connected to Um or Ud access point are shown in figure 8.

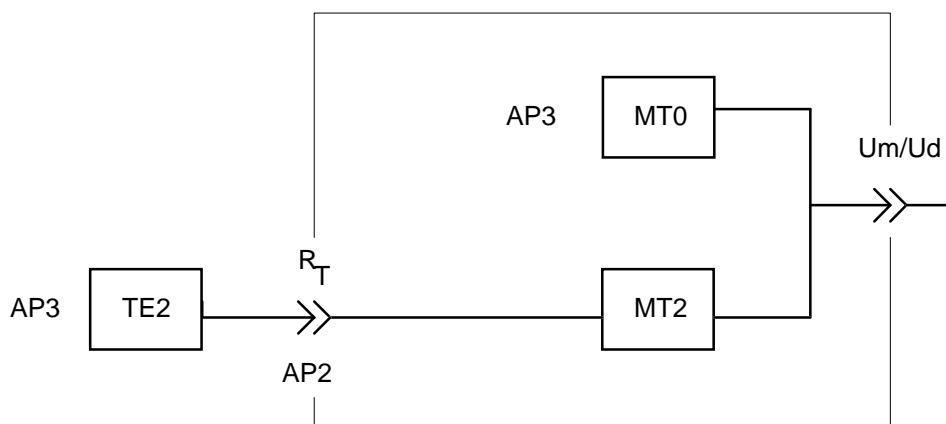


Figure 8: TETRA terminals connected to Um/Ud

5 Packet mode reference points

5.1 Introduction

This clause gives the reference points for the TETRA data services, 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.

5.2 Physical interfaces

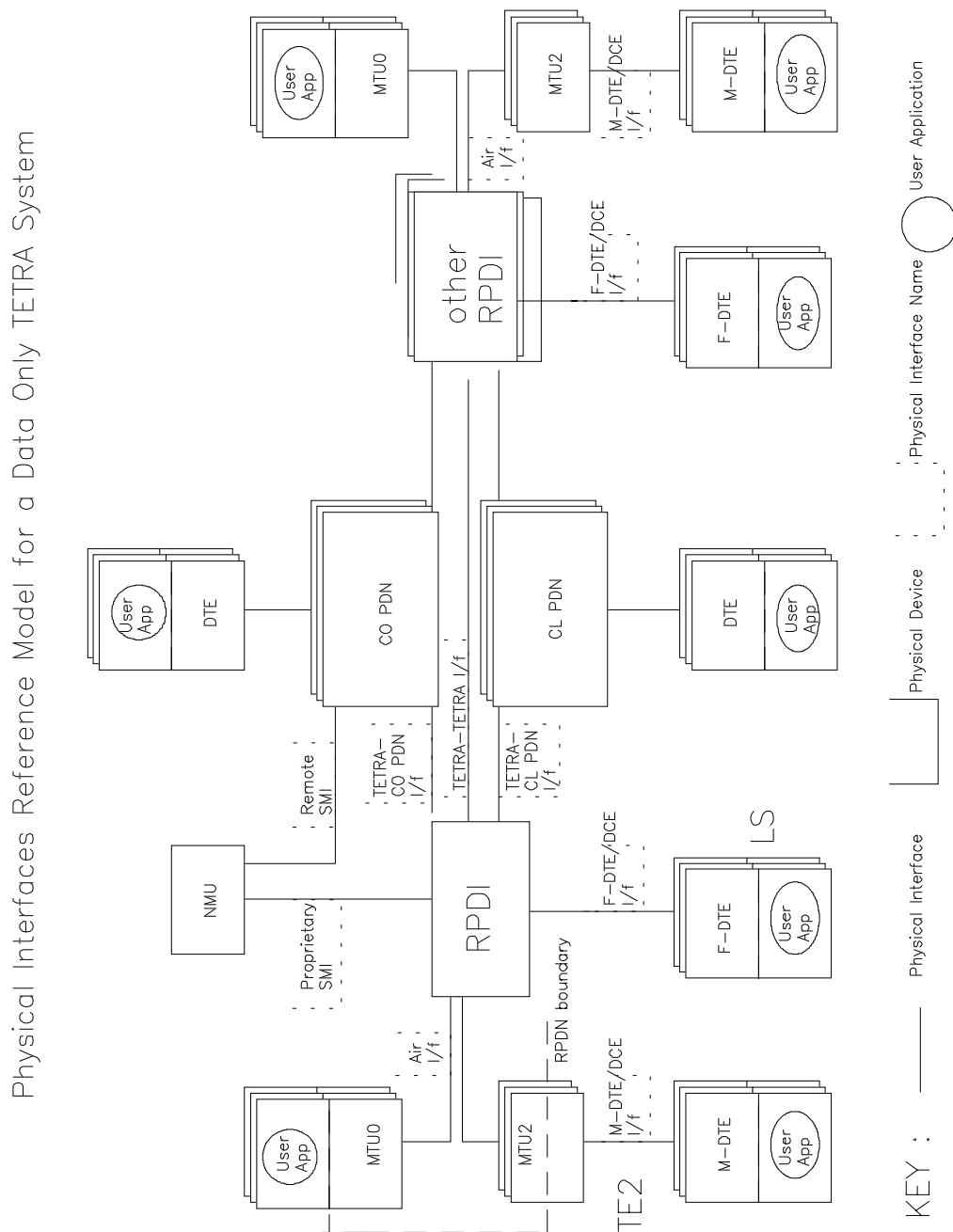


Figure 9: Physical interfaces reference model

The physical interfaces for TETRA packet data are shown in figure 9. 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.

5.3 Configurations

Figure 10 gives the basic configurations, figure 11 gives the specific configuration and figure 12 the NMU configuration. The PDN is assumed to handle connection and connectionless procedures.

5.3.1 Basic configurations

The different cases showing basic configurations are outlined in figure 10.

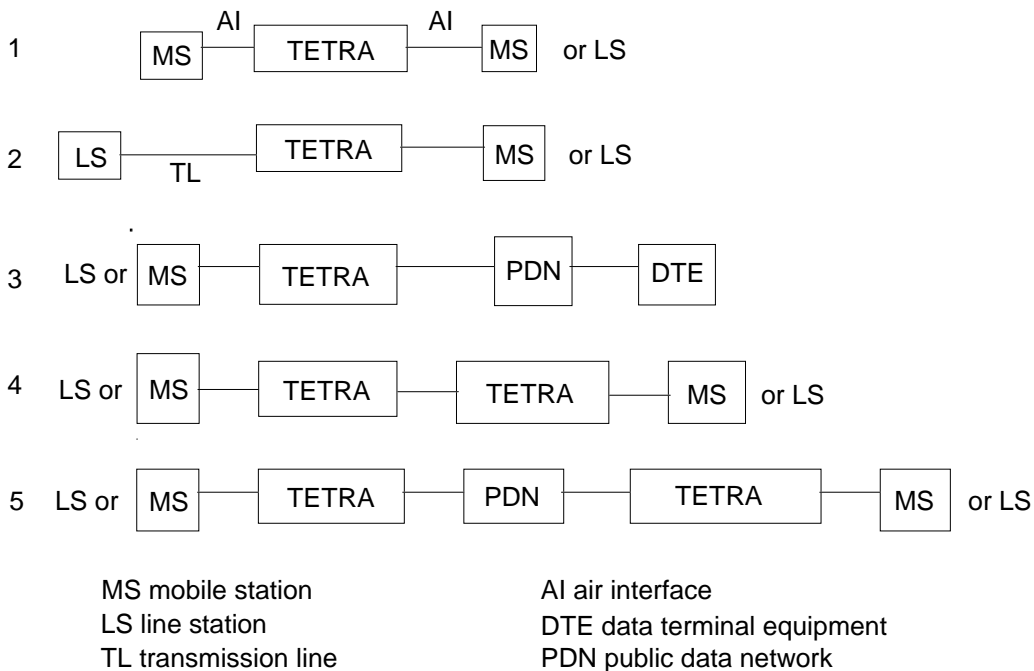


Figure 10: Basic configurations

- 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.

5.3.2 Specific configuration

A character mode LS shall be connected to a PAD in the TETRA network to a MS or LS (see figure 11).



Figure 11: Specific configuration

5.3.3 NMU configuration

The NMU configuration shall be connected to at least two TETRA networks. One or more of the connections may be achieved through a PDN (see figure 12).

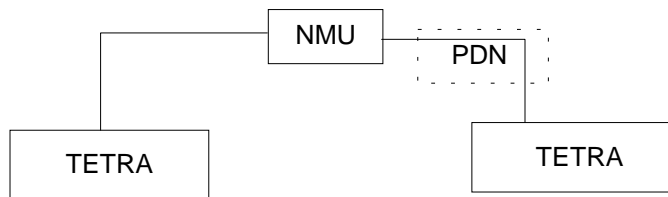


Figure 12: NMU configuration

5.4 Reference points

5.4.1 MS reference points

Figure 13 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 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 TE.

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. This reference point shall exist in all MTUs.

R1 shall be a reference point between packet mode TE (TE2) and the MTU (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.

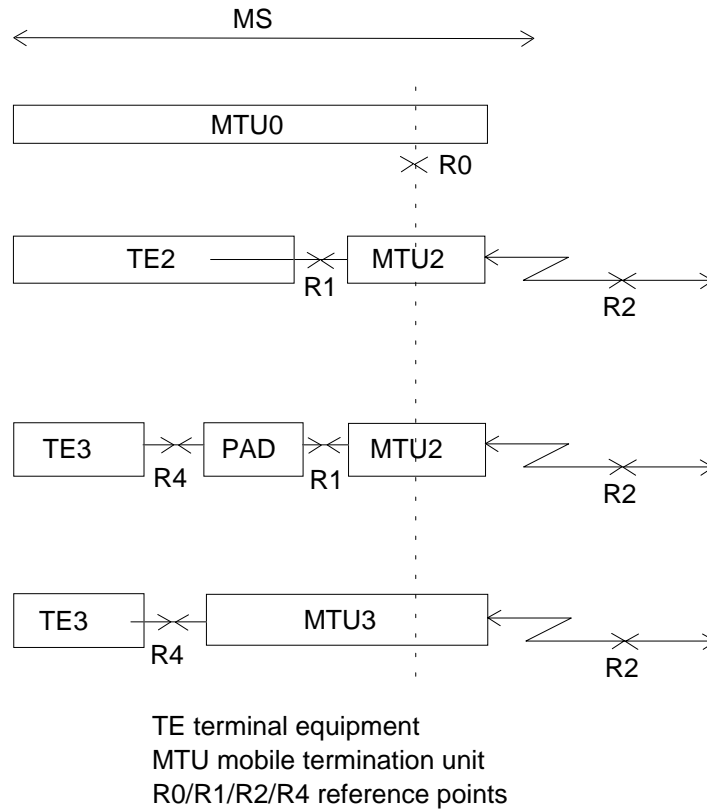


Figure 13: MS reference points

5.4.2 LS reference points

Figure 14 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.

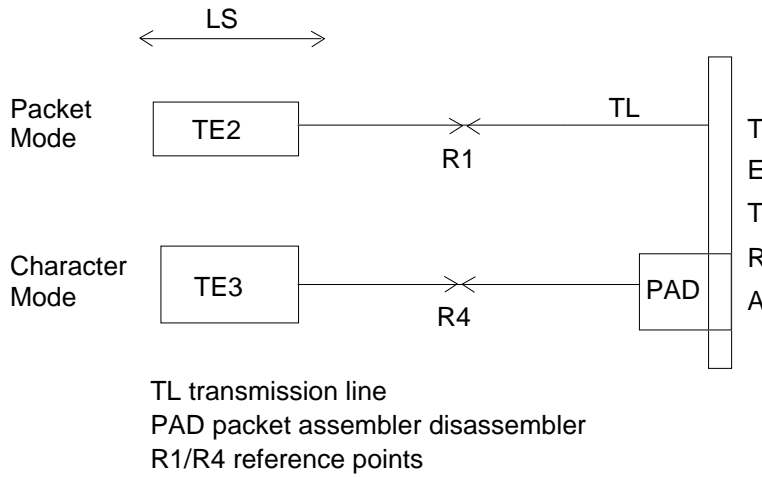


Figure 14: LS reference points

5.4.3 NMU reference point

Figure 15 shows R5 which shall be the reference point between the NMU and the TETRA network.

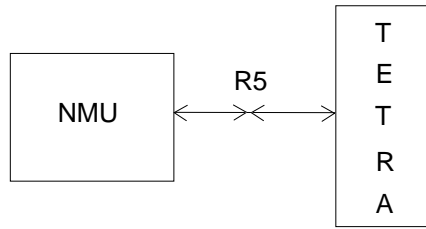


Figure 15: NMU reference point

5.4.4 TETRA to TETRA reference point

Figure 16 shows R6 which shall be the reference point between one TETRA network and another TETRA network.

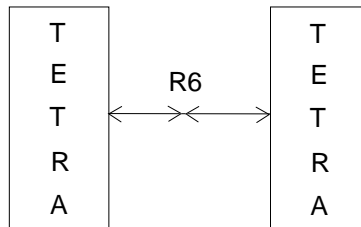


Figure 16: TETRA to TETRA reference point

Figure 17 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.

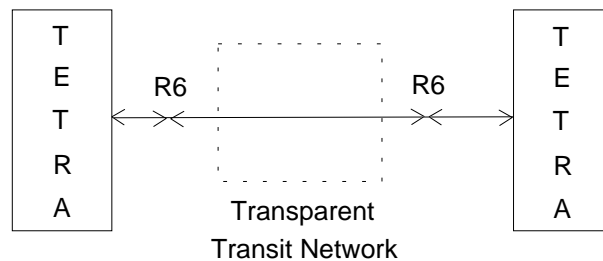


Figure 17: TETRA to TETRA reference point

5.4.5 TETRA to non-TETRA reference point

Figure 18 shows R7 which shall be the reference point between one TETRA network and a non-TETRA packet data network.

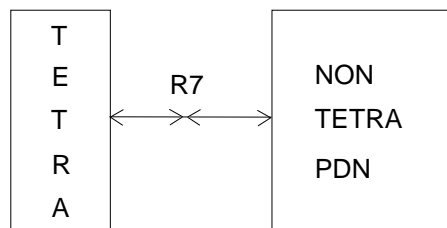


Figure 18: TETRA to non-TETRA reference point

5.5 Protocol stacks

5.5.1 Protocol stacks at R1 reference point

Figure 19 refers. The protocol stacks 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.

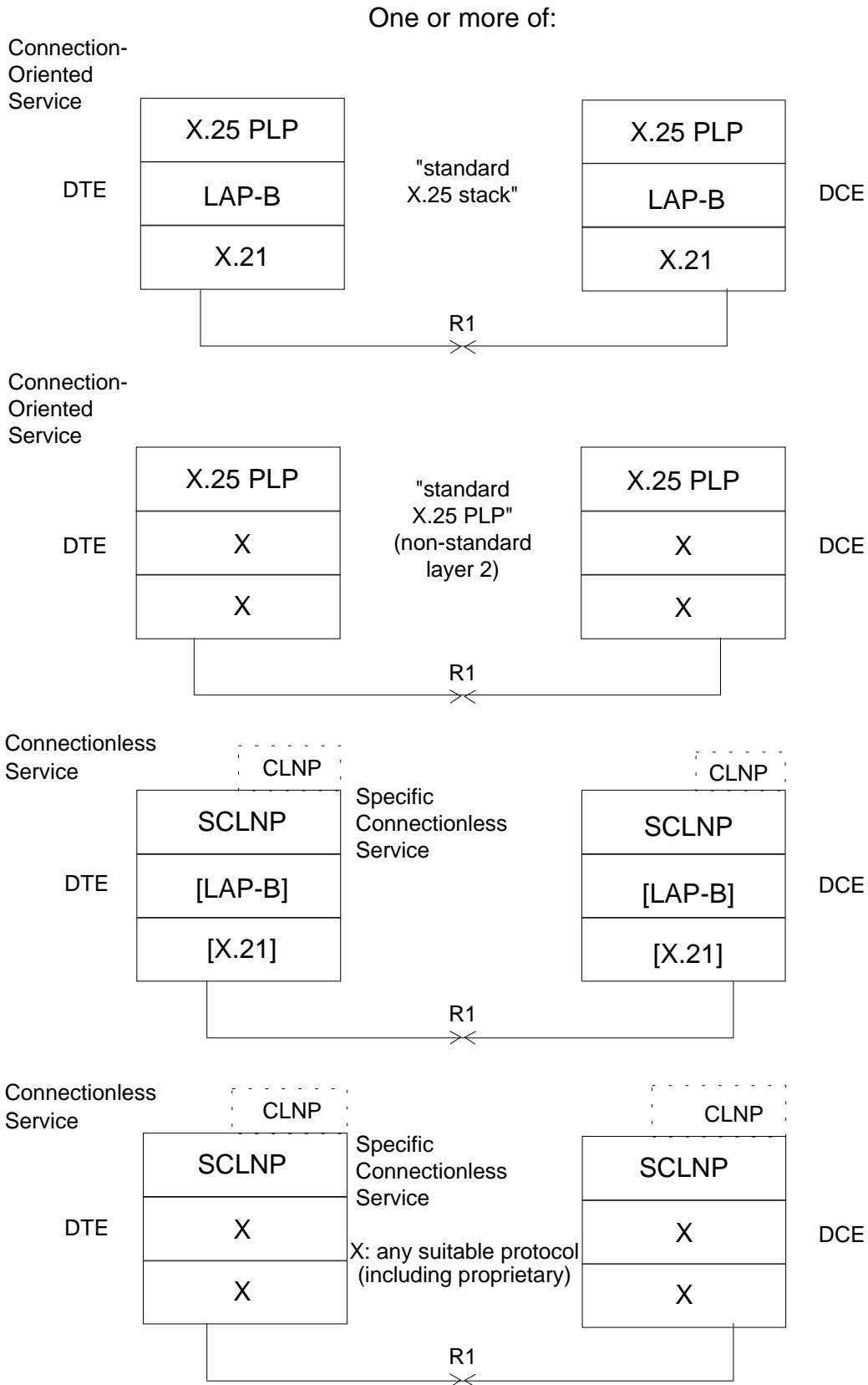


Figure 19: Protocol stacks at the R1 reference point

5.5.2 Protocol stacks at R2 reference point

Figure 20 refers. These protocol stacks shall be the TETRA air interface stack.

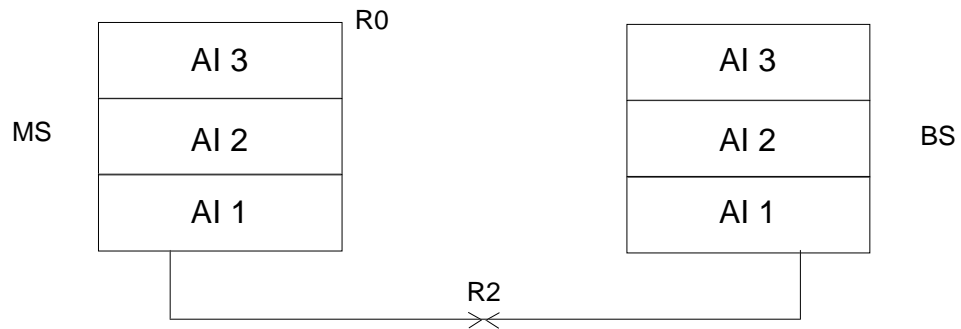


Figure 20: Protocol stacks at R2 reference point

5.5.3 Protocol stacks at R4 reference point

Figure 21 refers. These protocol stacks shall support character mode operation.

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

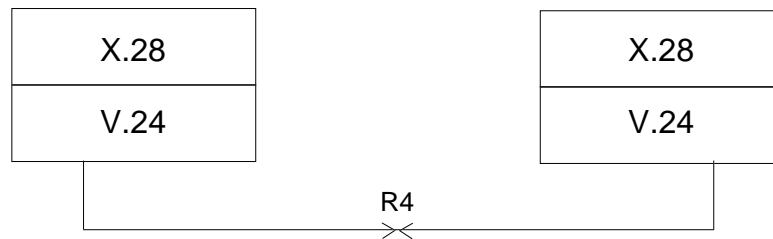


Figure 21: Protocol stacks at R4 reference point

5.5.4 Protocol stacks at R6 reference point

Figure 22 refers. 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.

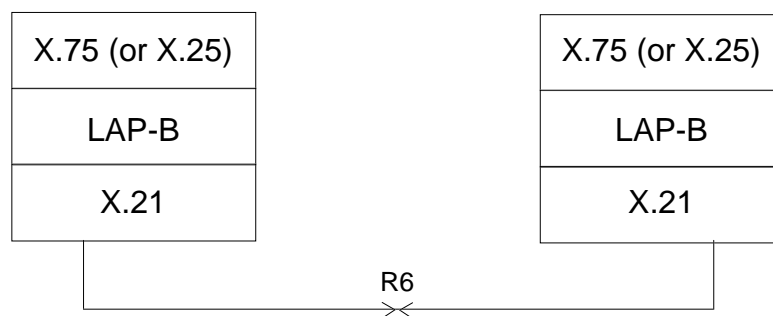


Figure 22: Protocol stacks at R6 reference point

6 Protocol architecture for V+D

6.1 Introduction

The purpose of this protocol architecture is to be a model where the different functions and processes are identified in the different layers in the mobile/base and LS protocol stacks. It gives an ISI overview as well.

NOTE: The protocol stacks are used to define the functionality of the TETRA protocols for interfaces. The protocol stacks in this clause and in all other related clauses are normative when used to describe functionality of interfaces, but these stacks and sub-division of protocol layers does not imply or restrict any implementation.

6.2 Mobile/base protocol architecture

6.2.1 Overview

The base of the protocol stack shall rest on the physical layer.

The data link layer shall be composed of two sub-layer entities as described hereafter (MAC and LLC).

An explicit Medium Access Control (MAC) sub-layer shall be introduced to handle the problem of sharing the medium by a number of users. At the MAC, the protocol stack shall be divided into two parts, the user plane (U-plane) for transporting information without addressing capability and the control plane (C-plane) for signalling with addressing capability.

A Logical Link Control Entity (LLCE) shall reside above the MAC and shall be responsible for controlling the logical link between a MS and a BS over a single radio hop. In cases where the protection offered by the MAC (FEC + CRC) is sufficient and acknowledged service is not requested, the functionality in the LLCE is small.

An explicit Mobile/Base Control Entity (MLE/BLE) sub-layer shall reside above the LLCE for handling establishment and maintaining the connection to the BS. The MLE/BLE shall also act as a convergence, so the same layer 3 entities can be used on top of different layer 2 entities.

At the top of the protocol stack (layer 3, see figure 23), several entities may be present: Mobility Management (MM), Circuit Mode Control Entity (CMCE), Connection Oriented Network Protocol (CONP) and Specific Connectionless Network Protocol (S-CLNP).

A Lower Layer Management Entity (LLME) shall contain the databases. The required layer management functionalities shall be contained in the layers. The interactions between non adjacent layers shall go through specific SAPs (see the model in subclause 6.3.1).

Figure 23 shows the protocol layering for the MS and the BS. The following subclauses describe the major functions handled by each layer.

6.2.2 Air interface layer 1

The air interface layer 1 shall be the physical interface. It shall deal with the physical burst, composed of bits and symbols (= association of 2 bits), which is to be sent and/or received.

The air interface layer 1 shall contain the following functions:

- radio oriented:
 - 1) modulation/demodulation as defined in ETS 300 392-2 [17], clause 5.
 - 2) transmitter/receiver switching as defined in ETS 300 392-2 [17], clause 6.
 - 3) RF characteristics: as defined in ETS 300 392-2 [17], clause 10:
 - frequency (or channel) setting;

- outputs Radio-Signal-Strength-Indicator (RSSI).
- 4) fine adjustments of radio parameters:
 - frequency correction: the synchronisation on to the BS frequency using a specific frequency correction sequence shall be located inside the Synchronisation burst as defined in ETS 300 392-2 [17], clauses 7 and 9;
 - power control: MS power level adjustment according to BS broadcast parameters and signal strength measurements in the MS as described in ETS 300 392-2 [17], clause 23;
 - broadcast parameters related to power control shall be part of the MAC block and hence shall be decoded at the MAC level (see ETS 300 392-2 [17], clause 21).
- bits and symbol oriented:
 - symbol synchronisation: a specific training sequence, located inside the burst, shall precisely determine the occurrence of the symbols. For first time synchronisation acquisition, an extended training sequence (longer than the normal one) shall be available on the synchronisation burst (see ETS 300 392-2 [17], clause 7). The physical layer shall then be able to determine the burst boundaries (i.e. the beginning and the end).
- burst building:
 - 1) receiving/submitting data from and to the MAC sub-layer: because the physical layer shall be able to determine the starting and ending points of the burst, at the emission, it shall map the MAC block onto the physical burst and shall add its specific information (layer 1 only) at the correct place. At the reception, it shall extract its specific information (layer 1 only) from the burst and shall rebuild MAC block(s), see ETS 300 392-2 [17], clause 9. The MAC block(s) shall then be passed to the MAC;
 - 2) slot flag coding/de-coding using two distinct training sequences, see ETS 300 392-2 [17], clause 9. The use of the slot flag is described in ETS 300 392-2 [17], clause 19;
 - 3) scrambling/de-scrambling: both BS and MS shall scramble frames prior to sending them. Scrambling shall be done according to the base station address, known as colour code. So, the frame shall be decoded correctly only by the receiving station having that colour code (de-scrambling). Refer to ETS 300 392-2 [17], clause 8.

6.2.3 Air interface layer 2

The air interface layer 2 shall handle logical connections and shall hide the physical medium from the upper layers. An overview can be found in ETS 300 392-2 [17], clause 19.

6.2.3.1 Medium Access Control (MAC)

The MAC shall handle radio channel access and radio resource management. For a detailed description of the services and protocol, see ETS 300 392-2 [17], clauses 20 and 23.

The main functions shall be as follows:

- channel coding:
 - a) interleaving, de-interleaving and re-ordering the protected bits over one block or two blocks allow spreading the errors instead of having them grouped as it is usually the case in radio systems (see ETS 300 392-2 [17], clause 8);

- b) channel coding see ETS 300 392-2 [17], clause 8:
 - 1) in order to protect bits transmitted on the radio path, Forward Error Correction (FEC) using convolutional coding shall add some redundancy (e.g. 2/3 coding, which encodes 2 bits of information into 3 transmitted bits) so that errors may be corrected afterwards;
 - 2) a Cyclic Redundancy Check (CRC) shall be performed on the incoming block of information so that errors may be detected up to a certain amount, depending on the size of the CRC. 16 bits CRC will ensure a protection against undetected errors. The receiving MS shall calculate the CRC on the received bit stream using the same algorithm and shall compare the results. The actions taken in case of error are described in ETS 300 392-2 [17], clause 23.
- radio channel access control:
 - the performed functions shall be as follows:
 - a) frame synchronisation:
 - keeps track of the frame number within a multiframe;
 - b) random access procedure:
 - contention control on a particular physical channel;
 - flow control of up-link random access.
 - c) fragmentation/re-association:
 - this shall split the content of one single PDU into several SDUs. On the other side, parts shall be re-associated together in order to re-constitute the original PDU;
 - d) multiplexing/de-multiplexing of the logical channels: in order to create all layer 2 parts of the burst (see ETS 300 392-2 [17], clause 9 and clause 23);
 - e) multiframe building and synchronisation: this is where the frames shall be assembled to form a multiframe or a hyper-frame which content may vary according to a cyclic law. They shall be numbered explicitly i.e. on the downlink, a synchronisation block shall contain information about time slot, frame and multiframe number, colour code information of the BS, and network code (see ETS 300 392-2 [17], clause 9).
- radio resource management:
 - this part shall be unique to one mobile or base station. It shall enable powerful control of the radio resources to be available at any time without explicit involvement of layer 3. The following functions shall be provided:
 - a) Bit Error Ratio (BER) and BLock Error Rate (BLER) measurements: independently or under control of other layers;
 - b) path loss calculation: monitoring of the serving cell and monitoring and scanning of adjacent cells (see ETS 300 392-2 [17], clause 23);
 - c) address management for individual, group or broadcast calls. Two MAC addresses can be used:
 - a copy of the ISSI, ASSI, USSI or GSSI (passed as a parameter from layer 3); and
 - an event label (see clause 7 and ETS 300 392-2 [17], clause 19);

- d) power control management (execution is in the physical layer);
- e) radio path establishment: frequency, time slot and colour code selection according to the MLE (layer 3) indications. ETS 300 392-2 [17], clauses 11, 14, and 23, shall apply;
- f) radio resource allocation shall be performed. Channel allocation (frequency and time slot) may depend on the system mode of operation, i.e. message trunking, quasi-transmission trunking, transmission trunking, discontinuous transmission. This functionality enables efficient and fast channel access and drop time;
- g) control information and speech frames should be buffered until transmitted;
- h) circuit mode applications (e.g. CODEC and circuit mode data) interface with MAC layer as represented in figure 23 (U-Plane) and described in more detail in ETS 300 392-2 [17], clause 20.

6.2.3.2 Logical Link Control (LLC)

The LLC shall handle the point-to-point logical links between the MS and the BS. It shall be appropriate only for C-plane operation. Two different services may be provided:

- a basic link shall be supported, which does not need any establishment phase; and
- on request, an advanced link may be supported for better grade of service (see ETS 300 392-2 [17], clauses 20 and 22 for details).

The functions shall be as follows:

- exchanging control and/or user data with the Mobile/Base Link control Entity sub-layer (MLE);
- logical link handling (basic link and advanced link);
- scheduling data transmission;
- re-transmissions (single in basic link and selective in advanced link);
- segmentation/re-assembly (advanced link only);
- error measurement (extended error detection in advanced link);
- flow control (advanced link only);
- acknowledgement of received data (basic link and advanced link);
- logical channel allocation negotiation with the MAC (advanced link only).

6.2.4 Air interface layer 3

The air interface layer 3 shall handle network procedures.

6.2.4.1 Mobile/Base Link control Entity (MLE/BLE)

This sub-layer, which is applicable to the C-plane, shall be a platform for the services offered in the layer (see ETS 300 392-2 [17], clause 17 and clause 18 for further details).

The functions shall be as follows:

- protocol discrimination;
- management of the mobile-base association (connection);
- identity management;

- quality of service selection;
- mobility within a Registered Area (RA).

Another function of the MLE shall be to handle common broadcast information. Through the C-SAP (refer to subclause 10.4), it may have interactions with all layers.

The functions shall be as follows:

- broadcast and receive network information;
- pass channel information to the layers below via C-SAP (refer to subclause 10.4).

6.2.4.2 Sub-Network Access Functions (SNAF)

This layer shall have SAPs for circuit-switched voice and data call control services, connection oriented and connectionless packet services, Short Data Service (SDS), Mobility Management (MM) and supplementary services. The functions for these different services shall be as listed below.

6.2.4.2.1 Mobility Management (MM)

MM shall handle functions that are necessary because of MS mobility (see ETS 300 392-2 [17], clauses 15 and 16 for further details).

The functions shall be as follows:

- selection of LA;
- registration;
- authentication;
- user attachment;
- network selection.

6.2.4.2.2 Circuit Mode Control Entity (CMCE)

The CMCE shall be subdivided into three sub-entities, i.e. SDS, Call Control (CC) and supplementary services control (see ETS 300 392-2 [17], clauses 11, 12, 13, and 14 for further details).

- SDS:
- SDS shall handle connectionless data messages with the following capabilities:
 - minimise the number of transmissions required to send the short data as signalling message;
 - source and destination address associated with the short data;
 - service available independent of whether a circuit switched call is in progress;
 - point-to-point and point-to-multipoint;
 - efficient coding of user messages (pre-defined and user-defined).

Refer to ETS 300 392-2 [17], clause 13 for further details.

- CC:
 - the call control shall handle circuit mode calls with the following functions:
 - establishing, maintaining and clearing basic service calls;
 - addressing (destination);
 - call identity.
 - supplementary services control:
 - supplementary services control shall handle the processes associated with supplementary services (see ETS 300 392-2 [17], clause 12 for further details).
 - The functions shall be as follows:
 - provision and withdrawal;
 - activation/deactivation;
 - definition;
 - registration;
 - invocation and operation;
 - interrogation;
 - cancellation.

6.2.4.2.3 Packet data handling

The packet handling entity shall handle the packet data services offered by TETRA.

6.2.4.2.4 Connection Oriented Network Protocol (CONP)

The CONP shall handle the standard ISO 8208 [11] (X.25 PLP) functions with the modifications described in ETS 300 392-2 [17], clauses 24 and 25.

The functions shall be as follows:

- CONP (X.25 PLP);
- network connection control;
- data transfer;
- queue management.

6.2.4.2.5 TETRA Specific-ConnectionLess Network Protocol (S-CLNP)

The TETRA S-CLNP shall handle the specific connectionless network protocol (see ETS 300 392-2 [17], clauses 26 and 27 for further details).

The functions shall be as follows:

- point-to-point data transfer;
- point-to-multipoint data transfer.

- facilities such as:
 - mail-box handling;
 - acknowledgements;
 - queue management.

6.2.5 Mobile/base protocol stack

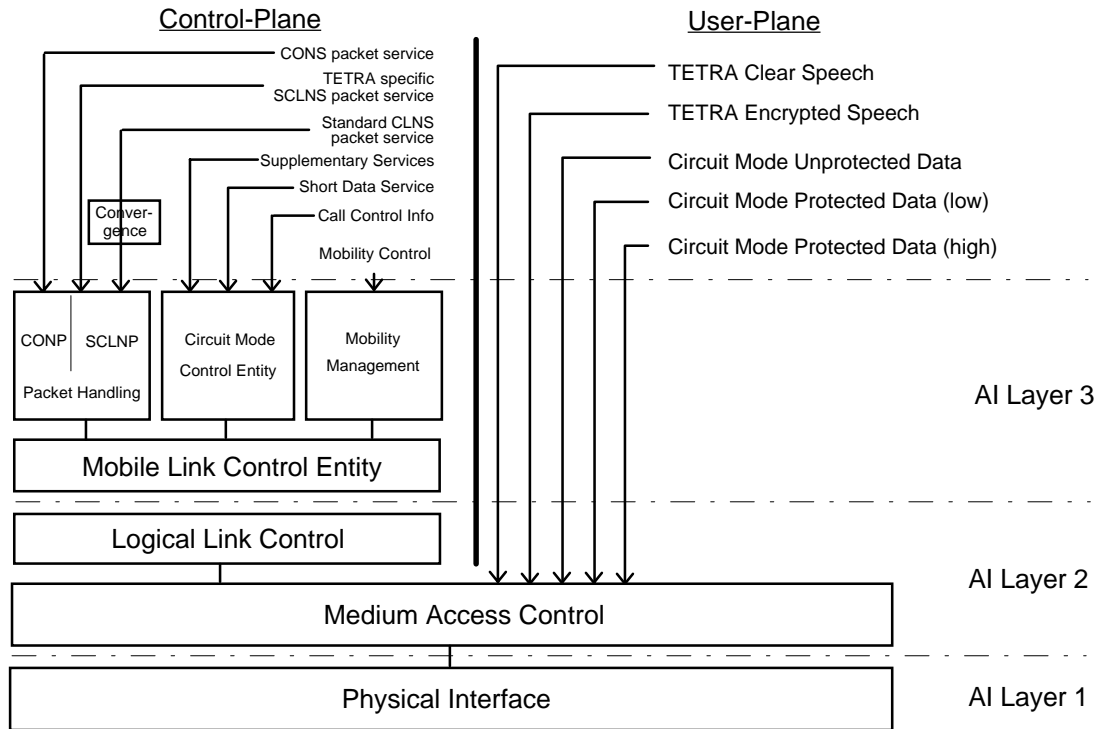


Figure 23: Mobile/base station protocol stack

- | Service Access Point (SAP);
- AI-1 Air Interface layer 1;
- AI-2 Air Interface layer 2;
- AI-3 Air Interface layer 3;
- C-plane Control-plane, control information available;
- CLNS ISO Connectionless Network Service;
- CMCE Circuit Mode Control Entity;
- CONP Connection Oriented Network Protocol;
- CONS Connection Oriented Network Service;
- LLC Logical Link Control;
- MM Mobility Management;
- S-CLNP TETRA Connectionless Network Protocol;
- S-CLNS TETRA Connectionless Network Service;
- SNAF Sub-Network Access Functions;
- U-plane User-plane, control information not available.

6.3 Lower Layer Management Entity (LLME) and other layers interaction

6.3.1 General description

The LLME is a vertical entity through which layers exchange information. It enables access to measured values, status, and to general information. Its interaction with the layers may be represented as shown in figure 24.

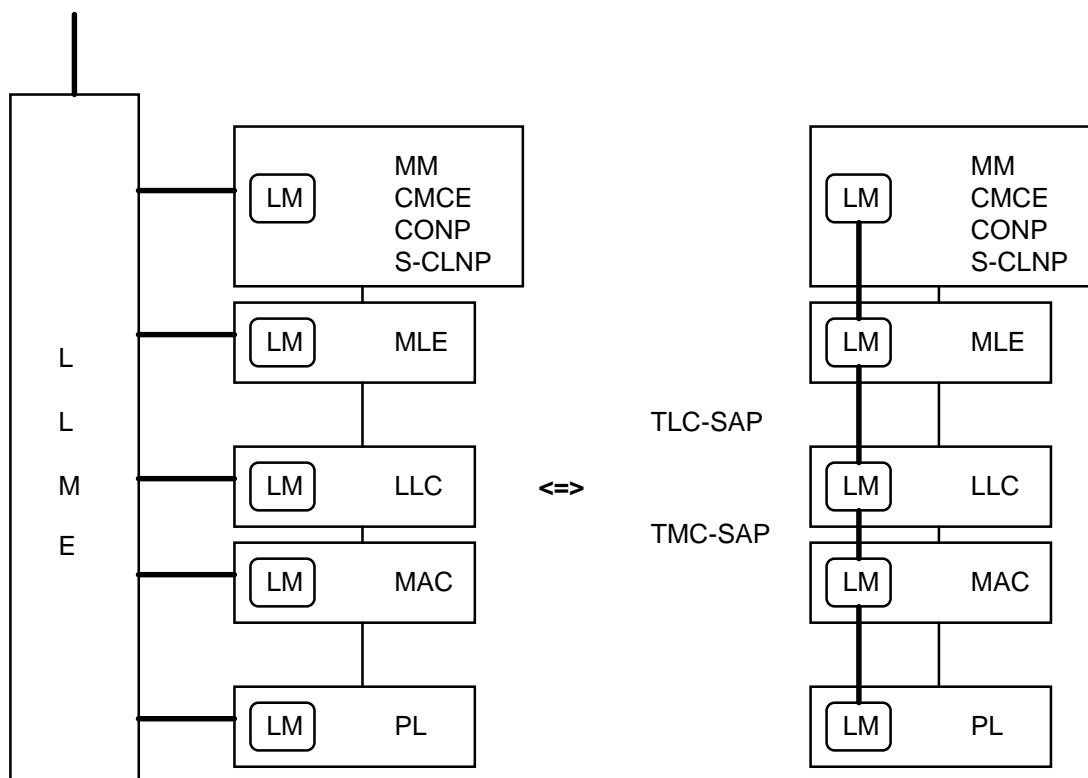


Figure 24: TETRA protocol stack with LLME interaction

Only testable parameters are standardised. Each layer shall have its own set of functions and measured values. The functions related to the management of a particular layer shall be described inside that layer. Although these parameters are exchanged with the LLME (stored and retrieved) using a set of messages (PDUs), they are standardised and described in appropriate subclauses of this ETS.

7 Addressing and identities

7.1 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:

- a) TETRA Subscriber Identities (TSI);
- b) Short Subscriber Identities (SSI);
- c) TETRA Management Identities (TMI);
- d) Network Layer SAP addresses (NSAP);
- e) TETRA Equipment Identities (TEI);
- f) 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 calls 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, i.e. 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 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 25. 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.

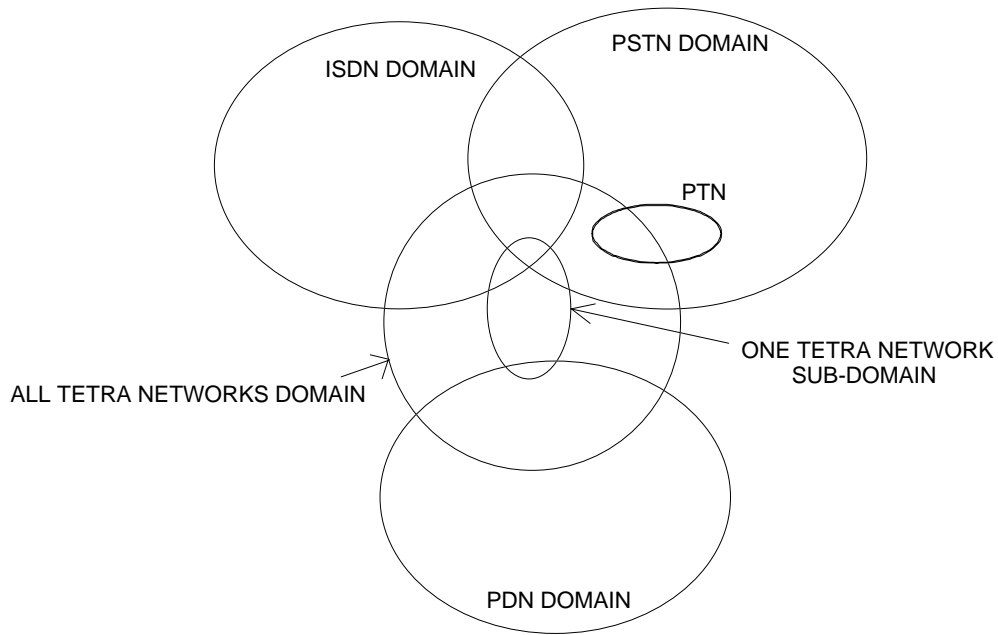


Figure 25: Addressing domains within TETRA

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 26.

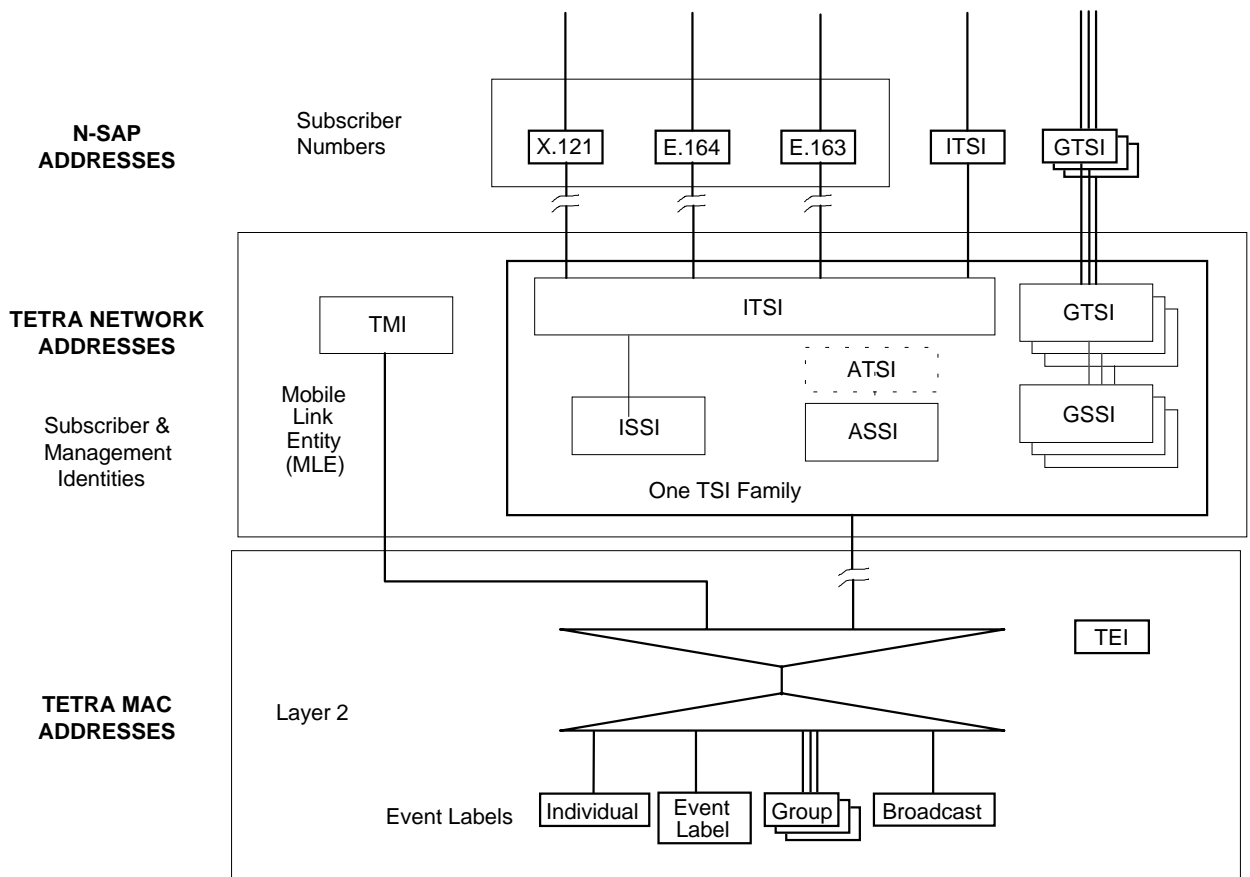


Figure 26: Relationship between TETRA addresses

The use of addresses in TETRA set-up messages and other messages are described in subclause 7.8.

7.2 Subscriber identities

7.2.1 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.

7.2.2 TSI

Each MS or LS shall contain at least one family of TSIs. Each family shall contain one Individual TETRA Subscriber Identity (ITSI) and may also have one ATSI and several Group TETRA Subscriber Identities (GTSIs):

One TSI family:

- 1 x ITSI;
- 1 x ATSI;
- N x 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 outside 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 MSs 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 7.2.6 and 7.8).

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 7.2.6 and 7.8.

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 7.2.8.

7.2.3 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 Mobile Country Code (MCC) and the Mobile Network Code (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 subclause 7.2.2 notes 1 and 2);
- GSSI = SSI from GTSI;
- USSI = SSI from a foreign ITSI (see subclause 7.2.2 note 2).

If an ASSI is available, this shall be used in place of the ISSI. (For more details see subclauses 7.2.6 and 7.8). 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 7.7. Additional rules for the use of SSIs are defined in subclause 7.7.

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.

7.2.4 Composition of subscriber identities

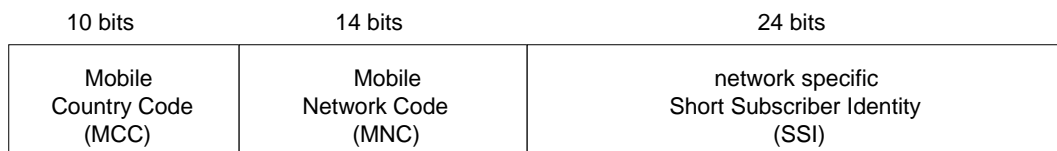


Figure 27: Contents of TSI

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, ATSI 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.

7.2.5 Allocation principles for subscriber identities

MCC shall use 10 bits to encode the 3 decimal digit value of the country code as defined in annex D of CCITT Recommendation X.121 [8].

EXAMPLE: France has the country code 208 Decimal.
This is coded as 00 1101 0000 Binary (0D0 hexadecimal).

The undefined binary codes (decimal values 1000 to 1023) 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 (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.

7.2.6 Use of subscriber identities

Subscriber identities shall be used for two distinct roles:

- a) as a lower layer address (MAC address) for the air interface as described in subclause 7.7 (SSI);
- b) as a network routing address (TSI).

The MM, the CMCE and the S-CLNP shall use subscriber identities as network routing addresses. This may include both source and destination addresses.

The CMCE or S-CLNP destination address shall be either:

- a) an ISSI or GSSI for intra-TETRA calls; if available, an ASSI shall be used by the SwMI. i.e. destination in the same TETRA network as the source; or
- b) an ITSI or GTSI for inter-TETRA calls; 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 calls.

The source address shall be either:

- a) an ISSI or ASSI for intra-TETRA calls, i.e. source in its home TETRA network; or
- b) an ITSI (downlink and ISI) or (V)ASSI (uplink) for inter-TETRA calls, 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.

7.2.7 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 [8];
- b) by the CMCE for external calls;
- c) by an external protocol, such as ISO CLNP or Internet IP.

NOTE: These external protocols are assumed to be converged onto S-CLNP.

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 7.4. 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 are not defined in this ETS.

7.2.8 Installation of ITSIs

ITSIs 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 by 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 300 392-2 [17], clause 16. 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.

7.3 TETRA Management Identity (TMI)

7.3.1 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.

7.3.2 Composition of management identities

The composition of the TMI shall be identical to the TSI as described in subclause 7.2.4. 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) (i.e. $MNI = MCC + MNC$) and Short Management Identity (SMI), (see also subclause 7.6).

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.

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

Figure 28: Contents of TMI

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

7.3.3 Use of management identities

The TMI shall only be used to support management functions such as defined in the MLE (see ETS 300 392-2 [17], clause 18). 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, e.g. they may allow no TMI functions at all.

7.4 Network layer SAP (NSAP) addresses

7.4.1 General

NSAP addresses are an additional method of addressing that may be used to provide direct compatibility with external (non-TETRA) networks. The use of NSAP addresses is an operator option for the V+D systems.

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.

7.4.2 Static binding

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

7.4.3 Dynamic binding

7.4.3.1 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 [8] 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 a gateway.

7.4.3.2 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 [8].

7.4.3.3 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 7.2.7).

NSAP addresses may also be used by the CMCE for routing calls from external users (non-TETRA users) according to the principles outlined in CCITT Recommendation E.213 [4].

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

7.4.3.4 Binding of NSAP addresses

In order to receive calls, 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.

7.5 TETRA Equipment Identity (TEI)

7.5.1 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.

7.5.2 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 29: Contents of TEI

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

7.5.3 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.

7.5.4 Use of TEI

TEI shall be used to support TETRA security functions e.g. MS enable and disable as described in ETR 086 [16].

7.6 Mobile Network Identity (MNI)

7.6.1 Contents of MNI

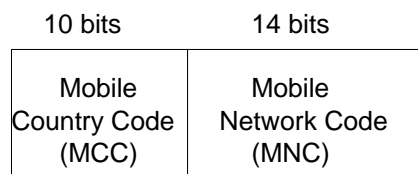


Figure 30: Contents of MNI

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 7.2.5.

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

7.7 Layer 2 addresses and labels

7.7.1 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 7.2.3. 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.

7.7.2 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.

7.7.3 Scrambling labelling

The scrambling labelling functions are defined to ensure that transmissions on a given channel are only received by the intended endpoints. Scrambling labelling 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.

7.7.4 Use and implementation of layer 2 addresses

7.7.4.1 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).

7.7.4.2 Implementation of event labels

Event labelling identities shall be either:

- a) a network/layer 3 call reference (for circuit mode call traffic channels) called Call ID, 14 bits (see ETS 300-392-2, clause 14);
- b) 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);
- c) 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.

7.7.4.3 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 300 392-2 [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).

7.7.5 Use of identities for V+D control channels

The following rules shall apply to all V+D control (signalling) channels.

MAC PDUs may be addressed with either an event label or an SSI or SMI. The SSI used for an SSI shall be used for all unreserved uplink MAC PDUs. This shall be:

- a) the ISSI or ASSI value that has been allocated by this network. For migrating mobiles this shall be the visitors (V)ASSI; or
- b) an USSI; or
- c) a GSSI.

NOTE 1: The use of USSI is indicated within the message.

The following rules give the precise usage:

- 1) for MS originated calls and all layer 3 responses to MS terminated group calls, the MS shall use the ISSI or ASSI if one is available. The ASSI shall be used in preference to an ISSI if both are available. An USSI shall only be used if no valid SSI is available;

NOTE 2: An USSI should only be used for the first access to a new (visited) TETRA network. This should be followed by an identity exchange to obtain a (V)ASSI.

- 2) for MS terminated individual calls (ISSI, ASSI), the MS shall reply with the same SSI as used by the BS;
- 3) for MS terminated management calls (STMI), the MS shall reply with the STMI;
- 4) on the uplink, a GSSI is used in the MAC header only for the layer 2 group presence indication.

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

On reserved access, the allocated event label should be used to replace SSI.

7.7.6 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).

7.7.6.1 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 mobiles 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).

7.7.6.2 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.

7.7.7 System information broadcast

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

7.7.8 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. For example it may be used as the distribution address for CMCE and S-CLNP calls. It may also be used by the SwMI for sending broadcast signalling messages.

7.8 Use of individual addresses

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

7.8.1 Air interface addressing functions

The address functions for all layers are summarised in table 1.

NOTE: Table 1 only considers address related functions. Refer to the protocol architecture in clauses 5 and 6 for details of other functions.

The overview through all layers of the functions related to the addresses are illustrated in figure 33.

Table 1: Addressing functions per layer

Layer	Protocol	Addresses used	Address function
3	CONP	No TETRA addresses (X.121 source+dest)	End-to-end routing
3	S-CLNP	ITSI/ISSI	End-to-end routing
3	CMCE	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 Event label	Uplink burst addressing Battery saving/wake-up (PDO) Battery saving (V+D) Downlink filtering
1	PHL	Scrambling label	Scrambling

7.8.2 Address placement in primitives and PDUs

7.8.2.1 Use of ISSI at layer 2

The placing of the SSI addresses into primitives and PDUs is shown in figure 33. Although the SSI is a layer 3 address, it shall also be used in the air interface layer 2.

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 7.7).

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).

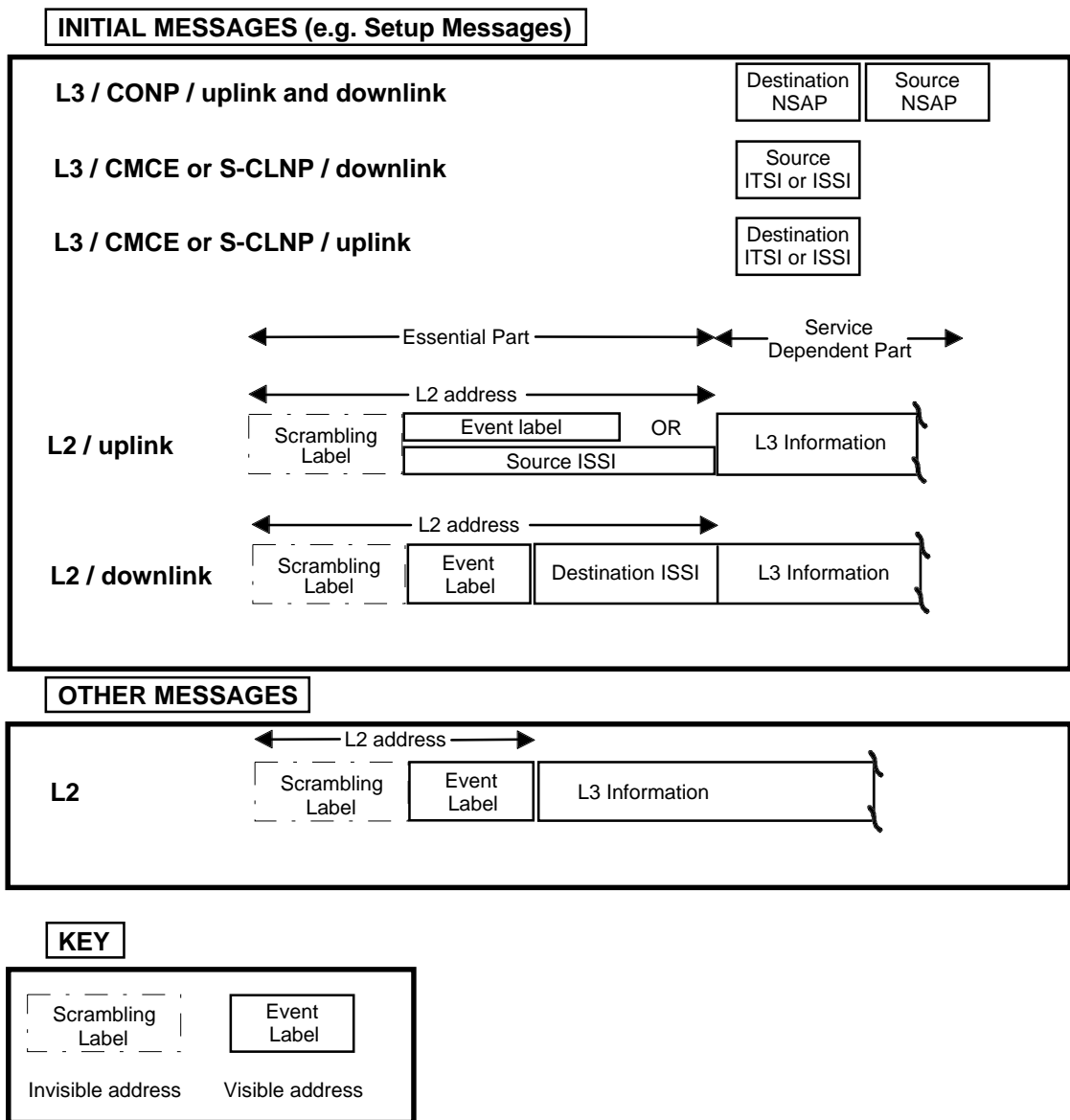


Figure 31: Message addressing for initial messages

A call set-up message using random access in V+D shall use the SSI.

7.8.2.2 Use of ITSI/ISSI at layer 3

7.8.2.2.1 Use of ITSI/ISSI by S-CLNP

The ITSI and ISSI addresses shall be used as the routing address for all S-CLNP 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 calls. The ITSI shall be used for inter-TETRA calls. As usual, alias identities shall replace individual addresses if appropriate.

When migrating, the S-CLNP shall retain its home network (H)ITSI, and calls 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 S-CLNP packet header over the air interface is designed to be as short as possible. As a result, three different PDUs have been defined for S-CLNP as described in ETS 300 392-2 [17], clause 22:

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

7.8.2.2.2 Use of ITSI/ISSI by CMCE

The ITSI, ISSI and GSSI shall be used as the routing address for CMCE, where the call routing shall be defined by the source and destination ITSI, ISSI or GSSI, and/or the call identifier.

The ISSI shall be used for all intra-TETRA calls for both source and destination. The ITSI shall be used for inter-TETRA calls as destination address. As usual, alias identities shall replace individual addresses when appropriate.

For external calls, the first message should follow the internal (TETRA) procedure to access a gateway and further addressing related to the network type should be provided in a subsequent message.

When migrating, the CMCE shall retain its home network ITSI, and calls to this subscriber shall continue to use the 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 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 CMCE header over the air interface is designed to be as short as possible. As a result, different PDUs have been defined for CMCE using the different addresses described in this clause. The CMCE PDUs are further described in ETS 300 392-2 [17], clause 14.

For the ISI, the PDU shall contain the full addresses (TSI) for both source and destination.

There shall only be one address field in the uplink and downlink PDUs at layer 3, respectively destination and source, 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 SSI (instead of the full ITSI) for addressing within one TETRA sub-domain.

The infrastructure shall convert between these different PDUs as appropriate.

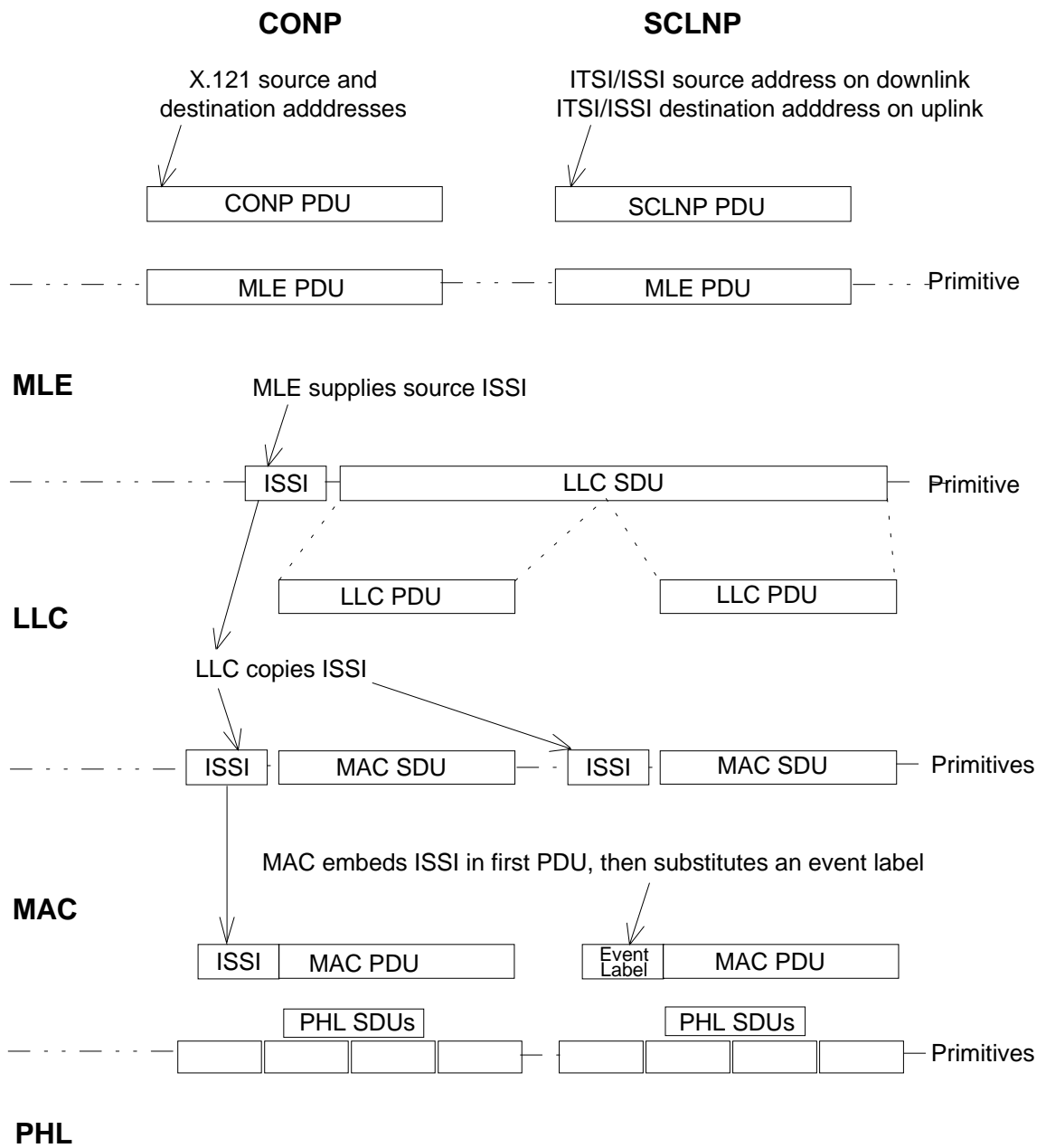


Figure 32: CONP and S-CLNP air interface addressing

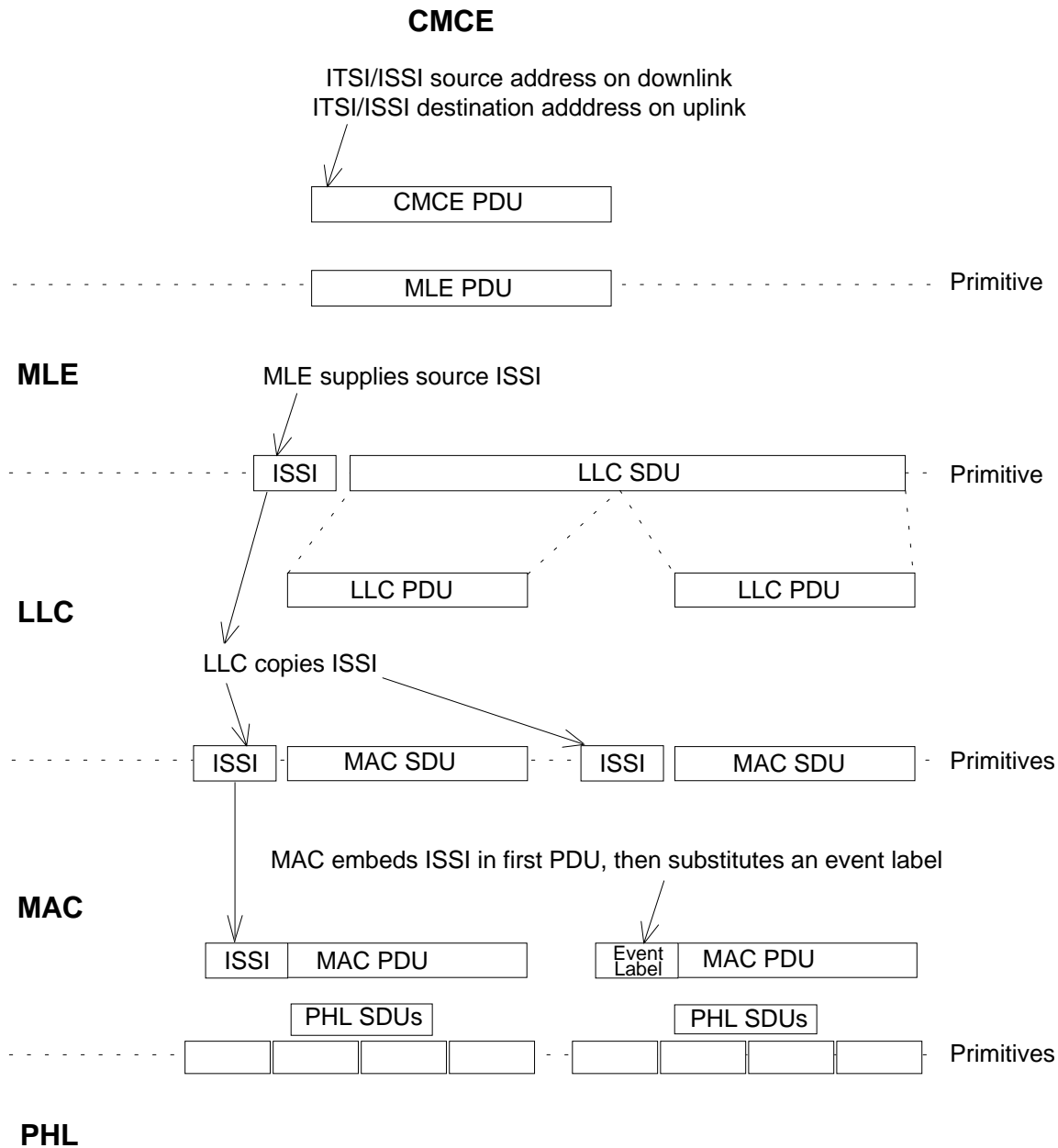


Figure 33: CMCE V+D air interface addressing

7.8.3 Routing principles

7.8.3.1 Routing of intra-TETRA calls (within one TETRA network)

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

SSI alone should be sufficient for intra-TETRA call routing and SSI-only operation should be used for V+D calls. Dual addressing (SSI plus NSAP) should be used as a V+D option for "telephony access". 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 calls, i.e. both the X.121 (NSAP) address and the ITSI shall be allocated by the TETRA network operator.

7.8.3.2 Routing of inter-TETRA calls (between two TETRA networks)

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

TSI alone should be sufficient, and TSI-only operation should be used for most V+D calls. However, dual addresses (TSI and NSAP) may be used as an operator choice in packet mode services.

7.8.3.3 Routing of external calls (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.

7.8.4 Address and identity comparison

TETRA addresses and identities are compared in table 2 to the ones used in other systems.

Table 2: 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: Refer also to 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.			

8 Overview of circuit mode basic services

8.1 Introduction

This clause identifies a technical realisation for the circuit mode services showing signalling between users on the U-plane and C-plane.

8.2 Functional groupings in circuit switched mode calls

8.2.1 Circuit switched call control, C-plane

Functions shall exist in the TETRA SwMI that can be accessed for setting up a basic service or performing a supplementary service process. The circuit mode applications shall invoke these services through SAPs at the top of the CMCE.

In the case of a circuit switched call, the C-plane shall be switched to the U-plane after the SwMI has given permission for the call to be set-up, and user data may be transferred, (this may be in the form of speech or data depending upon the application).

8.2.2 Circuit switched call, user data, U-plane

The propagation of circuit mode data, which shall not include control information, from point-to-point and point-to-multipoint shall be done on the U-plane. Examples of such data can be TETRA encoded speech, circuit mode speech and circuit mode data.

8.3 Protocols

Different types of protocols shall be required to convey information from different entities in one unit to another entity in another unit. The different protocols are described in the following subclauses.

8.3.1 TNP1

The TETRA specific layer 3 protocol between peers within a MS or LS over the R_T reference point to external TE.

8.3.2 TNP2

In order that the TETRA specific CMCE protocol can be supported between the LS and the SwMI across an ISDN network the TNP2 protocol shall be used.

8.3.3 TNP3

The TNP3 protocol shall be used to convey the CMCE and the MM protocol over the ISI.

8.3.4 TNP4

The TNP4 protocol shall be used to convey the TETRA specific CMCE protocol between the MS and the SwMI over the air interface (Um).

8.3.5 AI1

The TETRA specific layer 1 protocol shall be conveyed between the MS and the SwMI over the air interface (Um).

8.3.6 AI2

The TETRA specific layer 2 protocol shall be conveyed between the MS and the SwMI over the air interface (Um).

8.3.7 TLC1

The TLC1 protocol shall be used as the layer 2 protocol on the C plane, between an external terminal and an MS or LS over the R_T reference point.

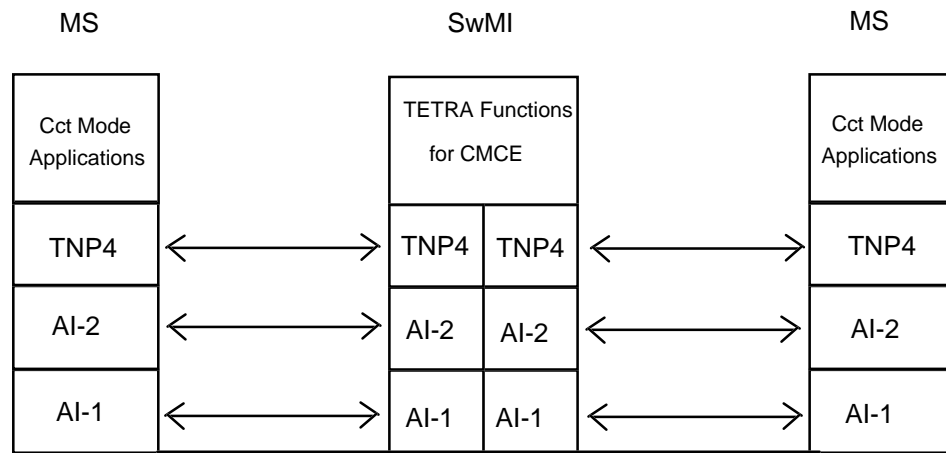
8.3.8 V.24T

The V.24T protocol shall be used to manage the physical layer between an external terminal and an MS or LS over the R_T reference point.

8.4 Example configuration

8.4.1 MS to MS

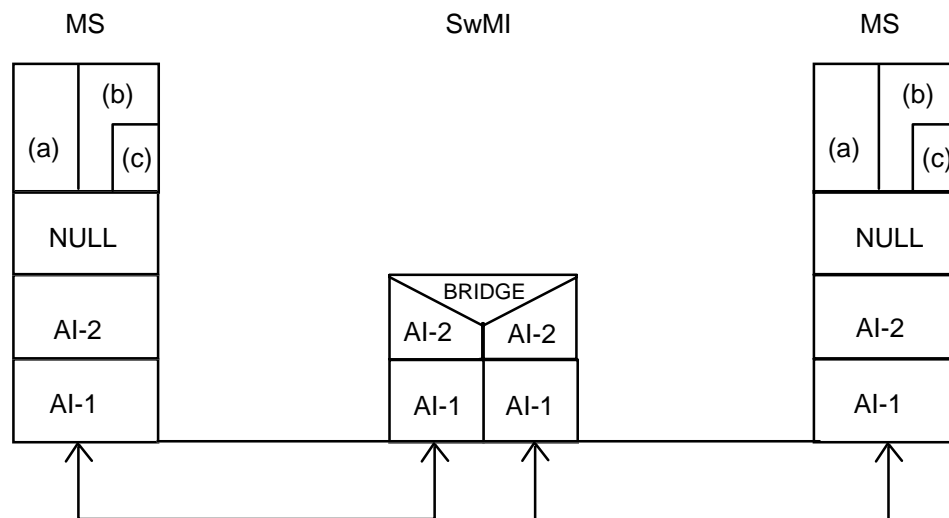
Figure 34 shows how CMCE data shall be exchanged between MS and SwMI.



Circuit (Cct)

Figure 34: MS connected to MS, exchange of CMCE information, C-plane

Figure 35 shows how user data on the U-plane shall be exchanged between two MSs over a LLC bridge in the SwMI.

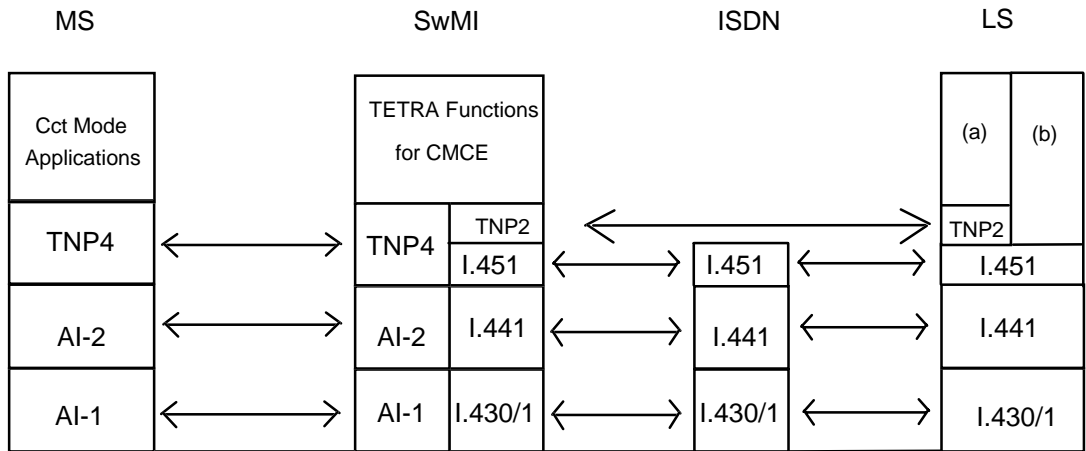


- (a) Circuit Mode applications
- (b) TETRA encoded speech
- (c) Encryption

Figure 35: MS connected to MS, exchange of user data, U-plane

8.4.2 MS to LS

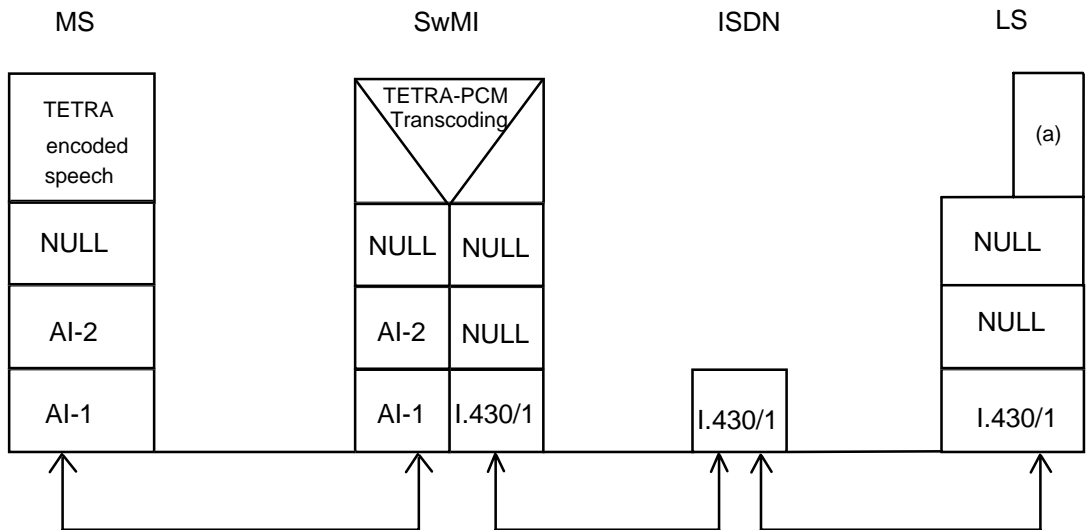
Figure 36 shows how CMCE data shall be exchanged between MS and SwMI and LS and SwMI by means of the TNP2 and TNP4 protocol.



- (a) Circuit Mode Applications
- (b) ISDN Applications

Figure 36: MS connected to LS, exchange of CMCE data, C-plane

Figure 37 shows how speech on the U-plane shall be exchanged between a MS and a LS over a SwMI. The TETRA encoded speech over the air interface shall be transcoded to A-law PCM encoded speech over the ISDN network.

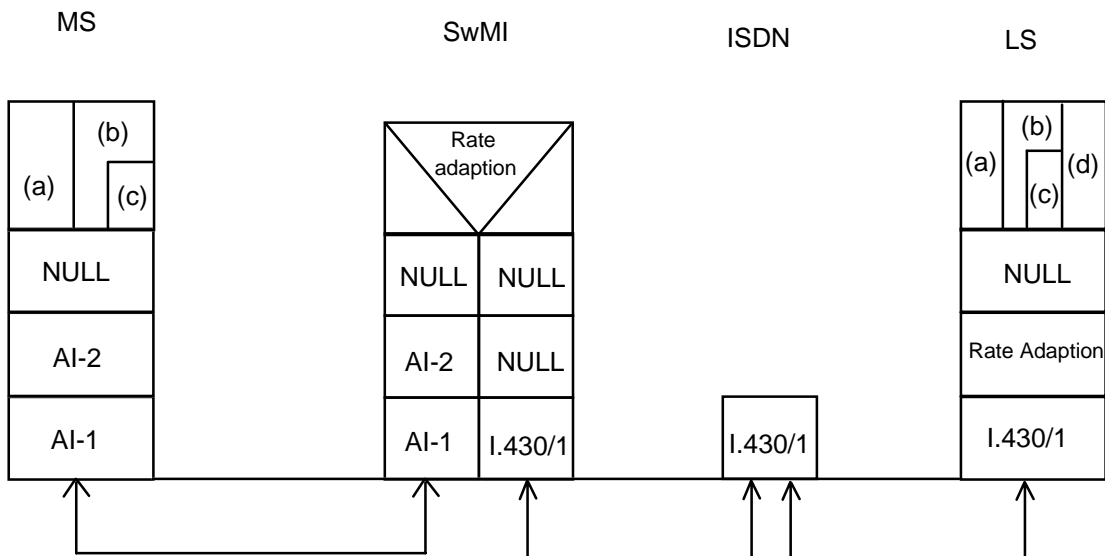


- (a) ISDN Application

Case: TETRA encoded speech, transcoding in SwMI

Figure 37: MS connected to an ISDN, telephone exchange of speech, U-plane

Figure 38 shows how TETRA encoded speech and circuit mode data on the U-plane shall be exchanged between a MS and a LS over a SwMI. The TETRA encoded speech, sent over the air interface, shall be rate adapted and sent in an Unrestricted Digital Data (UDD) channel of 64 kbit/s over the ISDN network. The TETRA encoded speech shall then be rate adapted back to its original rate in the LS, and decoded in the LS application.



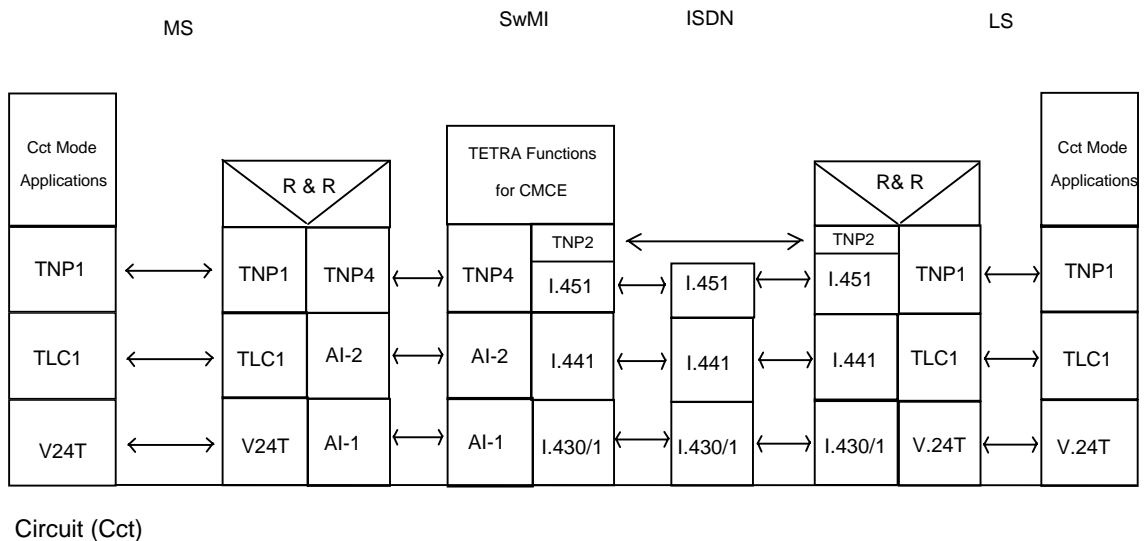
- (a) Circuit Mode applications
- (b) TETRA encoded speech
- (c) Encryption
- (d) ISDN Application

Case: UDD, Rate adaption in SwMI and LS

Figure 38: MS connected to LS, exchange of user data, U-plane

8.4.3 MS and LS connected over user-interface (R_T reference point)

Figure 39 shows how CMCE data shall be exchanged between application and termination in MS and LS by means of TNP1, TNP2 and TNP4 protocol. Figure 39 also shows how MT and SwMI and SwMI and NT shall exchange data.



Circuit (Cct)

Figure 39: MS (asynch terminal connected to MT in R_T ref. point) connected to LS, (ISDN terminal connected to NT in S_T ref. point) - exchange of CMCE data, C-plane

Figure 40 shows how circuit mode data on the U-plane shall be exchanged between a MS and a LS over the R_T reference point. TETRA encoded speech shall not be envisaged for this configuration.

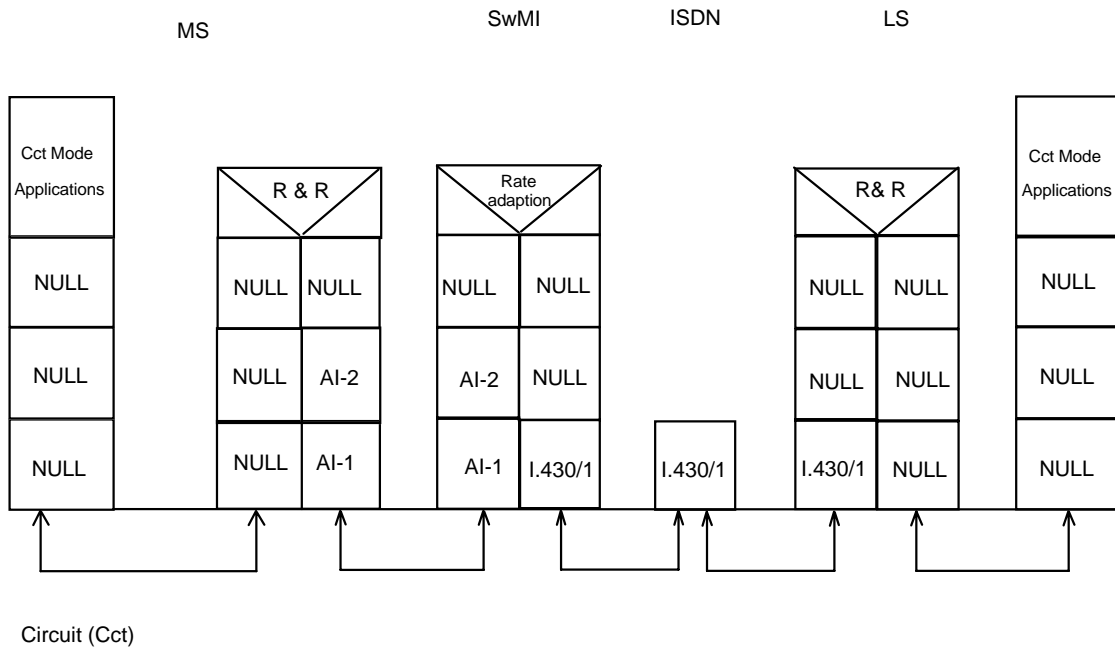


Figure 40: MS (asynch terminal connected to MT in R_T ref. point) connected to LS, (ISDN terminal connected to NT in S_T ref. point) - exchange of user data, U-plane

8.4.4 MS to MS over ISI

Figure 41 shows how CMCE data shall be exchanged between SwMI's by means of the TNP3 protocol.

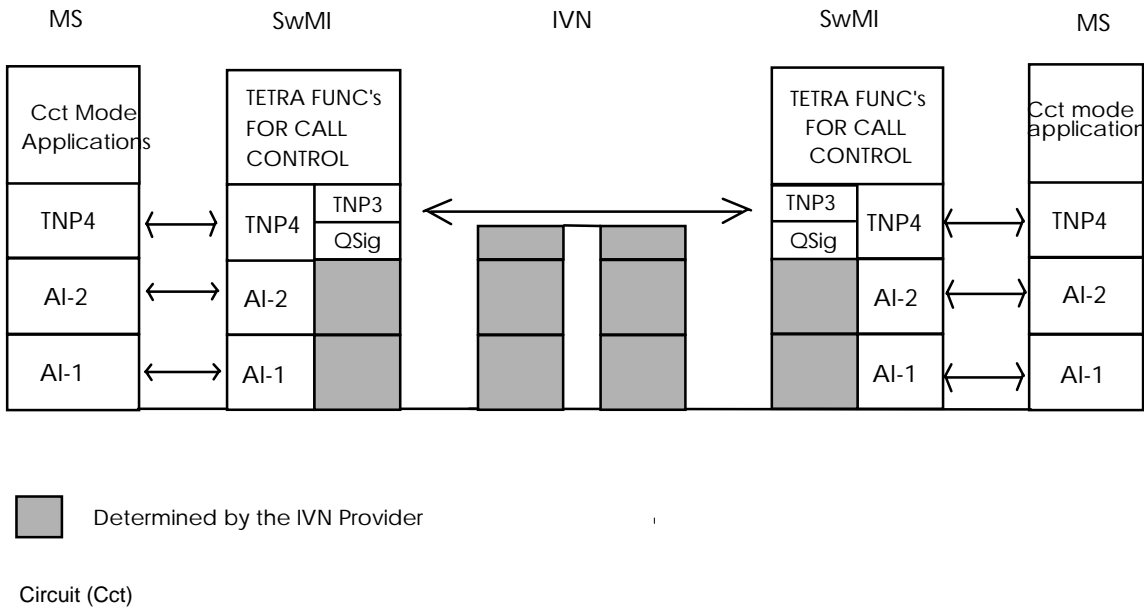
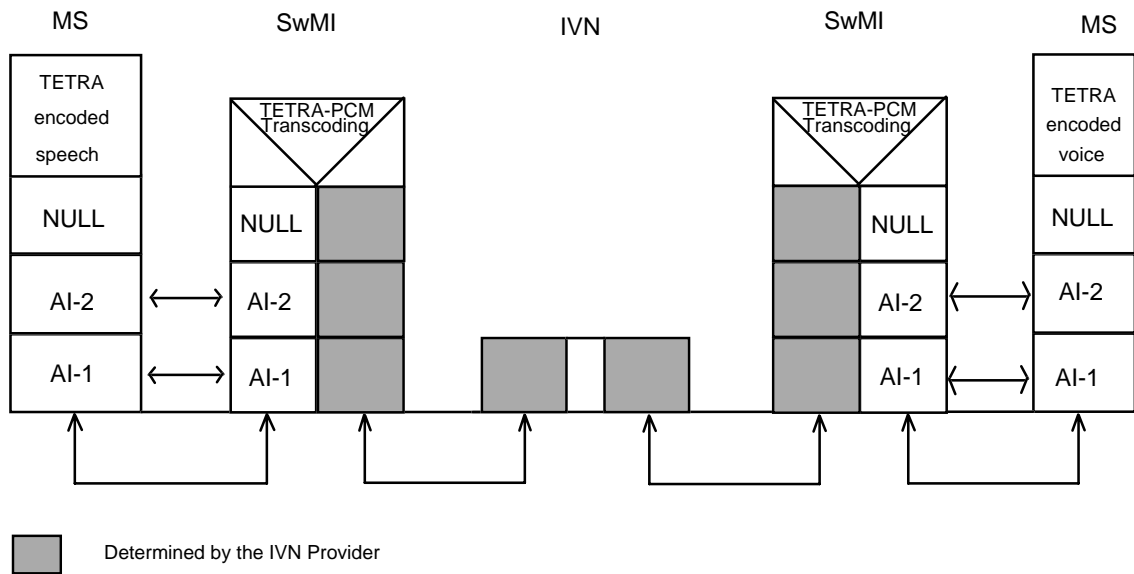


Figure 41: MS connected to MS via ISI - exchange of CMCE data, C-plane

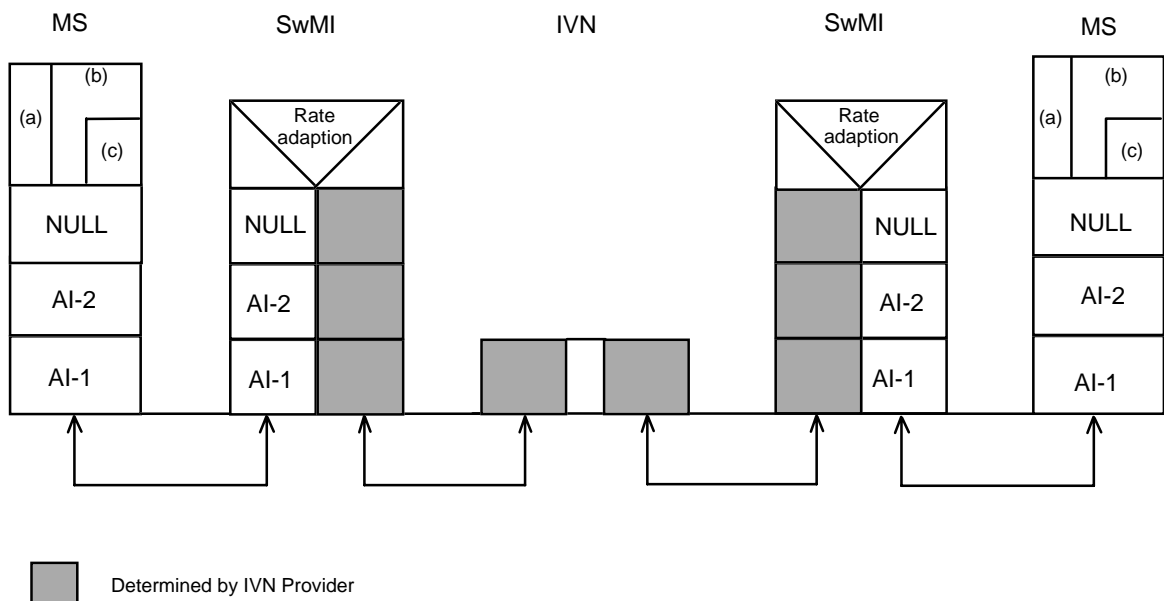
Figure 42 shows how TETRA encoded speech on the U-plane shall be exchanged between MSs over ISI, with transcoding. In this case two TETRA-PCM transcodings shall be required.



Case: TETRA encoded speech, Transcoding in SwMI

Figure 42: MS connected to MS via ISI - exchange of user data, U-plane

Figure 43 shows how TETRA encoded speech and circuit mode data on the U-plane shall be exchanged between MSs over ISI.



(a) Circuit mode applications

(b) Tetra encoded speech

(c) Encryption

Case: UDD, Rate adaption in SwMI

Figure 43: MS connected to MS via ISI - exchange of user data, U-plane

9 Mobility Management (MM) in MS

9.1 Introduction

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

9.2 Overview of MM relations and procedures

Figure 44 and figure 45 show the MM relations, stimulations and procedures on the MS side. The distinction between the MS MM and SwMI MM entities are presented in the scenarios.

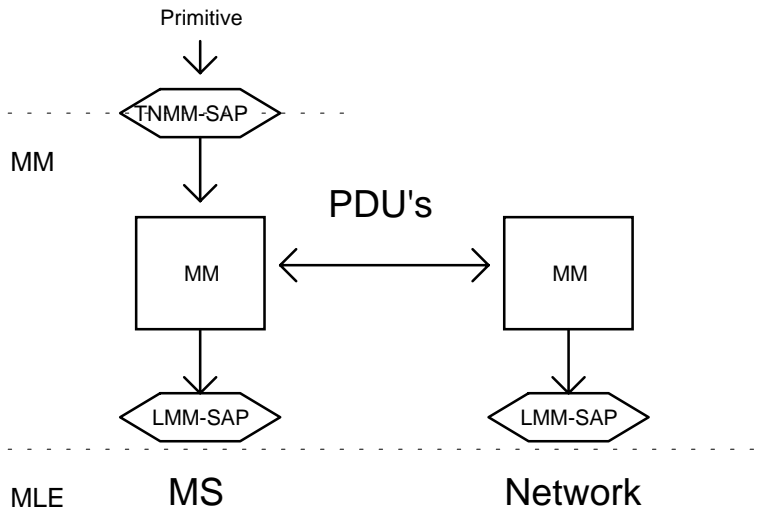


Figure 44: MM relation

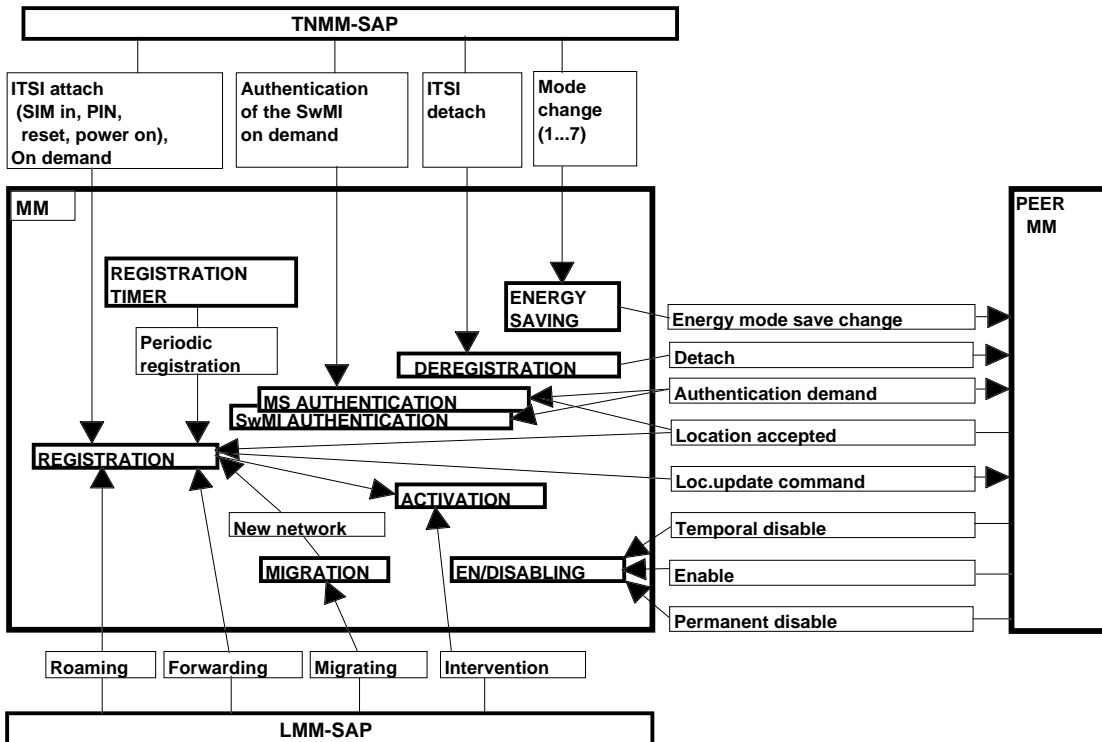


Figure 45: MM stimulations (thin boxes) and procedures (thick boxes)

9.3 Stimuli of MM

9.3.1 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;
 - "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;
 - 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 (base station). 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.

9.3.2 Stimulation through LMM-SAP

Stimulations through the LMM SAP are defined in ETS 300 392-2 [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 processes 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 shall require registration;
- **migrating:** the change of a LA from one TETRA network to another shall require registration.

9.3.3 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.

9.3.4 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.

9.4 Outputs from MM

9.4.1 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;
 - for a successful authentication;
 - for an unsuccessful authentication;
 - for an unsuccessful registration;
 - for a 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".

9.4.2 Outputs through LMM-SAP

Outputs from the LMM SAP are defined in ETS 300 392-2 [17], clause 17.

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

9.4.3 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>.

9.5 Database requirement

The identified data base requirements in the mobile 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 whether if ITSI detach is shall be reported to MM in the infrastructure or not;
- **the search area:** the total area in which the mobile may search for service.

9.6 MM procedures

9.6.1 Registration

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

9.6.1.1 Registration at roaming

9.6.1.1.1 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, e.g a CC message, or is responding, e.g. to a CC message.

9.6.1.1.2 Multiple registration

Multiple registration is when a MS is keeping 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 RA is enlarged. Multiple registration can also be pre-arranged by the operator arrangement. However, the function is not considered in the scope of this ETS.

9.6.1.1.3 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 46). The ISSI shall be used as sender identity. The database 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.

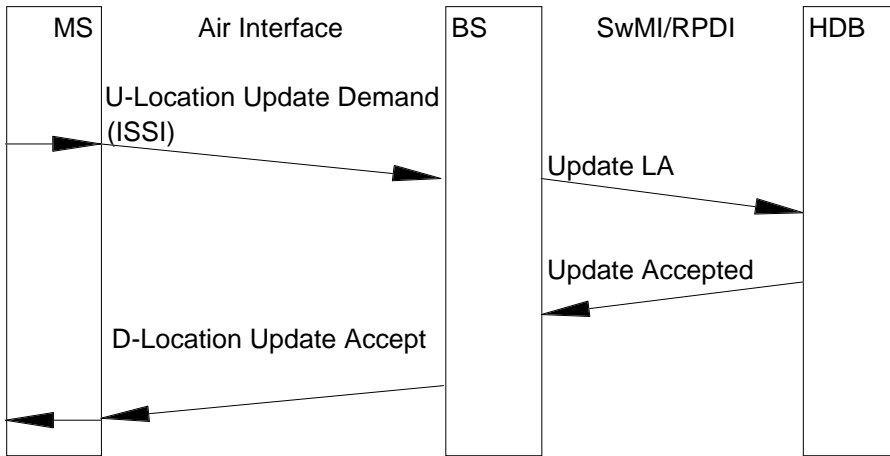


Figure 46: Registration at accepted roaming, with no authentication nor identity exchange

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 47).

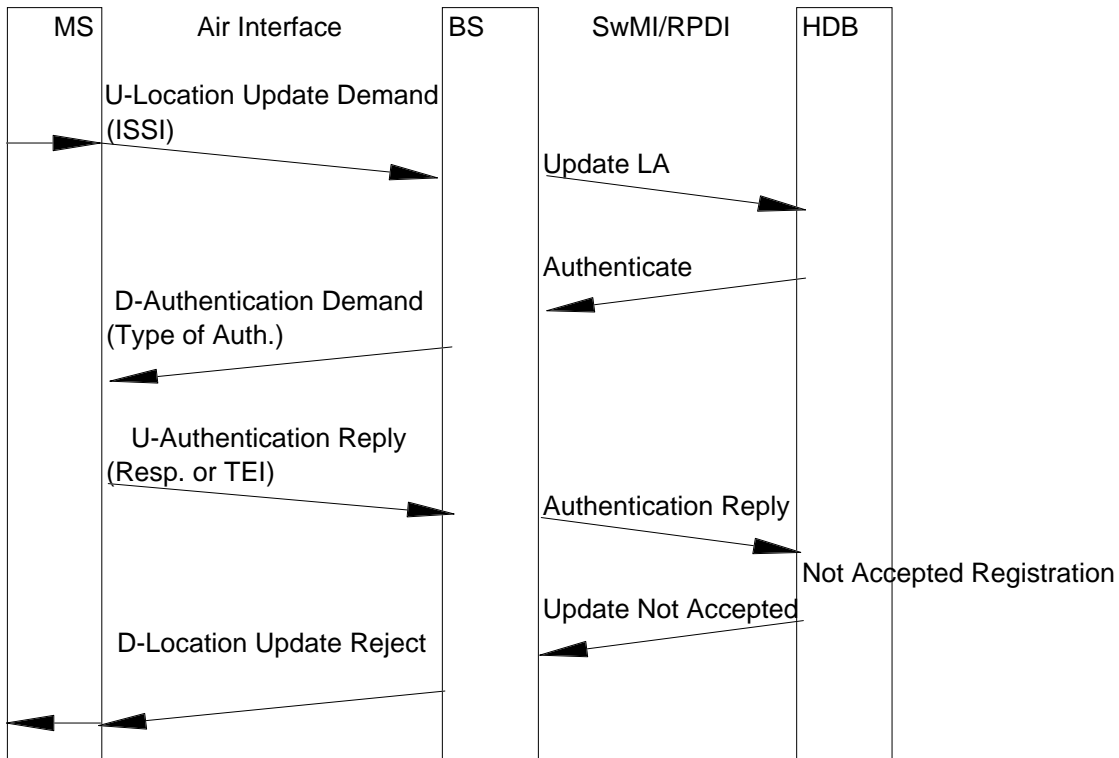


Figure 47: Registration at not accepted roaming, with authentication and no identity exchange

9.6.1.1.4 Registration with authentication

The network initiated authentication process (see subclause 9.6.2.1) may be included in the registration process (see figure 48).

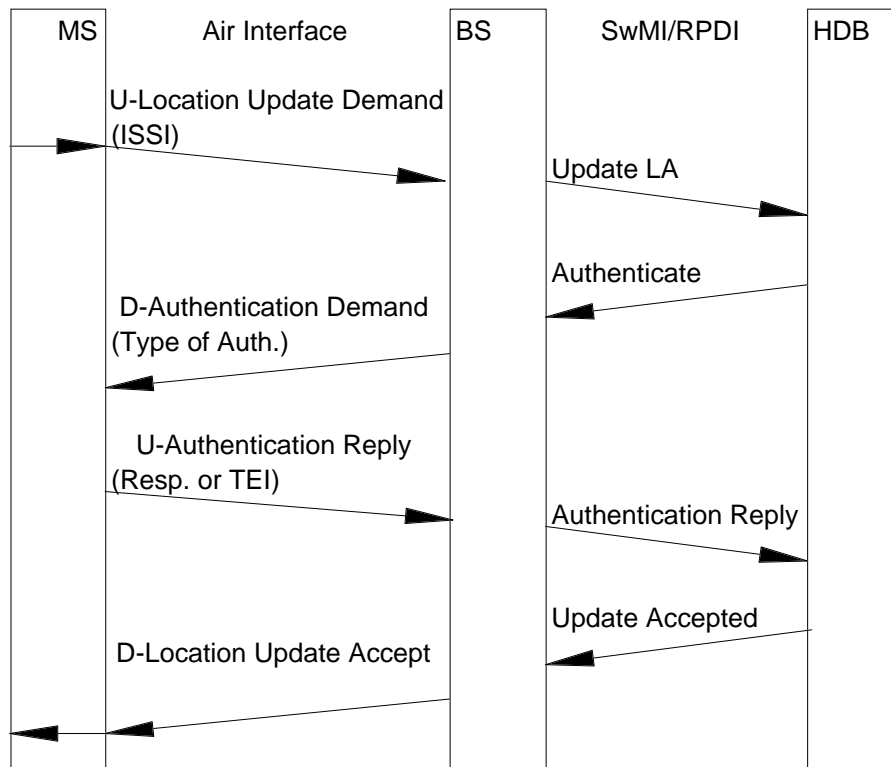


Figure 48 Registration at accepted roaming, with authentication and no identity exchange

9.6.1.1.5 Registration with identity exchange

When the message <Location Update Demand> is sent to the infrastructure (see figure 49), an ASSI if available, shall be used for sender identity. This ASSI should be translated in the infrastructure to the correct ITSI to gain access to the correct entry in the database. 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 the form of an ASSI. This new identity should now be used hereafter (see figure 50).

The authentication process may be included as described in subclause 9.6.1.1.4.

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.

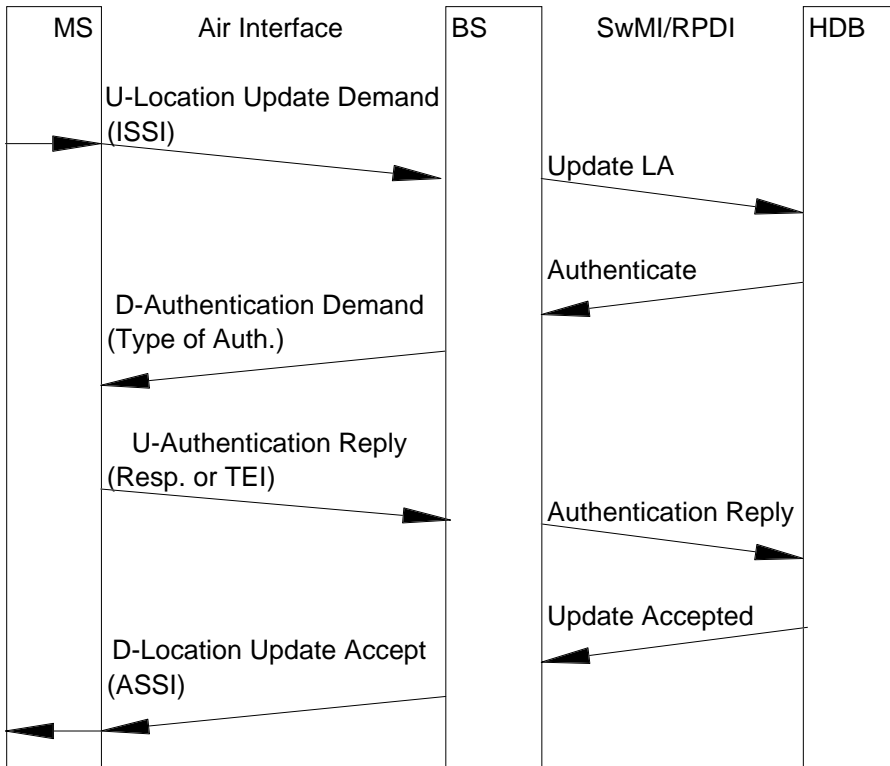


Figure 49: Registration at accepted roaming, with authentication and first identity exchange

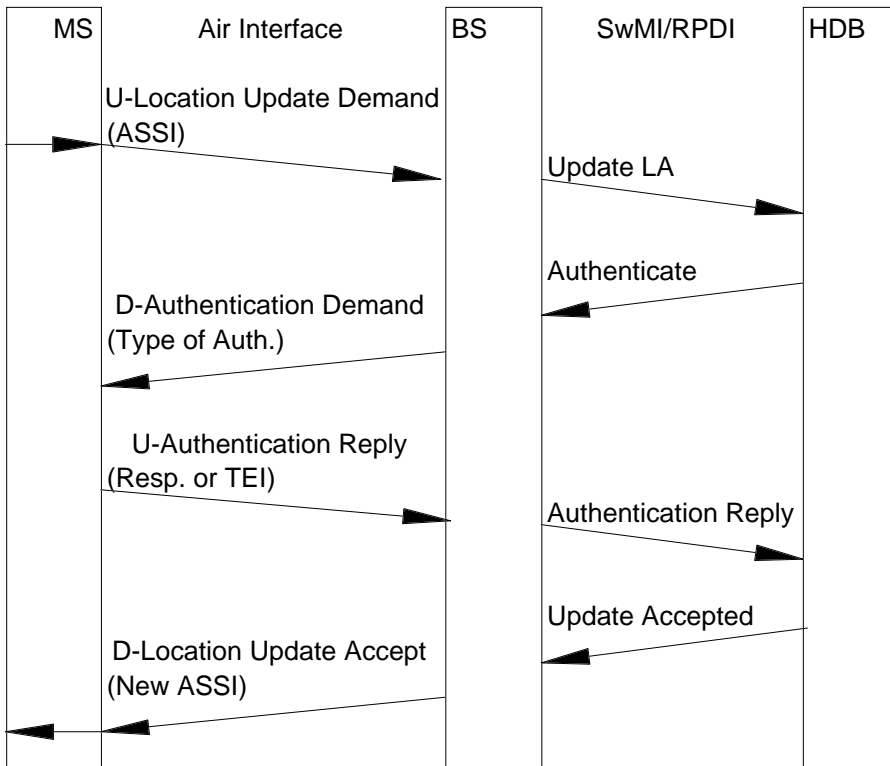


Figure 50: Registration at accepted roaming, with authentication and subsequent identity exchange

9.6.1.2 Registration at migration

9.6.1.2.1 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 51). In this case, the USSI shall be used for sender identity.

For V+D, this USSI shall be identified by the visited infrastructure which then immediately shall assign a (V)ASSI by sending a <Location Update Proceeding> message with the assignment of a (V)ASSI. The MS shall continue the information exchange with the SwMI with the (V)ASSI. The <Location Update Demand> shall now be repeated with the new (V)ASSI and with the full TETRA subscriber identity (ITSI) as parameter.

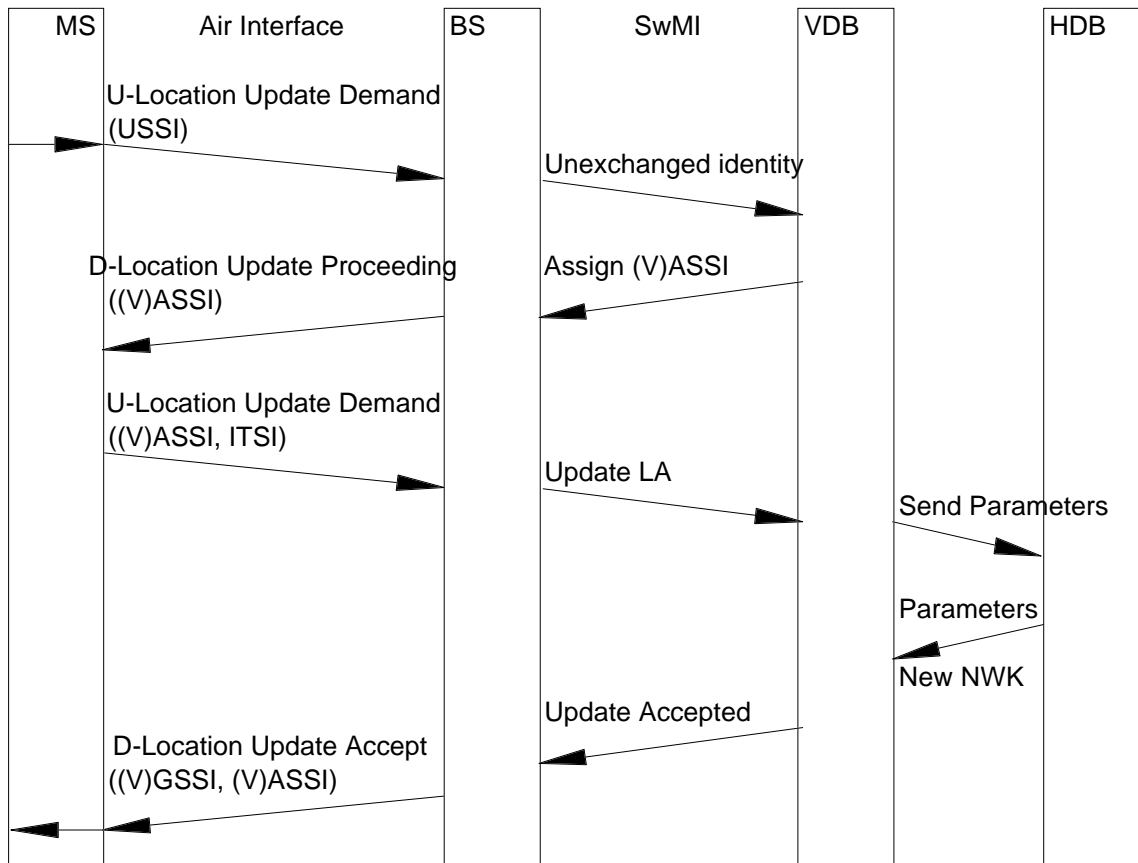


Figure 51: Registration at accepted migration, with identity exchange and no authentication (V+D)

For PDO (see figure 52) the <Location Update Demand> using the USSI shall contain the full TETRA subscriber identity (ITSI) as parameter. No <Location Update Proceeding> message should be needed.

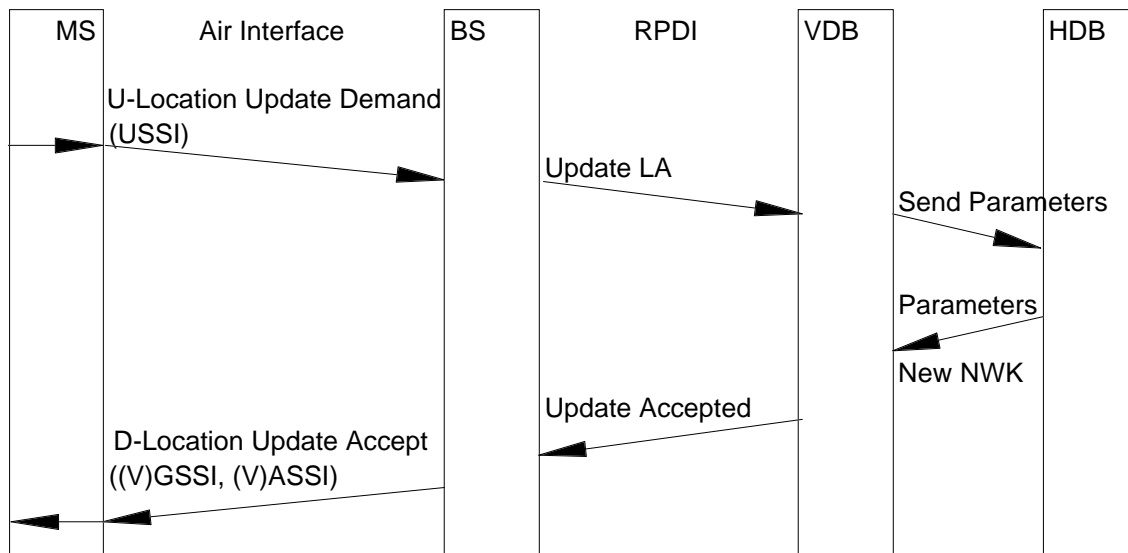


Figure 52: Registration at accepted migration, with identity exchange and no authentication

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.

9.6.1.2.2 Registration with authentication

For V+D there shall only be one type of identity exchange based upon the USSI as outlined in subclause 9.6.1.2.1, (see figure 53).

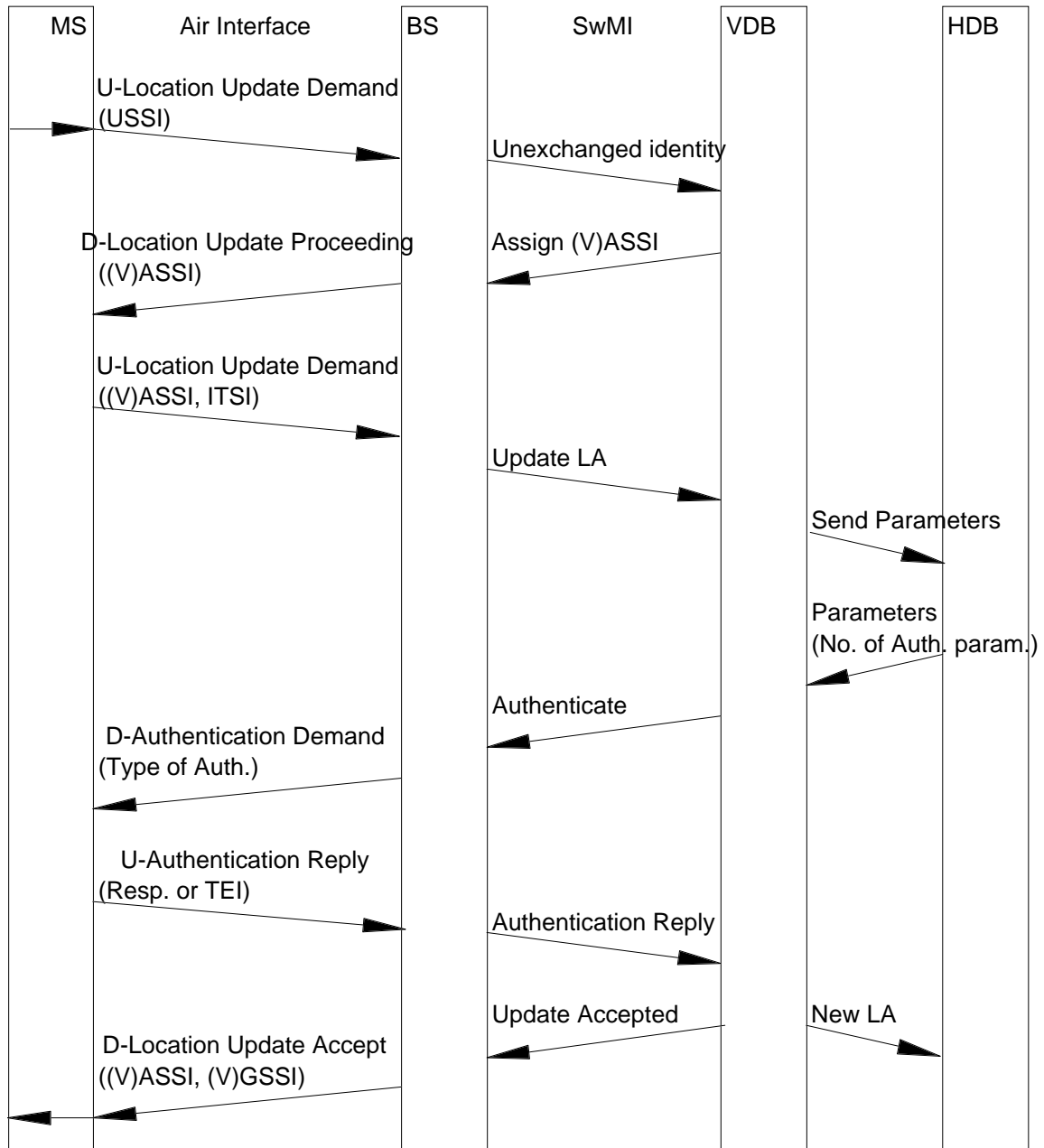


Figure 53: Registration at accepted migration, with identity exchange and authentication (V+D)

For packet mode data transfer the USSI shall be used during all the message exchanges and until a (V)ASSI has been assigned after <Location Update Accept> (see figure 54).

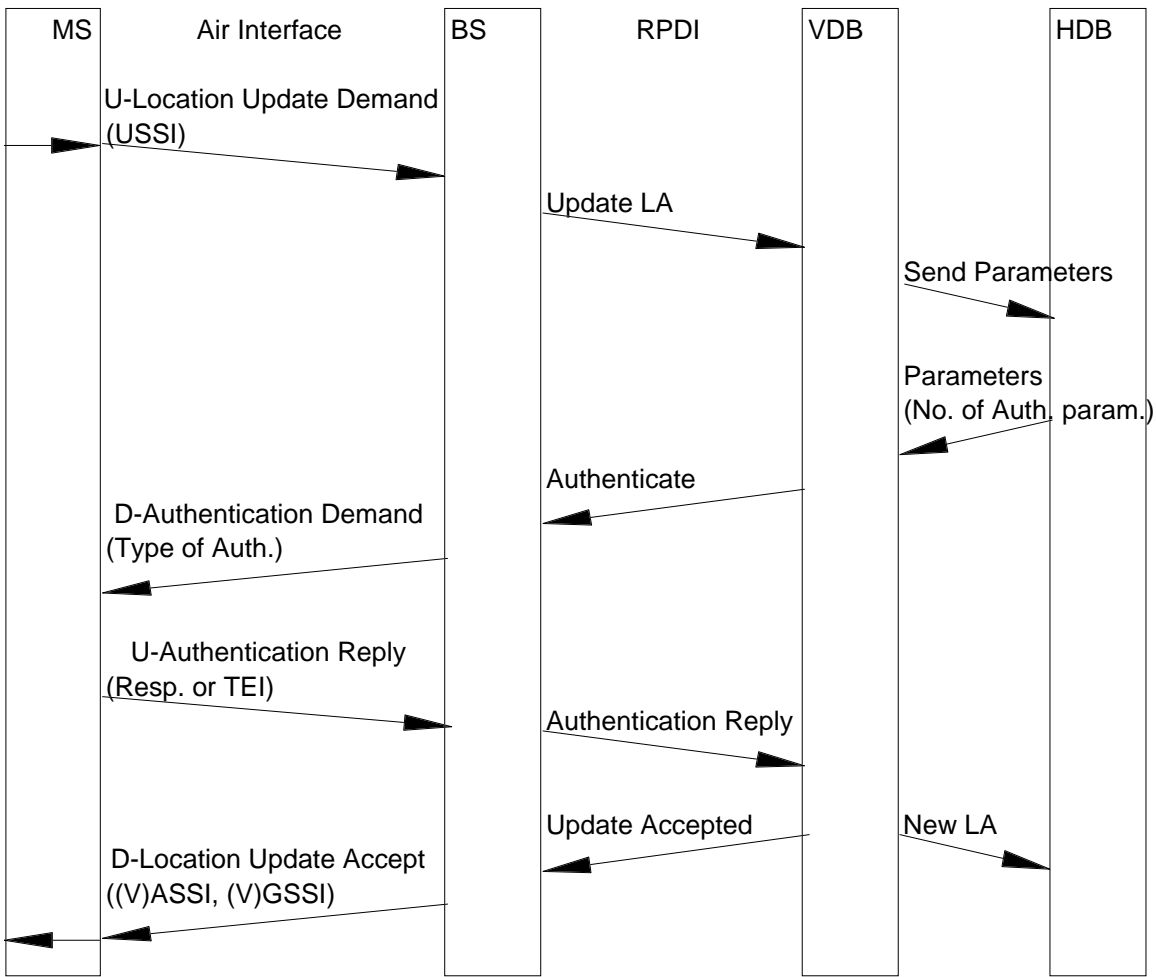


Figure 54: Registration at accepted migration, with identity exchange and authentication

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.

9.6.1.3 Network initiated registration

The network shall force the MS to initiate a location update procedure. This shall be activated by the <Location Update Command> message, (see figure 55).

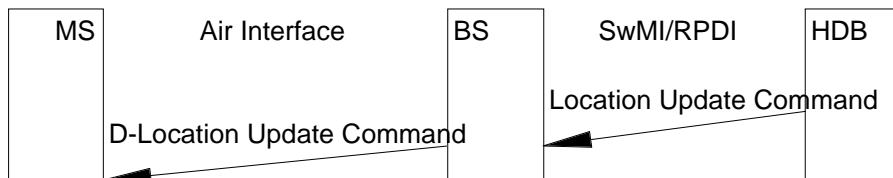


Figure 55: Network initiated registration

9.6.2 Authentication

NOTE: Authentication mechanisms to be used in TETRA are described in ETS 300 392-7 and are outside the scope of this part of the standard. The following descriptions are informative.

9.6.2.1 Network initiated authentication

It is possible for the network to authenticate a mobile without any previous MS initiated registration. This is done by sending the message <Authentication Demand>, (see figure 56).

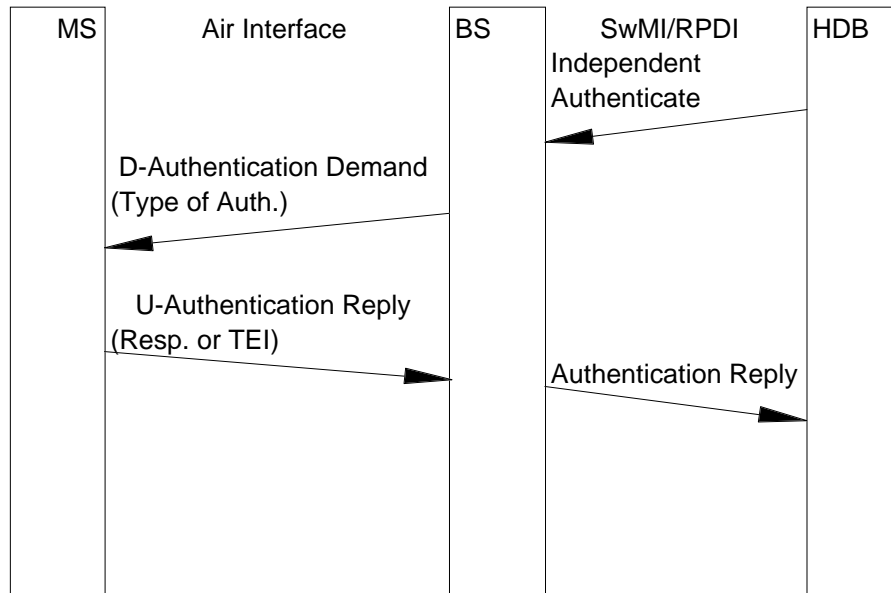


Figure 56: Independent authentication initiated by the network

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 57).

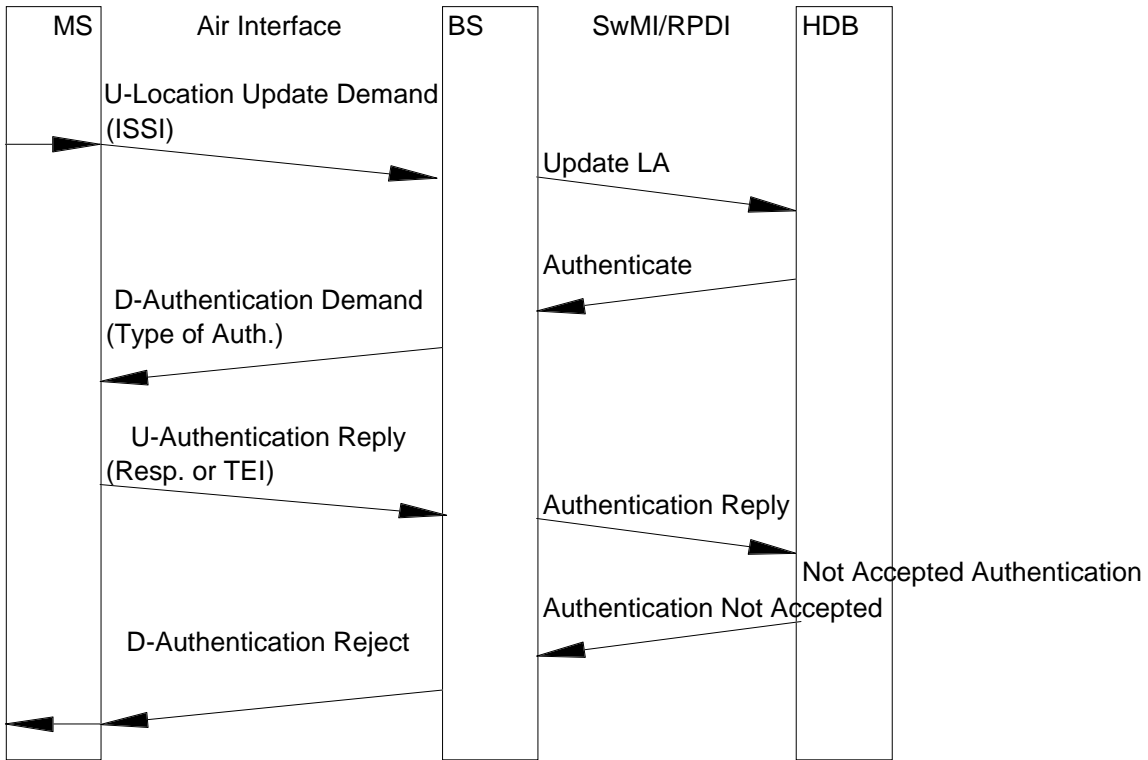


Figure 57: Registration at not accepted authentication, with authentication and no identity exchange

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

9.6.2.2 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 58).

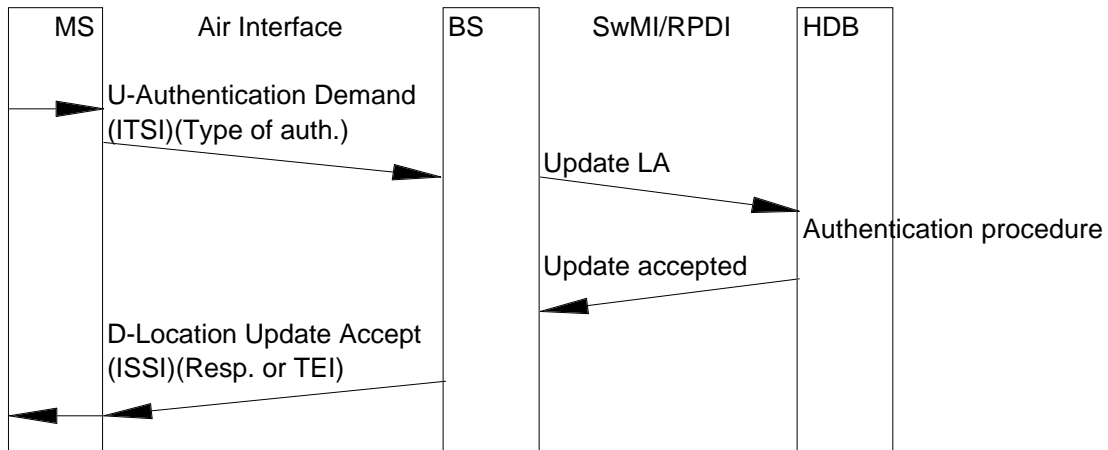


Figure 58: Authentication initiated by the MS

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.

9.6.3 De-registration

The individual (and group) TETRA subscriber identities (ITSI and GTSI's) 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 is sent to the infrastructure, (see figure 59).

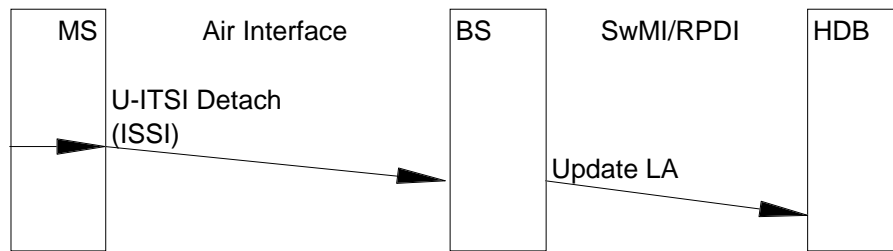


Figure 59: De-registration (ITSI detach)

9.6.4 Periodic registration

Registration of the MS to the network can be initiated periodically by an internal MS timer, the procedure is the same as described in figures corresponding to registration.

9.6.5 Disable/enable

9.6.5.1 Temporary disable

It may, as an operator option, be possible to temporarily disable an MS, (see figure 60). The MS will 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 remains until the message <Enable> is received. It is an operator option if an accepted authentication is performed before the disable order is executed.

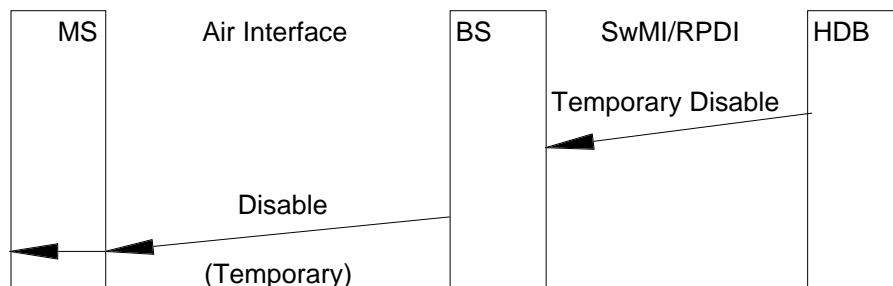


Figure 60: Temporary disabling a MS

9.6.5.2 Temporary enable

The message <Enable> is used to change an earlier "Temporary" <Disable> message, (see figure 61).

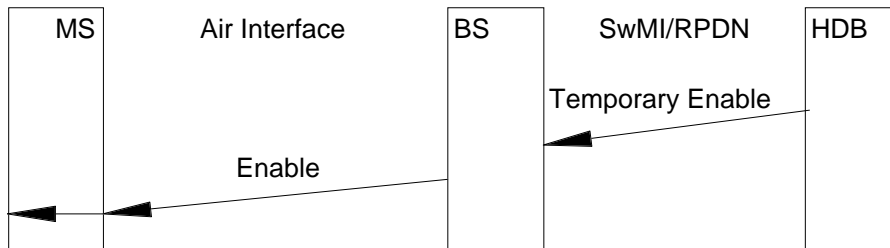


Figure 61: Temporary enabling a MS

9.6.5.3 Permanently disable

It may, as an operator option, be possible to permanently disable an MS, (see figure 62). The MS will 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 remains until the MS has been re-activated in an operator authorized service centre. It is an operator option if an accepted authentication is performed before the disable order is executed.

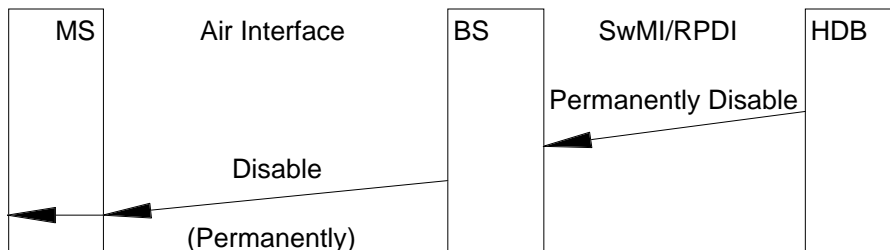


Figure 62: Permanently disabling a MS

9.6.6 Energy economy mode change

The mode changes for MS energy saving mode are reported to the infrastructure, either in normal registration or as a separate action. One of the 8 different energy saving schemes (including <No energy> saving) is reported.

9.7 Downloading of group identities

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

Dynamically defined GTSIs shall contain lifetime information (refer to SS-DGNA stage 2). During the migration process the visited system may allocate (V)GSSIs to be used instead of GSSI.

Temporary group addresses shall be valid only for the lifetime of the call.

9.7.1 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 63). The MS either accepts the complete list or rejects the whole list. The accept or reject shall be sent to the infrastructure in a <Group Identity Acknowledge> message.

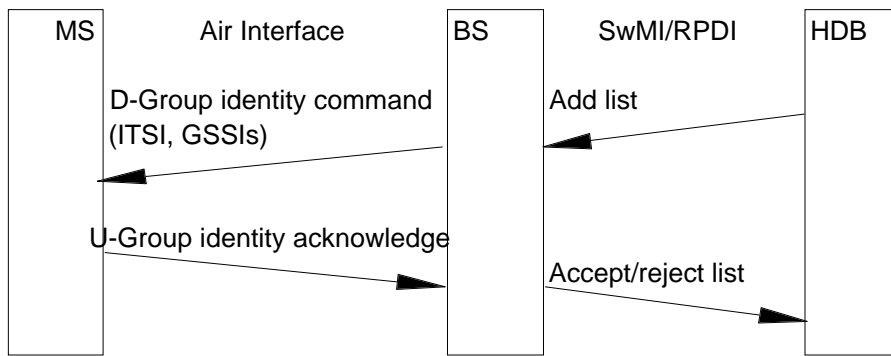


Figure 63: Network group identity (GSSI) download

9.7.2 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 64). 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.

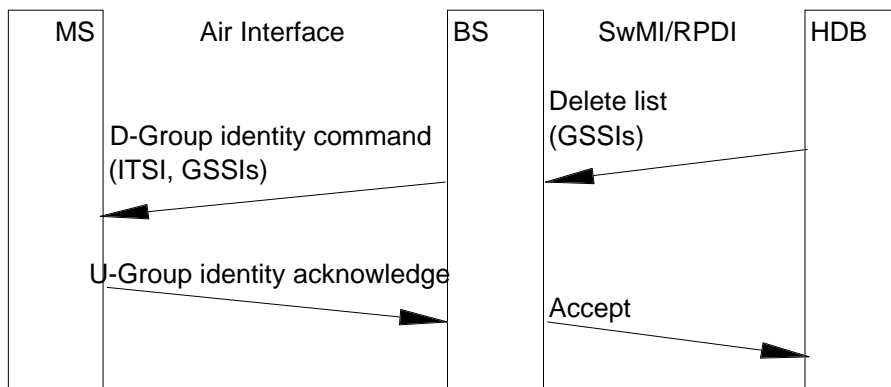


Figure 64: Deletion of a list of group identities (GSSI) by the network

9.7.3 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 65). 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.

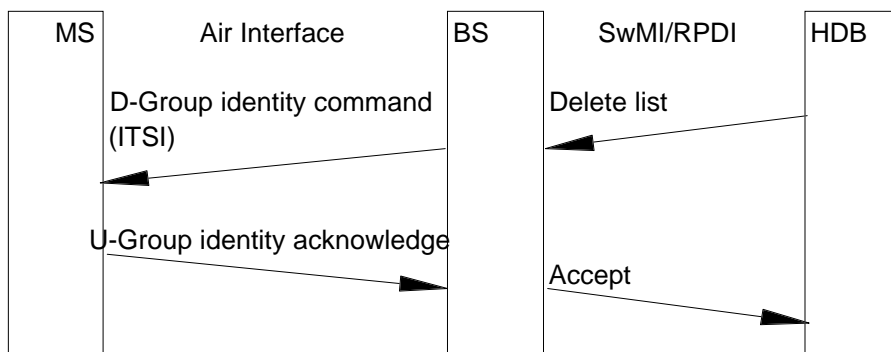


Figure 65: Deletion of all group identities (GSSI) by the network

9.7.4 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 66). 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.

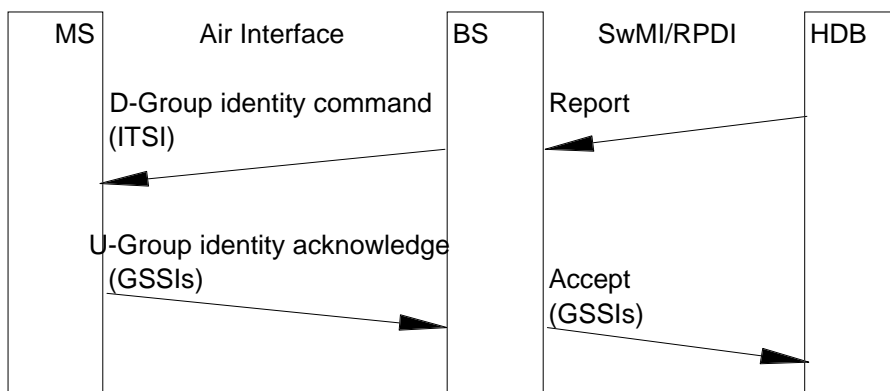


Figure 66: Reporting current group identities (GSSI) to the network

9.8 Exception conditions

9.8.1 Undisciplined de-registration

Prior to changing the ITSI of a subscriber, the "old" ITSI shall be detached. Failure to do so will result in two identical ITSI operating in the TETRA network sharing one equipment identity. This will cause disturbance to the operation.

10 MLE mobility scenarios and functionalities

10.1 Introduction

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

10.2 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, that is to keep track of the movements of the MS, or the functions may be applied to recover MLE connections between a MS and the SwMI during cell re-selection. The functions may also assist the recovery of communications (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 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.

10.3 MLE responsibilities

MS-MLE shall be responsible for the following:

- manage the scanning for suitable cells using the relevant LAs 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 LAs;
- invite MM entity intervention if a suitable cell is outside RA, whereby MM is envisaged to perform the registering procedure.

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

- manage the announced cell re-selection;
- manage the unannounced cell re-selection;
- 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;
- advise the higher layer 3 entities when an existing MLE connection has been terminated due to a lower layer failure;
- advise the higher layer 3 entities by the time MLE service is required, that due to ongoing cell re-selection service is not available;
- 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 SwMI 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 summarized in the following list:

- initial cell selection;
- announced cell re-selection type 1 by roaming;
- announced cell re-selection type 2 by roaming;
- announced cell re-selection type 3 by roaming;
- unannounced cell re-selection by roaming;
- undeclared cell re-selection by roaming;
- announced cell re-selection type 1 by migrating;
- announced cell re-selection type 2 by migrating;
- announced cell re-selection type 3 by migrating;
- unannounced cell re-selection by migration;

- undeclared cell re-selection by migration;
- no MLE recovery.

10.4 MS-MLE model

In the scenarios that follow, the LCMC SAP is taken as an example of an LXX SAP. The services offered to the LCMC SAP during the scenarios that follow may be the same as for the other LXX SAPs. In particular, interactions for the circuit-mode service (V+D only) with the CMCE through the LCMC-SAP become:

- interactions with the CONP through the LCO-SAP;
- interactions for the connectionless packet service with the S-CLNP through the LSCL-SAP.

For each scenario examined, two perspectives are considered:

- LMM SAP perspective (see figure 67);
- LCMC SAP perspective (see definitions and figure 67).

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

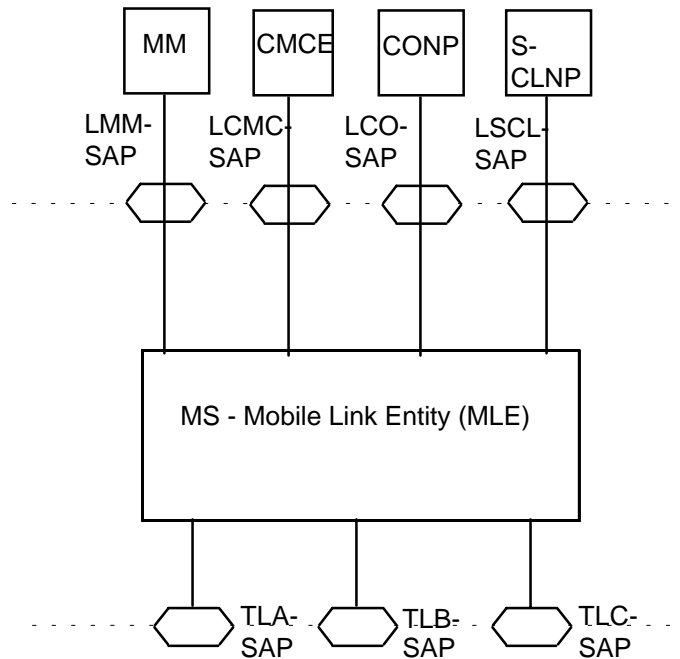


Figure 67: SAPs offered to the MS MLE

10.5 MLE functionalities

The overall mobility functionalities as outlined in figure 67 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 (SwMI/MS - side);
- 5) closing MLE services (SwMI/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 (SwMI - side);
- 11) initiating MLE broadcast (SwMI - side);
- 12) MM registering (MS - side);
- 13) announce old cell and to-to-channel (MS/SwMI - side);
- 14) announce old cell (MS/SwMI - side);
- 15) announce new cell and successful restoration (MS/SwMI - side);
- 16) announce new cell and restoration failure (MS/SwMI - side);
- 17) path lost to the serving cell (MS - side).

10.5.1 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 and the monitor function are described in ETS 300 392-2 [17], clause 23. 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 C_2 for the concerned cell should be passed as a parameter. Based upon the individual C_2 results from each of the neighbour cells, the MS-MLE should build a ranking list. The scenario is outlined in figure 68.

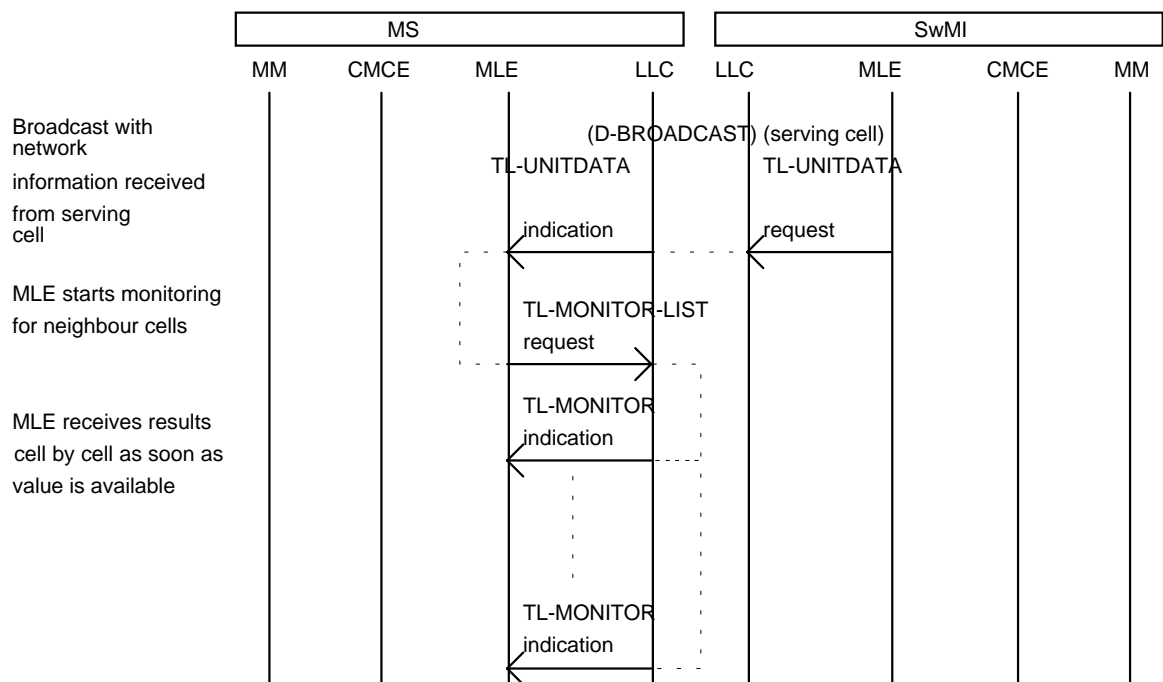


Figure 68: Monitoring of neighbour cells (Scenario 1)

10.5.2 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 utilized at the lower layers. The measurement methods applied to the scanning may be:

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

The measurement methods are described in ETS 300 392-2 [17], clause 23. Based upon the TL-SCAN request primitive parameters, the lower layers should be instructed to perform power measurements and to synchronize and read the information from the SYNC broadcast and the SYSINFO broadcast. When the lower layers have finalized 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 C_1 .

From now on, the path loss parameter C_1 shall be returned in a TL-SCAN-REPORT indication primitive every time the monitor process (scenario 1, figure 68) 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 C_1 parameter.

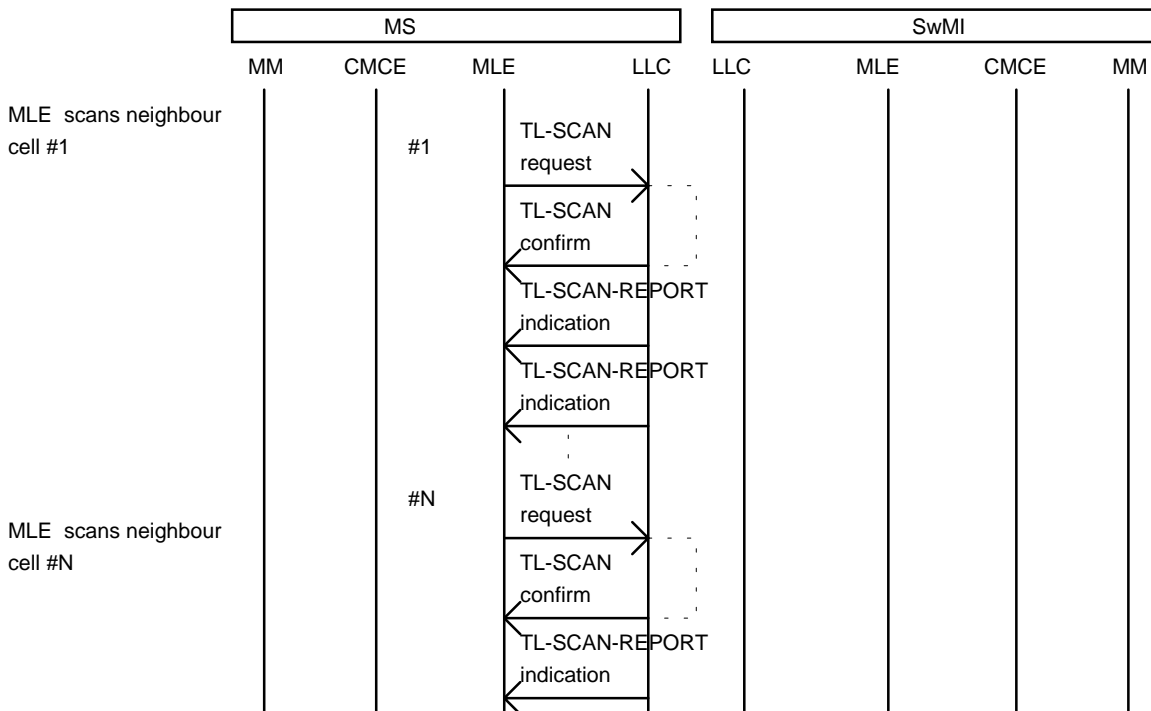


Figure 69: Scanning of neighbour cells (Scenario 2)

10.5.3 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 LAs 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 LAs.

The MS-MLE then should start scanning procedure according to subclause 10.5.2 and when a suitable cell is found, the selection procedure according to subclause 10.6 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 ETS 300 392-2 [17], clause 23.

NOTE: The activation of the MS-MLE may start with monitoring according to scenario 1 (see figure 68). 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 inform 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.

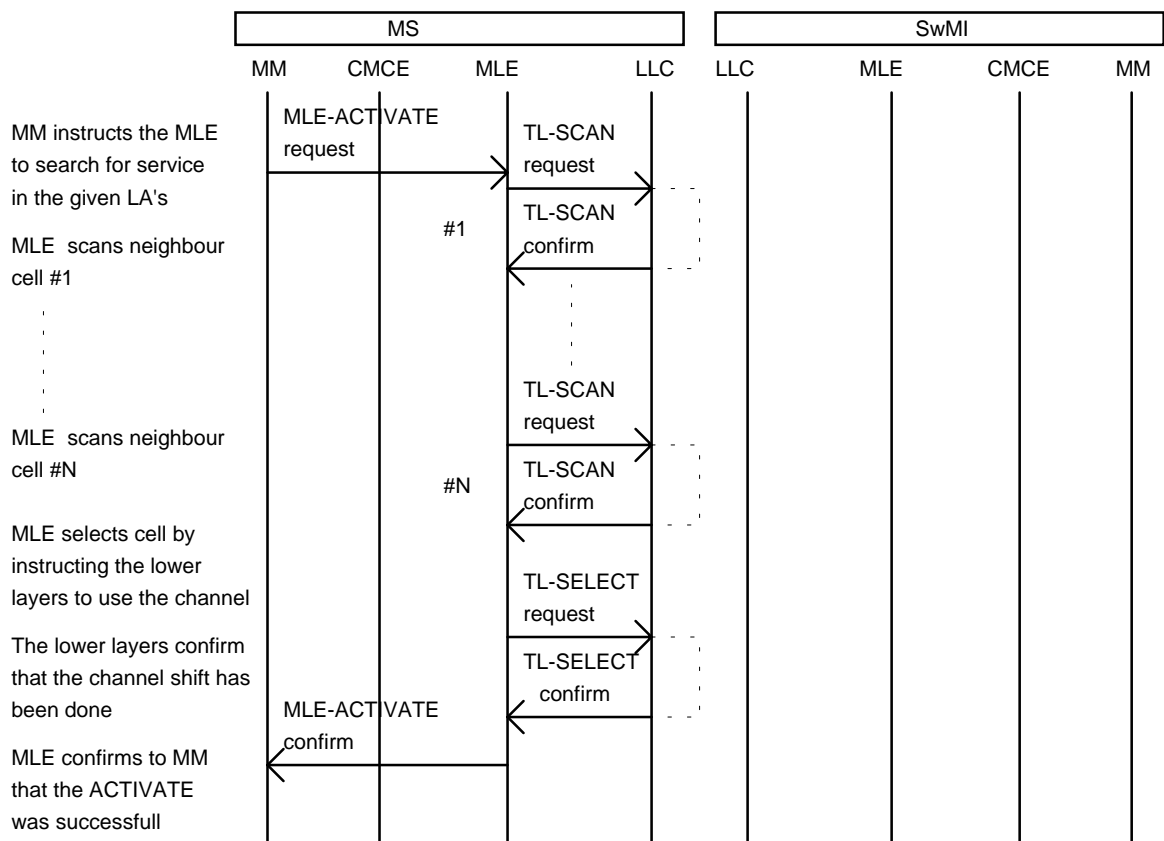


Figure 70: MM activation of the MS-MLE (Scenario 3)

10.5.4 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 SwMI. In order to synchronize the events, signalling between the MM entities in the MS and in the SwMI 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 SwMI-MLE should issue a MLE-OPEN indication primitive to their service users, e.g. CMCE, CONP and S-CLNP. After this sub-function is performed, the MLE service users should have access to the communication resources.

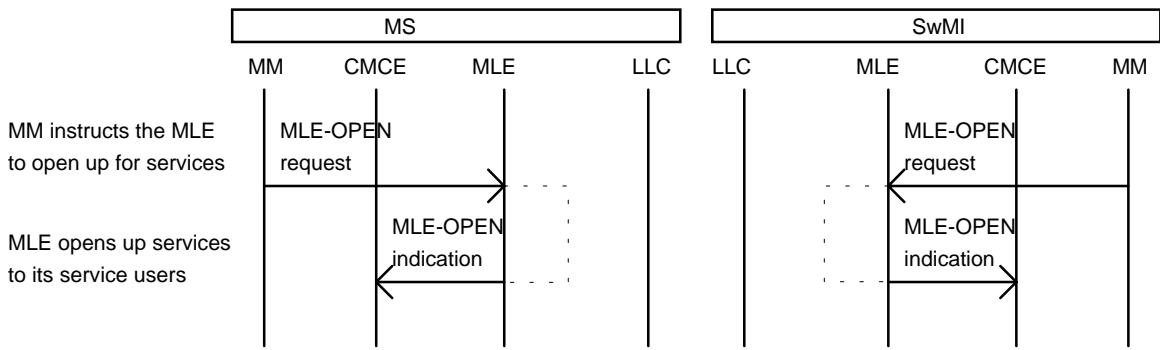


Figure 71: Open up MLE services (Scenario 4)

10.5.5 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 SwMI. In order to synchronize the events, signalling between the MM entities in the MS and in the SwMI 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 SwMI-MLE should issue a MLE-CLOSE indication primitive to their service users, e.g. CMCE, CONP and S-CLNP. After this sub-function is performed, only the MM entity shall have access to the communication resources. All other MLE SAPs shall be closed.

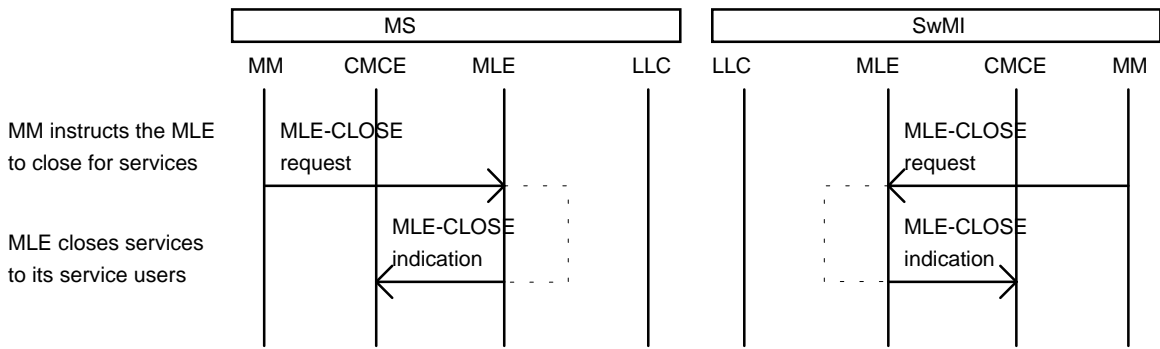


Figure 72: Close of MLE services (Scenario 5)

10.5.6 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.

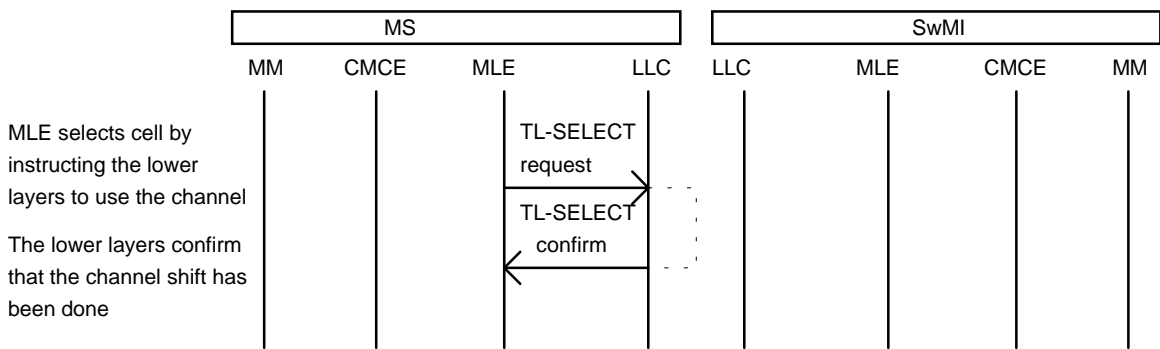


Figure 73: Changing to serving cell (Scenario 6)

10.5.7 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 utilizing 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 SwMI-MLE. The quality parameters in the TL-MEASUREMENT indication primitives should also contain the calculated path loss C_1 (refer to ETS 300 392-2 [17], clause 23) and may also 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 also contain network information related to the serving cell.

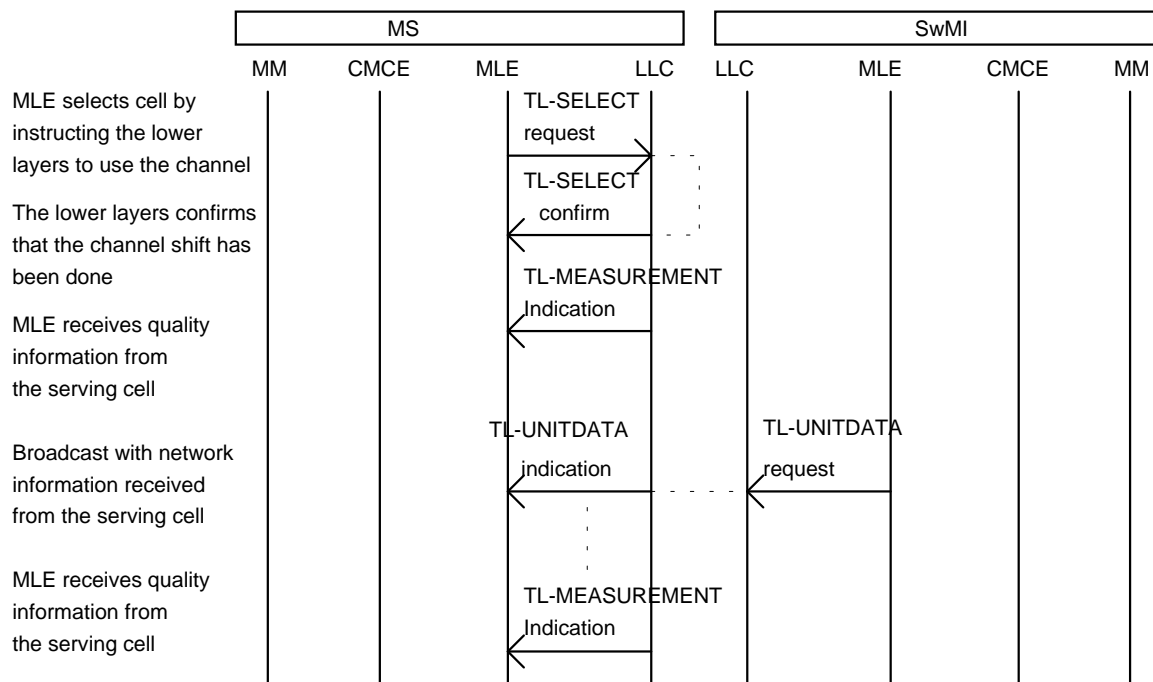


Figure 74: Surveillance of the serving cell (Scenario 7)

10.5.8 Inviting MM intervention

10.5.8.1 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 LAs. 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 LA, 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 10.5.3.

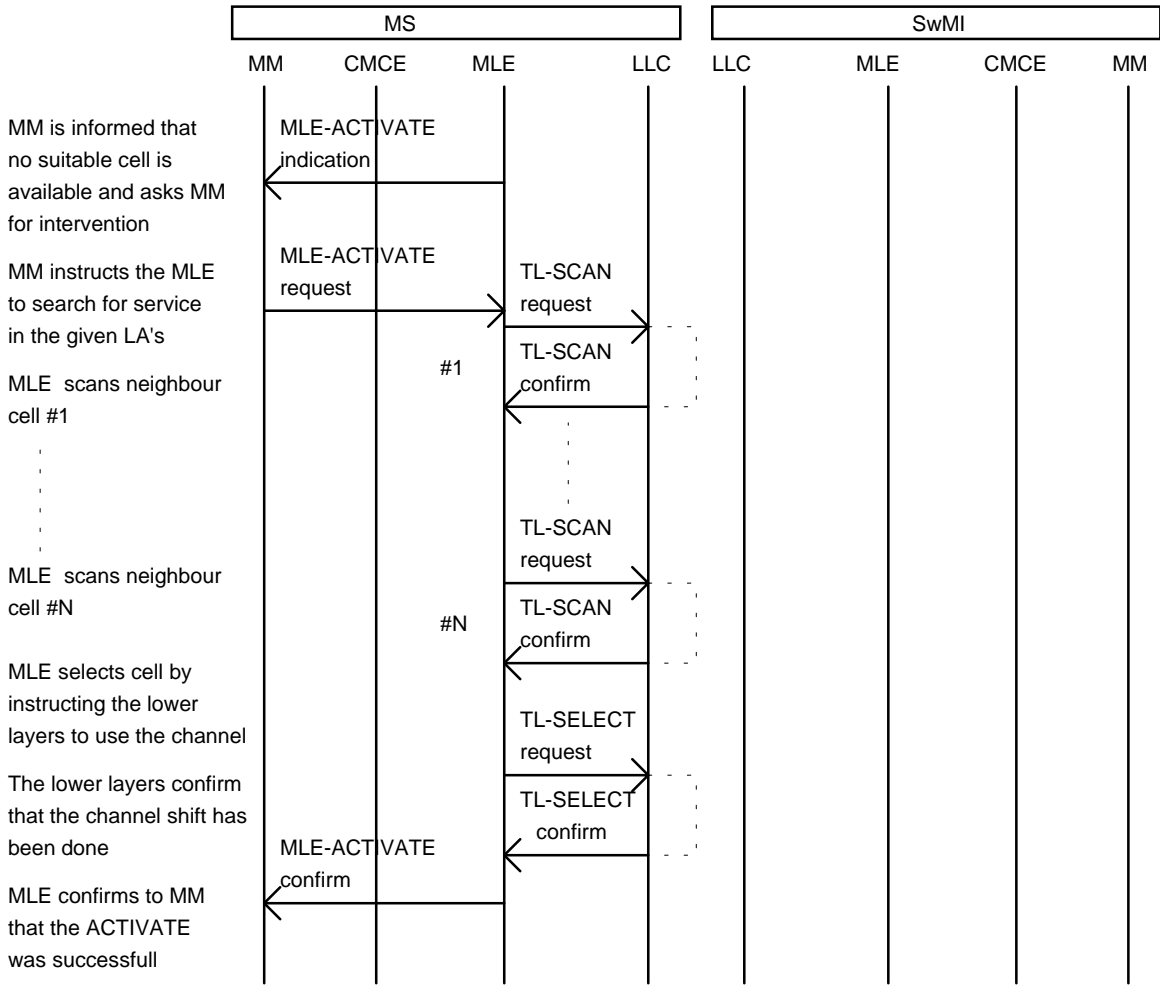


Figure 75: Inviting MM intervention - no service can be found (Scenario 8)

10.5.8.2 LA found outside RA (Scenario 9)

When MS-MLE finds a cell in a LA which is outside the current RA, it should invite MM entity intervention. As soon as the MS-MLE has discovered that the obtained LA is outside the RA, it should send a MLE-LINK indication primitive to the MM entity. The new LA 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 10.5.11 and according to clause 9. When the MM is satisfied with the new LA, it should send a MLE-UPDATE request primitive to the MS-MLE with the new RA in which the MS-MLE is empowered to search for service.

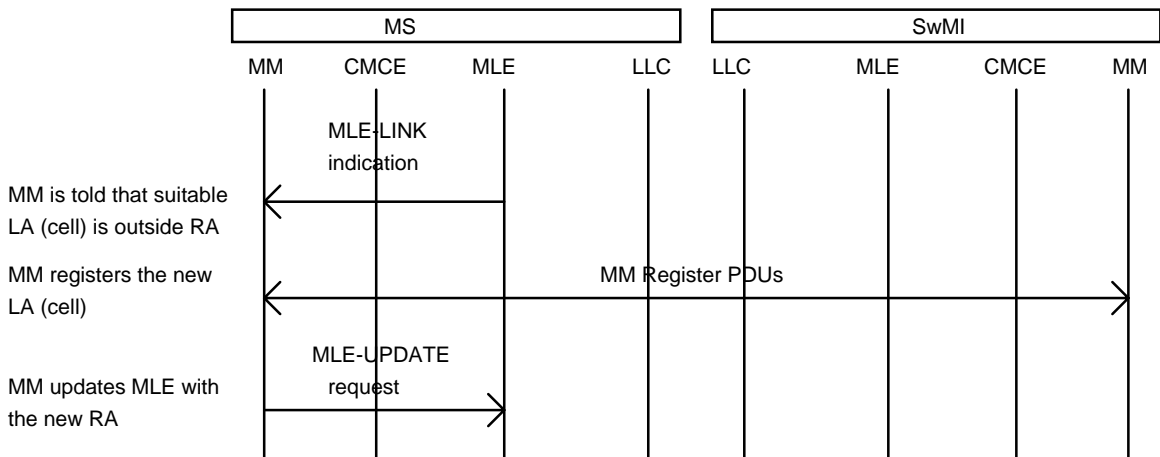


Figure 76: Inviting MM intervention - LA outside RA (Scenario 9)

10.5.9 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 10.5.7) and the scanning sub-function (see subclause 10.5.2). The SwMI-MLE should provide network information to the lower layers for broadcasting by issuing a TL-SYNC request primitive and a TL-SYSINFO request primitive.

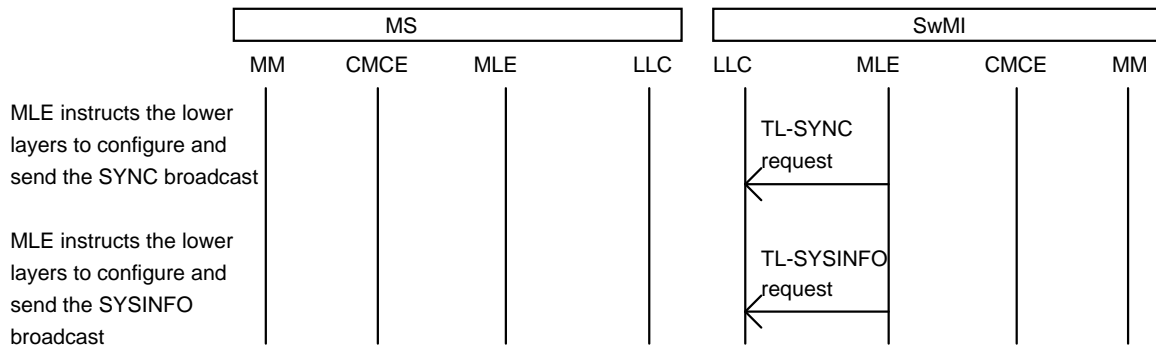


Figure 77: Set-up of MAC broadcast (Scenario 10)

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

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

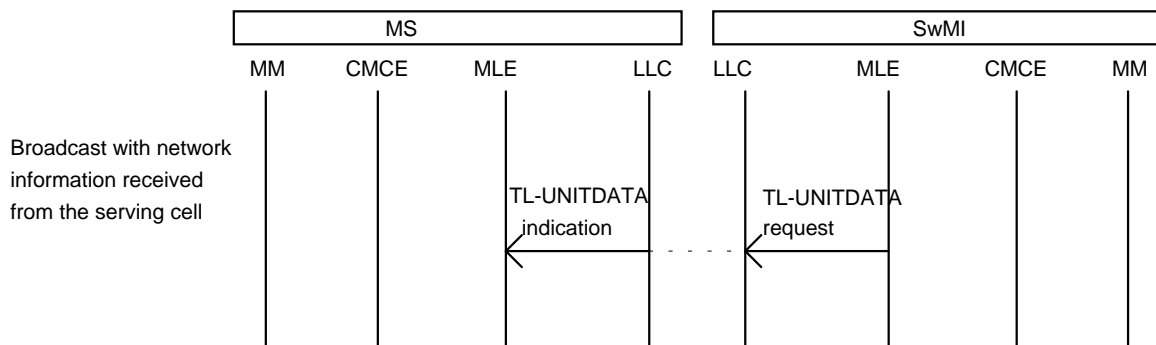


Figure 78: Set-up of MLE broadcast (Scenario 11)

10.5.11 MM registering (Scenario 12)

The MM entity may register without being triggered from the MS-MLE. When these procedures are applied (see clause 9) and when the MM is satisfied with the registering, the MS-MLE should receive a MLE-UPDATE request primitive with the new RA. The MS-MLE shall be empowered to search for service in the new RA.

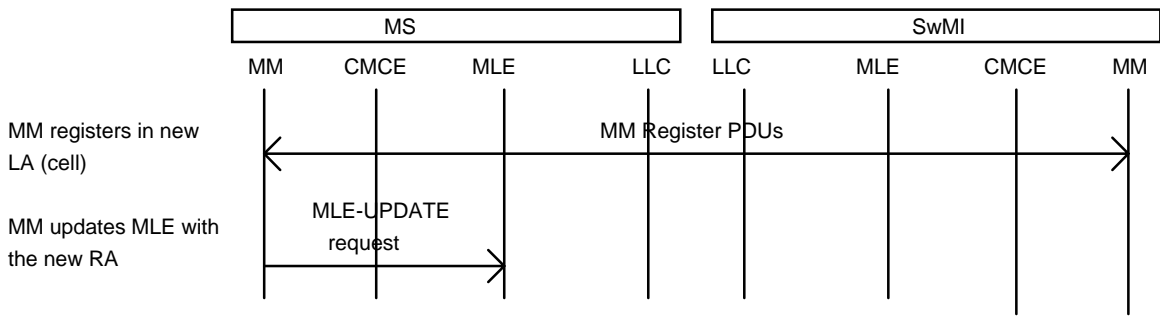


Figure 79: MM registering (Scenario 12)

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

Before announcing the SwMI-MLE, the MS-MLE shall issue a MLE-BREAK indication to the CMCE entity.

The MS-MLE shall then issue a <U-PREPARE CELL> PDU. This shall inform the SwMI-MLE that the MS intends to move to the new cell. The identity of the new cell shall be contained in the <U-PREPARE CELL> PDU. On receipt of the <U-PREPARE CELL> PDU, the SwMI-MLE should issue a MLE-BREAK indication primitive to the CMCE entity.

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

The SwMI MLE should then issue a <D-CHANGE CELL> PDU. This PDU should be transmitted through the existing cell and is piggybacked with lower layer information identifying a traffic channel in the next cell, e.g. a go-to-channel. After the <D-CHANGE CELL> PDU, no further communications are expected in the cell being disused. In the new cell, the configuration of logical channels (e.g. a traffic channel and associated control channels) available to the MS should enable the MS to preserve any connections which were established prior to the initiation of a cell re-selection.

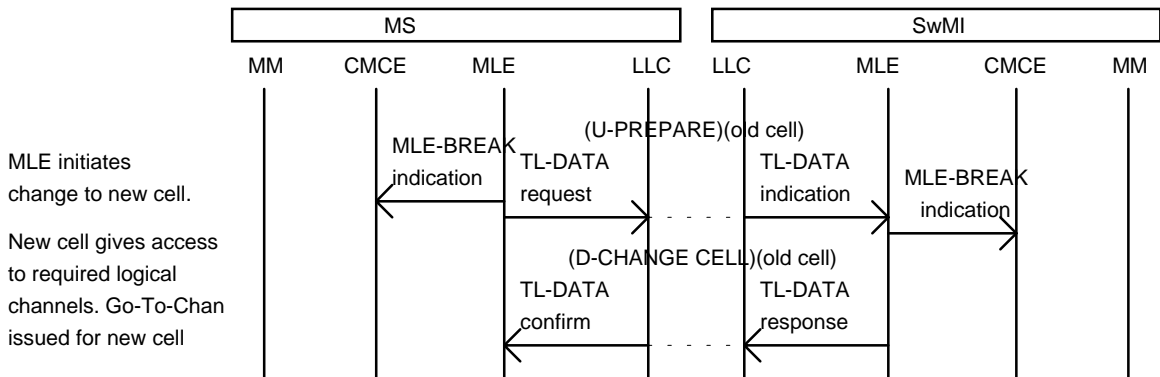


Figure 80: Announce old cell and go-to-channel (Scenario 13)

10.5.13 Announce old cell (Scenario 14)

Before announcing the SwMI-MLE, the MS-MLE shall issue a MLE-BREAK indication to the CMCE entity.

The MS-MLE shall then issue a <U-PREPARE CELL> PDU. This shall inform the SwMI-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 SwMI-MLE should issue a MLE-BREAK indication primitive to the CMCE entity.

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

The SwMI 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.

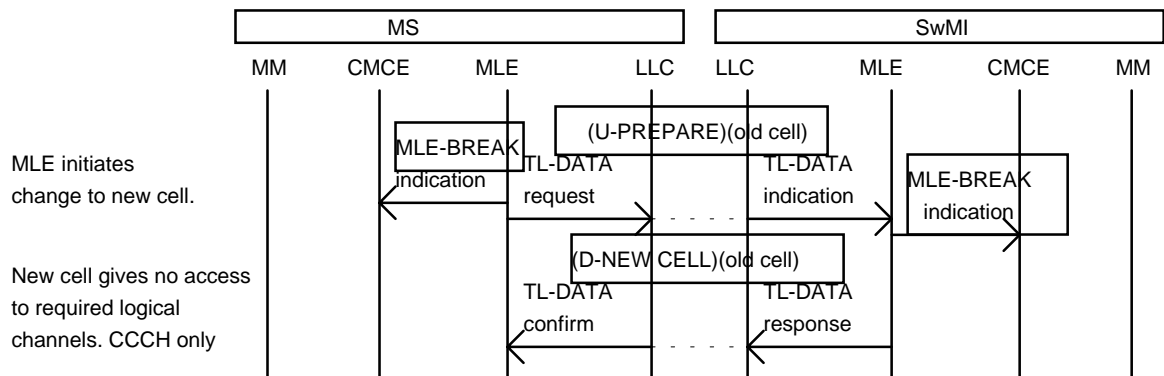


Figure 81: Announce old cell (Scenario 14)

10.5.14 Announce new cell and successful restoration (Scenario 15)

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

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

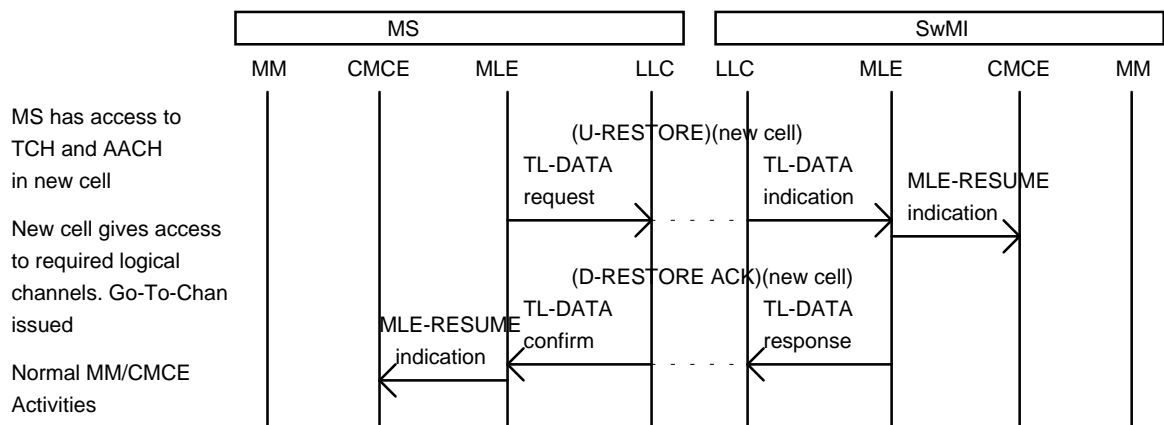


Figure 82: Announce new cell and successful restoration (Scenario 15)

10.5.15 Announce new cell and restoration failure (Scenario 16)

The MS-MLE shall send a <U-RESTORE> PDU to the SwMI using the new cell. This shall indicate to the SwMI-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 SwMI-MLE is unable to restore the connection to the MS in the new cell, the SwMI-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 SwMI MLEs shall issue a MLE-REOPEN indication primitive to the CMCE entity.

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

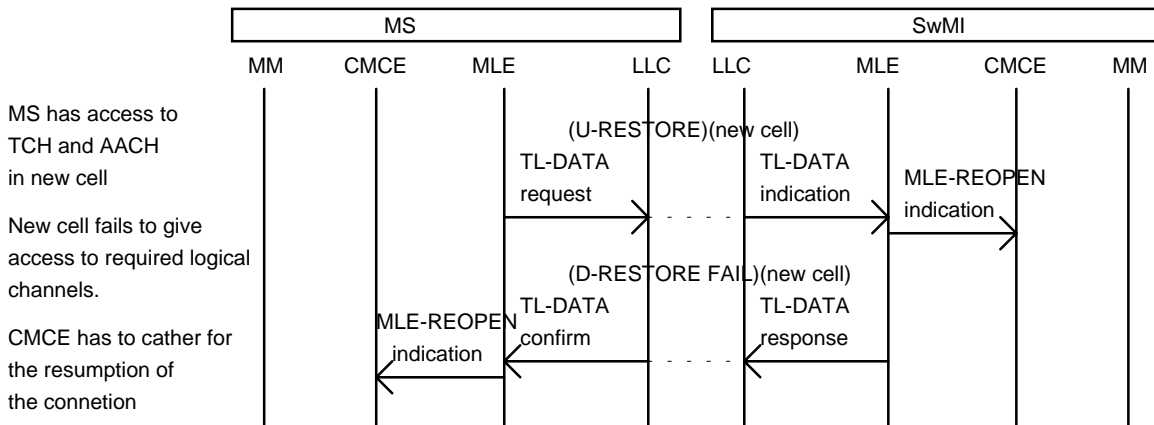


Figure 83: Announce new cell and restoration failure (Scenario 16)

10.5.16 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.

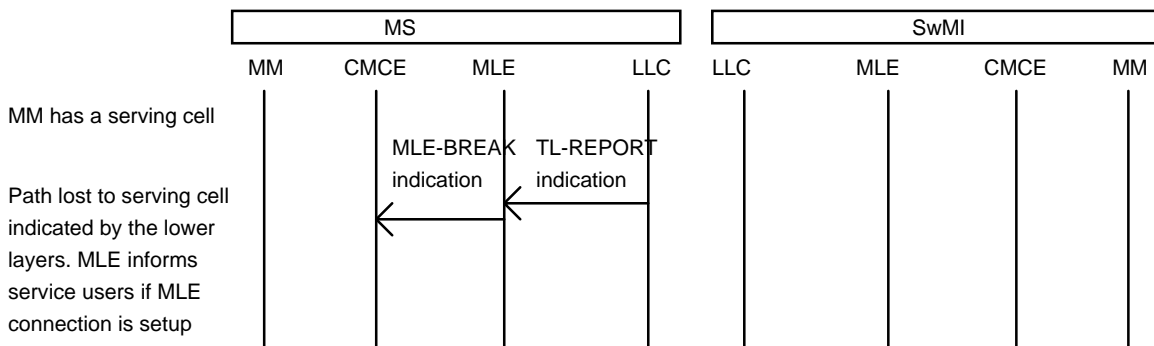


Figure 84: Path lost to the serving cell (Scenario 17)

10.6 Initial cell selection

While moving from cell to cell, the MS can 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 LA are unknown. The initial LAs 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 SwMI 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.

10.6.1 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 70).

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 RA by a MLE-UPDATE request primitive. Finally the MM shall open up the services as described in scenario 4 (see figure 71).

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 LAs. The initial cell selection procedure should now start all over again.

10.6.2 MLE functions

The MS-MLE shall use scanning when initial cell selection is performed. The procedure in scenario 2 (see figure 69) 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 70).

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 71).

Now the MS-MLE may prepare the monitoring of neighbour cells (see scenario 7, figure 74).

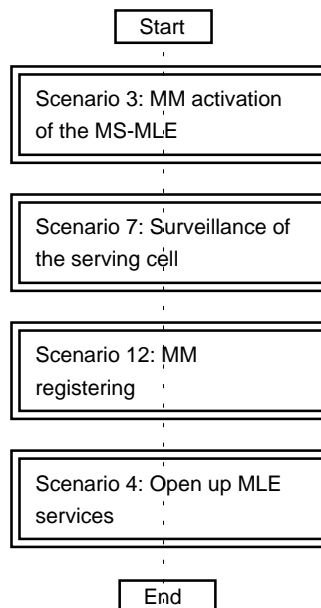


Figure 85: Initial cell selection

10.7 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 simply means that the cell re-selection shall be performed choosing a cell in another TETRA infrastructure (SwMI).

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 SwMI about the cell re-selection. It is assumed that migration shall lead to a change in LA.

10.7.1 Announced cell re-selection

When a 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 three different types of announced cell sub-functions for assistance of this overall procedure:

- type-1;
- type-2;
- type-3.

NOTE: A special case exists when the MS does not announce its decision to change cell to the old (leaving) cell. It may be due to external events such as loss of signal to the serving cell or it may be a controlled way of making cell re-selection. This case is known as the unannounced cell re-selection and is described in subclause 10.7.2.

10.7.1.1 Announced cell re-selection (type-1)

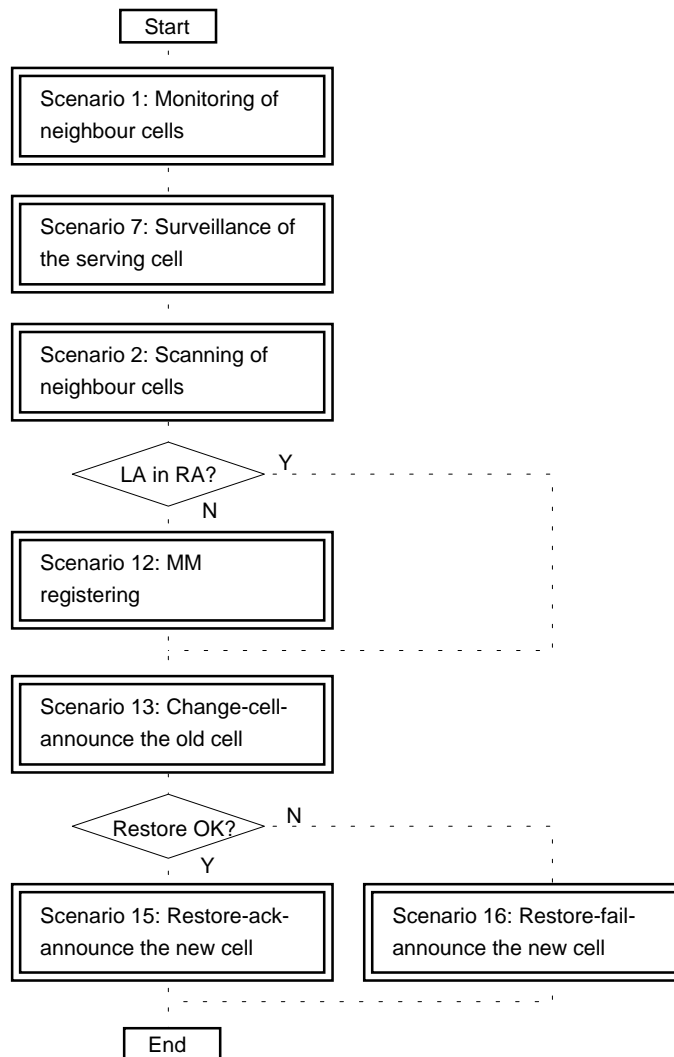


Figure 86: Announced type-1 cell re-selection

For the announced type-1 cell re-selection, the MS-MLE shall know the new Traffic Channel (TCH) in advance, e.g. before making the decision of changing to the new cell. The cell re-selection may then be performed "seamless", where the point of reference for the description "seamless" is the layer 3 service boundary.

The layer 3 service boundary is the sum of all the services offered by MM, CMCE, CONS, S-CLNS. This means that at this service boundary, the cell re-selection should not cause any significant interruption of services offered by existing MLE connections.

In order to achieve an announced type-1 cell re-selection, a "go-to-channel" message shall be issued in the present serving cell and direct the MS to one or more traffic channels in the new cell. This means that the announced type-1 cell re-selection can only be valid for a service user employing the MLE connection service.

10.7.1.1.1 MLE functions as viewed at the LMM SAP

When MM makes the activation of the MS-MLE, the parameters given by the activation shall be the LAs and preferred cells wherein the MS-MLE is empowered to search for service. By the activation, the MM should have also informed the MS-MLE of any rules for making the decision to change cell within the RA. The MS-MLE is empowered to initiate and perform changes from cell to cell within the RA, which is always maintained by the MM.

If the new cell is found suitable and it is a part of the current RA understood by the MS-MLE, the MM should not be involved at all in the cell re-selection procedure.

NOTE 1: If MS-MLE does not find a suitable cell, this should be reported to the MM, which then should instruct the MS-MLE to search for services in other LAs. The instruction should be initiated by a new activation of the MS-MLE (see subclause 10.5.8.1).

NOTE 2: If MS-MLE finds a suitable cell but it is outside the current RA, the MM should be informed. After the MM registering process is finished, the MS-MLE should be empowered to continue the cell change (see subclause 10.5.8.2).

10.7.1.1.2 MLE functions as viewed at the LCMC SAP

For announced type-1 cell re-selection to be meaningful to the CMCE service boundary, it is assumed that a MLE connection is set-up, i.e. to assist a circuit switched call re-establishment in the U-plane.

When the MS-MLE identifies a second cell in the same RA, which is preferred due to fulfilment of certain network parameters, the MS-MLE shall employ the change-cell-announce procedure described in scenario 13 (see figure 80) towards the current serving cell (old cell) and to all service users that have established a MLE connection. Once the cell change has been completed and the MLE connections have been re-established, the MS-MLE shall make a restore-cell-announce to the new cell according to scenario 15 (see figure 82).

NOTE: Service users that have not set-up a MLE connection in advance are not informed about the cell re-selection. However, if a MLE service is invoked during a cell re-selection, the service user should be informed about the current condition of the MLE - see subclause 10.9.

If the new cell is found suitable, but the MLE is unable to recover the MLE connection to the new cell, the MLE shall re-open the service user SAPs as described in scenario 16 (see figure 83).

When the LCMC SAP has been re-opened, it shall be the CMCE responsibility to recover the ongoing call in the U-plane using CMCE protocol.

10.7.1.1.3 MLE functions

Before reaching the point where to decide to start the cell re-selection procedure, the survey scenario 7 (see figure 74) should have been employed beforehand by the MS-MLE. As output from the surveillance process, the MS-MLE should receive path loss measurements and network broadcasts.

Also the monitoring process shown in scenario 1 (see figure 68) should be employed by the MS-MLE beforehand. A concurrent ranking of neighbour cells shall take place based upon the output from the monitoring process.

When the quality of the serving cell is then deteriorating below a certain threshold, the MS-MLE may start the scanning for a new cell employing the scanning scenario 2 (see figure 69) or the MS-MLE may base the choice of cell on the current ranking performed by the monitoring process (scenario 1, see figure 68).

The cell ranking from the monitoring process and the rules which may have been given to the MS-MLE by the MM during a former activation shall be used as parameters to the scanning scenario.

The path loss for the scanned cell and the network parameters obtained from the SYSINFO broadcast and the SYNC broadcast (ETS 300 392-2 [17], clause 23) shall be used as output from the scanning process.

If the new cell is found to be in the same RA and the MS-MLE has approved the quality information available for the new cell, the MS-MLE should decide to change to that cell and employ the change-cell-announce procedure for the old serving cell as described in scenario 13 (see figure 80). If MS-MLE is satisfied with the received information regarding the new cell, the MS-MLE should employ the restore-announce in the new cell as outlined in scenario 15 (see figure 82). The result of the restore-announcement in the new cell may either be successful or it may fail.

When the announced cell re-selection type-1 has finished, the MS-MLE should start the monitor sub-function in the new cell, as described in scenario 1 (see figure 68).

10.7.1.2 Announced cell re-selection (type-2)

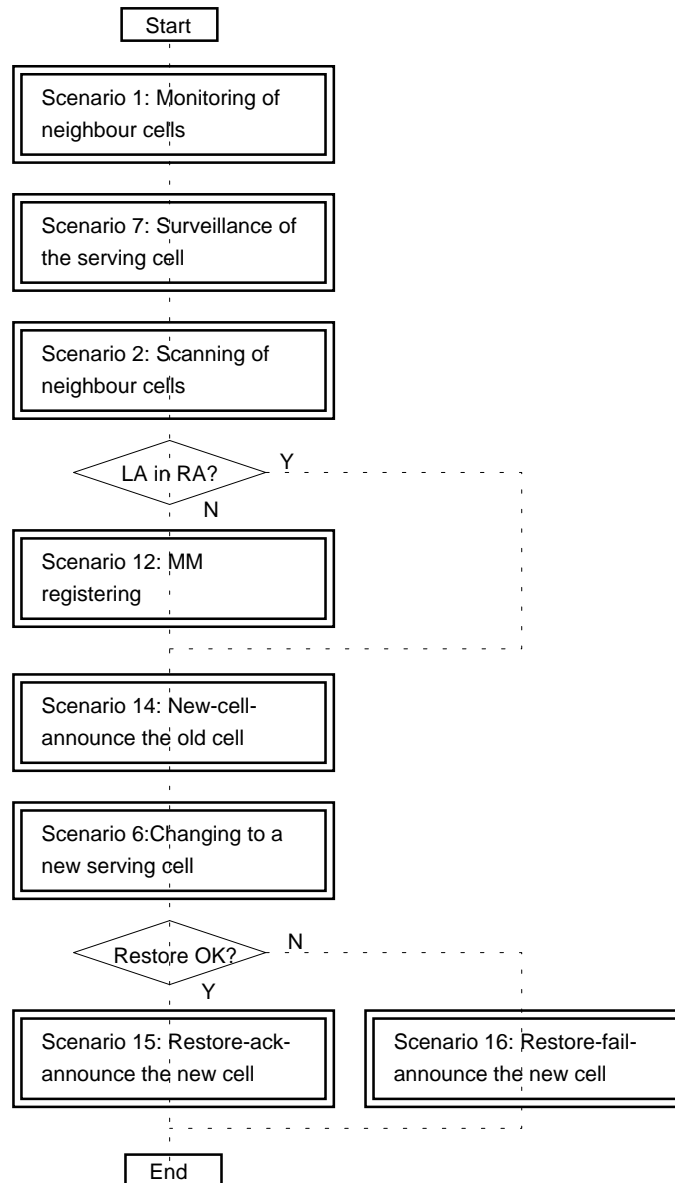


Figure 87: Announced type-2 cell re-selection

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 organization on the new cell before making the decision to change cell.

NOTE: The reason to utilize this type-2 announcement may be because the SwMI 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.

When employing the announced type-2 cell re-selection procedures, the MLE shall perform the same procedures as described in subclause 10.7.1.1.1 except for fact that when the MS-MLE decides to change to the new cell, it shall employ the new-cell-announce procedure for the old serving cell (described in scenario 14, see figure 81) instead of the change-cell-announce procedure. The restore-cell-announcement in the new cell shall be the same as described in subclause 10.7.1.1.

Figure 87 shows the scenarios sequence for the announced type-2 cell re-selection. The shaded scenarios are those which are in addition or in another order compared with figure 86 and which characterize this type of cell re-selection.

10.7.1.3 Announced cell re-selection (type-3)

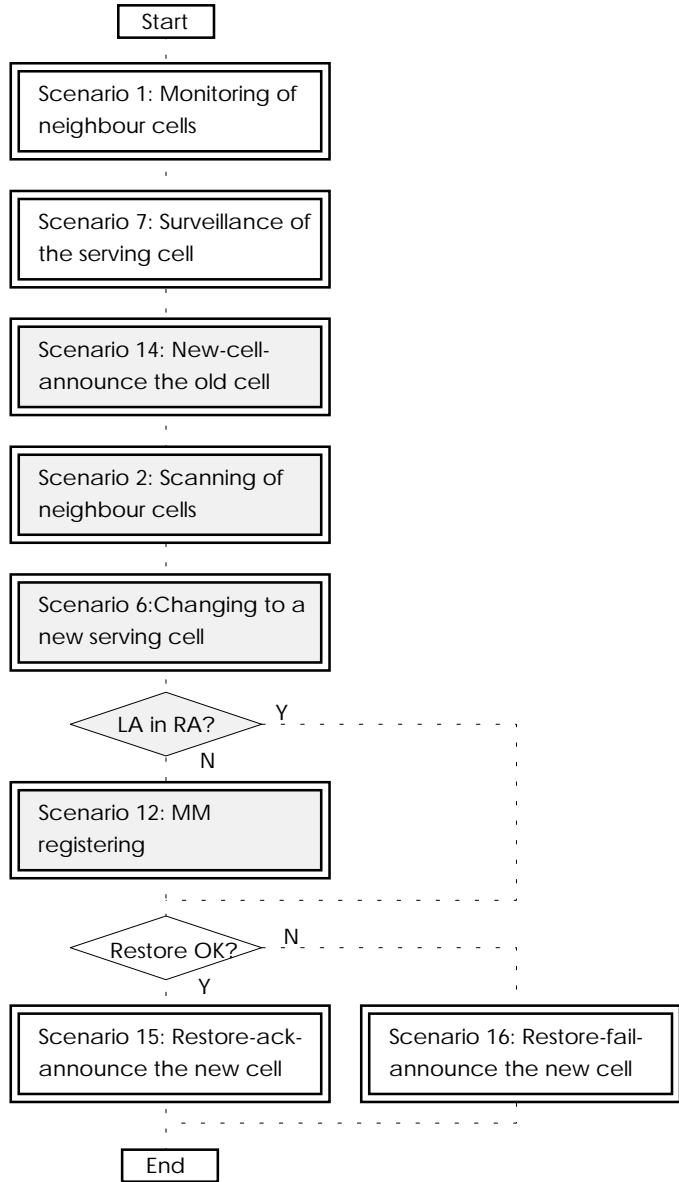


Figure 88: Announced type-3 cell re-selection

The announced type-3 cell re-selection implies that the MS-MLE does not know the new cell in 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.

10.7.1.3.1 MLE functions as viewed at the LCMC SAP

When MS-MLE decides to attempt to change cell based upon the quality information from the serving cell and the monitor information from the neighbour cells, new-cell announcement shall be performed in the old cell. Once the MS-MLE is satisfied with a new cell, restore-cell announcement shall be performed in the new cell.

10.7.1.3.2 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 figure 68 and figure 74). 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 69) is started. When a suitable cell is found, the MS-MLE shall change to the new serving cell according to scenario 6 (see figure 73).

Invitation of MM by MS-MLE depends on whether the new cell (LA) is within the current RA. If MM intervention is needed, MM registering scenario 12 (see figure 79) shall be applied.

Figure 88 shows the scenario sequence for the announced type-3 cell re-selection. The shaded scenarios are those which are in addition or in another order compared with figure 86, and which characterize this type of cell re-selection.

10.7.2 Unannounced cell re-selection

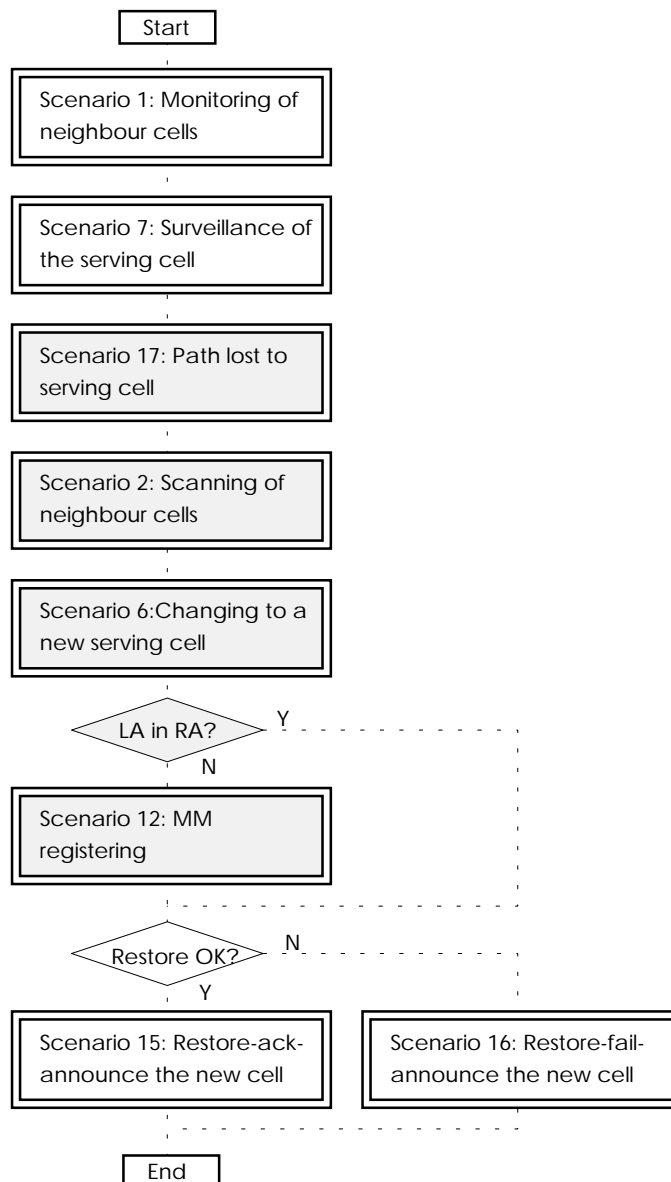


Figure 89: Unannounced cell re-selection

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 in 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 89 is for the unannounced 3 cell re-selection. The shaded scenarios are those which are in addition or in another order compared with figure 86, and which characterize this cell re-selection function.

10.7.3 Undeclared cell re-selection

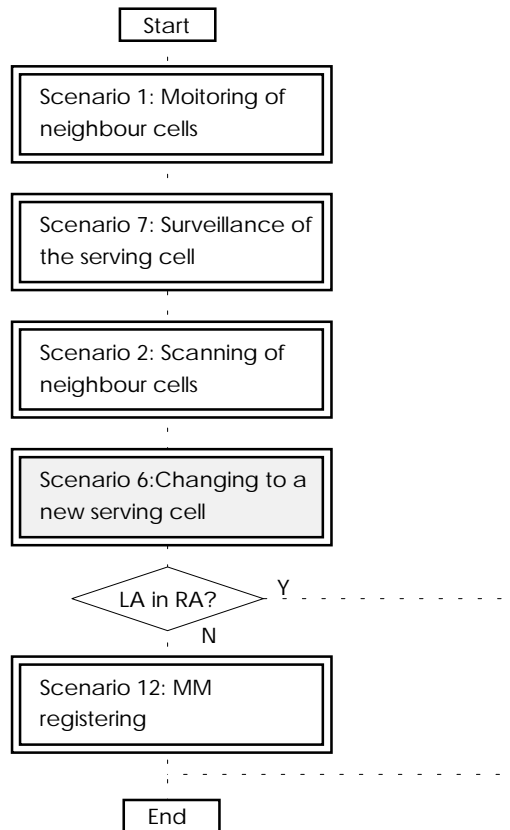


Figure 90: Undeclared cell re-selection

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 RA without contacting the SwMI.

10.7.3.1 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 69) is outside the current RA. The scenario 12 (see figure 79) may then apply according to the scenario sequence in figure 90. The shaded scenarios are those which are in addition or in another order compared with figure 86, and which characterize this type of cell re-selection.

10.8 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 91 may apply.

10.8.1 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.

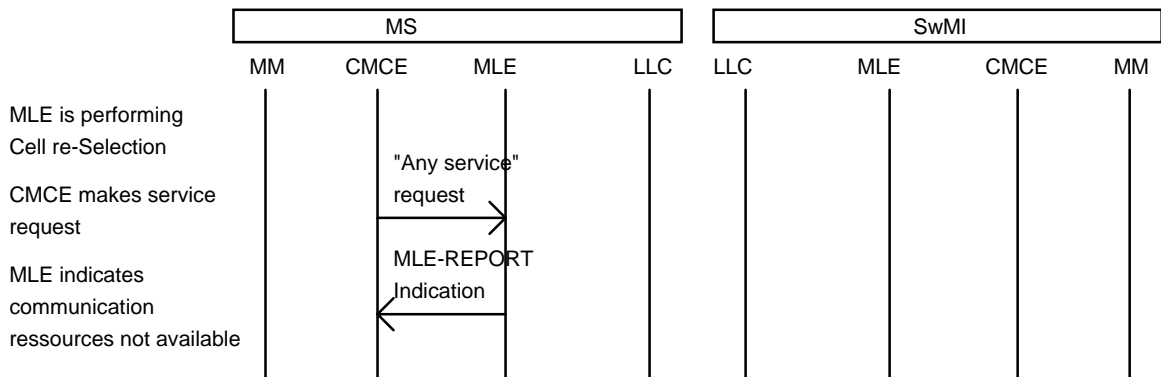


Figure 91: Service requests during undeclared cell re-selection

10.9 No MLE recovery

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

At the LCMC SAP, the MLE shall issue a MLE-BREAK indication primitive prior to the cell re-selection. After the cell re-selection is complete, the MLE shall apply the restore-fail announcement scenario issue a MLE-REOPEN indication primitive.

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

10.10 Use of LLC

The SwMI-MLE can use multiple LLCs simultaneously to provide links to different endpoints.

The MS-MLE can use multiple LLCs to support concurrent and different kinds of services.

Each LLC may offer two different types of logical links (basic link and advanced link) between one MS and one cell. A basic link and an advanced link shall provide different services to the MLE, which then may choose to use either of them based upon the type and the size of the MLE SDU and the quality parameters associated.

10.10.1 MS-MLE using the LLC basic link

Whenever a MS has registered and all mobility management activity is finished, the MS shall be attached to the SwMI.

The SAPs towards the MLE service users shall be opened, indicating that the communication path to the SwMI is available.

When a MS is attached to a SwMI the MLE shall have a basic link available from the LLC. This link has certain characteristics that the MLE shall recognize and use whenever the MS-MLE service users want to communicate with the SwMI. This basic link should be chosen using a set of decision parameters, which may be:

- the type of SDUs received on the MLE SAPs;
- the size of the SDUs delivered on the MLE-SAPs;

- other parameters available.

10.10.1.1 Basic link and connectionless MLE service

Figure 92 shows a MS attached to the SwMI and a MLE-UNITDATA is sent to the SwMI using the basic link of the LLC. The MLE-UNITDATA may originate from the S-CLNP entity and is examined in the MLE to be of limited size.

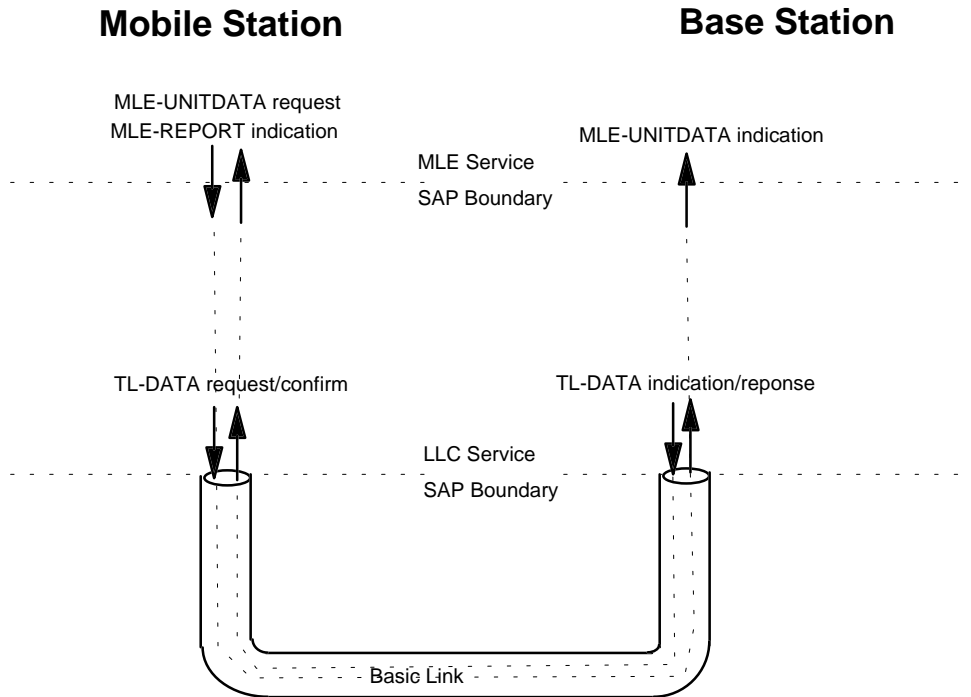


Figure 92: MLE utilizing the LLC basic link

10.10.1.2 Basic link and MLE connections

If a better service is desired from the MLE Service Users point of view, a MLE connection may be established. The connection is not a real connection, but simply an association both on the MS side and on the SwMI side. Establishing a MLE connection forces the MLE to synchronize the transportation of data with MLE controlled functions, such as cell re-selection.

The connection may be established at any time and removed when no use is required by using MLE-CONNECT and MLE-DISCONNECT primitives. The owner of the connection is the MLE service user who has established the connection. When establishing a connection, a connection identifier should be allocated and associated locally to the MLE. This connection identifier, which is provided to the MLE service users, should then be used hereafter whenever data is sent or received on this particularly MLE connection.

Figure 93 shows a MS attached to the SwMI and three MLE connections have been established. These connections may have been created by the CMCE. In order to create a MLE connection, MLE-CONNECT request shall be sent to the MLE. The connection identifier is returned in the MLE-CONNECT confirm. Hereafter only MLE-UNITDATA is necessary to send until MLE-DISCONNECT request is requested in order to break the MLE connection.

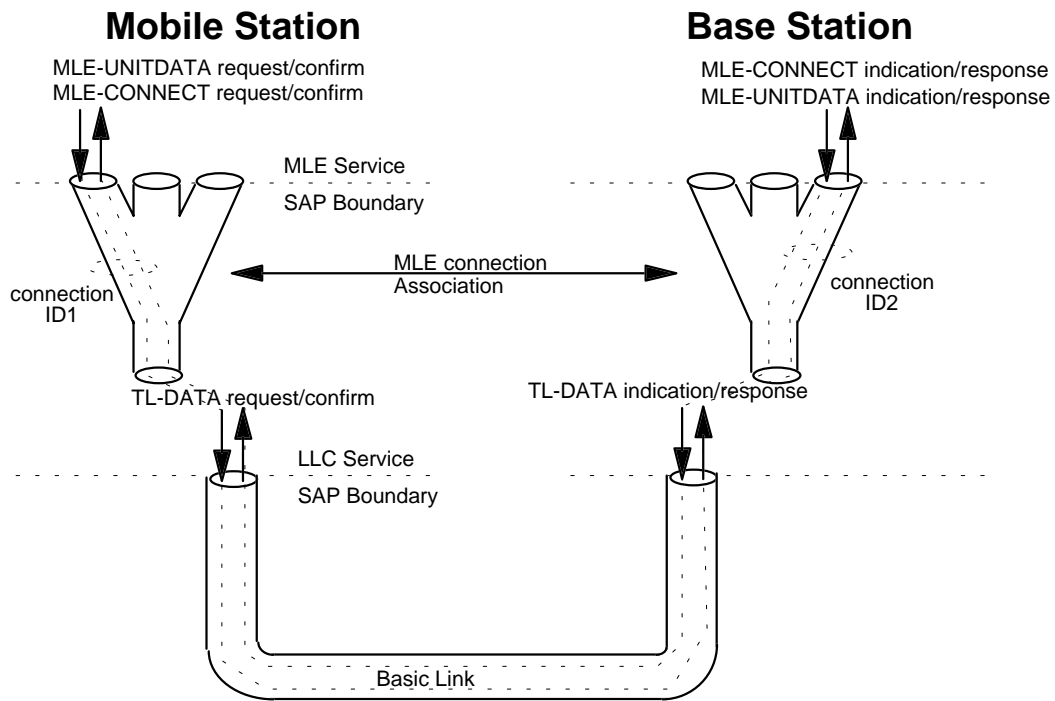


Figure 93: MLE attached and connections established

10.10.2 MS-MLE using the LLC advanced link

If the MLE receives a SDU from the service users that is considered not to be suitable for the LLC basic link, the MLE should create an advanced link on the LLC to the SwMI. The decision to deny access to the LLC basic link should be taken using the previously defined decision parameters.

Basically there are 2 reasons to create the advanced link:

- 1) the grade of service offered from the basic link results in very long transmission time, if packet size is too big. The advanced link will provide better grade of service, which will decrease transmission time and increase efficiency (throughput);
- 2) the load of the air interface, which is a precious resource, is increasing due to the acknowledgement scheme associated to the basic link. On the advanced link windowing will utilize the air interface in a more efficient way.

10.10.2.1 Advanced link and connectionless MLE service

Figure 94 shows a MS attached to the SwMI and a MLE-UNITDATA is sent to the SwMI using the advanced link of the LLC. The MLE-UNITDATA may originate from the CONP entity and is examined in the MLE to be too big in size.

Before using the advanced link on the LLC, the MLE shall create it since it is not present by default when attachment to the SwMI is performed. This creation shall be done by using TL-CONNECT request/confirm primitives. For the very first creation, this primitive can be used for transporting the MLE-UNITDATA PDU to the peer entity.

As long as the MS is attached to the SwMI using the same cell, the advanced link shall be available permanently after creation unless a TL-DISCONNECT is used to remove it. A MLE-DISCONNECT issued from the MLE service user or an automatically time out mechanism may be applied in order disconnect the advanced link.

Mobile Station

Base Station

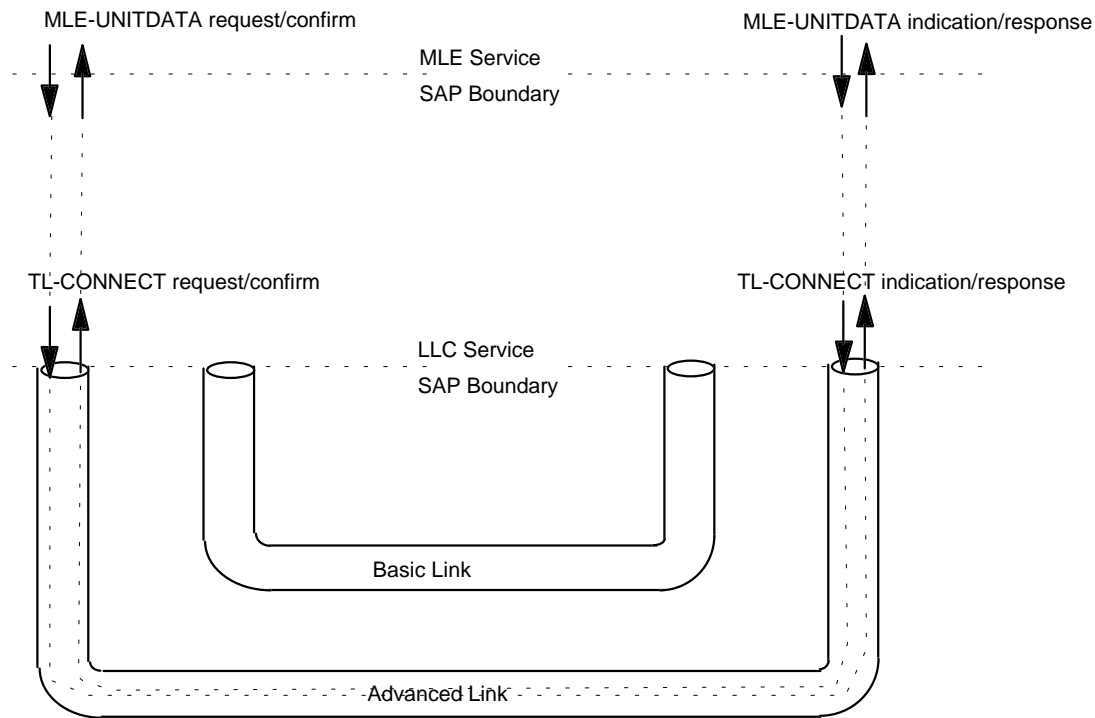


Figure 94: MLE utilizing the LLC advanced link

10.10.2.2 Advanced link and MLE connection

The MLE has also a choice of using the advanced link offered by the LLC based on the decision parameters defined previously.

NOTE: The QoS parameters negotiated at higher layers may also be the reason to choose the advanced link if the basic link is not capable of providing the necessary assistance.

11 Technical realisation of SDS

11.1 Introduction

This clause specifies the technical realization of the SDS on the network layer of the air interface, i.e. specifying:

- an overview of the architectural organization of the network layer, focusing on the short data entity;
- the services provided for the user of the SDS defined as primitives and parameters at the network layer SAP;
- the protocol function of the Short Data Protocol (SDP) defined as the encoding of the Protocol Data Units (PDU) and the descriptions of the related state machines.

11.2 General

The SDS is a message service which shall be optimized to be a quick service enabling the user to exchange a short user defined message or a short pre-defined message - e.g. emergency message. The message can be sent or received in parallel with an ongoing speech call.

In order to obtain a fast service, the SDS-message shall be carried or embedded in a single up link transmission, e.g. one transfer unit. The SDS shall apply to the random access procedure which implies

that the transfer unit shall be equal to half a TDMA slot. However, a double random access may be needed if full TSI addressing is chosen. Two half TDMA slots shall then be utilized.

The service shall comprise point-to-point and point-to-multipoint capabilities and shall have a limited number of data bits available for the user, depending on the addressing method used, i.e. Short Number Addressing (SNA), full TETRA Subscriber Identity (ITSI/GTSI) and Short Subscriber Identity (SSI) addressing. The relation of address method and SDS data length is an optimisation issue only.

The service shall not provide end to end acknowledgement, but shall use acknowledged services from the lower layers in order to obtain a more reliable transmission on a per hop basis.

Supplementary services defined in the CMCE associated with the SDS may be applied. The services shall not be invoked or activated by the SDS entity itself, but in order to be applicable, the services shall be invoked or activated in advance by other means. However, some supplementary services, i.e. SNA, priority and Area Selection (AS) may be invoked by the short data message itself.

Within the SwMI, storage capability may also be available. However, the management of the storage is beyond the scope of this ETS.

11.3 Internal organization of the network layer

The short data protocol entity shall reside on the layer 3 and should be a sub-entity in the circuit mode control entity. The service modelling and the network modelling is carried out with respect to this relationship throughout this ETS.

11.3.1 Service model

The service model describes the SDS from the perspective of the SDS-SAP as illustrated on figure 95. In order to send a short data message, the user shall send a request to the layer 3 SDS. When the request has been sent on the first link, a report indication shall be returned to the user with an indication of send-success or send-failure. At the receiver side, the short data message shall be seen as an indication.

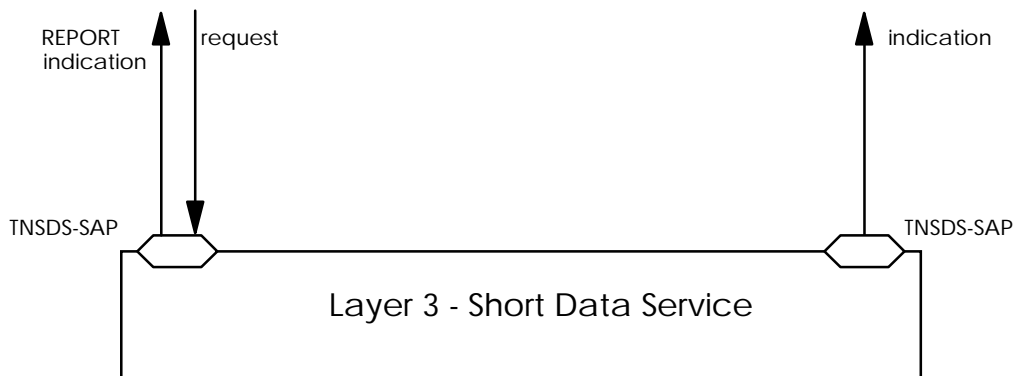
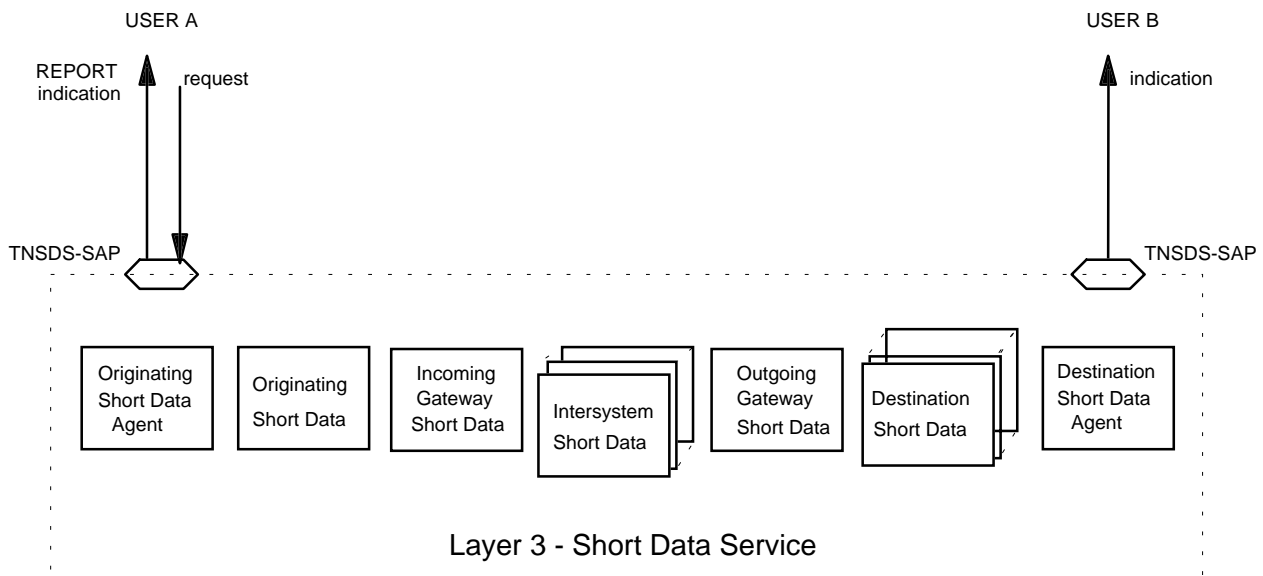


Figure 95: Service model for SDS

11.3.2 Network model

The layer 3 SDS entity may be broken down into a number of functional entities, each of them having special functional capabilities, in order to transport the message and provide the service for the user. In figure 96, the different functional entities are shown. Not all of them can be allocated within a message transfer. The ones which are not involved shall be idle.



NOTE: The functional entities shown are described in subclause 11.3.2.1. The use of the functional entities are described in subclause 11.3.3.

Figure 96: Network model for SDS

11.3.2.1 Description of the functional entities

Each functional entity shall comprise a set of entity specific functions:

NOTE: Priority is not valid in general for SDS but access priority may be applied.

- Originating Short Data Agent (OSDA) functional entity:
 - the OSDA shall be located both in the CMCE-MS and in the CMCE-LS;
 - it shall have capability to receive primitives and parameters from the user and send the information to the adjacent Originating Short Data (OSD) functional entity in the SwMI;
 - the following functional capabilities shall exist within the OSDA:
 - ability to send a user defined message limited in length;
 - ability to send a pre-defined message, e.g. emergency message;
 - ability to address a single point by using ISSI or ITSI address of the message receiver;
 - ability to address a multipoint by using GSSI or GTSI of the message receivers;
 - ability to address point-to-point or point-to-multipoint by using SDA;
 - ability to apply access priority to the message;
 - ability to apply 1 of 16 paging areas for the message receiver(s).

- Destination Short Data Agent (DSDA) functional entity:
 - the DSDA shall be located both in the CMCE-MS and in the CMCE-LS;
 - it shall have capability to receive information from the adjacent Destination Short Data (DSD) functional entity in the SwMI and then forward primitives and parameters to the user;
 - the following functional capabilities shall exist within the DSDA:
 - ability to receive a user defined message and relay it to the user;
 - ability to receive a pre-defined message and relay it to the user, e.g. emergency message;
 - ability to receive the ISSI or ITSI address of the message sender and relay it to the user;
 - ability to receive the priority applied to the message, and relay it to the user.
- Originating Short Data (OSD) functional entity:
 - the OSD shall be located in the CMCE-SwMI, e.g. in the BS at the message sender side in the SwMI;
 - it shall have the ability to receive information from the preceding OSDA functional entity in the MS or the LS and then forward requests to the subsequent Inter-system Short Data (ISD) functional entity or the subsequent Destination Short Data (DSD) functional entity;
 - the following specific functional capabilities shall exist within the OSD:
 - ability to multiply a received message to different DSDs or ISDs depending on the location of the MSs, having the same GSSI or GTSI;
 - ability to implement the priority set for the message either by selecting special routes, queues or by pre-emption of other messages within the SwMI;
 - ability to react on different supplementary services set for the service in advance, such as:
 - SNA;
 - AS;
 - Access Priority (AP);
 - Barring of Outgoing Calls (BOC);
 - List Search Call (LSC).
 - ability to multiply a received message to different DSDs or ISDs depending on the selected paging area.

NOTE 1: The OSD is located entirely within the SwMI and further specification and definition is beyond the scope of this ETS.

- DSD functional entity:
 - the DSD shall be located in the CMCE-SwMI;
 - it shall have the ability to receive information from the preceding OSD functional entity in the SwMI or the preceding ISD functional entity in the SwMI and then forward requests to the subsequent DSDA functional entity in the MS or in the LS;
 - the following specific functional capabilities shall exist within the DSD:
 - ability to validate the address of the message receiver, e.g. the SSI or the TSI;
 - ability to react on different supplementary services set for the service in advance, such as:
 - Call Forwarding Unconditional (CFU);
 - Call Forwarding No Reply (CFNRy);
 - Call Forwarding on mobile subscriber Not Reachable (CFNRc);
 - Call Authorised by Dispatcher (CAD);
 - Calling Line Identification Presentation (CLIP);
 - ability to store the message.

NOTE 2: The DSD is located entirely within the SwMI and further specification and definition is beyond the scope of this standard.

- ISD functional entity:
 - the ISD functional entity shall be located in CMCE-ISI, e.g. in the equipment of the ISI in the SwMI;
 - the functional entity shall exist both at the sending side and at the receiving side;
 - it shall have the ability to receive information from the preceding OSD functional entity in the same SwMI or the preceding ISD functional entity in another SwMI;
 - received information shall be forwarded as requests to the subsequent DSD functional entity in the same SwMI or the subsequent ISD functional entity in another SwMI;
 - the following specific functional capabilities shall exist within the ISD:
 - ability to multiply a received message from a preceding ISD to different DSDs or ISDs depending on the location of the MSs, having the same GSSI or GTSI;
 - ability to map received messages from a preceding OSD or ISD onto Remote Operations Service Element (ROSE) (as defined in CCITT Recommendation X.219 [10] and ECMA 165 [15]) via the co-ordination function ECMA 165 [15] at the ISI. This mapping shall be done by using the service provided by ROSE;
- Incoming Gateway Short Data (IGSD) functional entity:
 - the IGSD functional entity is located in CMCE-IGW, e.g. in the equipment of the gateway in the SwMI;
 - it shall have the ability to receive information from other non-TETRA networks;
 - received information shall be forwarded as requests to the subsequent DSD functional entity in the same SwMI or the subsequent ISD functional entity in the same SwMI;

- the following specific functional capabilities shall exist within the IGSD:
 - ability to map the address domain of the gateway network to the TETRA address domain.
- Outgoing Gateway Short Data (OGSD) functional entity:
 - the OGSD functional entity shall be located in CMCE-OGW, e.g. in the equipment of the gateway in the SwMI;
 - it shall have the ability to receive information from the preceding OSD functional entity or the ISD functional entity in the same SwMI;
 - received information shall be sent to other non-TETRA networks forwarded as requests;
 - the following specific functional capability shall exist within the OGSD:
 - ability to map the TETRA address domain to the address domain of the gateway network.

11.3.2.2 Description of the relationships between functional entities

Between each functional entity, a functional relationship shall specify the information flow between them. The relationships are called r_1 , r_2 and r_2^* .

The r_1 relationship shall specify the access relation between the OSD agent functional entity and the AOSD functional entity within the SwMI. It also shall specify the relation between the DSD functional entity within the SwMI and the adjacent DSDA. The r_1 relationship shall specify the TETRA air interface protocol at the U_m reference point (as defined in clause 4).

The r_2 relationship shall specify the distributive relation between ASD functional entities within one or several SwMIs. These are the ISD functional entity, the IGSD functional entity and the OGSD functional entity.

NOTE: Except for the relationship to the ISD functional entity, the r_2 relationships are beyond the scope of this ETS. Thus, these r_2 relationships should then only be considered as informative.

The r_2 relationship between two ISD functional entities shall specify part of the TETRA Network Protocol 3 (TNP3 protocol), which is visible at the Q reference point.

The r_2^* relationship shall specify the general relation between a gateway SDS functional entity (incoming or outgoing) and a non TETRA system, e.g. a PTN, a PSTN or an ISDN.

11.3.3 Allocation of functional entities

The functional entities described in subclause 11.3.2.1 may be allocated to different physical locations. figure 97 to figure 104 shows different allocations.

11.3.3.1 Point-to-point message transfer within one SwMI

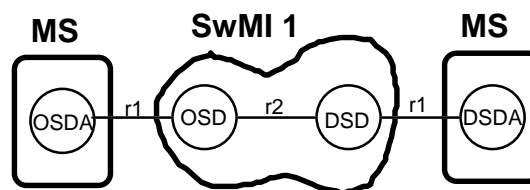


Figure 97: Point-to-point message transfer within one SwMI

11.3.3.2 Point-to-multipoint message transfer within one SwMI

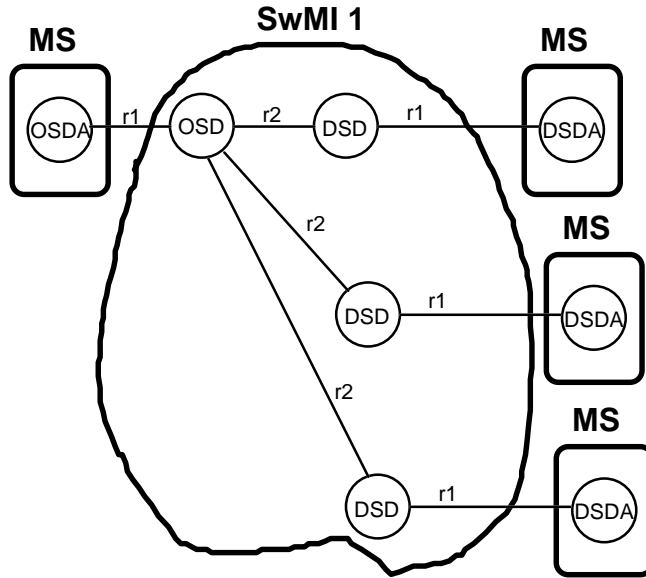


Figure 98: Point-to-multipoint message transfer within one SwMI

11.3.3.3 Point-to-point message transfer within two SwMI

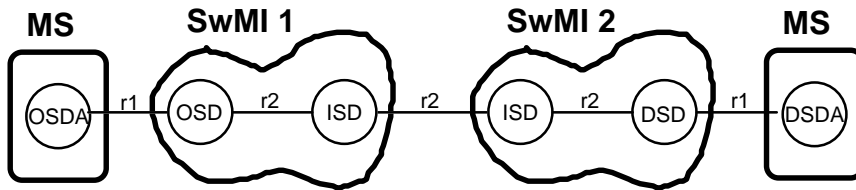


Figure 99: Point-to-point message transfer within two SwMI

11.3.3.4 Point-to-multipoint message transfer within two SwMI

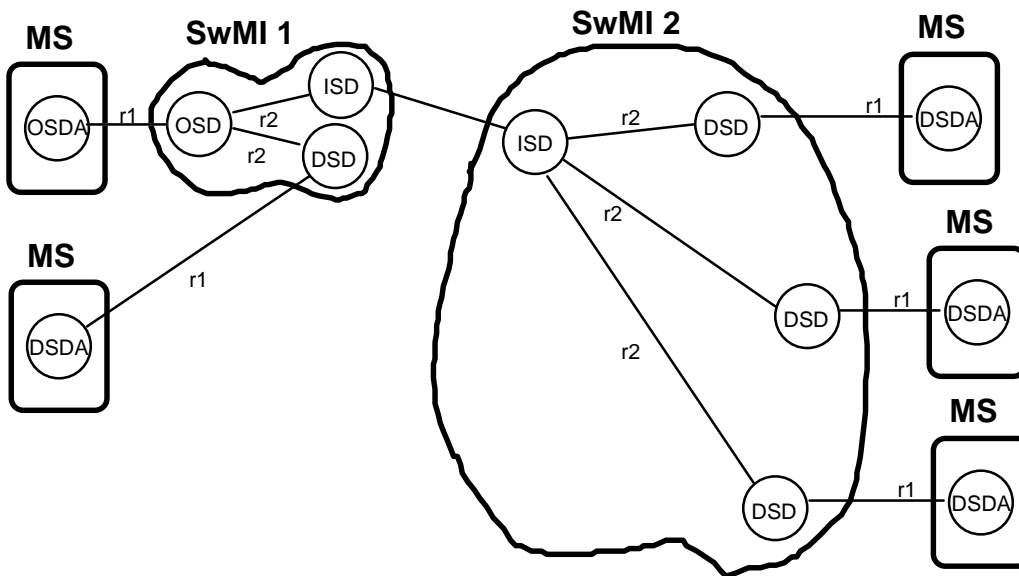


Figure 100: Point-to-multipoint message transfer within two SwMI

11.3.3.5 Point-to-point message transfer via an outgoing gateway

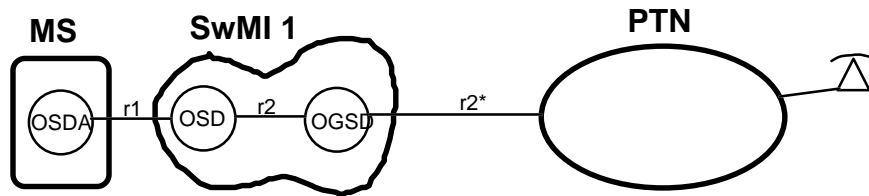


Figure 101: Point-to-point message transfer from a SwMI to a PTN, using OGSD

11.3.3.6 Point-to-point message transfer via an incoming gateway

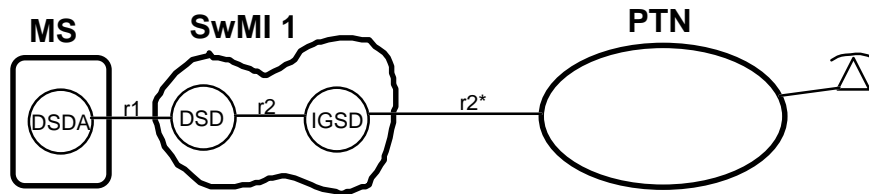


Figure 102: Point-to-point message transfer from a PTN to a SwMI, using IGSD

11.3.3.7 Point-to-multipoint message transfer via an outgoing gateway

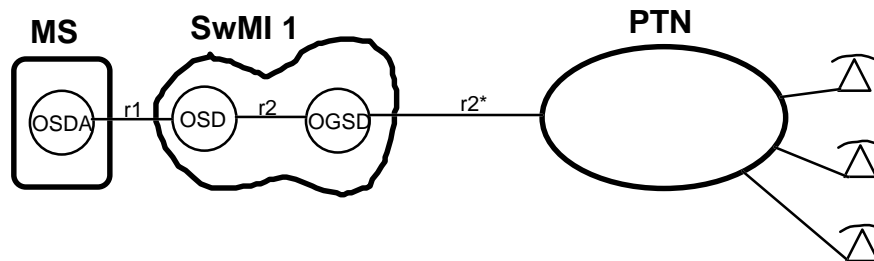


Figure 103: Point-to-multipoint message transfer from a SwMI to a PTN, using OGSD

11.3.3.8 Point-to-multipoint message transfer via an incoming gateway

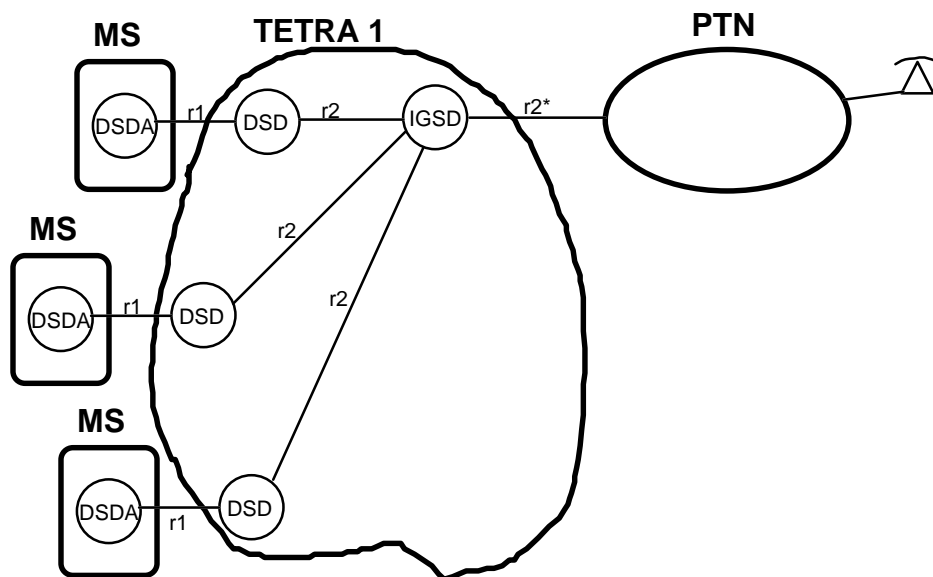


Figure 104: Point-to-multipoint message transfer from a PTN to a SwMI, using IGSD

11.4 Protocol architecture

The layer 3 SDS entity should be a sub-entity in the CMCE. The C-plane protocol stacks for the MS and the BS are shown on figure 105 and figure 106.

11.4.1 MS protocol stack

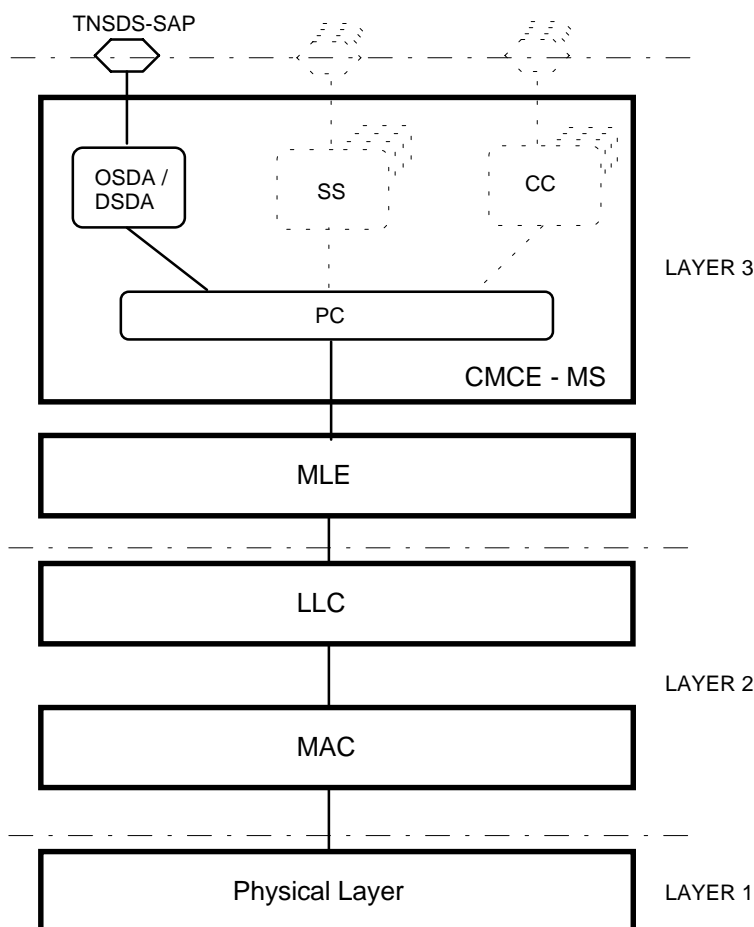


Figure 105: MS protocol stack

OSDA functional entity and DSDA functional entity are both located at the top of the Protocol Control (PC) within the CMCE-MS. The SDS shall be provided to the user via the TNSDS-SAP at the top of the CMCE-MS. The functions of the entities shall be as described in subclause 11.3.2.1.

PC contains the state/event machine for the air interface protocol, e.g. it handles short data PDU (as defined in ETS 300 392-2 [17], clause 14), and has a peer to peer relationship with the PC within the CMCE-SwMI. The PC shall use the normal MLE-primitives to achieve this peer-to-peer relationship.

MLE, LLC and MAC are entities which are described in clause 6.

11.4.2 BS protocol stack

This subclause contains information residing in the SwMI and as such shall be considered to be outside the scope of this ETS and is therefore informative only. The BS architecture is different from the MS regarding the SAP to the short data sub-entity. The SAP is a sub-network SAP since it provides service to another layer 3 sub layer within the SwMI, e.g. a routing and relaying capability.

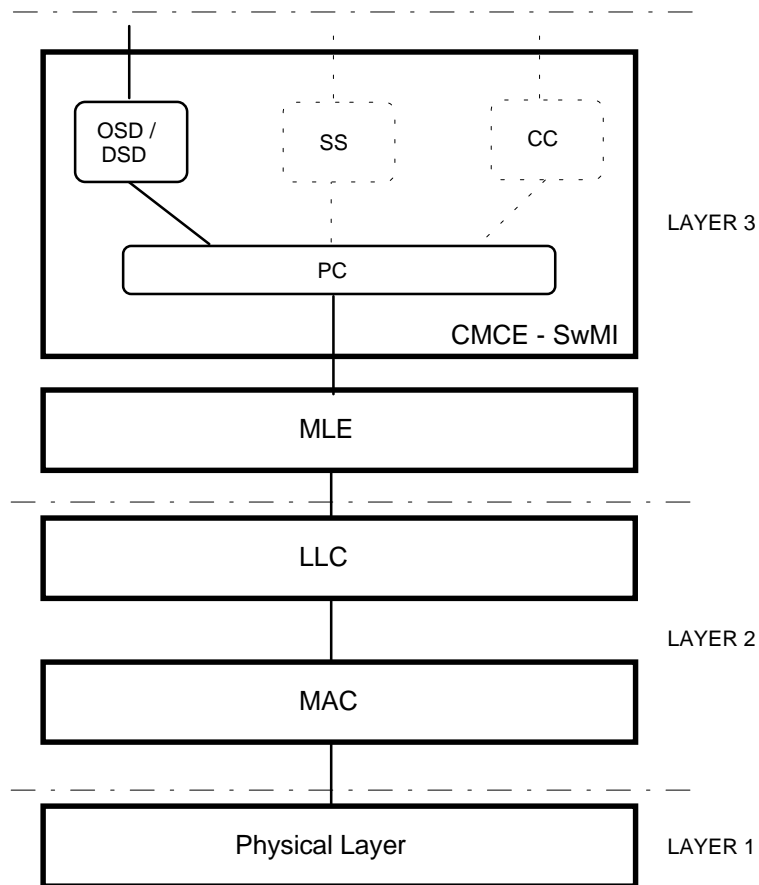


Figure 106: SwMI protocol stack

The OSD functional entity and the DSD functional entity are both located at the top of the PC within the CMCE-SwMI. The short data sub-entity has relationships to other short data functional entities within the SwMI as described in subclause 11.3.2.1.

PC shall have the same structure as the PC within the MS and LS.

MLE, LLC and MAC are entities which are described in clause 6.

11.5 Addressing

11.5.1 Uplink addressing on the air interface

The addressing to be used in connection with the SDS on the up link shall either be:

- SSI. When employed, it shall be used both as a destination address and as a source address; or
- TSI. When employed, it shall only be used as a destination address. The source address, i.e. MAC address, shall still be the SSI; or
- SNA. When employed, it shall only be used as a destination address. The full address, either the SSI or the TSI, should be expanded within the SwMI. The source address, i.e. MAC address, shall still be the SSI.

11.5.2 Downlink addressing on the air interface

The addressing to be used as a destination address in connection with the SDS on the downlink shall be a SSI.

The addressing to be used as a source address in connection with the SDS on the down link shall be either:

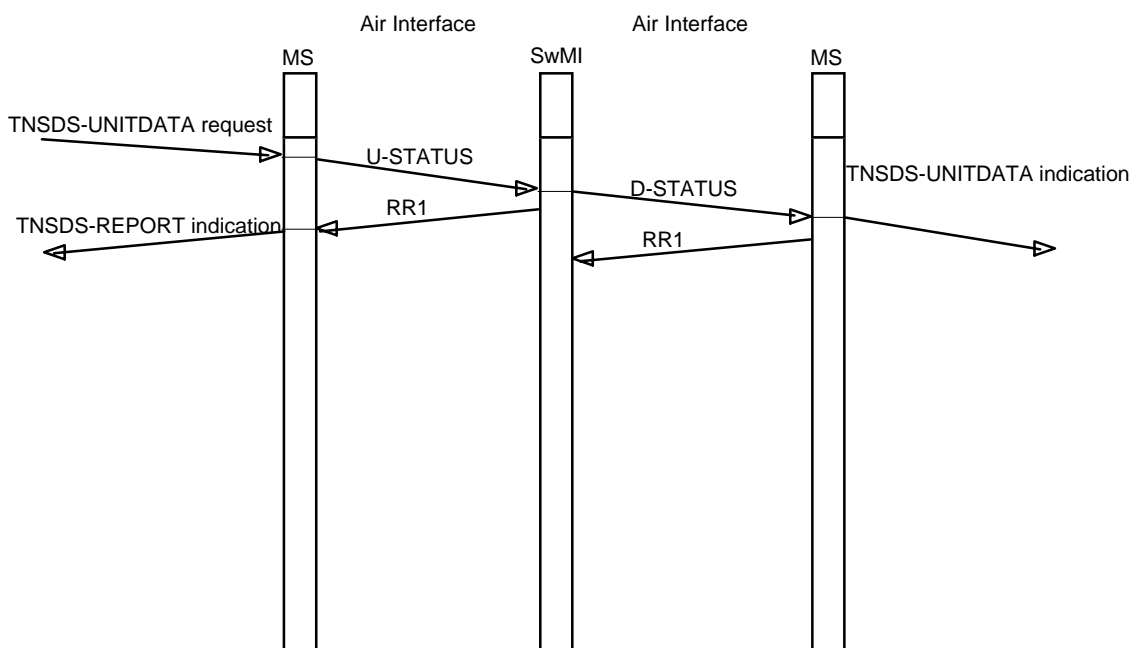
- a SSI; or
- a TSI.

A supplementary service may be invoked to suppress the source address on the downlink.

11.6 Services provided by the air interface protocol

The service offered by the short data sub-entity in the CMCE shall be:

- sending and receiving short messages without establishment of a connection over the air interface;
- sending and receiving user defined or pre-defined messages. Only one pre-defined message is defined as an emergency message;
- sending messages point-to-point as shown in figure 107 or point-to-multipoint as shown in figure 108.



RR1 : Layer 2 acknowledgement PDU
 U-STATUS, D-STATUS : Layer 3 PDU

Figure 107: Intra-TETRA (point-to-point)

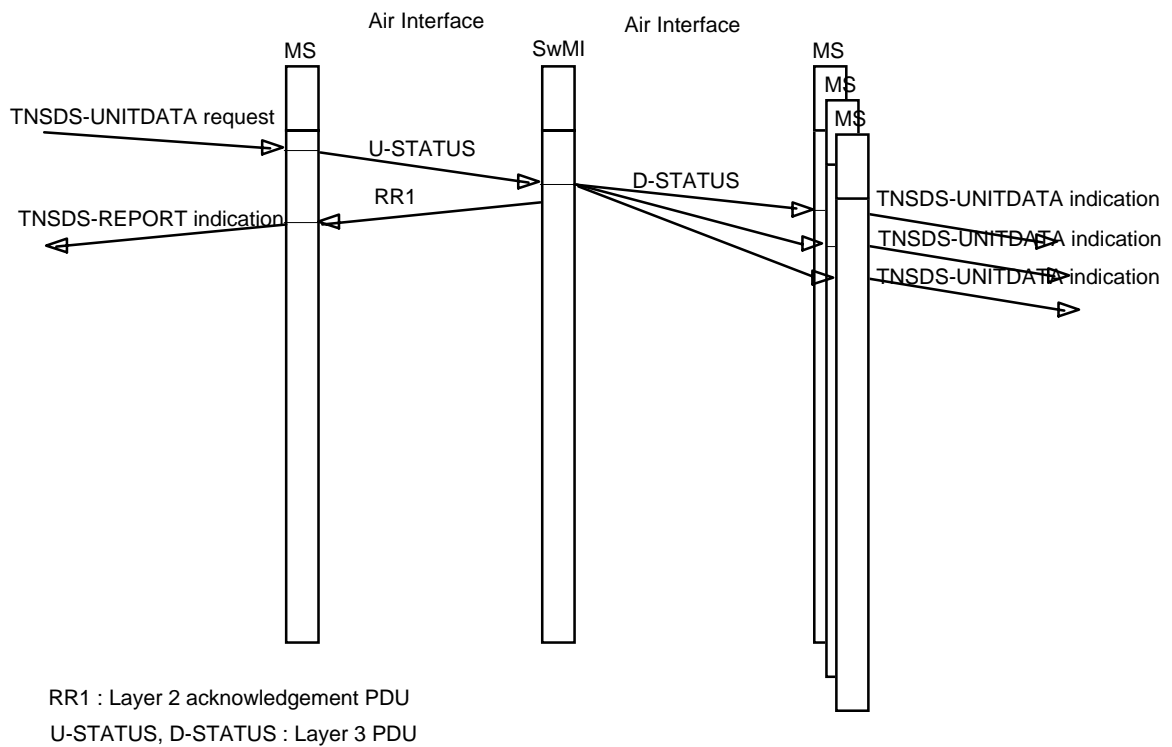


Figure 108: Intra-TETRA (point-to-multipoint)

11.7 Lower layer services used

The short data functional sub-entities shall use the services of other sub-entities within the CMCE. Depending on the location of the CMCE, different lower layers are applied.

11.7.1 MLE primitives used in the MS and the LS

The CMCE in the MS and the LS should use the following primitives at the LCMC-SAP in order to provide the necessary service to the short data functional sub-entities:

- MLE-UNITDATA request/indication - for providing unconfirmed service in order to transfer the short data message;
- MLE-REPORT indication - for providing a report on the transfer of the short data message over the air interface.

12. Technical realisation of TETRA connection mode CONP

12.1 Introduction

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

- the protocol services and functions;
- the primitives and sequences for the transmission of data and control information on the air interface.

12.2 Overview of the protocol

12.2.1 Internal organisation of the network layer and ISO

The architectural organisation of the network layer is described in clause 6. This protocol shall be used in the connection mode where figure 109 gives the layer 3 organisation concerned with CONP.

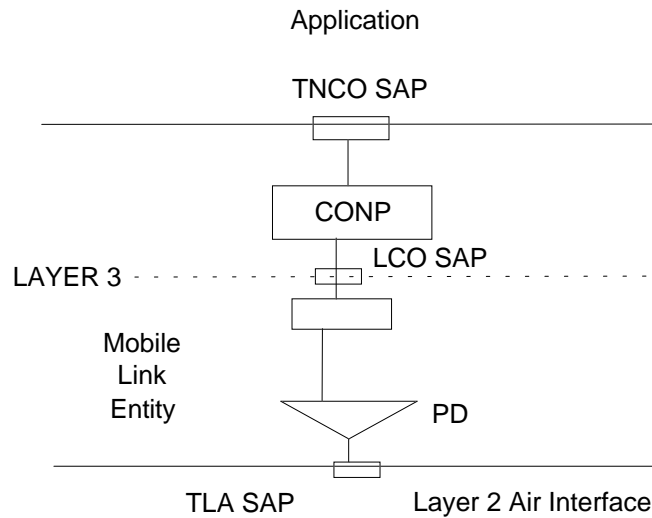


Figure 109: Layer 3 stack on the air interface

TETRA CONP is based on three ISO standards:

- the network service definition ISO 8348 [12] 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 8878 [14]:
 - proposing CONP primitives;
 - mapping between the CONP primitives and the X.25 packets and procedures;
- the X.25 packet layer protocol ISO 8208 [11] 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.

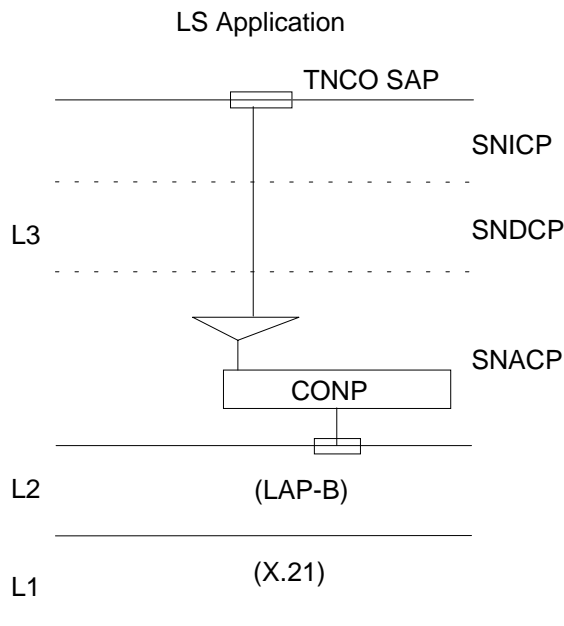


Figure 110: LS protocol stack

TETRA CONP shall offer services conforming to ISO 8348 [12] 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 8878 [14], and the protocol shall be based on ISO 8208 [11] (see figure 111). This is described in:

- ETS 300 392-2 [17], clause 24 which is the TETRA delta clause defining the connection mode network service at the TNCO SAP, in particular, the service primitives based on ISO 8348 [12] and ISO 8878 [14];
- ETS 300 392-2 [17], clause 25 which is the TETRA delta clause defining the connection mode network protocol, in particular, the packets formats and procedures based on ISO 8208 [11].

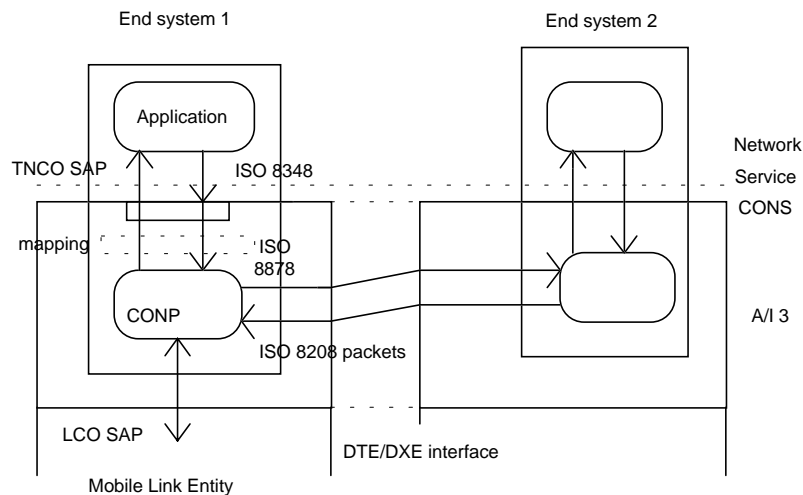


Figure 111: CONP and ISO

12.2.2 End-to-end protocol

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

- at the R0 reference point the ISO 8348 [12] (plus delta ETS 300 392-2 [17], clause 24) mandatory primitives shall apply;
- at the R2 reference point the ISO 8208 [11] (plus delta ETS 300 392-2 [17], clause 25) mandatory protocol shall apply;

- at the R10 which is a logical reference point equivalent to R0, on the infrastructure, the assumed but not mandatory ISO 8348 [12] (plus delta ETS 300 392-2 [17], clause 24) primitives shall apply.

This protocol is designed to accommodate variability where the underlying protocol can be the MLE, see ETS 300 392-2 [17], clause 17, on the MS or BS side or a TETRA specific layer 2 (or Lapb.) on the LS side, (see figure 109 and figure 110).

12.3 Handover and mobility

Mobility implies situations where the mobile changes from one BS to another during a slow handover without releasing the established virtual call. Then a set of data, for example state variables, packets sequence numbers has to be exchanged by the BS in order to keep the data sequence and avoid redundancies or loss of packets.

12.4 Packet through layer 3 in connection mode

Figure 112 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 standard ISO 8208 [11] PH.

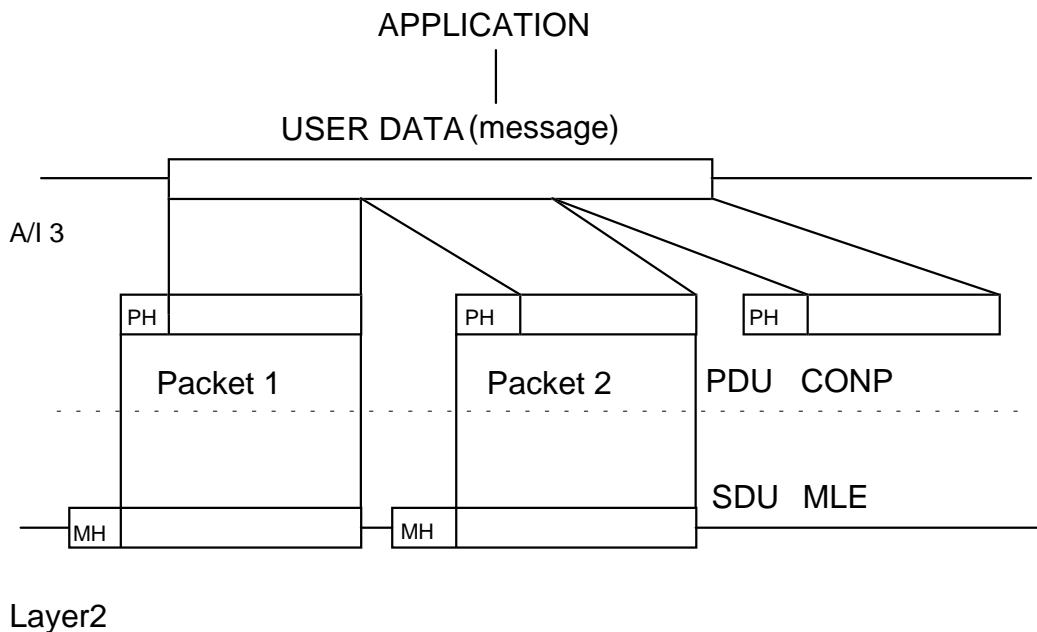


Figure 112: Data in CONP

12.5 Interconnection

Figure 113 to figure 121 position CONP in the protocol stack on the different nodes of the TETRA networks. The references points defined in clause 5 are also shown on the figures.

On figure 113 there is no direct connection between the two end systems which are the TE, i.e. TETRA and MTU2 act as a real sub-network. The MTU2 acts as an inter-working unit.

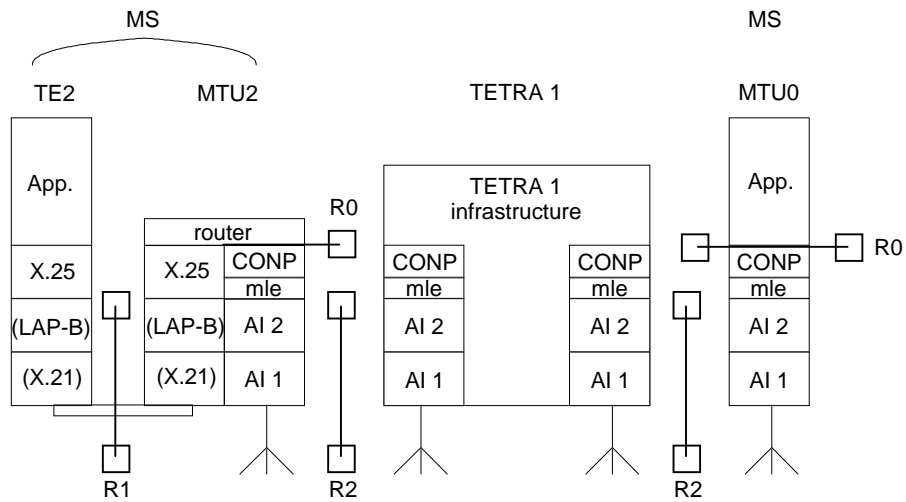


Figure 113: MS to MS through one TETRA network

Figure 114 represents the case of the LS with an example of possible layer 2/1 (LAPB-X.21).

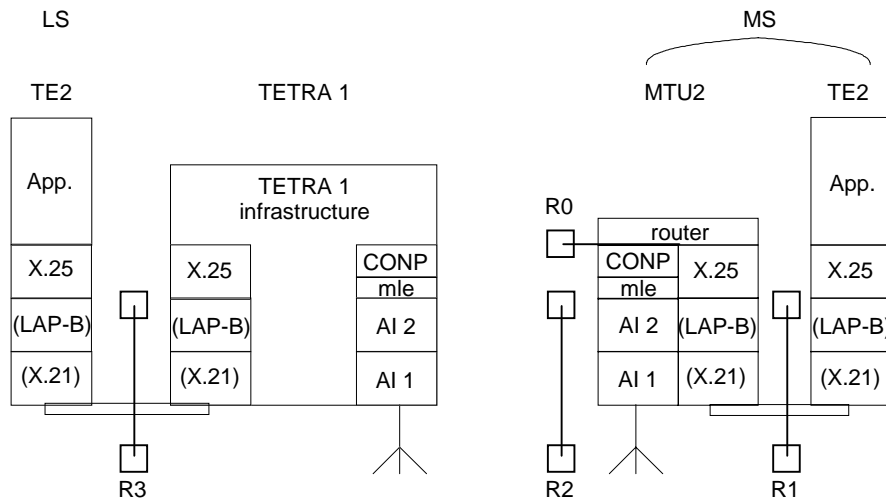


Figure 114: LS to MS through one TETRA network

Figure 115 represents the case of two TETRA networks interconnected through an X.25 or X.75 protocol.

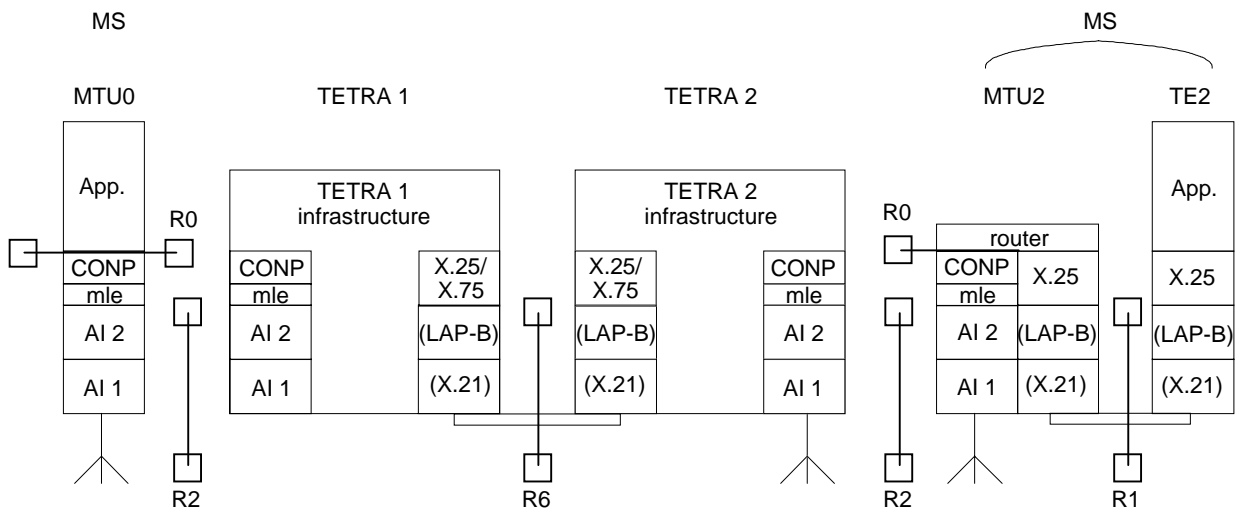


Figure 115: MS to MS through two TETRA networks

Figure 116 represents the case of two TETRA networks connected through an X.25 PDN using X.25 or X.75 protocol.

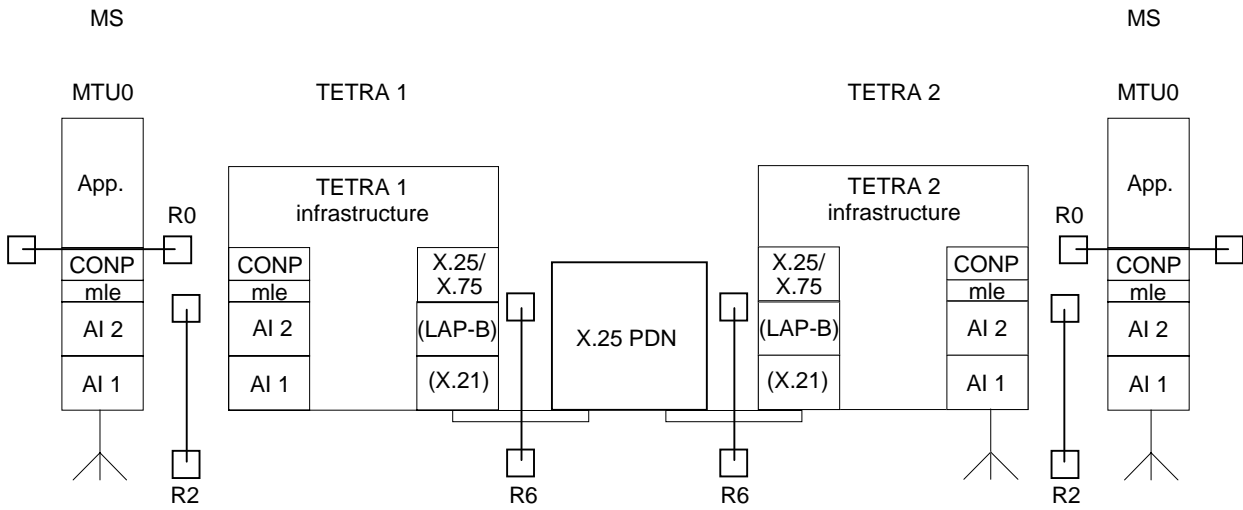


Figure 116: MS to MS through two TETRA networks and one X.25 PDN

Figure 117 represents the case of two TETRA networks connected through an X.25 or X.75 protocol.

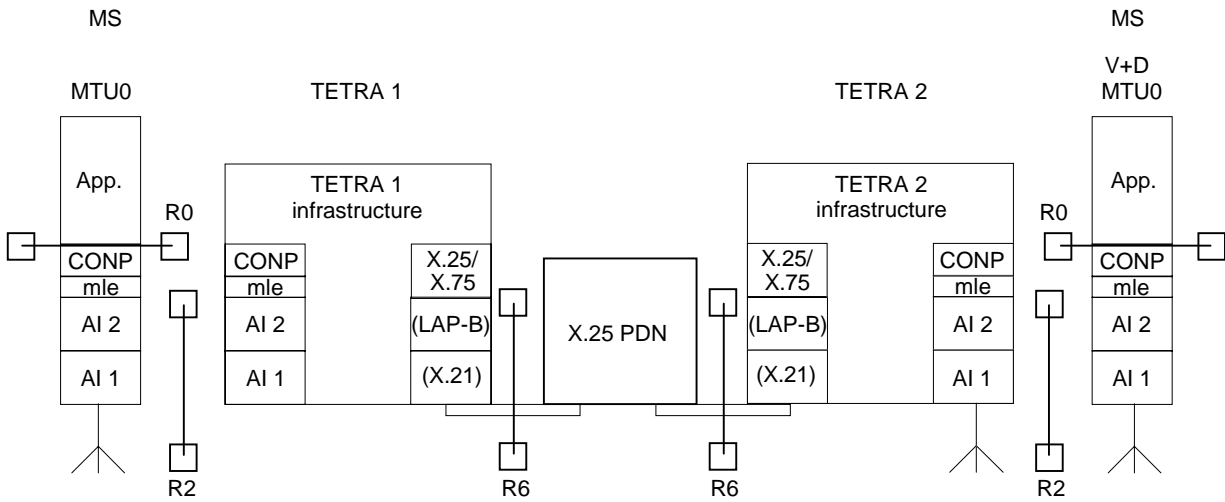


Figure 117: MS to MS through two TETRA networks via one X.25 PDN

Figure 118 represents MS to DTE through TETRA network and X.25 PDN.

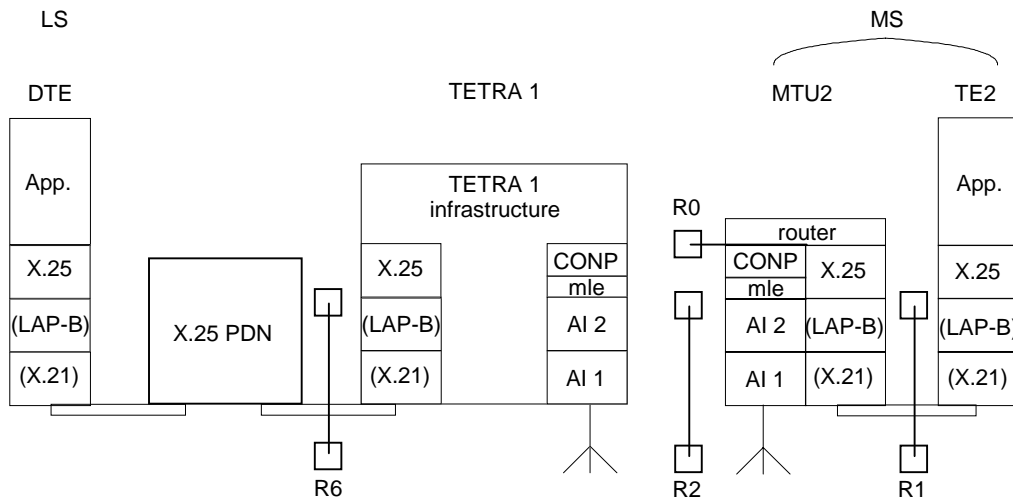


Figure 118: MS to standard DTE through one TETRA network and one X.25 PDN

Figure 119 represents the case of a character mode MS with integrated PAD and character mode LS connected via PSTN.

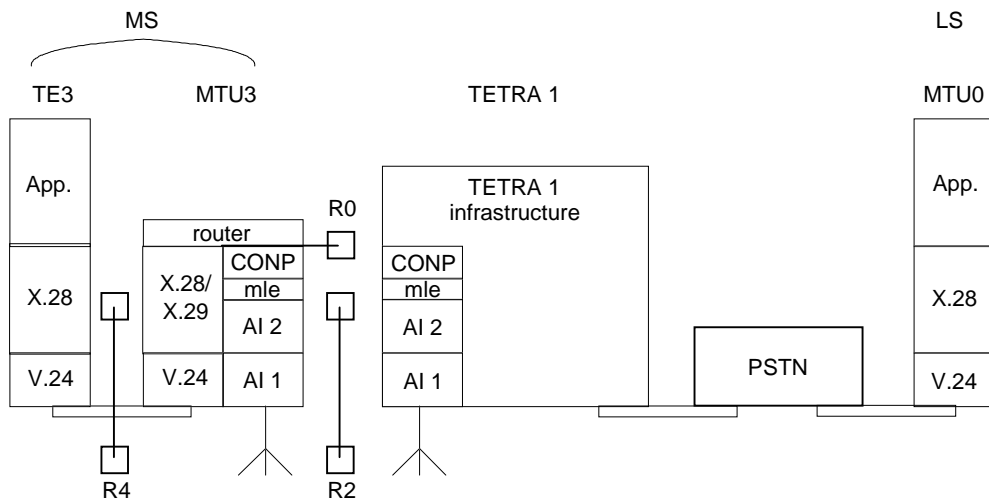


Figure 119: Character mode MS with integrated PAD (MTU3) connected to a character mode LS via PSTN

Figure 120 represents a character mode MS with discrete PAD.

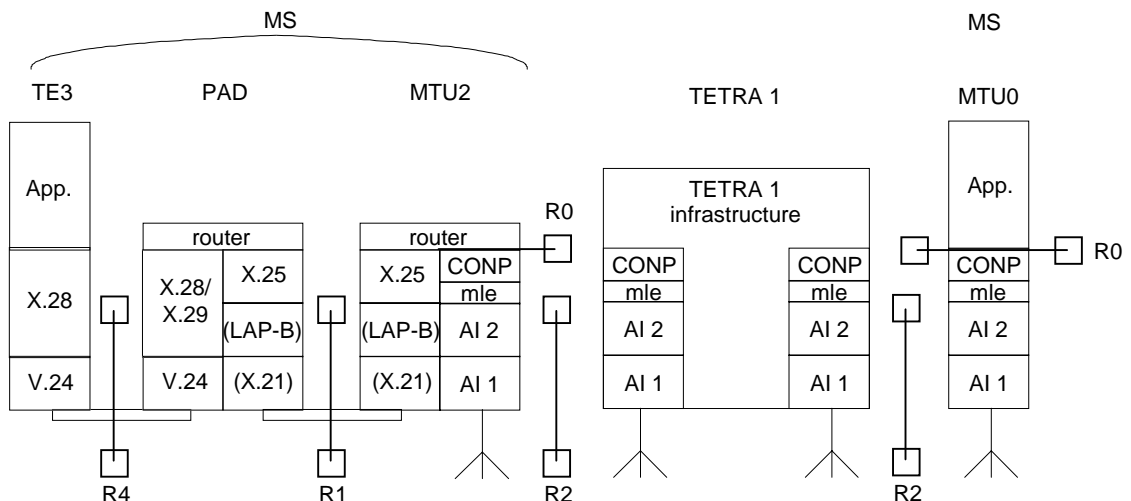
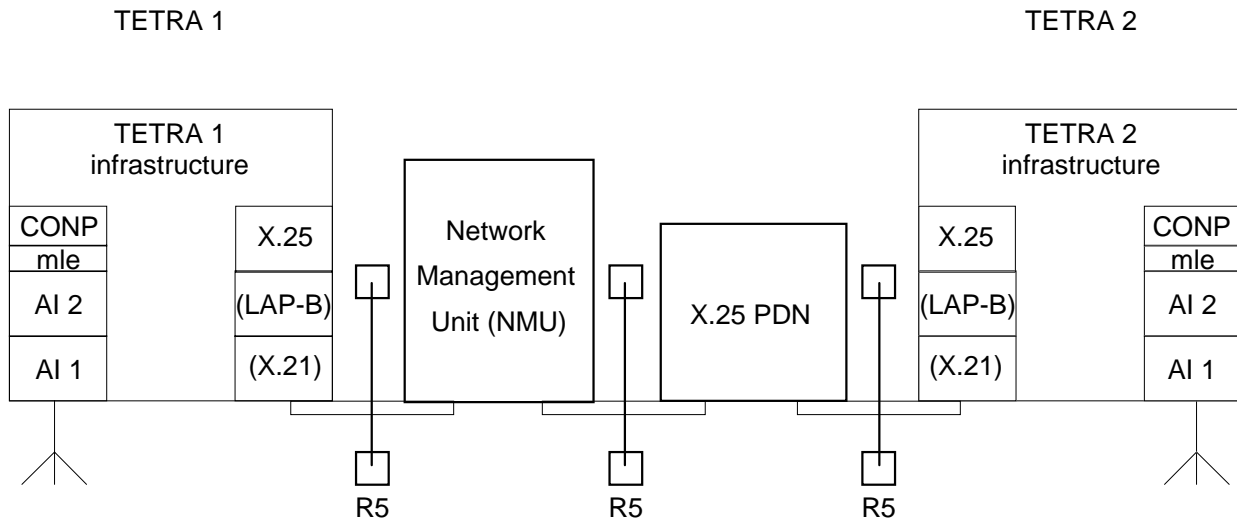


Figure 120: Character mode MS with discrete PAD

Figure 121 represents the connection of the NMU to local and remote TETRA.



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

Figure 121: Network management unit connected to a local and a remote TETRA

12.6 Addresses

See clause 7.

12.7 Lower layer service used

CONP shall be capable of operating over:

- the MLE, ETS 300 392-2 [17], clause 17, (figure 109) in a MS or BS environment; and
- a link layer protocol as shown in figure 110.

The service primitives at the LCO SAP are defined in ETS 300 392-2 [17], clause 17.

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

12.8 Services produced by the protocol

The protocol shall provide the connection mode network service at the TNCO SAP to the upper layer (see ISO 8878 [14] and ETS 300 392-2 [17], clause 24).

The services offered are:

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

12.9 Primitive definition

The primitives and sequence of primitives (figure 111) at the TNCO SAP are defined in ETS 300 392-2 [17], clause 25, these map to the corresponding packets with the fields corresponding to the primitives parameters.

12.10 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.

12.11 Structure and encoding of the PDUs

The PDUs shall be packets with a packet header as defined in ETS 300 392-2 [17], clause 25, 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 standard following information:

- general format identifier;
- logical channel identifier;
- packet type identifier;
- additional fields like sequence numbers, user data see ISO 8208 [11].

13 Technical realisation of TETRA specific connectionless S-CLNS

13.1 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.

13.2 Overview of the protocol

13.2.1 Internal organisation of the network layer

The architectural organisation of the network layer is described in clause 6. This protocol shall be used in the access protocol role (SNACP) as described in the ISO 8473 [13]. Figure 122 gives the layer 3 organisation concerned with SCLNS where the MLE is the Mobile Link Entity (or network link entity), see ETS 300 392-2 [17], clause 17.

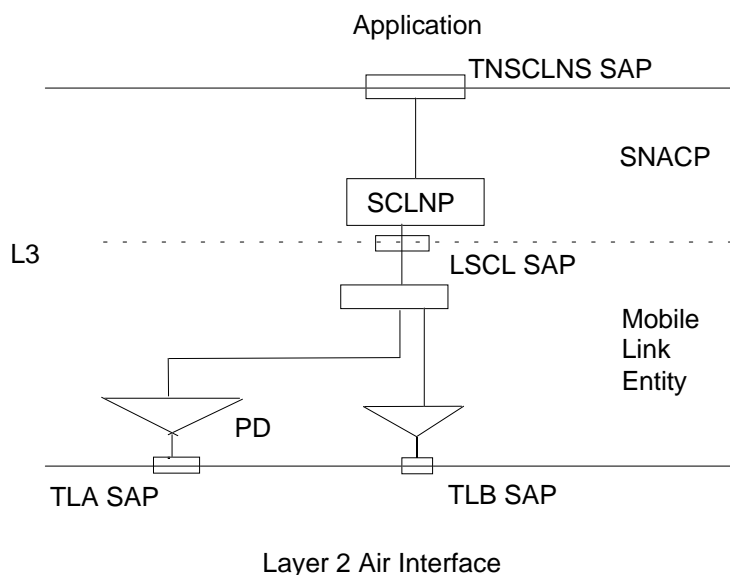


Figure 122: Layer 3 S-CLNP protocol stack on the air interface

This protocol shall be designed to accommodate variability where the underlying protocol can be the MLE on the MS (figure 122) or a sub-network dependant sub-layer (SNDCP) for convergence as described in figure 123. It shall also offer services to support a user application implementation of CLNP (figure 123).

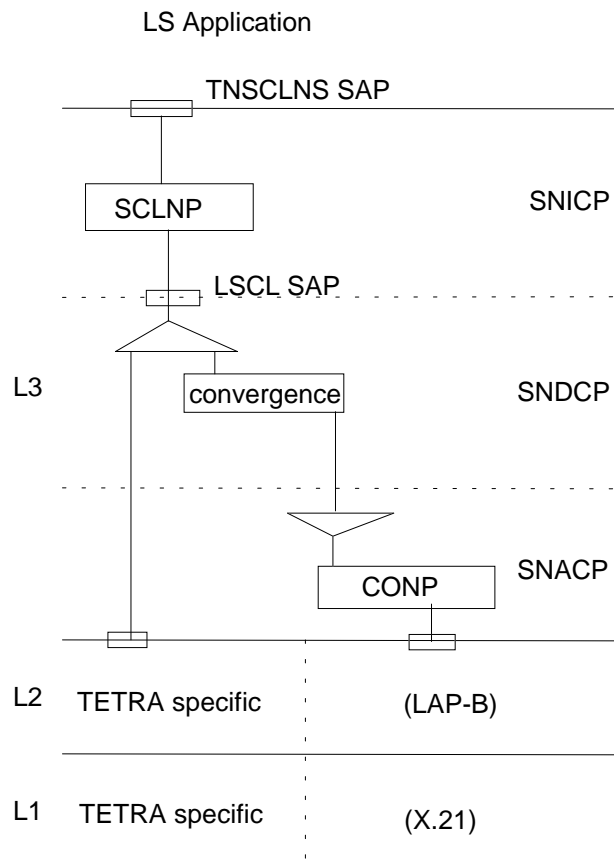


Figure 123: LS (LS) protocol stack

In order to optimise the protocol two versions are created:

- a full version with the TETRA specific facilities;
- a version without any facilities called the slim version.

13.2.2 Interconnection

Figure 124 to figure 129 position the S-CLNP in the protocol stack on the different nodes of the TETRA networks. The reference points are also shown on the figures.

Figure 124 gives the MS to MS interconnection through a TETRA network.

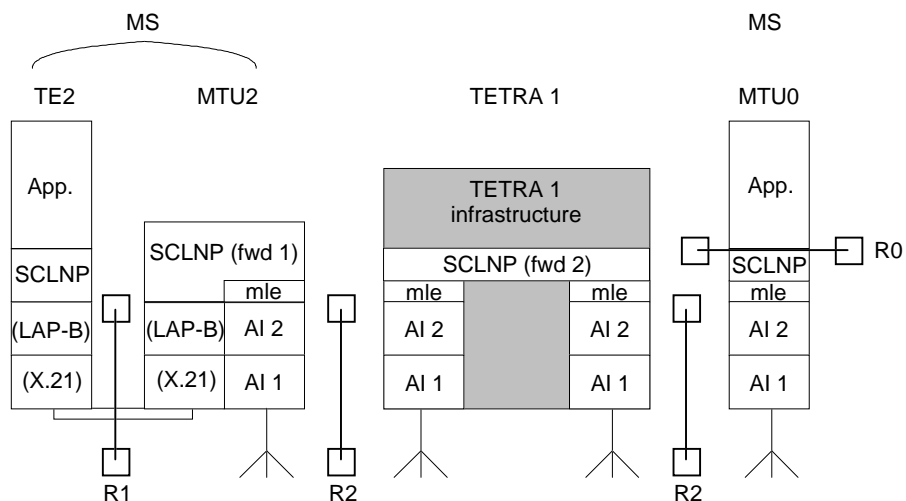


Figure 124: MS to MS through one TETRA network

Figure 125 gives the LS connection where different possibilities are offered as the layer 2 and layer 1 can be TETRA specific or existing standards (figure 122) where:

- case 1:** S-CLNP accesses through a CONP access protocol with the SNDCP convergence asking for a virtual circuit to be established in the connection mode (see table 3);
- case 2:** direct access of S-CLNP to layer 2 which can be in that case a specific TETRA layer 2 (see table 3).

Table 3: Standard possibilities for layer 1 and layer 2

	case 1	case 2
SNICP	S-CLNP	S-CLNP
SNDCP	CONV	NULL
SNACP	CONP	NULL

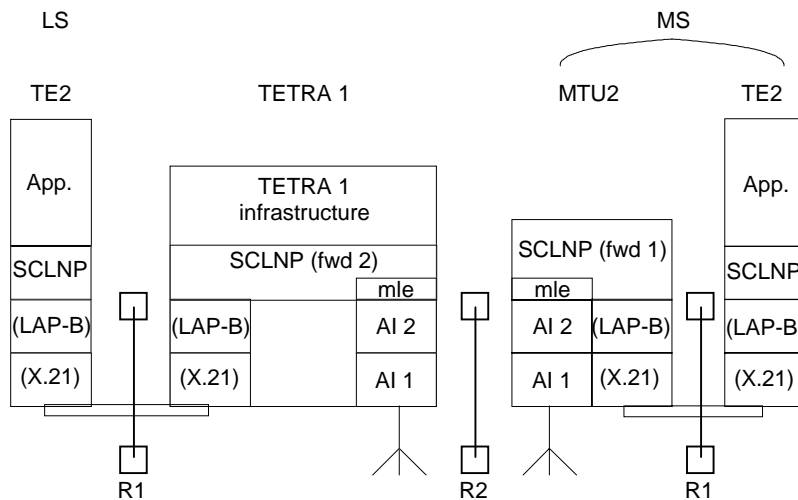


Figure 125: LS to MS through one TETRA network

Figure 126 shows the interconnection of two TETRA networks where TETRA1 adds a X.75 header to the specific connectionless packet and sends it via an X.25 protocol to the network in a connection mode.

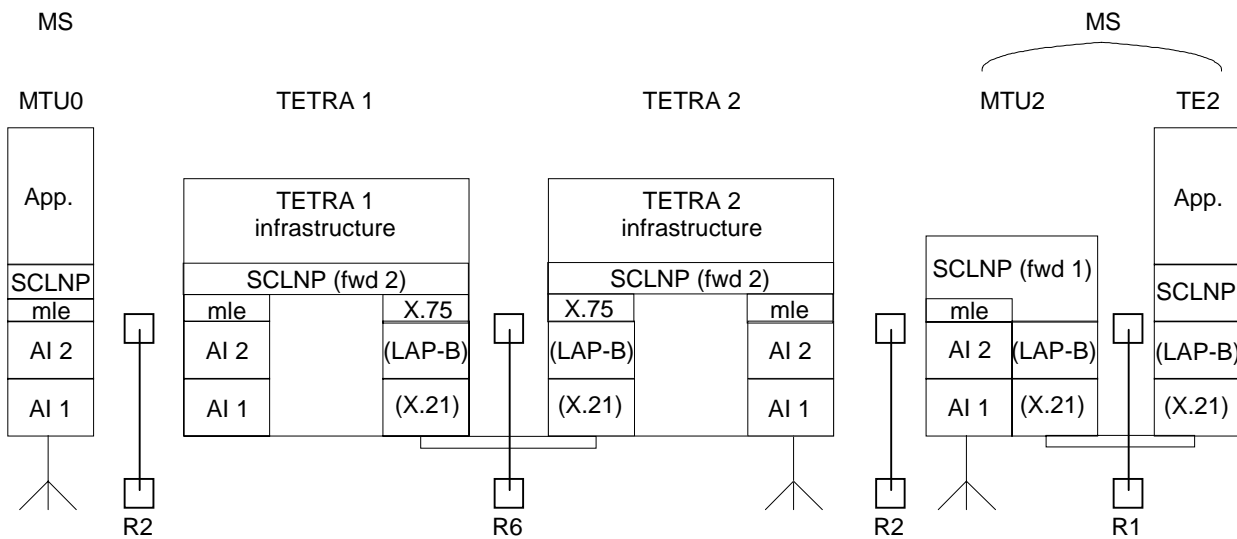


Figure 126: MS to MS through two TETRA networks

Figure 127 shows the case of two TETRA networks interconnected through a CLPDN.

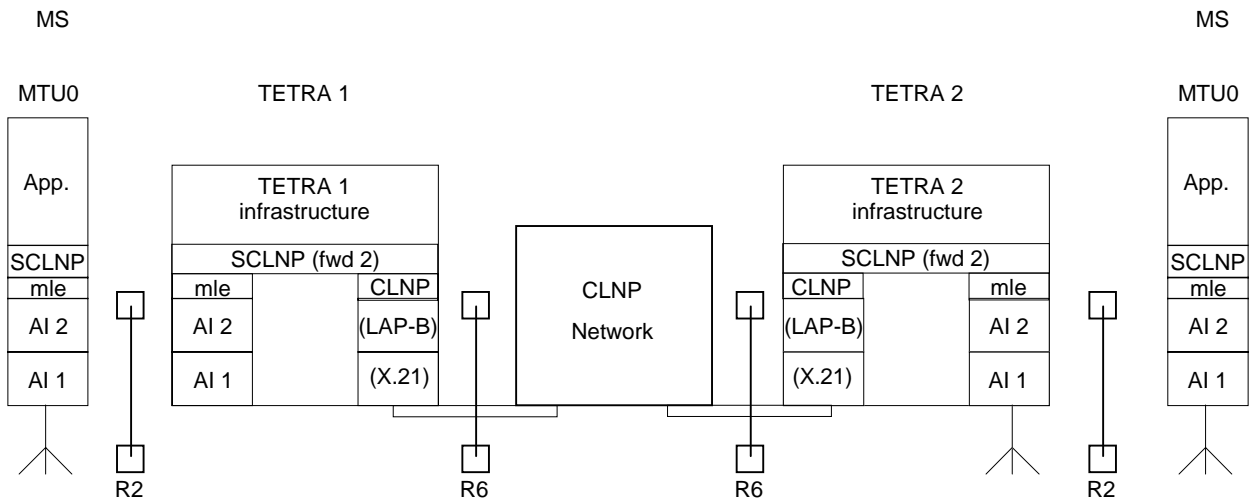


Figure 127: MS to MS through two TETRA networks and one CLPDN

Figure 128 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.

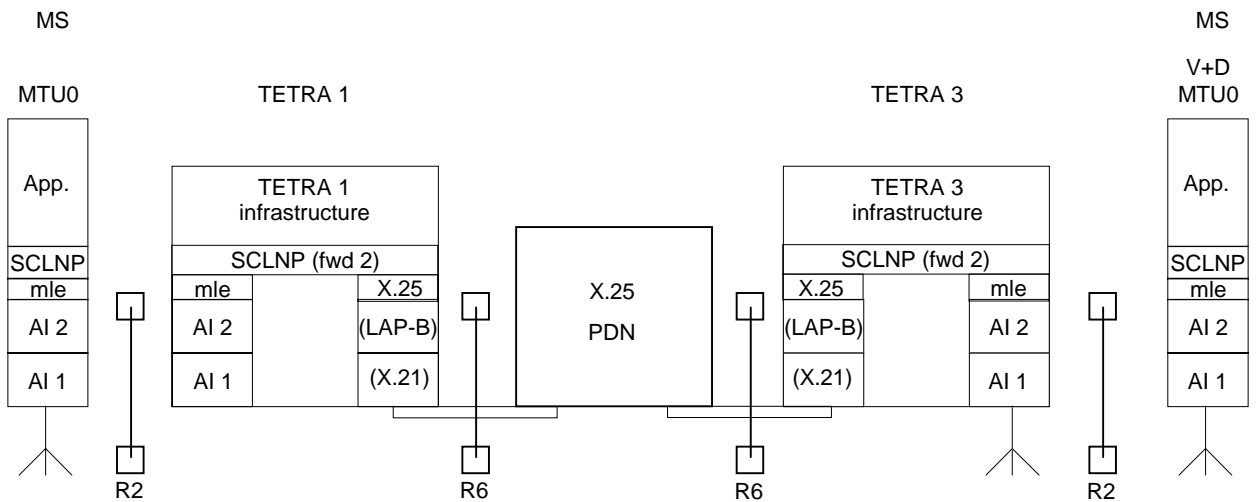


Figure 128: MS to MS through two TETRA networks via one X.25 PDN

Figure 129 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.

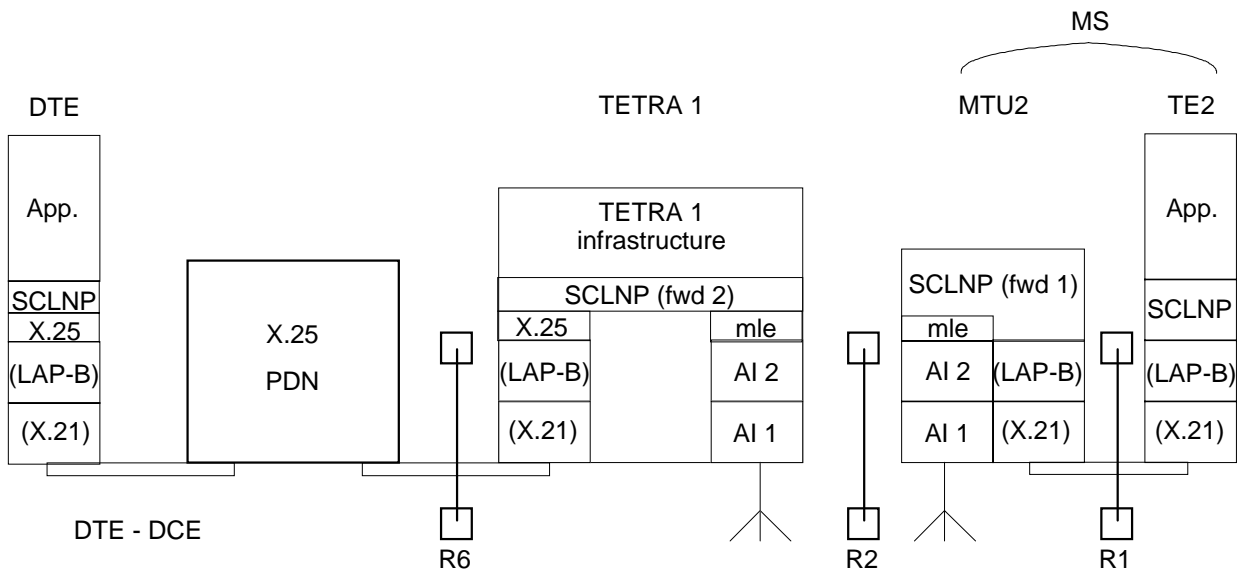


Figure 129: MS to standard DTE through one TETRA network and one X.25 PDN

13.3.3 Addresses

The source address and destination address shall be TETRA addresses described in clause 7.

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.

13.3 Lower layer service used

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

- a) the MLE (figure 122) in a MS or BS environment; or
- b) an 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 S-CLNP 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-UNITDATA request to send control data;
- MLE-UNITDATA indication to indicate the arrival of control data;
- MLE-UNITDATA 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 123).

13.4 Services provided by the protocol

The protocol shall provide the S-CLNS 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: The ISO CLNP is intended to be carried by the slim version.

13.4.1 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 i.e. the delivery report.

This service informs the sender that his data has been delivered to the remote destination.

13.4.2 Slim version

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

13.5 Primitives definition

The set of primitives to offer the services described concerns the data transmission (see ETS 300 392-2 [17], clauses 26 and 27).

13.5.1 Data transmission group

The request and indication primitives at the S-CLNP SAP for data transmission shall be:

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

The parameters are described in ETS 300 392-2 [17], clause 27.

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 300 392-2 [17], clause 27.

Delivery of the user data shall be reported by:

- TN-DELIVERY indication (parameters).

The parameters are described in ETS 300 392-2 [17], clause 27.

13.5.2 Protocol sequences

Figure 130 shows the layer 3 protocol sequence on the MS side.

Figure 131 shows the protocol sequence at layer 3 MS to BS for point-to-point with delivery disposition.

Figure 132 is the multipoint case with delivery disposition.

Figure 133 shows the inter TETRA case.

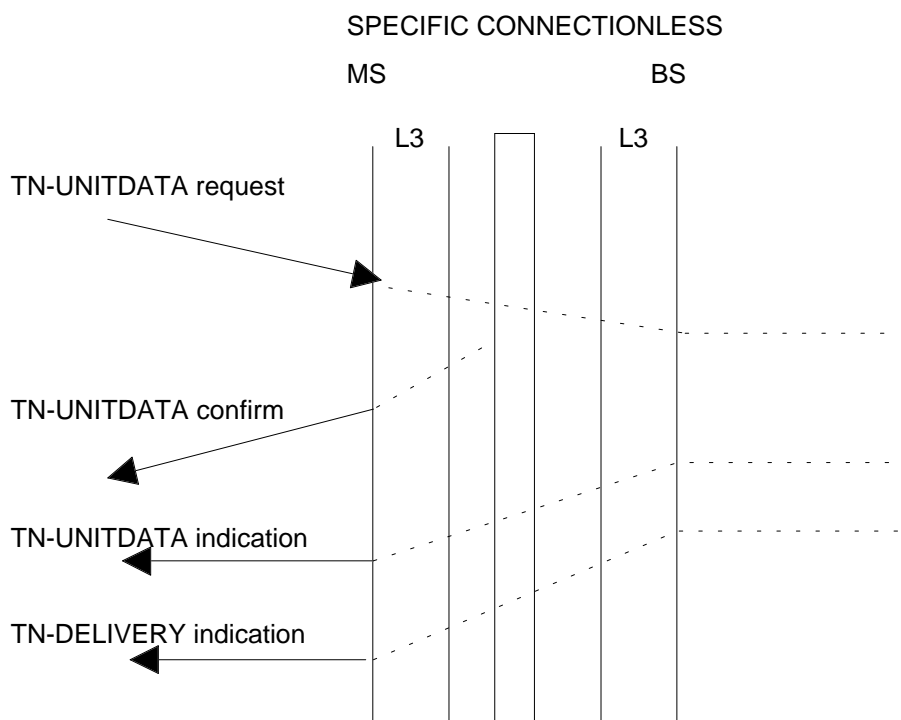


Figure 130: Network layer service primitives sequences specific connectionless at TNSCLNS SAP

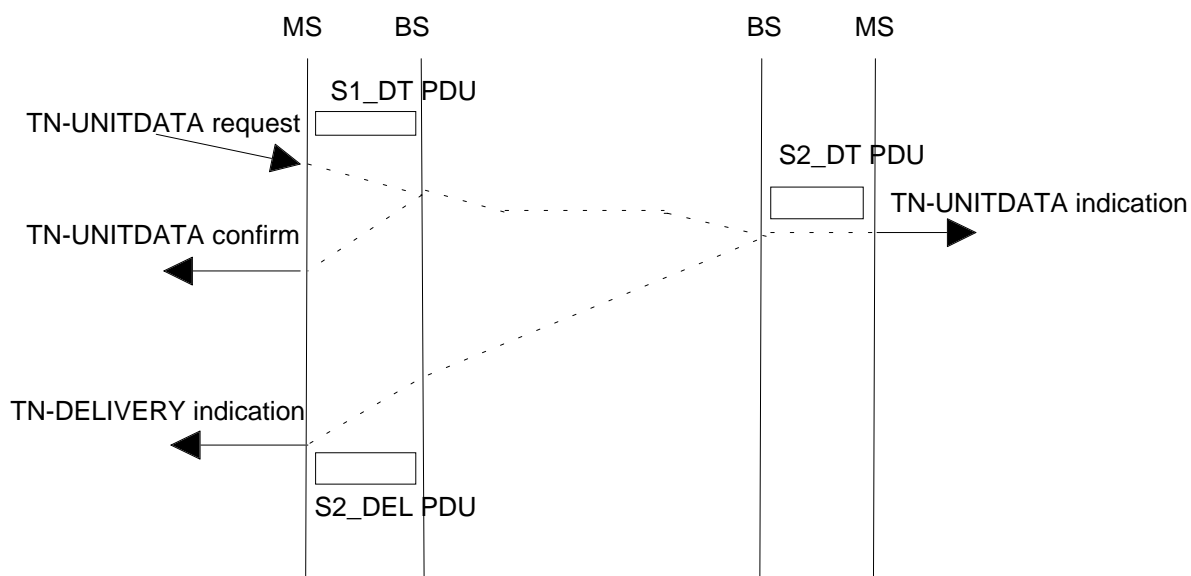


Figure 131: Point-to-point SCLNS

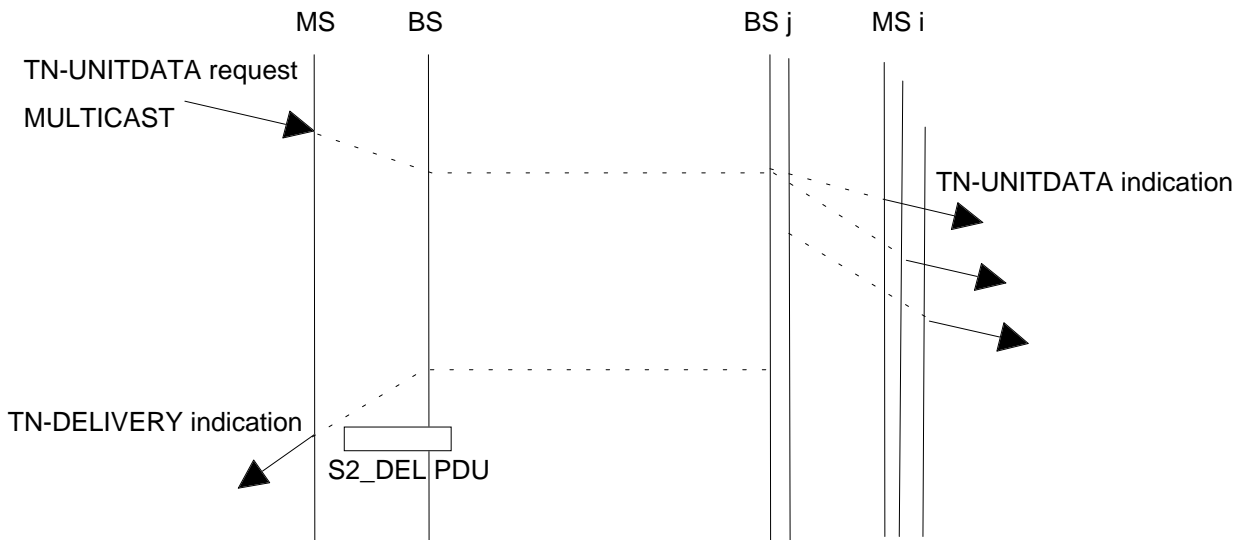


Figure 132: Multipoint case

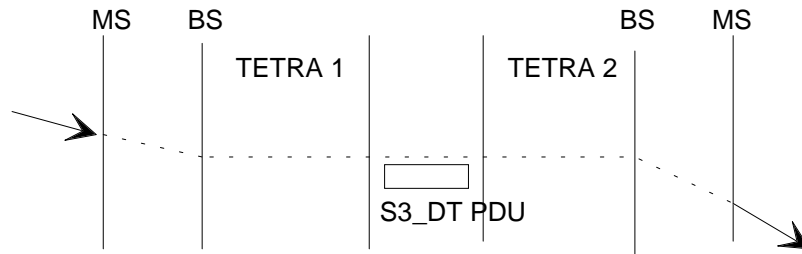
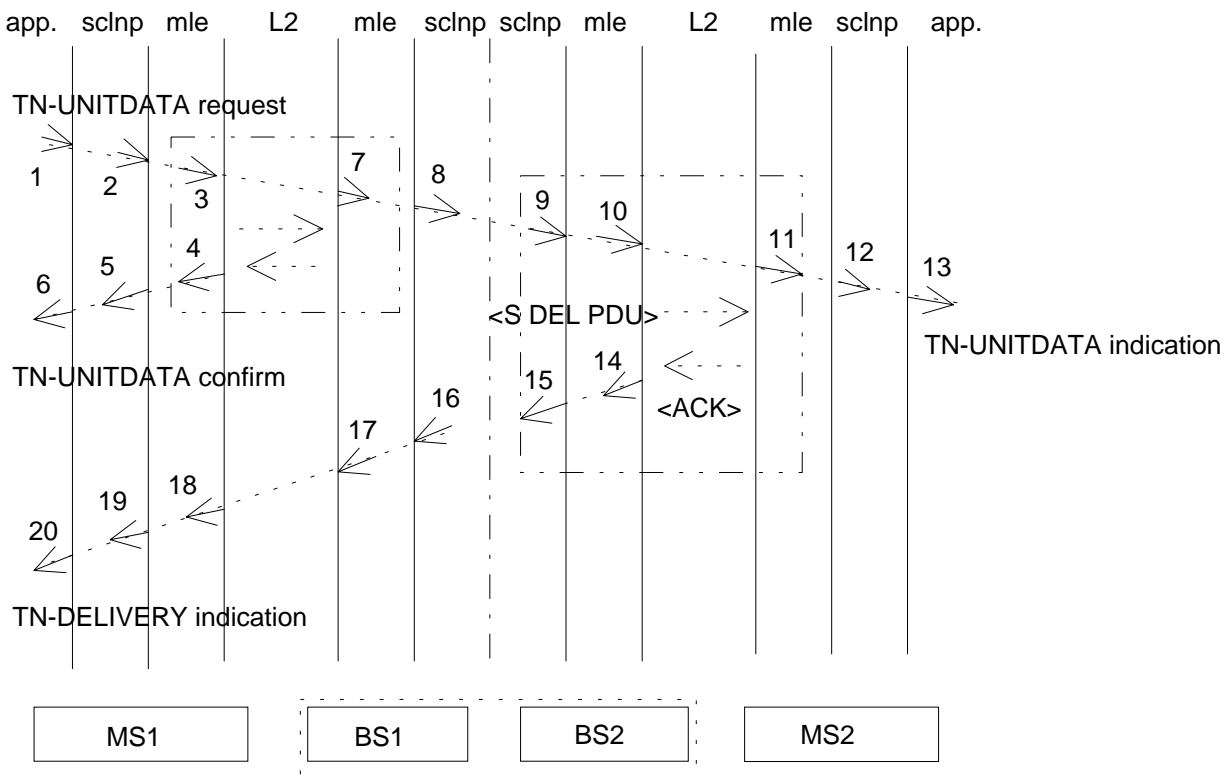


Figure 133: Inter-TETRA case

Figure 134, figure 135 and figure 136 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, and a delivery indication to the sender.

In the report indication scenario (figure 135) 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.

In the delivery indication scenario with status, a status shall be set by a TN-SETSTATUS request. The uplink data shall be acknowledged at layer 2 by the remote entity (MS) and the ACK shall carry the status message read in the LLME. The network layer 2 shall issue a primitive TL-DATA confirm becoming a MLE-UNITDATA confirm at the S-CLNP boundary. Assuming the delivery confirmation has been set the network shall build an S DEL PDU which is sent back to the MS including the status.



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

Figure 134: End-to-end scenario, involving confirmation and delivery confirmation

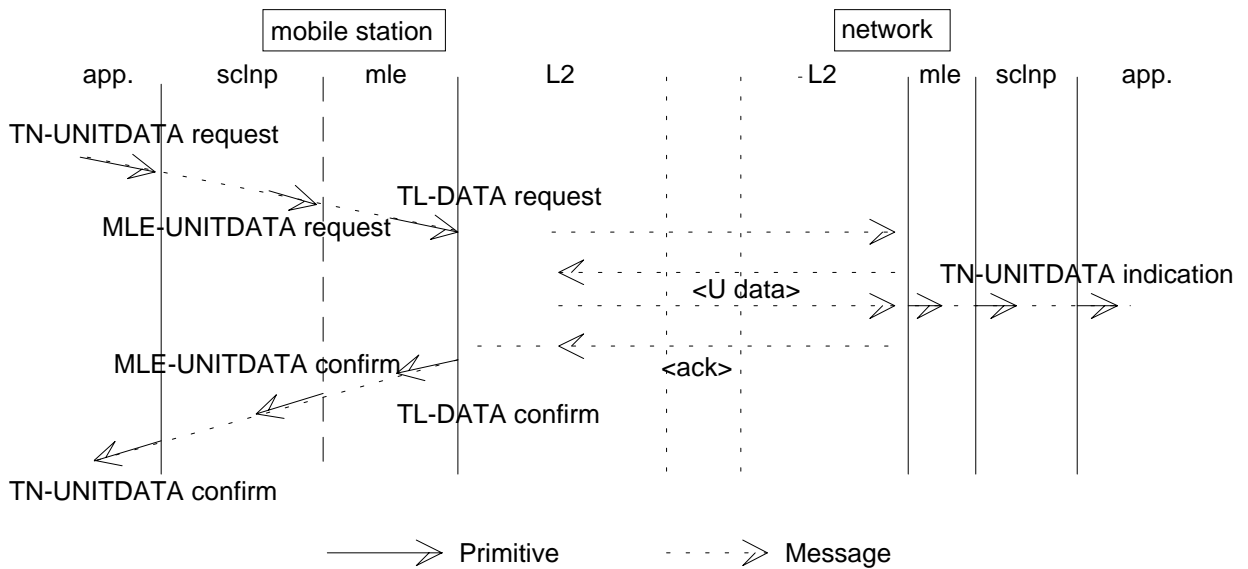


Figure 135: Report indication scenario

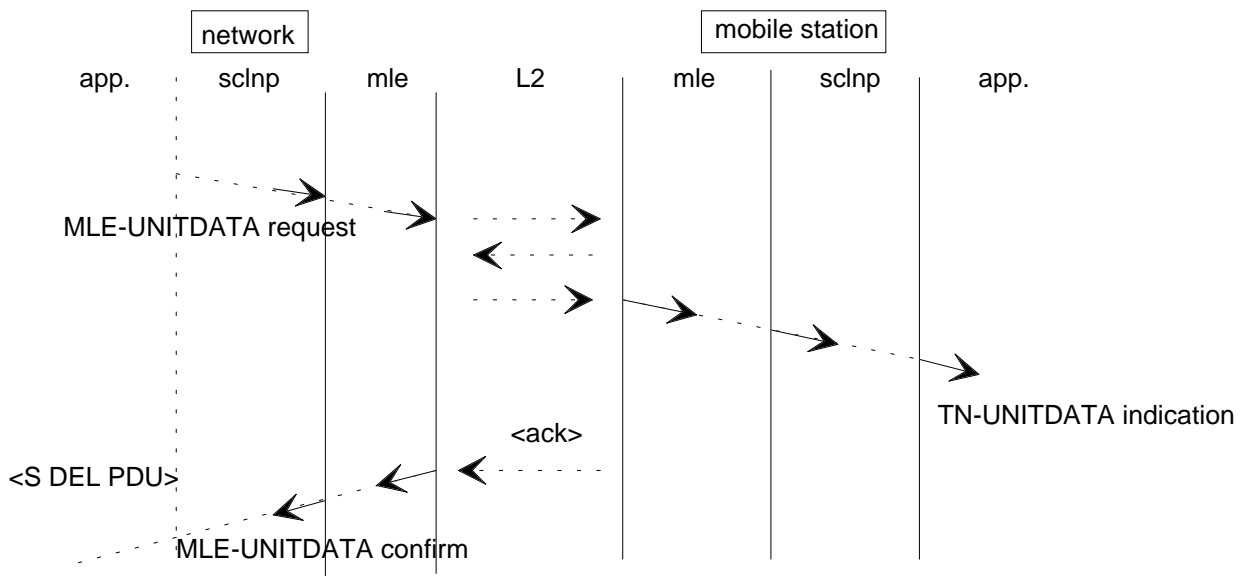


Figure 136: Delivery indication scenario

13.6 Protocol functions

The S-CLNP may provide different functions depending where it is located, i.e. on a send system type, or a forward or a receive system type. The forward system type is on the MTU or on the infrastructure, (see ETS 300 392-2 [17], clause 27).

The functions shall be:

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

13.7 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 300 392-2 [17], clause 27. Figures 131, 132 and 133 show the types of PDUs on the uplink and downlink.

The different types of PDUs shall be S1 meaning uplink, S2 meaning downlink and S3 meaning ISI:

- 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.

14 General on supplementary services

14.1 Introduction

The purpose of this clause is to define a recommended set of supplementary services to the teleservices and bearer services which should be supported by a TETRA network in connection with other networks as a basis for the definition of the network capabilities required. Further it recommends a strategy for the description of supplementary services.

NOTE: The abbreviation SS is only used when referring to a specific supplementary service.

14.2 General

14.2.1 Framework for the description of supplementary services

ETR 086 [16] describes the principles of the telecommunication services provided in a TETRA network. It defines the concepts of telecommunication services and describes their characterization by appropriate attributes. Bearer services and teleservices, which are offered by a TETRA network in connection with other networks, are also defined in ETR 086 [16].

A supplementary service modifies or enhances a basic bearer service or teleservice or other supplementary service. The same supplementary service may be offered with a number of different telecommunication services.

Table 4 illustrates the description of telecommunication services.

Table 4: Categorisation of telecommunication services

Telecommunication service			
Bearer service		Teleservice	
Basic Bearer Service	Basic bearer Service + Supplementary service	Basic Teleservice	Basic Teleservice + Supplementary service

In accordance with CCITT Recommendation I.130 [5], the following three level structure is used to describe the supplementary telecommunications services as provided by European TETRA Operators:

- **Stage 1:** is an overall service description, from the user's stand-point;
- **Stage 2:** identifies the functional capabilities and information flows needed to support the service described in stage 1;
- **Stage 3:** defines the signalling system protocols and switching functions needed to implement the service described in stage 1.

14.2.2 Alignment with the European Computer Manufacturers Association (ECMA)

Stage 1, stage 2 and stage 3 descriptions of the TETRA supplementary services shall align with the appropriate corresponding ECMA standard. Deviations from these standards, which are applicable to TETRA networks, shall be recorded as Deltas. In so doing a harmonised and speedy implementation of many TETRA supplementary services may be realised.

Where no ECMA standards exist, then new descriptions shall be devised, following the principles laid out in the ECMA documentation.

14.2.3 Methodology

The purpose of stage 1 and 2 specifications is to guide and constrain the work on signalling protocols at stage 3.

Stage 1 is a general description of the overall functioning of the service.

Stage 2 consists of the following steps:

- **Step 1:** functional model identification of functional entities and their relationship;
- **Step 2:** information flow diagrams;
- **Step 3:** SDL diagrams for each functional entity;
- **Step 4:** functional entity actions;
- **Step 5:** allocation of functional entities to physical locations.

The decision to follow ECMA's stage 2 is an important one and is based on considerations of signalling across the ISI. In the case of inter-working, unless it is clearly understood where functional entities reside, then there is no means of understanding the signalling protocols across the ISI.

Steps 1, 4 and 5 of stage 2 identify functional entities within the infrastructure, allocate them to physical locations within it, and examine their behaviour. It is appreciated that, depending on the equipment manufacturer and service application, there may be many different combinations possible to locate functional entities.

The specific combination of functional entities may determine the type and content of messages across the ISI.

The protocol design at stage 3 can now be understood. Different allocations of functional entities to physical locations may produce different protocols and procedures across the ISI.

The stage one descriptions of the different supplementary services are contained in ETS 300 392-10 [18].

14.3 Supplementary service concepts

A supplementary service modifies or supplements a basic bearer service or teleservice or other supplementary services.

14.3.1 Concepts associated with supplementary services

The terms used in the stage 1 descriptions are defined in the following subclauses.

14.3.1.1 Provision

An action to make a service available to a user. The provision may be:

- **general:** where the service is made available to all users (subject to compatibility restrictions enforced) without prior arrangements being made with the service provider;
- **pre-arranged:** where the service is made available to an individual user only after the necessary arrangements have been made with the service provider.

14.3.1.2 Withdrawal

An action taken by the service provider to remove an available service from a user's access. The withdrawal may be:

- **general:** where the service is removed from all users provided with the service;
- **specific:** where the service is removed on an individual basis from users provided with the service;
- **temporary:** where the service is removed for a period of time and may be provided later without further arrangements.

14.3.1.3 Activation

An action taken by either the service provider or the served/authorized user to enable a process to run, as and when required, by the service concerned. The time during which the process is activated is defined as the active phase. During activation the service shall be either "operative" or "not operative" according to whether or not the system is actually using the service, e.g. to forward a call or to apply call waiting indication.

14.3.1.4 Deactivation

An action taken by either the service provider or the served/authorized user to terminate the process started at the activation. A supplementary service can be automatically deactivated at the end of a call if the supplementary service was specifically activated for that call. Additionally, a supplementary service may be automatically deactivated by the network as a consequence of activation of another supplementary service if it conflicts with the other activated supplementary service.

14.3.1.5 Definition

An action taken by either the service provider or the served/authorized user in order to define or redefine parameters relating to a particular supplementary service, (e.g. redefine short numbers within SS-SNA, or defining personalised areas in a network within SS-AS).

14.3.1.6 Registration

The programming by the service provider to identify certain authorized users, who may be allowed to activate/deactivate/invoke/define/cancel/interrogate a certain supplementary service.

14.3.1.7 Interrogation

An action taken by the served/authorized user in order that useful information regarding a particular supplementary service may be obtained, e.g. to ascertain the activity state and parameters of a given supplementary service.

A general interrogation of all supplementary services may be provided.

EXAMPLE: possible interrogation and testing processes.

The following interrogation and testing processes are identified here for possible use:

- **status check:** the following values can be returned by the infrastructure:
 - not supported;
 - not subscribed to;
 - activated;
 - deactivated.

Not all values are applicable to supplementary services.

- **data check:** this interrogation function compares the data input by the user during an interrogation procedure with the information stored in the infrastructure. The infrastructure signals an appropriate indication e.g. "check is positive" or "check is negative";
- **data request:** this interrogation function enables the user to obtain confirmation of his input data. The infrastructure signals an appropriate indication;
- **testing:** this test procedure allows the user to check whether or not the service is operating as the user desires. In some cases the use of the service is sufficient, for others a method of testing is included in the control procedure.

14.3.1.8 Cancellation

An action taken by the served/authorized user in order to stop an invoked supplementary service from continuing with its procedures.

14.3.1.9 Invocation

An action to invoke the service required, taken by the user (e.g. pressing a specific button) or automatically by the network or terminal as a result of a particular condition (e.g. calling number identification for each incoming call).

14.3.1.10 Operation

Description of the normal operation of the service, the user's actions and the system response. Decision points, timing and call progress signals should be some of the aspects described for the service if they can be perceived by the users.

14.3.1.11 Exceptional procedures

Abnormal situations which are not described in subclauses 14.3.1.1 to 14.3.1.10 shall be identified, the causes given and the responses expected. Procedures on time-out, unexpected signalling response and other such events should be defined.

14.3.1.12 Inter-working considerations

Identification of user perceptions when a call exits from a TETRA network to another TETRA.

14.3.2 Supplementary service invocation order

Before offering an incoming call to the called user, or before allowing an outgoing call from a calling user to be completed, the infrastructure should search through the user supplementary service database for the activation of supplementary services and proceed with their invocation in the following order:

Incoming Calls		Outgoing Calls	
1	CAD		
2	BIC		
3	CFU	1	CAD
4	CW	2	SNA
5	CFB	3	BOC
6	CFNRc	4	AS

14.3.3 Use of a password option in relation to supplementary services

Some supplementary services (e.g. call barring) may be offered to a user with the subscription option of using a password to control the service. When this option is selected every action (related to that supplementary service), such as registration, activation or deactivation should be performed by the mobile user with the concurrent entry of the password.

14.3.3.1 Description

When the subscription option "control of a supplementary service by the user using a password" is provided, password handling shall be supported by the network.

14.3.3.2 Management - normal procedures

14.3.3.2.1 Provision of password option

Each supplementary service for which the control by the usage of a password is relevant may be offered with the subscription option "control of the supplementary service". The values of this option may be:

- by the user using a password;
- by the service provider.

A service provider need not offer this option to its users.

14.3.3.2.2 Withdrawal of the password option

The password option may be withdrawn for administrative reasons or due to subscription modification.

14.3.3.2.3 Registration of password

If a mobile user selects at provision time the option of using a password for any given supplementary service, the password shall be registered at the same time.

Furthermore, the user should be able to change the password by an appropriate control procedure at any time.

14.3.3.2.4 Erasure of password

A password may be erased in two ways:

- 1) registration of a new password erases the previous one; or
- 2) withdrawal of the password option.

14.3.3.2.5 Password checking

If the mobile user, in an attempt to control a supplementary service requiring a password, enters a correct password, the corresponding request shall then be considered by the network.

14.3.3.3 Management - exceptional procedures

If the mobile user, in an attempt to control a supplementary service requiring a password or in an attempt to register a new password, enters an incorrect password, the corresponding request should be rejected by the network and the user should be notified.

If the mobile user enters incorrect password more than possibly three consecutive times, all control procedures related to the use of the password should be made impossible until the service provider instructs the network to again accept password-related requests from the user.

14.4 Supported supplementary services

Table 5 gives a list of the supplementary services standardized in TETRA, the service definitions of which are given in ETS 300 392-10 [18].

NOTE: All supplementary services identified within this table are defined for calls within a TETRA system or between two TETRA systems which support the supplementary service.

Table 5 lists the categories for all supported supplementary services. The following list shows the abbreviations used.

Provision:

- g = generally available;
- p = pre-arrangement (subscription basis).

Withdrawal:

- u = user's request or for administrative reasons;
- = not applicable.

Activation:

- p = as a result of provision;
- r = as a result of registration;
- d = as a result of definition;
- u = user controlled procedure;
- c = when the conditions in the subscription options are met;
- = not applicable.

Deactivation:

- w = as a result of withdrawal;
- u = user controlled procedure;
- n = when the conditions in the subscription. options are not met;
- = not applicable.

Definition:

- u = user controlled procedure;
- a = service provider controlled procedure;
- = not applicable.

Registration:

p = as a result of provision;
a = service provider controlled procedure;
u = user controlled procedure;
- = not applicable.

Interrogation:

u = user controlled procedure;
- = not applicable.

Cancellation:

u = user controlled procedure;
- = not applicable.

Invocation:

n = automatic invocation by the network as a result of a particular condition;
u = user invocation, by means of a control procedure;
- = not applicable.

Table 5: Supported supplementary services

	Pro	Wit	Act	Deac	Def	Reg	Int	Can	Inv
Number ident SS									
1) CLIP	g	u	p/u	w/u	-	-	u	-	n
2) CLIR	p	u	p	w	-	-	u	-	n
3) COLP	g	u	p/u	w/u	-	-	u	-	n
4) CR	g	u	p	w/u	u	-	u	u	u
5) TPI	p	u	p	w/u	-	-	u	-	u/n
Call forwarding SS									
1) CFU	g	u	u	w/u	u	p	u	-	n
2) CFB	g	u	u	w/u	u	p	u	-	n
3) CFNRy	g	u	u	w/u	u	p	u	-	n
4) CFNRc	g	u	u	w/u	u	p	u	-	n
Call offering SS									
1) LSC	p	u	d	w/u	u	p	u	u	n
2) CAD	p	u	p	w	a	p	u	-	n
3) SNA	p	u	p	w/u	u	p	u	-	u/n
4) AS	p	u	u	w/u	u/a	p	u	u	u/n
5) AP	p	u	p	w	-	-	u	-	u/n
6) PC	p	u	p	w	-	-	u	-	u/n
Call completion SS									
1) CW	g	u	p	w/u	-	-	u	-	n
2) HOLD	g	u	p	w	-	-	u	-	u
3) CCBS	g	u	p	w	-	-	u	u	u
4) LE	p	u	p	w	-	p	u	u	u
5) TC	p	u	p	w	-	p	u	-	u
6) PPC	p	u	p	w	-	p	u	-	u/n
7) CCNR	g	u	p	w	-	-	u	u	u
Multi party SS									
1) IC	g	u	p	w	-	-	u	u	u
2) DGNA	p	u	p	w	u	-	u	u	u
Charging SS									
1) AoC									
Call restriction SS									
1) BOC	p	u	p	w/u	u/a	p	u	-	n
2) BIC	p	u	p	w/u	u/a	p	u	-	n
Call intrusion SS									
1) DL	p	u	p	w	-	p	u	-	u
2) AL	p	u	p	w	-	p	u	-	u
Call retention SS									
1) CRT	p	u	p	w	-	-	u	-	u
NOTE:	The individual abbreviations for the supplementary services are not repeated here but given in clause 3.								

14.4.1 Format of description

The supplementary services shall be described according to the following format:

Supplementary services stage 1

- a) service within TETRA:
 - definition;
 - description;
 - general description;
 - qualifications on applicability to telecommunication services;
 - procedures;
 - provision/withdrawal;
 - normal procedures;
 - exceptional procedures;
 - interaction with other supplementary services;
- b) inter-working considerations;
- c) overall SDL;

Supplementary service stage 2

- d) functional model:
 - functional model description;
 - description of functional entities;
- e) information flows;
- f) functional entity actions;
- g) functional entity behaviour;
- h) relationship to basic call and mapping onto physical equipment;
- j) inter-working considerations;

Supplementary service stage 3

- k) coding requirements;
- l) signalling protocol.

Annex A (informative): Individual circuit mode call scenarios

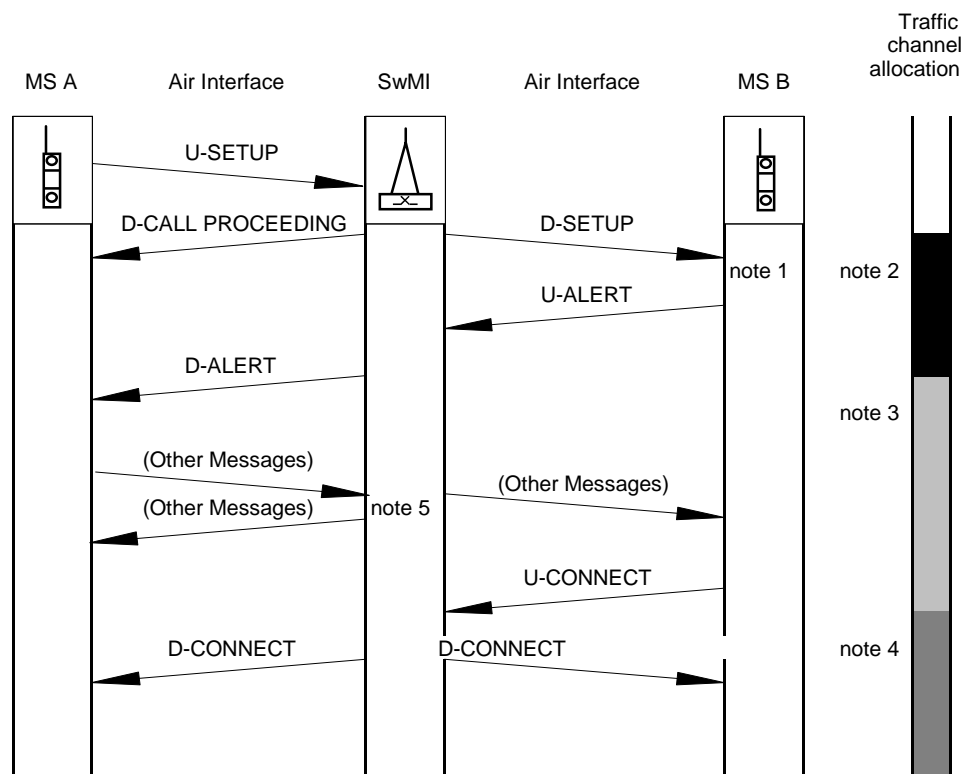
A.1 Introduction

This annex show the typical scenarios and time-sequence diagrams for individual calls. The annex is split into three parts dealing with message trunked procedures (see clause A.2), transmission trunked procedures (see clause A.3) and quasi transmission trunked procedures (see clause A.4).

A.2 Procedures - message trunked systems

A.2.1 Call set-up - on/off hook signalling

Figure A.1 refers. The call set-up request can be started by an up-link message <U-SETUP> from the MS. The SwMI may acknowledge the call set-up request by sending a down-link message <D-CALL PROCEEDING> and to indicate that the call is being processed.



NOTE 1: The indication of on/off hook signalling is indicated in the D-SETUP message.

NOTE 2: Early assignment, i.e. the traffic channel is allocated at earliest possible point.

NOTE 3: Medium assignment, i.e. the traffic channel is allocated when the called mobile's presence is established.

NOTE 4: Late assignment, i.e. the traffic channel is allocated when the called user has answered.

NOTE 5: Example of other signalling.

Figure A.1: Call set-up, on/off hook signalling, message trunked system

If following the receipt of a <U-SETUP> message, the SwMI determines that for some reason the call cannot be supported, or if it is indicated to the SwMI that the call cannot be supported by the called user, then the SwMI should initiate call clearing as defined in subclause A.2.9.

If the call can be supported, the SwMI should send a down-link message <D-SETUP> to the called MS to start the alerting process at the called mobile. It should be indicated to the called MS that on/off hook signalling is being used for this call. This message may be acknowledged by a <U-ALERT> to indicate that the called mobile has begun the alerting process.

Upon receiving an indication that the called party is alerting (<U-ALERT>), the SwMI should send a <D-ALERT> to the calling party.

When the called MS answers, a <U-CONNECT> message should be sent from the called MS to the SwMI.

Upon receipt of the <U-CONNECT> message the SwMI should send a <D-CONNECT> message to the calling MS and a <D-CONNECT ACKNOWLEDGE> to the called MS.

Communication can commence.

NOTE: As an implementation option the network may support other signalling from the calling MS to the SwMI and visa versa during the call set-up phase, for the purposes of supplementary services et al. Similarly the network may support signalling to the called MS at this time.

A.2.1.1 Traffic channel assignment

There may be three methods for assigning a traffic channel:

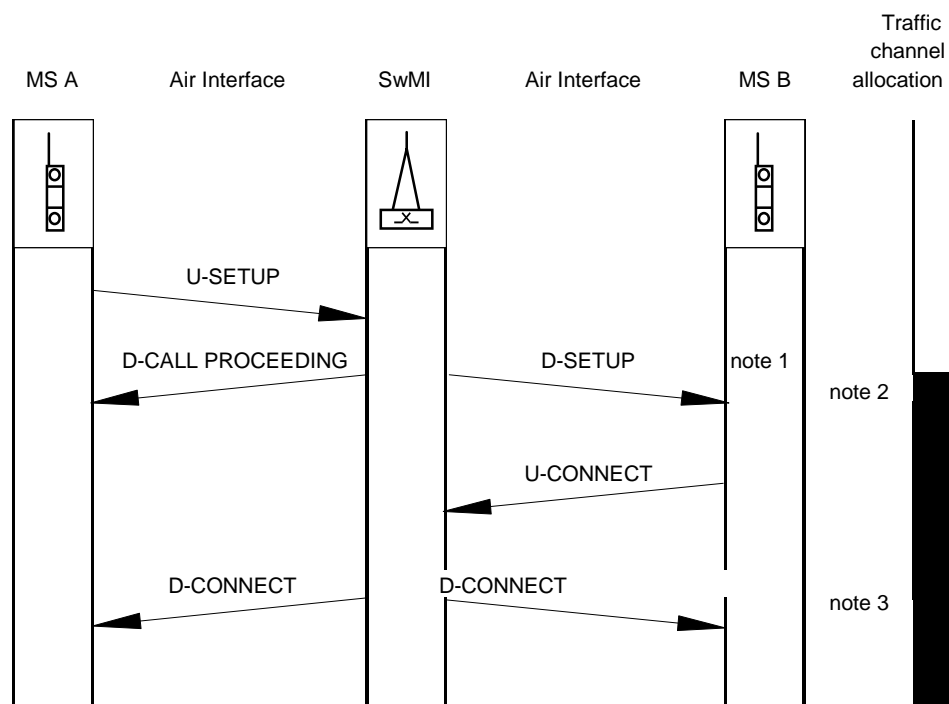
- 1) **early assignment** the traffic channels can be assigned and indicated to the calling and called MS along with the <D-CALL PROCEEDING> and <D-SET-UP> messages respectively, (contained in the lower layer part of those messages). In this case the calling MS should move immediately to the traffic channel in anticipation of the call and should receive all call control messages on this channel;
- 2) **medium assignment** the traffic channels can be assigned and indicated to the calling MS along with (in the lower layers) the <D-ALERT> message. and indicated to the called MS in a layer 2 acknowledgement to the called MS <U-ALERT> message. In this case the calling MS should move to the traffic channel in anticipation of the call and should receive all call control messages on this channel;
- 3) **late assignment** the traffic channels cannot be assigned until the called MS sends a <U-CONNECT> message. Upon receipt of this message the traffic channels can be indicated to the calling and called MS along with the <D-CONNECT> and <D-CONNECT ACKNOWLEDGE> messages respectively, (contained in the lower layer part of those messages). In this case the calling MS should remain listening on the control channel until he is told to move to the traffic channel.

A.2.2 Call set-up - direct set-up signalling

Figure A.1 refers. The call set-up request can be started by an up-link message <U-SETUP> from the MS. The SwMI may acknowledge the call set-up request by sending a down-link message <D-CALL PROCEEDING> and to indicate that the call is being processed.

If following the receipt of a <U-SETUP> message, the SwMI determines that for some reason the call cannot be supported, then the SwMI should initiate call clearing as defined in subclause 2.9.

If the call can be supported, the SwMI should send a down-link message <D-SETUP> to the called MS and it should be indicated to the called MS that direct set-up signalling is being used. This message should be acknowledged by a <U-CONNECT> to indicate that the called mobile is able to receive the call.



NOTE 1: The request to send direct signalling is indicated in the D-SETUP message.

NOTE 2: Early assignment, i.e. the traffic channel is allocated at the earliest possible point.

NOTE 3: Late assignment, i.e. the traffic channel is allocated when the called user has answered.

Figure A.2: Call set-up, direct set-up signalling, message trunked system

Upon receipt of the <U-CONNECT> message the SwMI should send a <D-CONNECT> message to the calling MS and a <D-CONNECT ACKNOWLEDGE> to the called MS.

Communication can commence.

A.2.2.1 Traffic channel assignment

There can be two methods for assigning a traffic channel:

- 1) **early assignment** the traffic channels can be assigned and indicated to the calling and called MS along with the <D-CALL PROCEEDING> and <D-SET-UP> messages respectively, (contained in the lower layer part of those messages). In this case the calling MS should move immediately to the traffic channel in anticipation of the call and should receive all call control messages on this channel;
- 2) **late assignment** the traffic channels cannot be assigned until the called MS sends a <U-CONNECT> message. Upon receipt of this message the traffic channels should be indicated to the calling and called MS along with the <D-CONNECT> and <D-CONNECT ACKNOWLEDGE> messages respectively, (contained in the lower layer part of those messages). In this case the calling MS should remain listening on the control channel until he is told to move to the traffic channel.

A.2.3 Request-to-transmit

The SwMI should be in full control over which MS is allowed to transmit because the MS should request permission to transmit, and permission should be granted before the MS can do so.

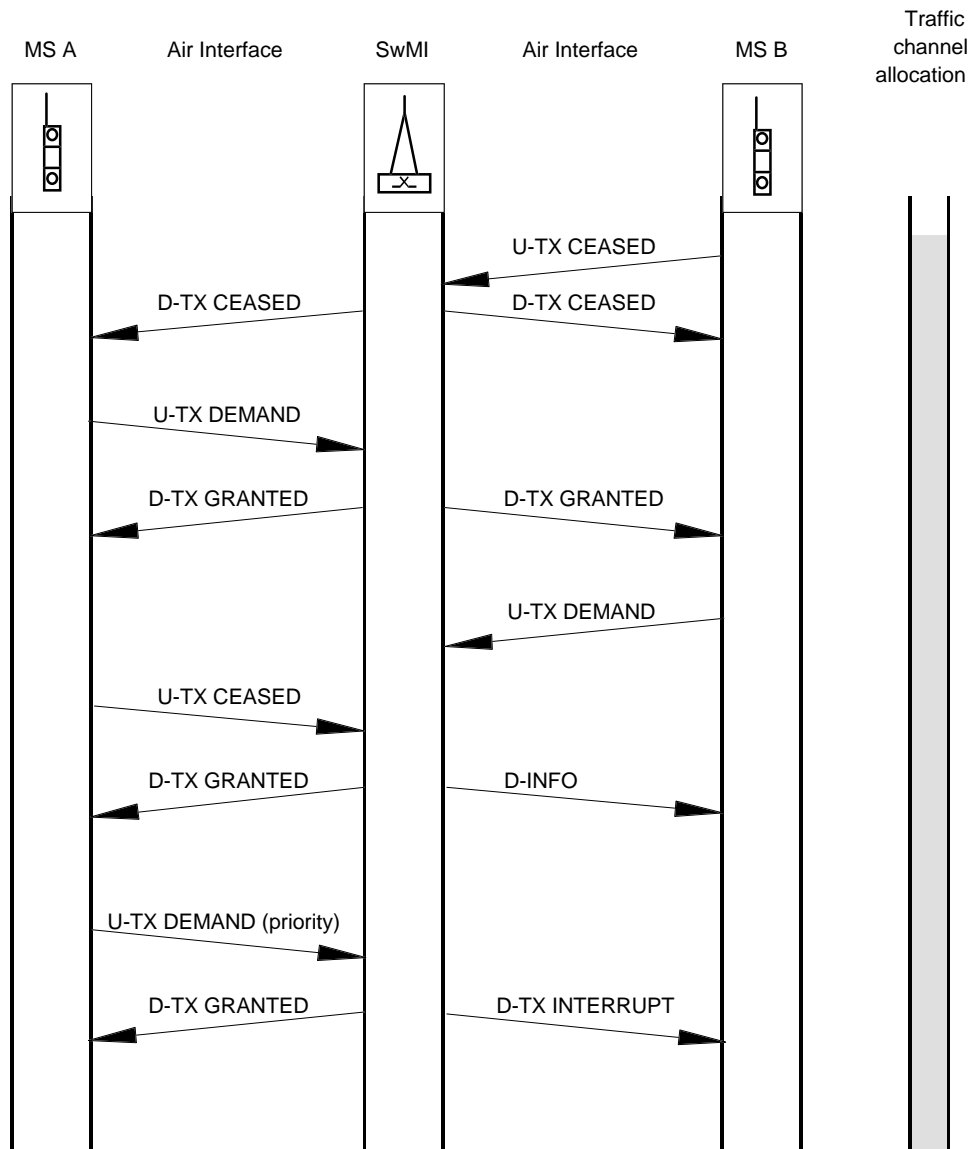


Figure A.3: Request to transmit, direct or on/off hook signalling, message trunked system

If on/off hook signalling is used, it should be normal system operation that the called MS is given permission to transmit by default in the <D-SET-UP> message and early, medium or late assignment should apply as appropriate. However, if desired, the calling MS can ask for permission to transmit in the <U-SETUP> message. The response to this request is dealt with in subclause A.2.4, case (1).

If direct set-up signalling is used, it should be normal system operation that the calling MS should given the permission to transmit immediately upon call set-up. Traffic channel assignment should be as previously discussed in subclause A.2.2.1.

For both signalling methods, when the awarded mobile has finished the communication it should send a <U-TX CEASED>. Figure A.3 refers.

Upon receipt of the <U-TX CEASED> message, the SwMI should send a <D-INFO> message to the "receiving" MS to inform him that the transmission from the other MS has now ceased. The SwMI should await further demands from the calling and called MS's. When either MS wishes to make a request to transmit, it should send a <U-TX DEMAND> message. The response to this request is dealt with in subclause A.2.4, case (2).

A.2.4 Response to request-to-transmit

Case 1: if on/off hook signalling applies and the calling MS has asked for permission to transmit at the call set-up, the SwMI can award permission as appropriate and should respond to this request in the <D-CALL PROCEEDING> message. If permission is granted, then the SwMI should also inform the called MS in the <D-SET-UP> message that permission has not been granted to him.

Case 2: figure A.3 refers. During any call, a <U-TX DEMAND> message may be sent by either MS. If the other MS is not already transmitting then the SwMI response should be a <D-TX GRANTED> message sent to the awarded MS, and a D-INFO sent to the other MS.

If a <U-TX DEMAND> message is sent and the other MS is already transmitting, then the SwMI should wait for that party to finish the transmission, (identified by the receipt of a <U-TX CEASED> message). Subsequently the SwMI should send a <D-TX GRANTED> message to the awarded MS and a D-INFO to the other MS. Priority requests are dealt with under subclause A.2.8.

A.2.5 Permission to transmit withdrawn

The SwMI may decide to interrupt transmission when resources are required for another call or that the SwMI requires that the call should temporarily pause. In this case the SwMI should send a <D-TX WAIT> message to both mobiles. Permission to transmit should be withdrawn, or should not be given to a requesting mobile. The MSs should obey channel allocation and await further instructions on the channel that they have been directed to. The <D-TX WAIT> should:

- confirm to the MSs that the call is in a queue;
- indicate to the MSs that they should not send further requests-to-transmit.

If the request-to-transmit is granted but queued, the MS may be allowed to withdraw its request-to-transmit by means of the message <U-TX CEASED>.

A.2.6 Permission to continue with withdrawn call

When the SwMI has decided that the call can continue, the SwMI may send a <D-TX GRANTED> message to the awarded mobile and a <D-TX CONTINUE> message to the other mobile and the mobiles may be told to go to the traffic channel. If no mobiles have been given permission to transmit then they should be sent a <D-TX CONTINUE> message and are free to make a request to the SwMI.

A.2.7 End of transmission

At the end of a communication, the MS should send <U-TX CEASED> and listen to the traffic channel. Figure A.3 refers. The SwMI should send a <D-INFO> to the other participant.

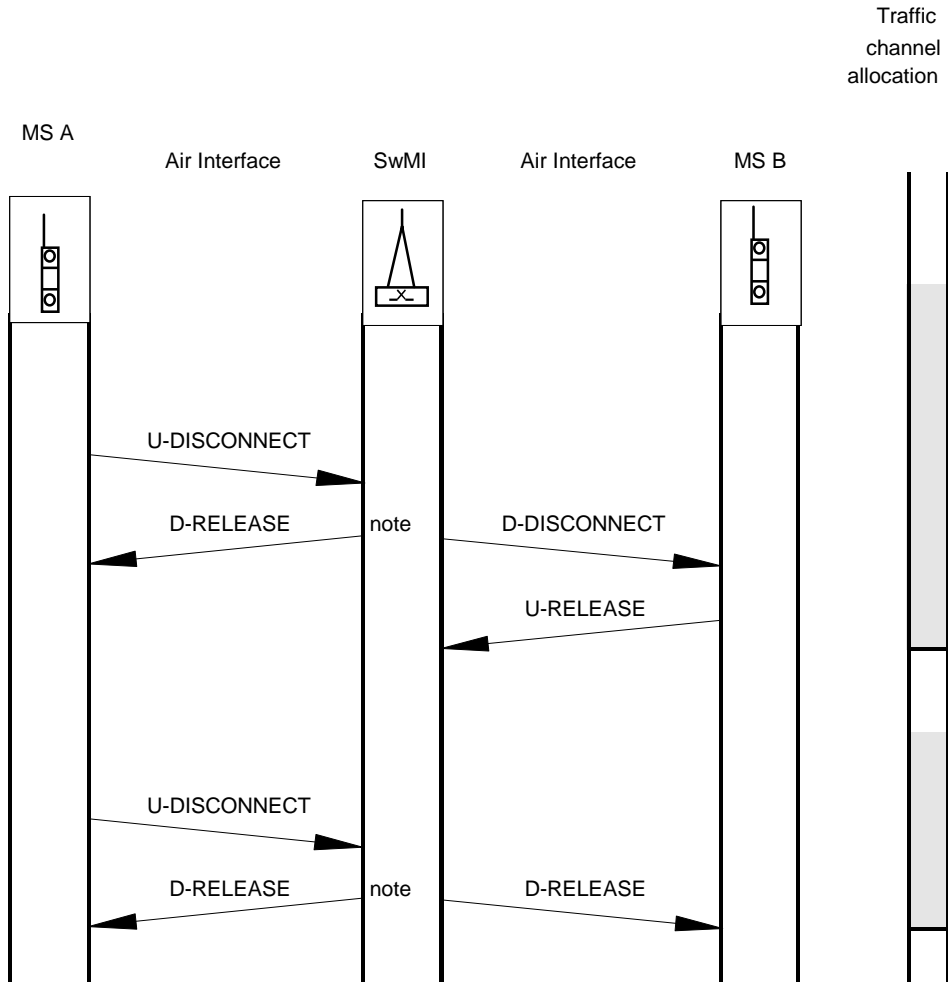
A.2.8 Stop-transmission order

Figure A.3 refers. If, during the course of a transmission, a MS wishes to interrupt the transmitting MS with a higher priority request, a <U-TX DEMAND> message should be sent indicating the level of priority, the SwMI should send a <D-INTERRUPT> message to the transmitting MS and a <D-TX GRANTED> message to the requesting MS. Both messages should indicate the permission to transmit has been re-awarded and should indicate the level of priority.

A.2.9 Call clearing

A.2.9.1 Mobile originated

Figure A.4 refers. The mobile originated call clearing procedure can be started by one of the MS sending an up-link <U-DISCONNECT> message. The SwMI should respond to this message by sending a down-link <D-RELEASE> message to that mobile and that mobile should be released from the call.



NOTE: The SwMI may start the CC-SS retention timer.

Figure A.4: Request to disconnect, direct or on/off hook signalling, message trunked system

The other MS should be informed of the call clearance by a <D-DISCONNECT> message. Its response may be one of the following:

- 1) the MS may respond by sending a <U-DISCONNECT ACKNOWLEDGE>. This should allow that mobile a time delay required for user interaction, such as the invoking of supplementary services. The MS should send a <U-RELEASE> when the user interaction has been completed and the mobile should be released;
- 2) the MS may respond by sending a <U-RELEASE> message. This should immediately release the mobile from the call.

Alternatively, the connected MS may be informed of the call clearance by a <D-RELEASE> message from the SwMI. This message should not be responded to.

A.2.9.2 SwMI originated

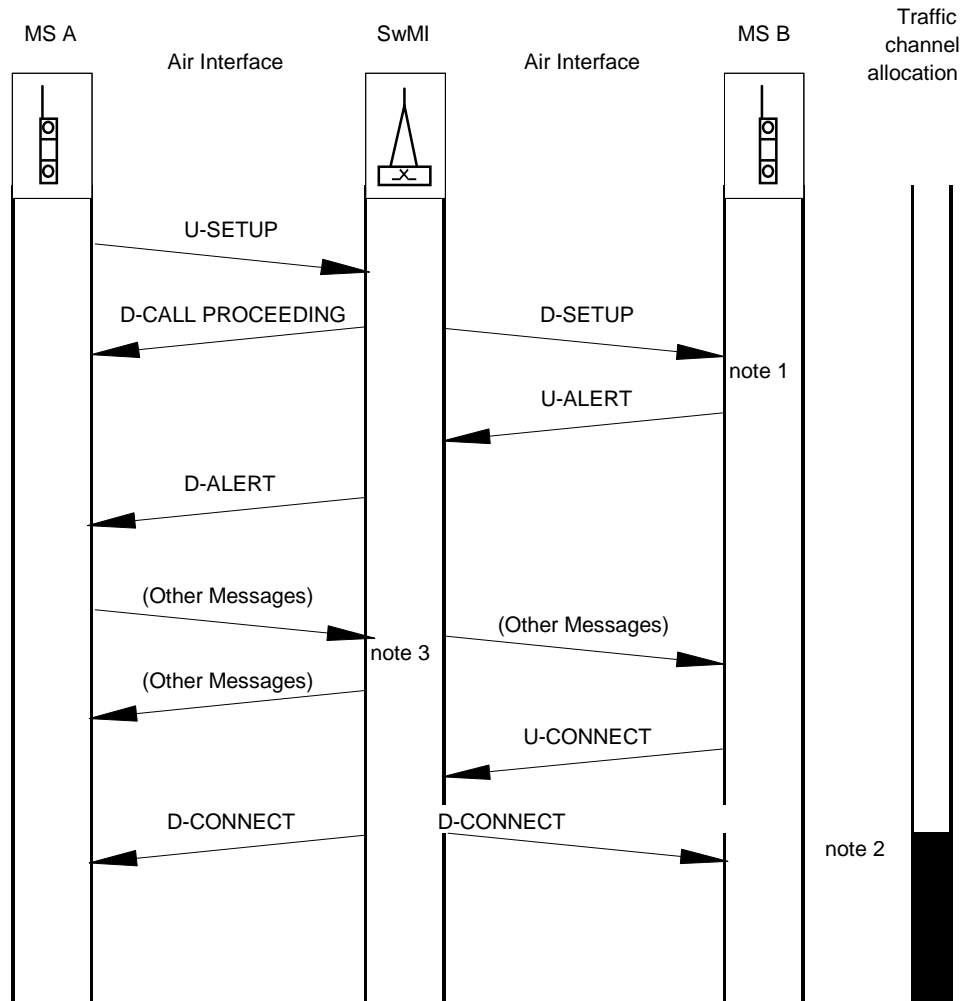
In the case where the SwMI cannot support a request for a call from the calling MS, the SwMI should send a <D-RELEASE> message, containing the reason for failure, to the calling MS.

In the case where the SwMI can no longer support an established call, it should send a <D-RELEASE> message to the calling and called MS's containing the reason for disconnection, and should subsequently release the call.

A.3 Procedures - transmission trunked systems

A.3.1 Call set-up - on/off hook signalling

Figure A.5 refers. The call set-up request can be started by an up-link message <U-SETUP> from the MS. The SwMI may acknowledge the call set-up request by sending a down-link message <D-CALL PROCEEDING> and to indicate that the call is being processed.



NOTE 1: The indication of on/off hook signalling is indicated in the D-SETUP message.

NOTE 2: Late assignment, i.e. the traffic channel is allocated when the called user has answered.

NOTE 3: Example of other signalling.

Figure A.5: Call set-up, on/off hook signalling, transmission trunked system

If following the receipt of a <U-SETUP> message, the SwMI determines that for some reason the call cannot be supported, then the SwMI should initiate call clearing as defined in subclause A.3.9.

If the call can be supported, the SwMI should send a down-link message <D-SETUP> to the called MS to start the alerting process at the called mobile. It should be indicated to the called MS that on/off signalling is being used for this call. This message may be acknowledged by a <U-ALERT> to indicate that the called mobile has begun the alerting process.

Upon receiving an indication that the called party is alerting (<U-ALERT>), the SwMI should send a <D-ALERT> to the calling party.

When the called MS answers, a <U-CONNECT> message should be sent from the called MS to the SwMI.

Upon receipt of the <U-CONNECT> message the SwMI should send a <D-CONNECT> message to the calling MS and a <D-CONNECT ACKNOWLEDGE> to the called MS.

Communication can commence.

NOTE: As an implementation option the network may support intermediate signalling from the calling MS to the SwMI and visa versa during the call set-up phase, for the purposes of supplementary services et al. Similarly the network may support signalling to the called MS at this time.

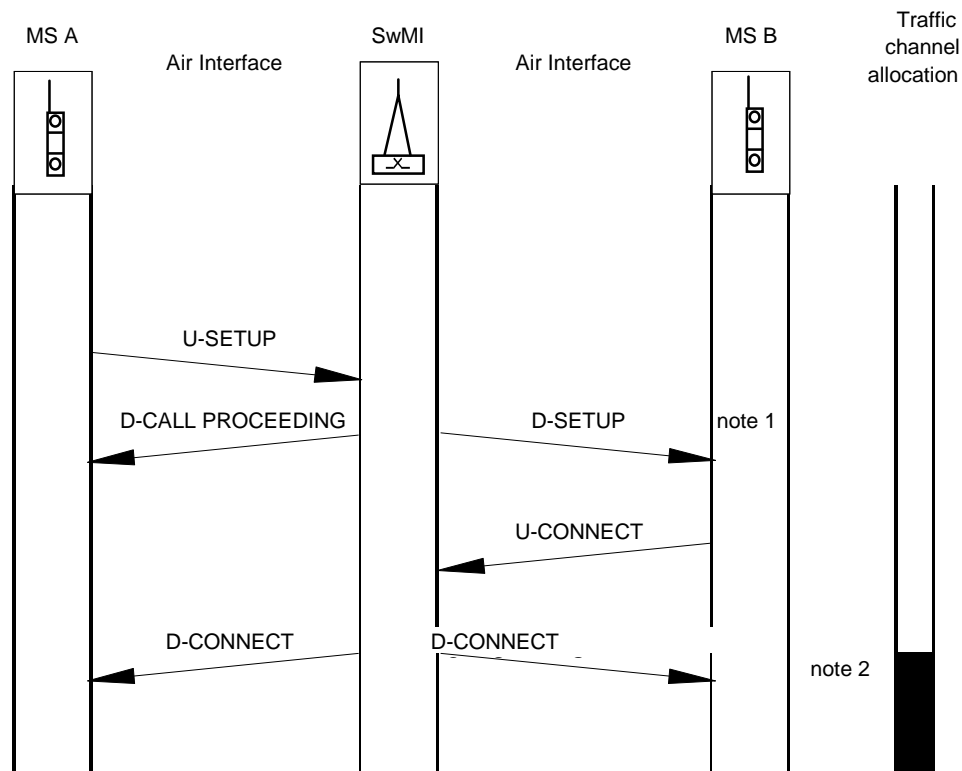
A.3.1.1 Traffic assignment

There should be one method for assigning a traffic channel:

- 1) **late assignment:** the traffic channels should not be assigned until the called MS sends a <U-CONNECT> message. Upon receipt of this message the traffic channels should be indicated to the calling and called MS along with the <D-CONNECT> and <D-CONNECT ACKNOWLEDGE> messages respectively, (contained in the lower layer part of those messages). In this case the calling MS should remain listening on the control channel until he is told to move to the traffic channel.

A.3.2 Call set-up - direct set-up signalling

Figure A.6 refers. The call set-up request can be started by an up-link message <U-SETUP> from the MS. The SwMI may acknowledge the call set-up request by sending a down-link message <D-CALL PROCEEDING> and to indicate that the call is being processed.



NOTE 1: The request to send direct signalling is indicated in the D-SETUP message.

NOTE 2: Late assignment, i.e. the traffic channel is allocated when the called user has answered.

Figure A.6: Call set-up, direct set-up signalling, transmission trunked system

If following the receipt of a <U-SETUP> message, the SwMI determines that for some reason the call cannot be supported, then the SwMI should initiate call clearing as defined in subclause A.3.9.

If the call can be supported, the SwMI should send a down-link message <D-SETUP> to the called MS and it should be indicated to the called MS that direct set-up signalling is being used. This message should be acknowledged by a <U-CONNECT> to indicate that the called mobile is able to receive the call.

Upon receipt of the <U-CONNECT> message the SwMI should send a <D-CONNECT> message to the calling MS and a <D-CONNECT ACKNOWLEDGE> to the called MS.

Communication can commence.

A.3.2.1 Traffic channel assignment

There should be one method for assigning a traffic channel:

- 1) **late assignment:** the traffic channels should not be assigned until the called MS sends a <U-CONNECT> message. Upon receipt of this message the traffic channels should be indicated to the calling and called MS in the <D-CONNECT> and <D-CONNECT ACKNOWLEDGE> messages respectively. In this case the calling MS should remain listening on the control channel until it is told to move to the traffic channel.

A.3.3 Request-to-transmit

The SwMI should be in full control over which MS is allowed to transmit because the MS should request permission to transmit, and permission should be granted before the MS can do so.

If on/off hook signalling is used, it should be normal system operation that the called MS should be given permission to transmit by default in the <D-SET-UP> message and late assignment may apply if appropriate. However, if desired, the calling MS can ask for permission to transmit in the <U-SETUP> message. The response to this request is dealt with in subclause A.3.4, case (1).

If direct set-up signalling is used, it should be normal system operation that the calling MS should be given the permission to transmit. Traffic assignment is as previously discussed in subclause A.3.2.1.

For both signalling methods, when the awarded mobile has finished transmitting it should send a <U-TX CEASED>. Figure A.7 refers.

Upon receipt of the <U-TX CEASED> message, the SwMI may send both MSs a <D-TX CEASED> message, the MSs should be cleared from the traffic channel and the SwMI can await further demands from the calling and called MSs. When either MS wishes to make a request to transmit, it should send a <U-TX DEMAND> message. The response to this request is dealt with in subclause A.3.4, case (2).

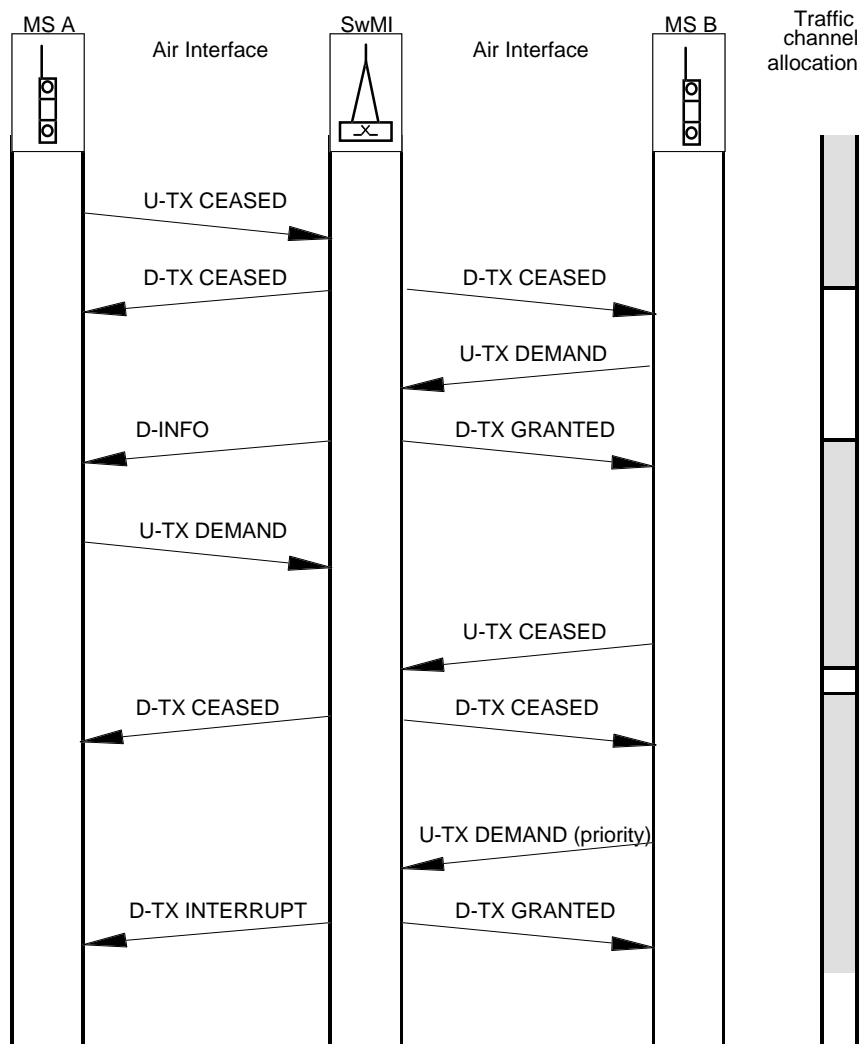


Figure A.7: Request to transmit, direct set-up or on/off hook signalling, transmission trunked system

A.3.4 Response to request-to-transmit

Case 1: if on/off hook signalling applies and the calling MS has asked for permission to transmit at the call set-up, the SwMI can award permission as appropriate and can respond to this request in the <D-CALL PROCEEDING> message. If permission is granted, then the SwMI should also inform the called MS in the <D-SET-UP> message that permission has not been granted to him.

Case 2: figure A.7 refers. During any call, a <U-TX DEMAND> message may be sent by either MS. If the other MS is not already transmitting then the SwMI response should be a <D-TX GRANTED> message sent to the awarded MS, and a D-INFO sent to the other MS. The messages can be accompanied by the traffic channel allocation (contained in the lower layer parts). supplementary service information can also be appended to this message if appropriate.

If a <U-TX DEMAND> message is sent and the other MS is already transmitting, then the SwMI should wait for that party to finish the transmission, (identified by the receipt of a <U-TX CEASED> message). Subsequently the SwMI can send a <D-TX GRANTED> message to the awarded MS and a D-INFO to the other MS. Priority requests are dealt with under subclause A.3.8.

A.3.5 Permission to transmit withdrawn

The SwMI may decide to interrupt transmission when resources are required for another call or that the SwMI requires that the call should temporarily pause. In this case the SwMI should send a <D-TX WAIT> message to both mobiles. Permission to transmit should be withdrawn, or should not be given to a requesting mobile. The MSs should obey channel allocation and await further instructions on the channel that they have been directed to. The <D-TX WAIT> should:

- confirm to the MSs that the call is in a queue;
- indicate to the MSs that they should not send further requests-to-transmit.

If the request-to-transmit is granted but queued, the MS should be allowed to withdraw its request-to-transmit by means of the message <U-TX CEASED>.

A.3.6 Permission to continue with withdrawn call

When the SwMI has decided that the call can continue, the SwMI may send a <D-TX GRANTED> message to the awarded mobile and a <D-TX CONTINUE> message to the other mobile and the mobiles may be told to go to the traffic channel. If no mobiles have been given permission to transmit then they should be sent a <D-TX CONTINUE> message and should not be sent to the traffic channel. They are now free to make a request to the SwMI.

A.3.7 End of transmission

At the end of a transmission, the MS should send <U-TX CEASED>. The SwMI should send a <D-TX CEASED> to all concerned MS's to return them to the Control Channel. Figure A.6 refers.

A.3.8 Stop-transmission order

Figure A.7 refers. If, during the course of a transmission, a MS wishes to interrupt the transmitting MS with a higher priority request, a <U-TX DEMAND> message should be sent indicating the level of priority, the SwMI should send a <D-INTERRUPT> message to the transmitting MS and a <D-TX GRANTED> message to the requesting MS. Both messages should indicate the permission to transmit has been re-awarded and should indicate the level of priority. (If the SwMI wishes to change the traffic channel, then this instruction may also be appended to the <D-TX GRANTED> message).

A.3.9 Call clearing

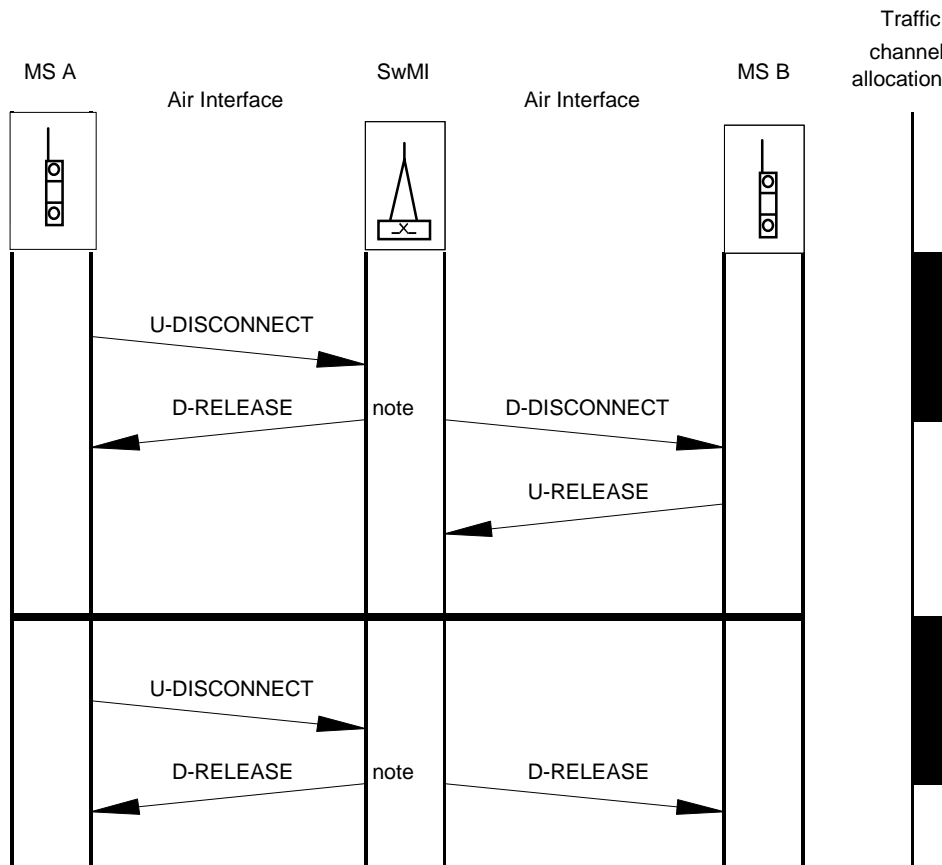
A.3.9.1 Mobile originated

Figure A.8 refers. The mobile originated call clearing procedure can be started by one of the MS sending an up-link <U-DISCONNECT> message. The SwMI should respond to this message by sending a down-link <D-RELEASE> message to that mobile and that mobile should be released from the call.

The other MS is informed of the call clearance by a <D-DISCONNECT> message. Its response may be one of the following:

- 1) the MS may respond by sending a <U-DISCONNECT ACKNOWLEDGE>. This should allow that mobile a time delay required for user interaction, such as the invoking of supplementary services. The MS should send a <U-RELEASE> when the user interaction has been completed and the mobile should be released;
- 2) the MS may respond by sending a <U-RELEASE> message. This should immediately release the mobile from the call.

Alternatively, the connected MS may be informed of the call clearance by a <D-RELEASE> message from the SwMI. This message should not be responded to.



NOTE: The SwMI may start the CC-SS retention timer.

Figure A.8: Request to disconnect, direct set-up or on/off hook signalling, transmission trunked system

A.3.9.2 SwMI originated

In the case where the SwMI cannot support a request for a call from the calling MS, the SwMI should send a <D-RELEASE> message, containing the reason for failure, to the calling MS.

In the case where the SwMI can no longer support an established call, it should send a <D-RELEASE> message to the calling and called MS's containing the reason for disconnection, and should subsequently release the call.

A.4 Procedures - quasi-transmission trunked systems

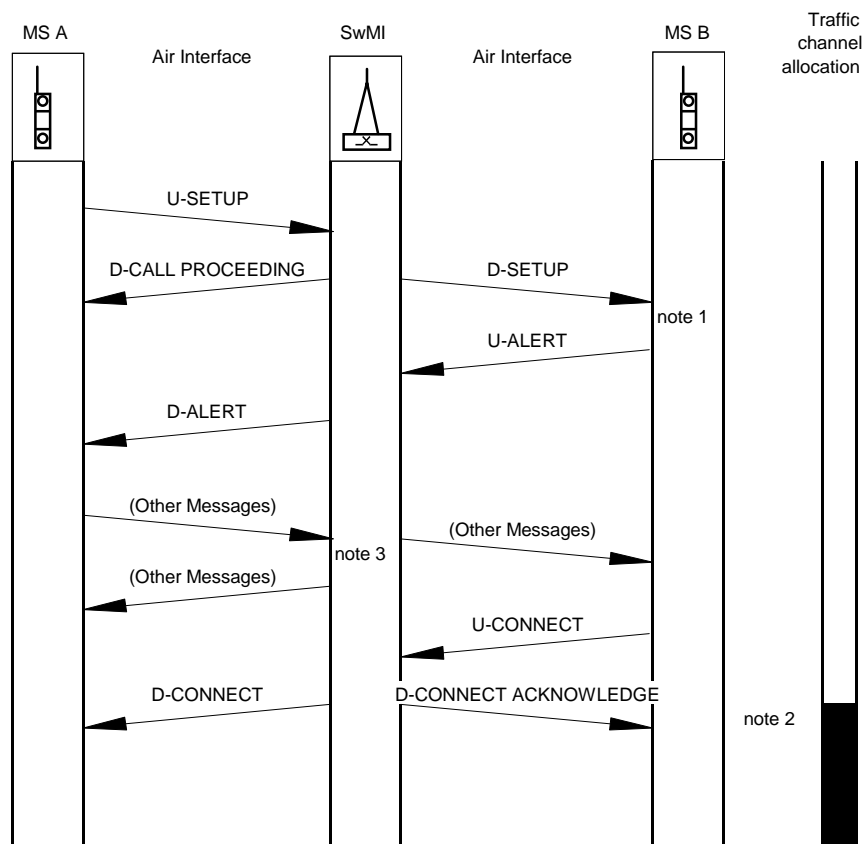
A.4.1 Call set-up - on/off hook signalling

Figure A.9 refers. The call set-up request can be started by an up-link message <U-SETUP> from the MS. The SwMI may acknowledge the call set-up request by sending a down-link message <D-CALL PROCEEDING> and to indicate that the call is being processed.

If following the receipt of a <U-SETUP> message, the SwMI determines that for some reason the call cannot be supported, then the SwMI should initiate call clearing as defined in subclause A.4.9.

If the call can be supported, the SwMI should send a down-link message <D-SETUP> to the called MS to start the alerting process at the called mobile. It should be indicated to the called MS that on/off signalling is being used for this call. This message may be acknowledged by a <U-ALERT> to indicate that the called mobile has begun the alerting process.

Upon receiving an indication that the called party is alerting (<U-ALERT>), the SwMI should send a <D-ALERT> to the calling party.



NOTE 1: The indication of on/off hook signalling is indicated in the D-SETUP message.

NOTE 2: Late assignment, i.e. the traffic channel is allocated when the called user has answered.

NOTE 3: Example of other signalling.

Figure A.9: Call set-up, on/off hook signalling, quasi-transmission trunked system

When the called MS answers, a <U-CONNECT> message should be sent from the called MS to the SwMI.

Upon receipt of the <U-CONNECT> message the SwMI should send a <D-CONNECT> message to the calling MS and a <D-CONNECT ACKNOWLEDGE> to the called MS.

Communication can commence.

NOTE: As an implementation option the network may support intermediate signalling from the calling MS to the SwMI and visa versa between the <D-ALERT> message and the <D-CONNECT> message for the purposes of supplementary services et al. Similarly the network may support signalling to the called MS at this time.

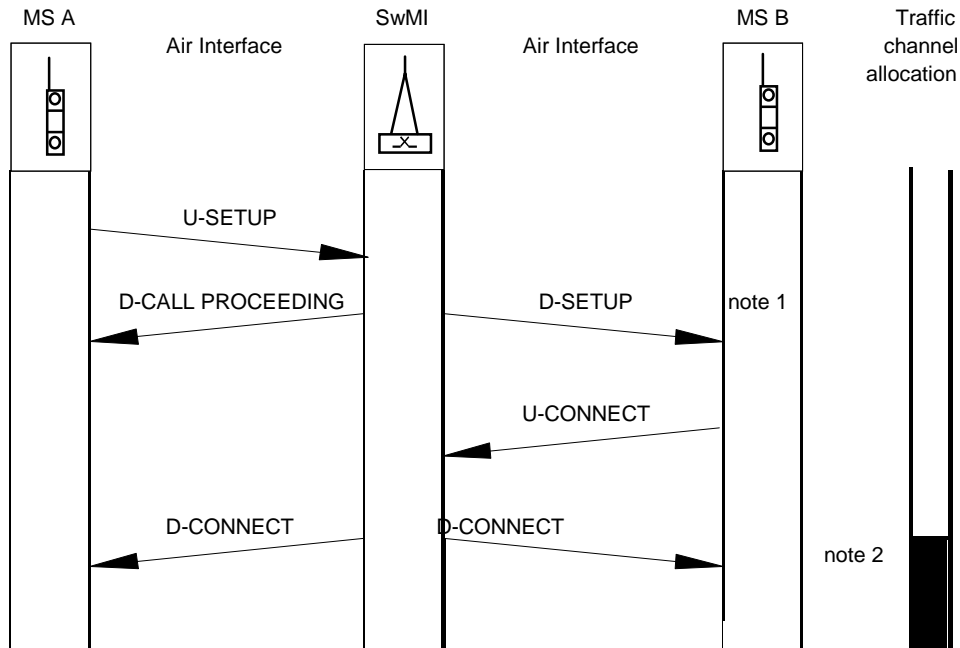
A.4.1.1 Traffic assignment

There should be one method for assigning a traffic channel:

- 1) **late assignment:** the traffic channels should not be assigned until the called MS sends a <U-CONNECT> message. Upon receipt of this message the traffic channels should be indicated to the calling and called MS along with the <D-CONNECT> and <D-CONNECT ACKNOWLEDGE> messages respectively, (contained in the lower layer part of those messages). In this case the calling MS remains listening on the control channel until he is told to move to the traffic channel.

A.4.2 Call set-up - direct set-up signalling

Figure A.10 refers. The call set-up request can be started by an up-link message <U-SETUP> from the MS. The SwMI may acknowledge the call set-up request by sending a down-link message <D-CALL PROCEEDING> and to indicate that the call is being processed.



NOTE 1: The request to send direct signalling is indicated in the D-SETUP message.

NOTE 2: Late assignment, i.e. the traffic channel is allocated when the called user has answered.

Figure A.10: Call set-up, direct set-up signalling, quasi-transmission trunked system

If following the receipt of a <U-SETUP> message, the SwMI determines that for some reason the call cannot be supported, then the SwMI should initiate call clearing as defined in subclause A.4.9.

If the call can be supported, the SwMI should send a down-link message <D-SETUP> to the called MS and it should be indicated to the called MS that direct set-up signalling is being used. This message should be acknowledged by a <U-CONNECT> to indicate that the called mobile is able to receive the call.

Upon receipt of the <U-CONNECT> message the SwMI should send a <D-CONNECT> message to the calling MS and a <D-CONNECT ACKNOWLEDGE> to the called MS.

Communication can commence.

A.4.2.1 Traffic assignment

There should be one method for assigning a traffic channel:

- 1) **late assignment:** the traffic channels should not be assigned until the called MS sends a <U-CONNECT> message. Upon receipt of this message the traffic channels should be indicated to the calling and called MS along with the <D-CONNECT> and <D-CONNECT ACKNOWLEDGE> messages respectively, (contained in the lower layer part of those messages). In this case the calling MS should remain listening on the control channel until he is told to move to the traffic channel.

If on/off hook signalling is used, it should be normal system operation that the called MS should be given permission to transmit by default in the <D-SET-UP> message and early, medium or late assignment should apply as appropriate. However, if desired, the calling MS can ask for permission to transmit in the <U-SETUP> message. The response to this request is dealt with in subclause A.4.4, case 1.

If direct set-up signalling is used, it should be normal system operation that the calling MS should be given the permission to transmit. Traffic assignment should as previously discussed in subclause A.4.2.1.

For both signalling methods, when the awarded mobile has finished transmitting it should send a <U-TX CEASED>. Figure A.11 refers.

Upon receipt of the <U-TX CEASED> message, the SwMI should start a timer (hang time) and should send the receiving MS a <D-INFO> to inform that the transmission from the other MS has now ceased. After expiry of the timer, and no MSs have sent any messages, the SwMI should send both mobiles the <D-TX CEASED> message which informs both mobiles to leave the traffic channel and that they are able to request permission to transmit. Any MS may explicitly request for permission to transmit by sending a <U-TX DEMAND> message. The response to this request should be determined by whether the Timer has expired or not and is dealt with in subclause A.4.4, case 2.

If the hang-time is infinite the TETRA may become message trunked.

A.4.4 Response to request-to-transmit

Case 1: if on/off hook signalling applies and the calling MS has asked for permission to transmit at the call set-up, the SwMI can award permission as appropriate and should respond to this request in the <D-CALL PROCEEDING> message. If permission is granted, then the SwMI should also inform the called MS in the <D-SET-UP> message that permission has not been granted to him.

Case 2: figure A.11 refers. During any call, a <U-TX DEMAND> message may be sent by either MS. If the other MS is not already transmitting and the timer has expired, then the SwMI response should be a <D-TX GRANTED> message sent to the awarded MS, and a D-INFO sent to the other MS. The messages should contain the traffic channel assignment. Supplementary service information can also be appended to this message if appropriate.

If a <U-TX DEMAND> message is sent when no MS is transmitting but the hang timer has not expired, then the SwMI response may be a <D-TX GRANTED> message sent to the awarded MS and a D-INFO to the other MS. The MSs are assumed to be still on the traffic channel and a new assignment need not be given.

If a <U-TX DEMAND> message is sent and the other MS is already transmitting, then the SwMI should wait for that party to finish the transmission, (identified by the receipt of a <U-TX CEASED> message). Subsequently the SwMI should send a <D-TX GRANTED> message to the awarded MS and a D-INFO to the other MS. The MSs are assumed to be still on the traffic channel and a new assignment need not be given. Priority requests are dealt with under subclause A.4.8.

A.4.5 Permission to transmit withdrawn

The SwMI may decide to interrupt transmission when resources are required for another call or that the SwMI requires that the call should temporarily pause. In this case the SwMI should send a <D-TX WAIT> message to both mobiles. Permission to transmit should be withdrawn, or should not be given to a requesting mobile. The MSs should obey channel allocation and await further instructions on the channel that they have been directed to. The use of this message is optional. Figure A.11 refers. The <D-TX WAIT> should:

- confirm to the MSs that the call is in a queue;
- indicate to the MSs that they should not send further requests-to-transmit.

If the request-to-transmit is granted but queued, the MS is allowed to withdraw its request-to-transmit by means of the message <U-TX CEASED>.

A.4.6 Permission to continue with withdrawn call

When the SwMI has decided that the call can continue, the SwMI may send a <D-TX GRANTED> message to the awarded mobile and a <D-TX CONTINUE> message to the other mobile and the mobiles may be told to go to the traffic channel. If no mobiles have been given permission to transmit then they should be sent a <D-TX CONTINUE> message and are free to make a request to the SwMI.

A.4.7 End of transmission request

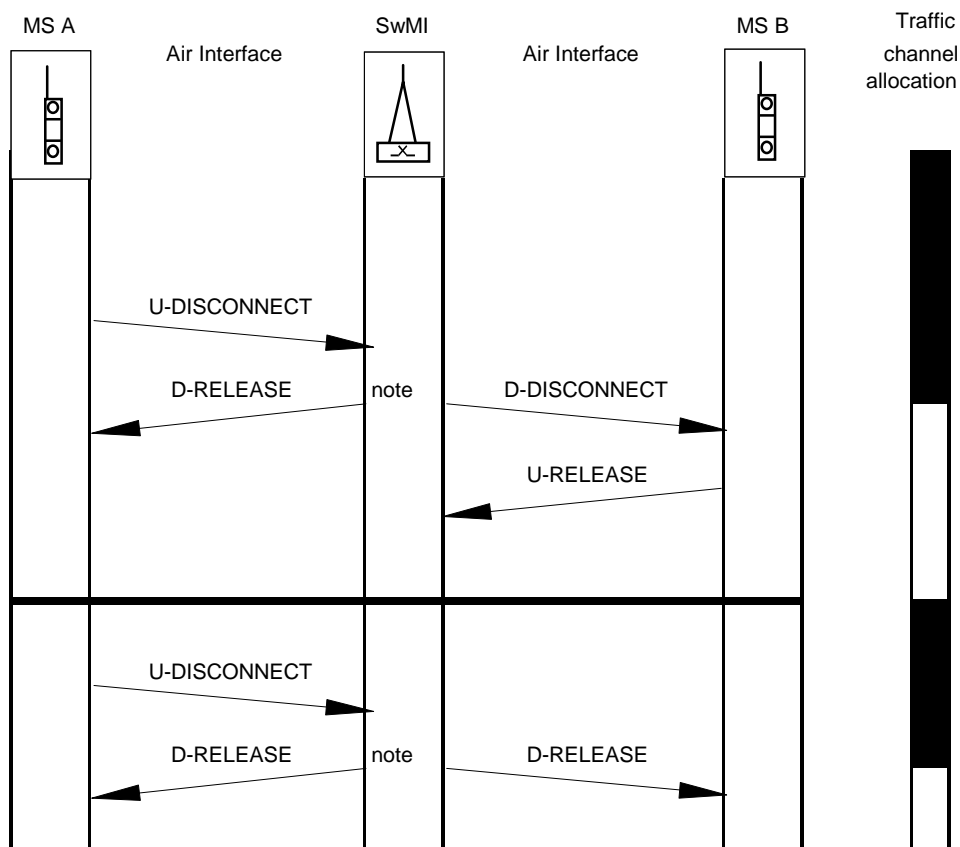
At the end of a transmission, the MS should send <U-TX CEASED> and should listen to the traffic channel. Upon receipt of the <U-TX CEASED> message, the SwMI should start a timer (hang time) and should send a <D-INFO> message to the other MS to indicate that the transmission has ceased.. After expiry of the timer, and no MSs have sent any messages, the SwMI should send both mobiles the <D-TX CEASED> message which should inform both mobiles to leave the traffic channel and go to the control channel. Figure A.11 refers.

A.4.8 Stop-transmission order

If, during the course of a transmission, the other mobile wishes to interrupt the transmitting mobile with a higher priority request and sends a <U-TX DEMAND> message indicating the level of priority, the SwMI should send a <D-TX CEASED> message to both mobiles followed by a <D-TX GRANTED> message to both mobiles re-awarding permission to the requesting mobile and indicating the level of priority to both mobiles.

A.4.9 Call clearing

A.4.9.1 Mobile originated



NOTE: The SwMI may start the CC-SS retention timer.

Figure A.12: Request to disconnect, quasi-transmission trunked system

Figure A.12 refers. The mobile originated call clearing procedure can be started by one of the MS sending an up-link <U-DISCONNECT> message. The SwMI should respond to this message by sending a down-link <D-RELEASE> message to that mobile and that mobile should be released from the call.

The other MS should be informed of the call clearance by a <D-DISCONNECT> message. Its response may be one of the following:

- 1) the MS may respond by sending a <U-DISCONNECT ACKNOWLEDGE>. This should allow that mobile a time delay required for user interaction, such as the invoking of supplementary services. The MS should send a <U-RELEASE> when the user interaction has been completed and the mobile should be released;
- 2) the MS may respond by sending a <U-RELEASE> message. This should immediately release the mobile from the call.

Alternatively, the connected MS may be informed of the call clearance by a <D-RELEASE> message from the SwMI. This message should not be responded to.

A.4.9.2 SwMI originated

In the case where the SwMI cannot support a request for a call from the calling MS, the SwMI should send a <D-RELEASE> message, containing the reason for failure, to the calling MS.

In the case where the SwMI can no longer support an established call, it should send a <D-RELEASE> message to the calling and called MSs containing the reason for disconnection, and should subsequently release the call.

Annex B (informative): Group voice call scenarios

B.1 Procedures for message trunked systems

B.1.1 General

All group calls are considered as employing only direct set-up signalling procedures. This procedure allows immediate communication to take place between the calling and called users without the necessity of having an alerting process and without an explicit response from the called user that he has answered. The called users normally go straight to the traffic channel.

For acknowledged group calls, it is an operator option if the call is to proceed immediately by giving the originator permission to transmit. Alternatively, the operator may choose to poll the MS on the traffic channel and act according upon the receipt of a response from the polled MS.

NOTE 1: This procedure is known as presence checking.

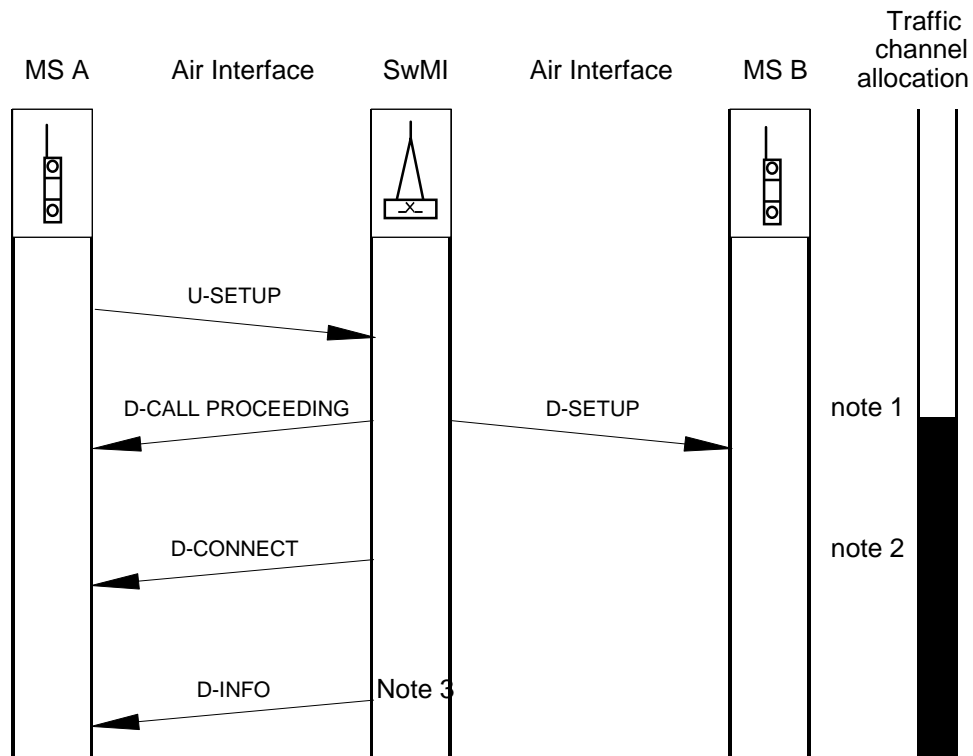
According to a predefined criteria the call may be allowed to proceed.

It is an operator option to disconnect the call if insufficient members are present, and the right to transmit has not yet been given.

It is an operator option to continue with presence checking beyond the point where the originator has been given permission to transmit.

NOTE 2: For clarity, the time sequence diagrams in this clause only show two participating members of the group call.

B.1.2 Call set-up



- NOTE 1: Early assignment, i.e. the calling MS and the called MS may be sent to the traffic channel at this stage.
- NOTE 2: Late assignment, i.e., the calling MS may be sent to the traffic channel at this stage.
- NOTE 3: For acknowledged group calls, the presence of the members of the group may be indicated here.

Figure B.1: Call set-up phase for a group call in a message trunked system

The call set-up request is started by an up-link message <U-SETUP> from the MS. The SwMI may optionally acknowledge the call set-up request by sending a down-link message <D-CALL PROCEEDING> to indicate that the call is being processed, (see figure B.1).

If, following the receipt of a <U-SETUP> message, the SwMI determines that for some reason the call cannot be supported, then the SwMI initiates call clearing as defined in subclause B.1.9.

If the call can be supported, the SwMI sends a down-link message(s) <D-SETUP> to the called MS.

During, or as an option upon completion of, the transmission of the <D-SETUP> message, the SwMI may send a <D-CONNECT> message to the calling MS.

On completion of this procedure communication can commence.

The option depends upon whether the group call is an acknowledged one. If it is acknowledged, the SwMI may delay the transmission of the <D-CONNECT> message to the calling MS, and wait for acknowledgements from the called MS before proceeding. If at this stage the SwMI decides that the call cannot be supported it initiates call clearing as defined in subclause B.1.9.

If the group call is acknowledged, the call owner may be informed of the presence of the other members of the group in the <D-INFO> message.

B.1.2.1 Traffic channel assignment

For the called MS, the traffic channel assignment is always given in the <D-SET-UP> message.

There are two methods for assigning a traffic channel to the calling MS:

- 1) early assignment: the traffic channel is assigned and indicated to the calling MS along with the <D-CALL PROCEEDING>, (contained in the lower layer part of that message). In this case the calling MS moves immediately to the channel that has been made available as the future traffic channel, and receives all further call control messages on this channel in anticipation of the call; or
- 2) late assignment: the traffic channel is not assigned until appropriate conditions are met.

NOTE: These conditions may be as a result of the finite time required to locate group members, or as a result of the call being acknowledged. In this case the calling MS remains listening on the control channel (or other if instructed by the SwMI), until it is told to move to the traffic channel. The traffic channel is indicated to the calling MS along with the <D-CONNECT> message, (contained in the lower layer part of that message).

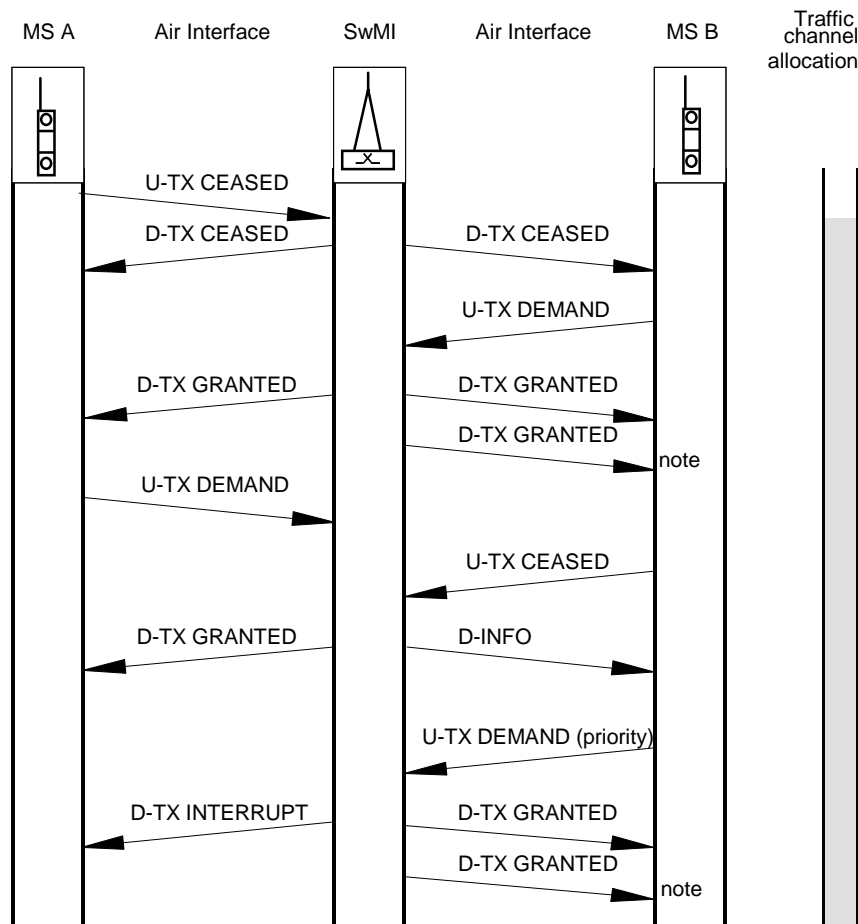
B.1.3 Request-to-transmit

The SwMI is in full control over which MS is allowed to transmit because the MS is obliged to request permission to transmit, and permission must be granted before the MS can do so.

It is normal system operation that the calling MS will be given the permission to transmit immediately upon call set-up. Traffic channel assignment is as previously discussed in subclause B.1.2.

When the awarded MS has finished the communication it sends a <U-TX CEASED>, (see figure B.2).

Upon receipt of the <U-TX CEASED> message, the SwMI sends a <D-INFO> message to the "receiving" MS to inform them that the transmission has now ceased. The SwMI awaits further demands from the calling and called MS. When any MS wishes to make a request to transmit, it sends a <U-TX DEMAND> message. The response to this request is dealt with in subclause B.1.4.



NOTE: D-TX granted is sent to the remaining members of the group upon awarding permission to MS B.

Figure B.2: Request to transmit for a group call in a message trunked system

B.1.4 Response to request-to-transmit

During any call, a <U-TX DEMAND> message may be sent by any MS. If any other MS is not already transmitting, then the SwMI may respond with a <D-TX GRANTED> message sent to the awarded MS addressed by his Individual TETRA Subscriber Identity (ITSI), and a <D-INFO> sent to the remaining MS addressed by the Group TETRA Subscriber Identity (GTSI), (see figure B.2).

If a <U-TX DEMAND> message is sent and another MS is already transmitting, then the SwMI waits for that MS to finish its transmission, (identified by the receipt of a <U-TX CEASED> message). Subsequently the SwMI sends a <D-TX GRANTED> message to the requesting MS addressed by his ITSI, awarding permission to transmit, and a <D-INFO> message to the remaining MS, addressed by the GTSI. Priority requests are dealt with under subclause B.1.8.

B.1.5 Permission to transmit withdrawn

The SwMI may decide to interrupt transmission when resources are required for another call or that the SwMI requires that the call should temporarily pause. In this case the SwMI sends a <D-TX WAIT> message to all MS. Permission to transmit is be withdrawn, or is not given to a requesting MS. The MS should obey channel allocation and await further instructions on the channel that they have been directed to. The <D-TX WAIT> will:

- confirm to the MS that the call is in a queue;
- indicate to the MS that they may not send further requests-to-transmit.

If the request-to-transmit is granted but queued, the MS is allowed to withdraw its request-to-transmit by means of the message <U-TX CEASED>.

B.1.6 Permission to continue with withdrawn call

When the SwMI has decided that the call can continue, the SwMI sends a <D-TX GRANTED> message to the awarded MS, addressed by his ITSi, and a <D-TX CONTINUE> message to all remaining MS, addressed by the GTSi. The MS are told to go to the traffic channel.

If no MS have been given permission to transmit then they are sent a <D-TX CONTINUE> message and are free to make a request to the SwMI.

B.1.7 End of transmission

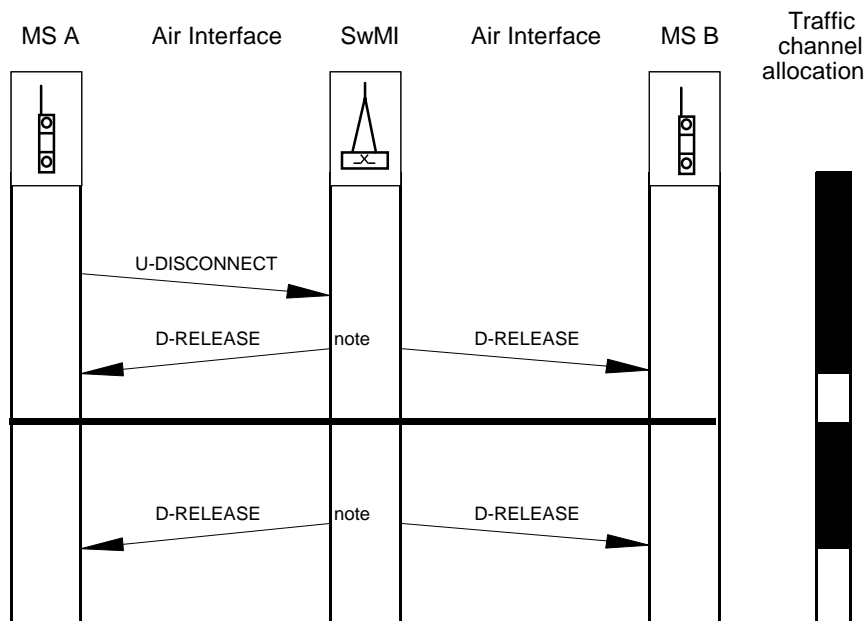
At the end of a communication, the MS sends <U-TX CEASED> and listens to the traffic channel, (see figure B.2). The SwMI sends <D-INFO> to all participants addressed by the GTSi to inform them that the transmission has now ceased.

B.1.8 Stop-transmission order

If, during the course of a transmission, a MS wishes to interrupt the transmitting MS with a higher priority request, a <U-TX DEMAND> message is sent indicating the level of priority, the SwMI sends a <D-INTERRUPT> message to the transmitting MS addressed by his ITSi, a <D-TX GRANTED> message to the awarded MS, addressed by his ITSi and a <D-INFO> to all other MS, addressed by the GTSi. All messages indicate that the permission to transmit has been re-awarded and should indicate the level of priority, (see figure B.2).

B.1.9 Call clearing

B.1.9.1 Mobile originated



NOTE: The SwMI may start the CC-SS retention timer.

Figure B.3: Call clearing for a group call in a message trunked system

The call owner may disconnect the call at any stage of the call, (see figure B.3). Only the call owner can complete this operation. The MS originated call clearing procedure is started by the call owner sending an up-link <U-DISCONNECT> message. The SwMI responds to this message by sending a down-link <D-RELEASE> message to all MS and they are released from the call.

B.1.9.2 SwMI originated

In the case where the SwMI cannot support a request for a call from the calling MS, the SwMI sends a <D-RELEASE> message, containing the reason for failure, to the calling MS.

In the case where the SwMI can no longer support an established call, it sends a <D-RELEASE> message to all MS, containing the reason for disconnection, and subsequently releases the call.

B.2 Procedures for transmission trunked systems

B.2.1 General

All group calls are considered as employing only direct set-up signalling procedures. This procedure allows immediate communication to take place between the calling and called users without the necessity of having an alerting process and without an explicit response from the called user that he has answered. The called users normally go straight to the traffic channel.

For acknowledged group calls, it is an operator option if the call is to proceed immediately by giving the originator permission to transmit. Alternatively, the operator may choose to poll the MS on the traffic channel and act according upon the a response from the polled MS.

NOTE 1: This procedure is known as presence checking.

According to a predefined criteria the call may be allowed to proceed.

It is an operator option to disconnect the call if insufficient members are present, and the right to transmit has not yet been given.

It is an operator option to continue with presence checking beyond the point where the originator has been given permission to transmit.

NOTE 2: For clarity, the time sequence diagrams in this clause only show two participating members of the group call.

B.2.2 Call set-up

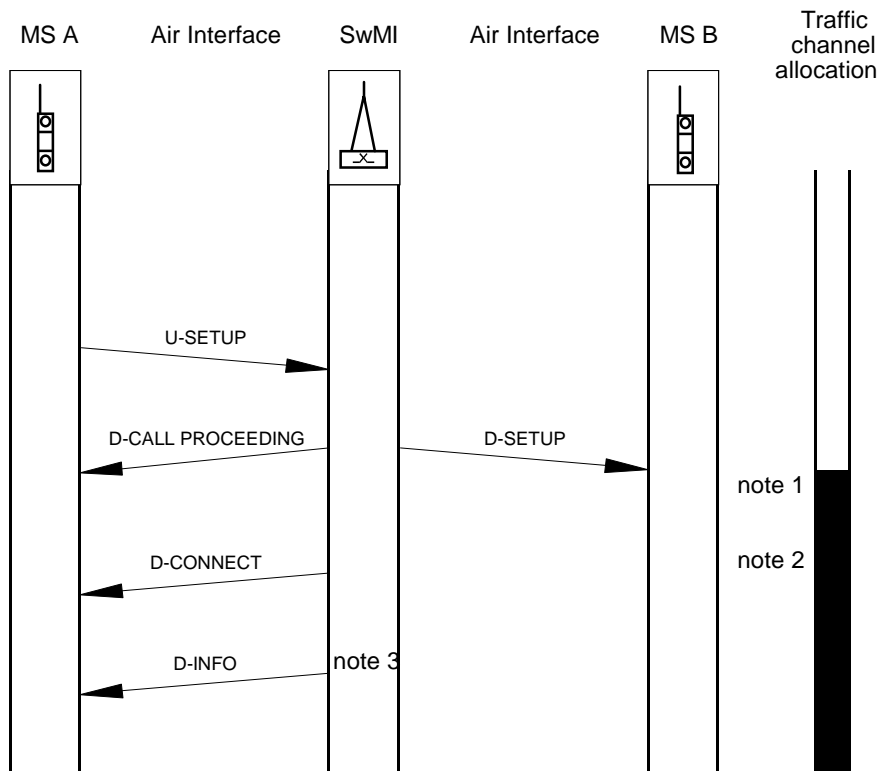
The call set-up request is started by an up-link message <U-SETUP> from the MS. The SwMI may optionally acknowledge the call set-up request by sending a down-link message <D-CALL PROCEEDING> and to indicate that the call is being processed, (see figure B.4).

If following the receipt of a <U-SETUP> message, the SwMI determines that for some reason the call cannot be supported, then the SwMI may initiate call clearing as defined in subclause B.1.9.

If the call can be supported, the SwMI sends a down-link message <D-SETUP> to the called MS.

During, or as an option upon completion of, the transmission of the <D-SETUP> message, the SwMI sends a <D-CONNECT> message to the calling MS.

On completion of this procedure communication can commence.



- NOTE 1: Late assignment, i.e. the called MS are sent to the traffic channel at this stage.
- NOTE 2: The calling MS is sent to the traffic channel at this stage.
- NOTE 3: For acknowledged group calls, the presence of the members of the group may be indicated here.

Figure B.4: Call set-up phase for a group call in a transmission trunked system

The option depends upon whether the group call is an acknowledged one. If it is acknowledged, the SwMI may delay the transmission of the <D-CONNECT> message to the calling MS, and wait for acknowledgements from the called MS before proceeding. If at this stage the SwMI decides that the call cannot be supported it may initiate call clearing as defined in subclause B.1.9.

If the group call is acknowledged, the call owner may be informed of the presence of the other members of the group in the <D-INFO> message.

B.2.2.1 Traffic channel assignment

For the called MS, the traffic channel assignment is given in the <D-SET-UP> message.

There is one method for assigning a traffic channel to the calling MS:

- late assignment: the traffic channel is not assigned until appropriate conditions are met. (These conditions may be as a result of the finite time required to locate group members, or as a result of the call being acknowledged.) The traffic channel is indicated to the calling MS along with the <D-CONNECT> message, (contained in the lower layer part of that message). In this case the calling MS remains listening on the control channel (or other channel if instructed by the SwMI) until he is told to move to the traffic channel.

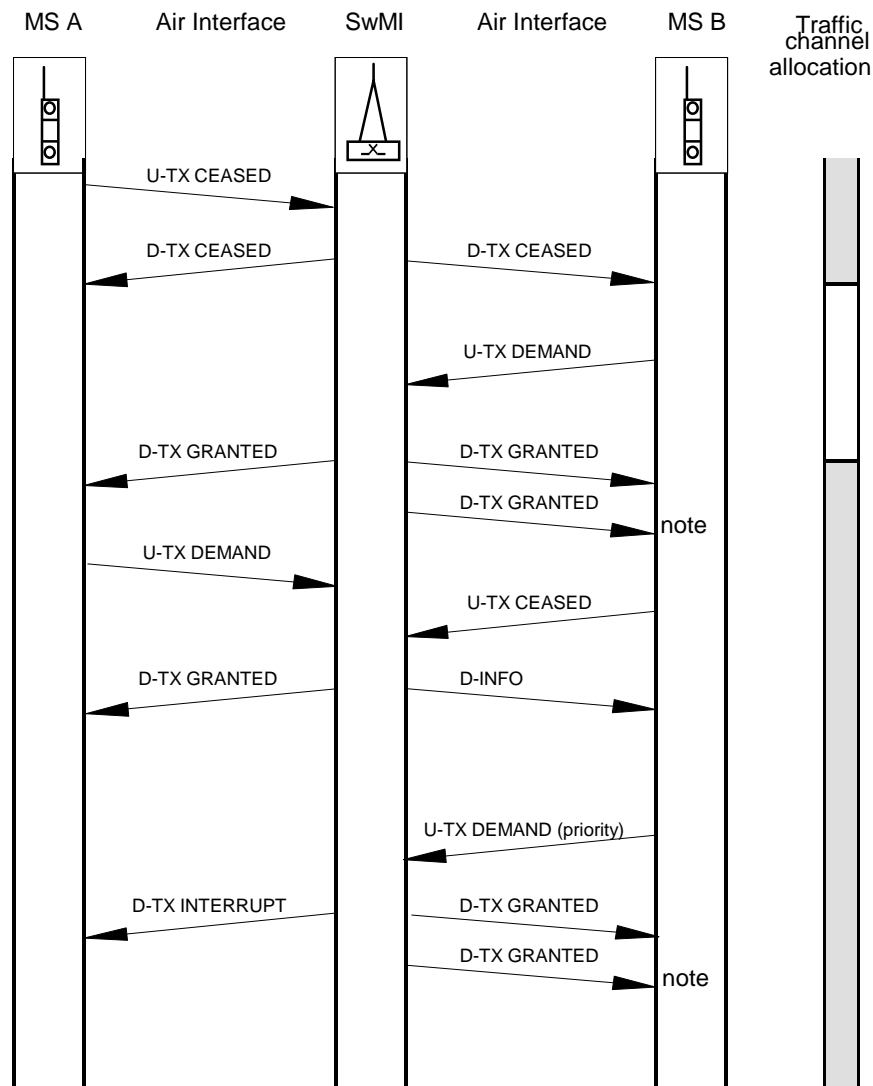
B.2.3 Request-to-transmit

The SwMI is in full control over which MS is allowed to transmit because the MS is obliged to request permission to transmit, and permission must be granted before the MS can do so.

It is normal system operation that the calling MS is given the permission to transmit immediately upon call set-up. Traffic channel assignment is as previously discussed in subclause B.2.2.1.

When the awarded MS has finished the communication it sends a <U-TX CEASED>, (see figure B.5).

Upon receipt of the <U-TX CEASED> message, the SwMI sends all MS a <D-TX CEASED> message, the MS obey channel allocation and the SwMI awaits further demands from the calling and called MS. When any MS wishes to make a request to transmit, it sends a <U-TX DEMAND> message. The response to this request is dealt with in subclause B.2.4.



NOTE: D-TX granted is sent to the remaining members of the group upon awarding permission to MS B.

Figure B.5: Request to transmit for a group call in a transmission trunked system

B.2.4 Response to request-to-transmit

During any call, a <U-TX DEMAND> message may be sent by any MS. If any other MS is not already transmitting, then the SwMI response should be a <D-TX GRANTED> message sent to the awarded MS addressed by his ITSI and a <D-INFO> sent to the remaining MS addressed by the GTSI. The message may be accompanied by the traffic channel allocation (contained in the lower layer parts). Supplementary service information may also be appended to these messages if appropriate (see figure B.5).

If a <U-TX DEMAND> message is sent and another MS is already transmitting, then the SwMI should wait for that party to finish the transmission, (identified by the receipt of a <U-TX CEASED> message). Subsequently the SwMI sends a <D-TX GRANTED> message to the requesting MS, addressed by his ITSI, awarding permission to transmit to him and a <D-INFO> message to the remaining MS, addressed by the GTSI. (If the SwMI wishes to change the traffic channel, then this instruction may also be appended to the <D-TX GRANTED> and <D-INFO> messages.) Priority requests are dealt with in subclause B.2.8.

B.2.5 Permission to transmit withdrawn

The SwMI may decide to interrupt transmission when resources are required for another call or that the SwMI requires that the call should temporarily pause. In this case the SwMI sends a <D-TX WAIT> message to all MS. Permission to transmit is withdrawn, or is not given to a requesting MS. The MS should obey channel allocation and await further instructions on the channel that they have been directed to.

If the request-to-transmit is granted but queued, the MS is allowed to withdraw its request-to-transmit by means of the message <U-TX CEASED>. The <D-TX WAIT> will:

- confirm to the MS that the call is in a queue;
- indicate to the MS that they may not send further requests-to-transmit.

B.2.6 Permission to continue with withdrawn call

When the SwMI has decided that the call can continue, the SwMI sends a <D-TX GRANTED> message to the awarded MS, addressed by his ITSI, and a <D-TX CONTINUE> message to all remaining MS addressed by the GTSI. The MS are then told to go to the traffic channel.

On the other hand, if no MS have been given permission to transmit then they may be sent a <D-TX CONTINUE> message and are not sent to the traffic channel. They are free to make a request to the SwMI.

B.2.7 End of transmission

At the end of a transmission, the MS sends <U-TX CEASED>. The SwMI sends a <D-TX CEASED> to all MS's to return them to the control channel, (unless another MS has asked for permission to transmit, see subclause B.2.4 and figure B.5).

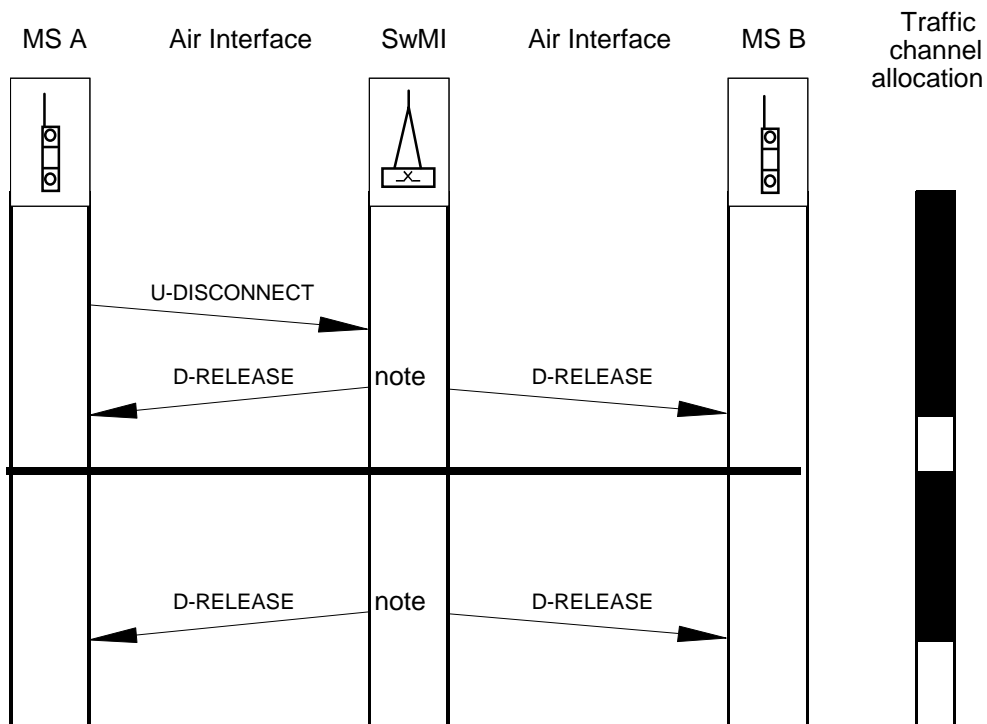
B.2.8 Stop-transmission order

If, during the course of a transmission, a MS wishes to interrupt the transmitting MS with a higher priority request, a <U-TX DEMAND> message is sent indicating the level of priority, the SwMI sends a <D-INTERRUPT> message to the transmitting MS addressed by his ITSI, a <D-TX GRANTED> message to the awarded MS, addressed by his ITSI and a <D-INFO> to all other MS, addressed by the GTSI. All messages indicate that the permission to transmit has been re-awarded and indicate the level of priority. (If the SwMI wishes to change the traffic channel, then this instruction may also be appended to the <D-TX GRANTED>, <D-INTERRUPT> and <D-INFO> messages), (see figure B.5).

B.2.9 Call clearing

B.2.9.1 Mobile originated

The call owner may disconnect the call at any stage of the call, (see figure B.6). Only the call owner can complete this operation. The MS originated call clearing procedure is started by the call owner sending an up-link <U-DISCONNECT> message. The SwMI may respond to this message by sending a down-link <D-RELEASE> message to all MS and they are released from the call.



NOTE: The SwMI may start the CC-SS retention timer.

Figure B.6: Call clearing for a group call in a transmission trunked system

B.2.9.2 SwMI originated

In the case where the SwMI cannot support a request for a call from the calling MS, the SwMI may send a <D-RELEASE> message, containing the reason for failure, to the calling MS.

In the case where the SwMI can no longer support an established call, it may send a <D-RELEASE> message to all MS, containing the reason for disconnection, and subsequently release the call.

B.3 Procedures for quasi-transmission trunked systems

B.3.1 General

All group calls are considered as employing only direct set-up signalling procedures. This procedure allows immediate communication to take place between the calling and called users without the necessity of having an alerting process and without an explicit response from the called user that he has answered. The called users normally go straight to the traffic channel.

For acknowledged group calls, it is an operator option if the call is to proceed immediately by giving the originator permission to transmit. Alternatively, the operator may choose to poll the MS on the traffic channel and act according upon the receipt of a response from the polled MS.

NOTE 1: This procedure is known as presence checking.

According to a predefined criteria the call may be allowed to proceed.

It is an operator option to disconnect the call if insufficient members are present, and the right to transmit has not yet been given.

It is an operator option to continue with presence checking beyond the point where the originator has been given permission to transmit.

NOTE 2: For clarity, the time sequence diagrams in this clause only show two participating members of the group call.

B.3.2 Call set-up

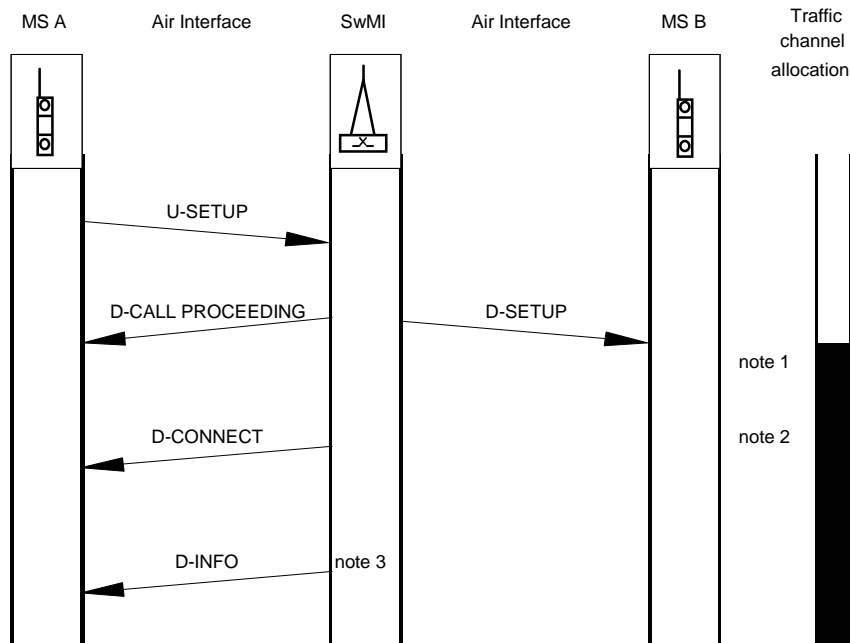
The call set-up request is started by an up-link message <U-SETUP> from the MS. The SwMI may optionally acknowledge the call set-up request by sending a down-link message <D-CALL PROCEEDING> and to indicate that the call is being processed, (see figure B.7).

If following the receipt of a <U-SETUP> message, the SwMI determines that for some reason the call cannot be supported, then the SwMI initiates call clearing as defined in subclause B.3.9.

If the call can be supported, the SwMI sends a down-link message <D-SETUP> to the called MS.

During, or as an option upon completion of, the transmission of the <D-SETUP> message, the SwMI may send a <D-CONNECT> message to the calling MS.

On completion of this procedure communication can commence.



- NOTE 1: Late assignment, i.e. the called MS are sent to the traffic channel at this stage.
- NOTE 2: The calling MS is sent to the traffic channel at this stage.
- NOTE 3: For acknowledged group calls, the presence of the members of the group may be indicated here.

Figure B.7: Call set-up phase for a group call in a quasi-transmission trunked system

The option depends upon whether the group call is an acknowledged one. If it is acknowledged, the SwMI may delay the transmission of the <D-CONNECT> message to the calling MS, and wait for acknowledgements from the called MS before proceeding. If at this stage the SwMI decides that the call cannot be supported it initiates call clearing as defined in subclause B.3.9.

If the group call is acknowledged, the call owner may be informed of the presence of the other members of the group in the <D-INFO> message.

B.3.2.1 Traffic channel assignment

For the called MS, the traffic channel assignment is always given in the <D-SET-UP> message. There is one method for assigning a traffic channel to the calling MS:

- late assignment: the traffic channel is not assigned until appropriate conditions are met. (These conditions may be as a result of the finite time required to locate group members, or as a result of the call being acknowledged.) The traffic channel is indicated to the calling MS along with the <D-CONNECT> message, (contained in the lower layer part of that message). In this case the calling MS remains listening on the control channel until he is told to move to the traffic channel.

B.3.3 Request-to-transmit

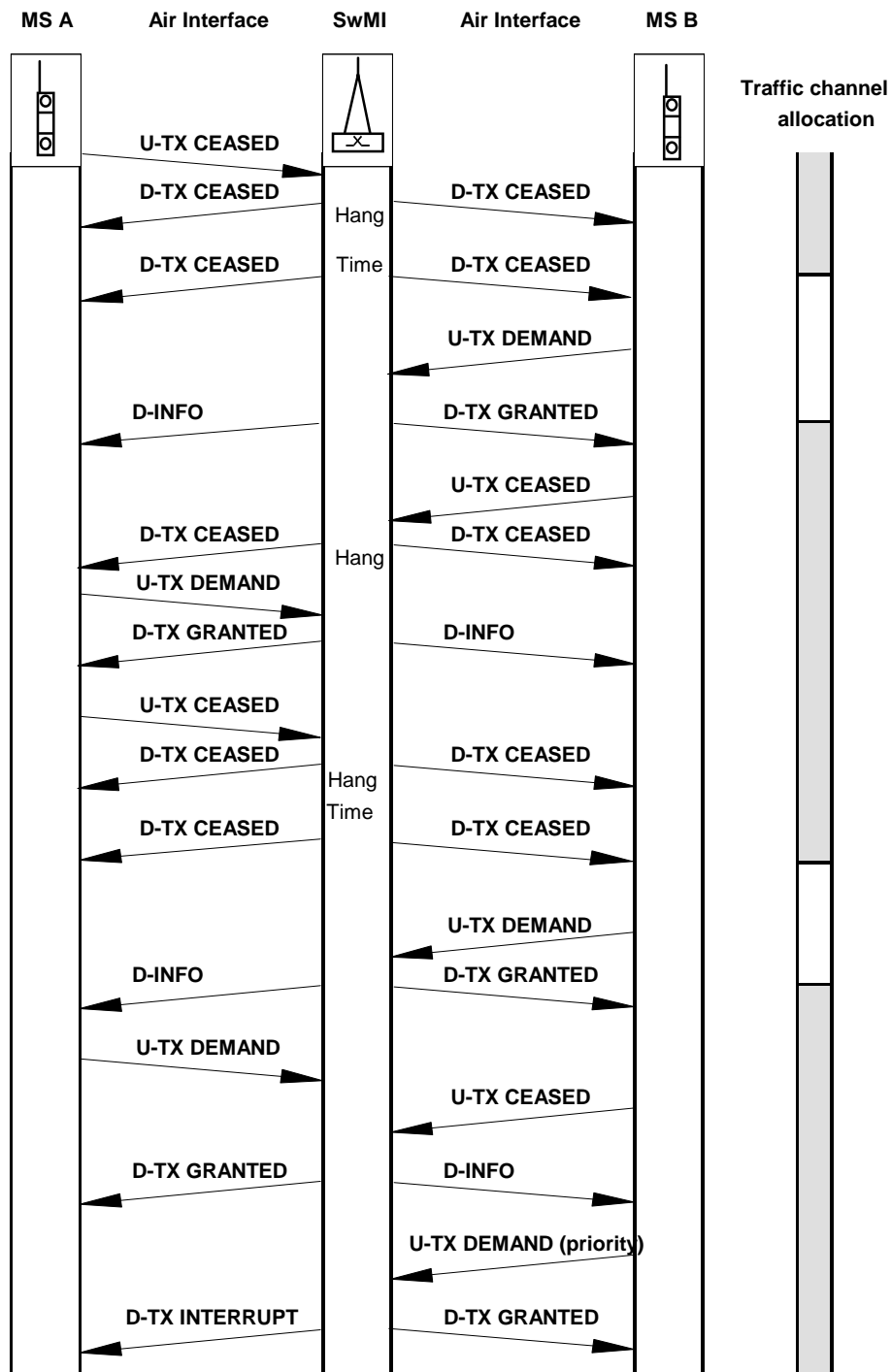


Figure B.8: Request to transmit for a group call in a quasi-transmission trunked system

The SwMI is in full control over which MS is allowed to transmit because the MS is obliged to request permission to transmit, and permission must be granted before the MS can do so.

It is normal system operation that the calling MS will be given the permission to transmit immediately upon call set-up. Traffic channel assignment is as previously discussed in subclause B.3.2.1.

When the awarded MS has finished the communication it sends a <U-TX CEASED>, (see figure B.8).

Upon receipt of the <U-TX CEASED> message, the SwMI starts a timer (hang time) and sends a <D-INFO> message to the "receiving" MS to inform them that the transmission has now ceased. After expiry of the timer, and no MS have sent any messages, the SwMI may send all MS a <D-TX CEASED> message, the MS should obey channel allocation and the SwMI awaits further demands from the calling and called MS. When any MS wishes to make a request to transmit, he sends a <U-TX DEMAND> message. The response to this request is dealt with in subclause B.3.4.

If the hang time is infinite the TETRA system becomes message trunked.

B.3.4 Response to request-to-transmit

During any call, a <U-TX DEMAND> message may be sent by any MS. If any other MS is not already transmitting, and the hang timer has expired, then the SwMI response is a <D-TX GRANTED> message sent to the awarded MS addressed by his ITSI and a <D-INFO> message sent to the remaining MS addressed by the GTSI. The message should be accompanied by the traffic channel allocation (contained in the lower layer parts). Supplementary service information may also be appended to these messages if appropriate (see figure B.8).

If a <U-TX DEMAND> message is sent when no MS is transmitting, but the hang timer has not expired, then the SwMI response is a <D-TX GRANTED> message sent to the awarded MS addressed by his ITSI awarding permission to transmit to him, and a <D-INFO> message sent to the remaining MS addressed by the GTSI. The MS are assumed to be still on the traffic channel and a new assignment is not necessarily given.

If a <U-TX DEMAND> message is sent and another MS is already transmitting, then the SwMI should wait for that party to finish the transmission, (identified by the receipt of a <U-TX CEASED> message). Subsequently the SwMI sends a <D-TX GRANTED> message, to the requesting MS, addressed by his ITSI, awarding permission to transmit to him, and a <D-INFO> message to the remaining MS, addressed by the GTSI. (If the SwMI wishes to change the traffic channel, then this instruction may also be appended to the <D-TX GRANTED> and <D-INFO> messages.) Priority requests are dealt with under subclause B.3.8.

B.3.5 Permission to transmit withdrawn

The SwMI may decide to interrupt transmission when resources are required for another call or that the SwMI requires that the call should temporarily pause. In this case the SwMI sends a <D-TX WAIT> message to all MS. Permission to transmit is withdrawn, or is not given to a requesting MS. The MS should obey channel allocation and should await further instructions on the channel that they have been directed to. The <D-TX WAIT> will:

- confirm to the MS that the call is in a queue;
- indicate to the MS that they may not send further requests-to-transmit.

If the request-to-transmit is granted but queued, the MS is allowed to withdraw its request-to-transmit by means of the message <U-TX CEASED>.

B.3.6 Permission to continue with withdrawn call

When the SwMI has decided that the call can continue, the SwMI should send a <D-TX GRANTED> message to the awarded MS, addressed by his ITSI, and a <D-TX CONTINUE> message to all remaining MS addressed by the GTSI. The MS are told to go to the traffic channel.

On the other hand, If no MS have been given permission to transmit then they are sent a <D-TX CONTINUE> message and are not sent to the traffic channel. They are free to make a request to the SwMI.

B.3.7 End of transmission

At the end of a transmission, the MS sends <U-TX CEASED> and listens to the traffic channel. Upon receipt of the <U-TX CEASED> message, the SwMI starts a timer (hang time) and sends a <D-INFO> message to the "receiving" MS to inform them that the transmission has now ceased. After expiry of the timer, and no MS have sent any messages, the SwMI sends all MS, addressed by the GTSI, the <D-TX CEASED> message which informs the MS to obey channel allocation and await further instructions on the channel that they have been directed to, (see figure B.8).

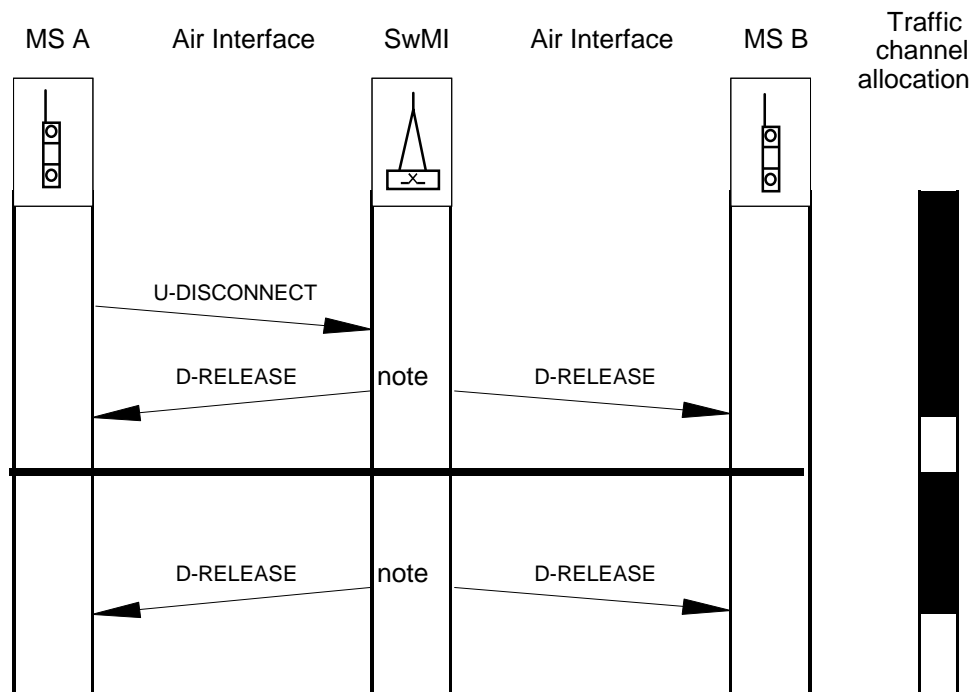
B.3.8 Stop-transmission order

If, during the course of a transmission, a MS wishes to interrupt the transmitting MS with a higher priority request, a <U-TX DEMAND> message is sent indicating the level of priority, the SwMI sends a <D-INTERRUPT> message to the transmitting MS addressed by his ITSI, a <D-TX GRANTED> message to the awarded MS, addressed by his ITSI, and a <D-INFO> to all other MS addressed by the GTSI. All messages should indicate the permission to transmit has been re-awarded and should indicate the level of priority. (If the SwMI wishes to change the traffic channel, then this instruction may also be appended to the <D-TX GRANTED> and <D-INFO> messages), (see figure B.8).

B.3.9 Call clearing

B.3.9.1 Mobile originated

The call owner may disconnect the call at any stage of the call, (see figure B.9). Only the call owner can complete this operation. The MS originated call clearing procedure is started by the call owner sending an up-link <U-DISCONNECT> message. The SwMI responds to this message by sending a down-link <D-RELEASE> message to all MS and they are released from the call.



NOTE: The SwMI may start the CC-SS retention timer.

Figure B.9: Call clearing for a group call in a quasi-transmission trunked system

B.3.9.2 SwMI originated

In the case where the SwMI cannot support a request for a call from the calling MS, the SwMI should send a <D-RELEASE> message, containing the reason for failure, to the calling MS.

In the case where the SwMI can no longer support an established call, it should send a <D-RELEASE> message to all MS, containing the reason for disconnection, and subsequently release the call.

Annex C (informative): Priority functions for circuit mode services

C.1 Introduction

This annex covers only the priority functions for circuit mode calls in the TETRA voice and data standard. It describes the priority requirements. This annex identifies the mechanisms which can be available to TETRA users and operators in order to achieve their priority requirements.

Priority information may be used by both the TETRA network operators and TETRA users in order to ensure that quality of service objectives can be met. This annex recognises 6 identifiable priority requirements, any one of which or any combination of which may be requested in order to meet the demands of the users and networks. The selection of priority requirements may be seen as a network implementation.

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 LLME.

This arrangement is shown schematically in figure C.1.

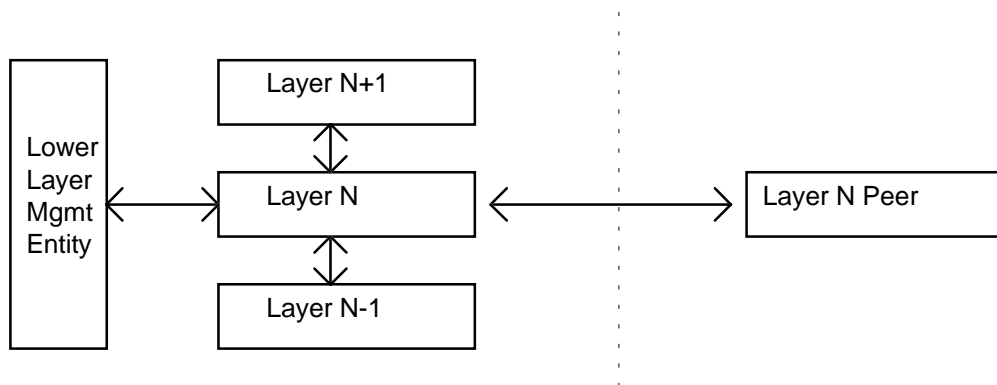


Figure C.1: Sources and destinations of priority information

C.2 Priority requirements

These should be the priority requirements of the TETRA system as perceived by the user and operator. Generally any individual user should only be aware of three levels of priority; normal, high and emergency.

C.2.1 Access priority

There can be methods of controlling the access of subscribers to the system during times of congestion. The controlling methods should allow favourable access on a pre-defined measure of quality.

C.2.2 Call type priority

The operator may elect to have equal or unequal priority attributed to the type of call.

EXAMPLE 1: A speech group call may take priority over an individual call, speech calls over data calls etc.

Different subscribers on the same system may have different call type priority requirements.

EXAMPLE 2: Fleet 1 may elect secure voice to be a higher priority than fleet 1 data calls, however fleet 2 may have different requirements.

C.2.3 Queue priority

Queue priority can be related to queuing for any limited resource in the network (e.g. down-link air interfaces, leased lines, access to databases etc.). The attribution of a measure of quality can enable the limited resources to be allocated to the queuing subscribers on a priority basis rather than e.g. on a first come first served basis.

C.2.4 Pre-emptive priority

Pre-emptive priority allows any resource that is being used to be freed for a call of pre-emptive priority. The resource may be any resource controlled by the TETRA system.

EXAMPLE 1: During times of high system loading, existing calls may be cleared to provide resource for calls with priority to warrant this action.

EXAMPLE 2: Existing calls may be cleared to allow a pre-emptive priority call to be made to a terminal that was engaged in the existing call.

C.2.5 Call retention priority

Call retention priority should define the relative level of protection of a call (once established) against the pre-emption of its network connection.

C.2.6 Subscriber priority

The priority of a call may be associated with the subscriber.

EXAMPLE: Within a fleet, certain subscribers by virtue of their position within that organisation may automatically have a higher priority for their calls than other members of that fleet occupying a different position within the same organisation.

C.3 Mechanisms for supporting priority

There can be a number of mechanisms available to the operator and to the user for supporting priority. Each mechanism can support several methods.

Those available to the operator are:

- 1) layer 2 access broadcast;
- 2) layer 3 system broadcast.

Those available to the user are:

- supplementary service activation and Invocation.

NOTE: There is no distinction made between CC message and supplementary service messages in this ETS.

C.3.1 Supplementary service activation and invocation

The network operator may offer users the ability to activate and invoke supplementary services. Generally, TETRA supplementary services may be activated by the user only when he has subscribed to them, however some operators may wish to make the supplementary services available on a general basis. In the event where the user should firstly subscribe to the supplementary service, the service may be permanently activated, so that for example, when the user indicates to the network that he wishes to make a call, the supplementary service should be automatically invoked.

Alternatively a supplementary service may be invoked with a facility information element contained within a CC, call maintenance or facility message.

The supplementary services that are of interest to priority are:

- 1) access priority;
- 2) priority call;
- 3) pre-emptive priority call;
- 4) call retention.

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

D.1 Introduction

This annex is largely based on ISO.8348 [12] (which is equivalent to CCITT Recommendation X.213 [9]). These two documents have the same section numbering.

Some sections 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 the ISO.8348 [12] (or CCITT Recommendation X.213 [9]) source documents.

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 annex is largely based on ISO.8348 [12] and CCITT Recommendation X.213 [9], but has been modified to suit the requirements of TETRA.

D.2 Quality of network service

Refer to ISO.8348 [12] (or CCITT Recommendation X.213 [9]) 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 subnetworks where each subnetwork 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 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.

D.2.1 Determination of quality of network service

Refer to ISO.8348 [12] (or CCITT Recommendation X.213 [9]) subclause 10.1.

QoS 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.

D.2.1.1 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 D.2.3.

D.2.1.2 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 D.2.13.

D.2.2 QoS negotiation and non-negotiation

Refer to ISO.8348 [12] (or CCITT Recommendation X.213 [9]) subclause 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.

D.2.3 QoS parameter set for connection oriented services

D.2.3.1 Summary

Refer to ISO.8348 [12] (or CCITT Recommendation X.213 [9]) 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.

The following tables summarise the QoS parameters:

Table D.1: Classification of performance QoS-parameters

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

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

NC protection NC priority Maximum acceptable cost NC resilience
--

D.2.3.2 NC establishment delay

Refer to ISO.8348 [12] (or CCITT Recommendation X.213 [9]) subclause 10.2.1.

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

D.2.3.3 NC establishment failure probability

Refer to ISO.8348 [12] (or CCITT Recommendation X.213 [9]) 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).

D.2.4 Throughput (User information transfer rate)

D.2.4.1 Throughput for constant delay services

Refer to ISO.8348 [12] (or CCITT Recommendation X.213 [9]) 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; and
- 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.

D.2.4.2 Throughput for variable delay services

This parameter does not appear in ISO.8348 [12] or CCITT Recommendation X.213 [9].

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

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: 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.

D.2.5 Transit delay

D.2.5.1 Transit delay for constant delay services

Refer to ISO.8348 [12] (or CCITT Recommendation X.213 [9]) 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.

D.2.5.2 Transit delay for voice services

Transit delay for voice services shall be based on the definition for a constant delay service, where the NSDU is defined to be a single speech frame.

Transit delay for voice services shall be specified in terms of the one way delay time corresponding to a single transmission across the air interface.

D.2.5.3 Transit delay for variable delay services

This parameter does not appear in ISO.8348 [12] or CCITT Recommendation X.213 [9].

Transit delay for variable delay services can vary due to the existence of automatic retransmission protocols.

Transit delay for variable delay services refers to the delay that will apply under ideal conditions, when no automatic retransmissions have occurred. Any automatic retransmissions will increase this delay.

D.2.6 Residual error rate

Refer to ISO.8348 [12] (or CCITT Recommendation X.213 [9]) subclause 10.2.5.

The residual error rate (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;

$$\text{RER} = \frac{N(e) + N(l) + N(x)}{N}$$

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.

D.2.7 Transfer failure probability

Refer to ISO.8348 [12] (or CCITT Recommendation X.213 [9]) 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 will 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.

This parameter shall only apply to packet mode services.

D.2.8 NC resilience

Refer to ISO.8348 [12] (or CCITT Recommendation X.213 [9]) 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.

D.2.8.1 NC release delay

D.2.8.1.1 NC release delay at the peer user

Refer to ISO.8348 [12] (or CCITT Recommendation X.213 [9]) 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.

D.2.8.1.2 NC release delay at the invoking user

This parameter does not appear in ISO.8348 [12] or CCITT Recommendation X.213 [9].

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.

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.

D.2.8.2 NC release failure probability

Refer to ISO.8348 [12] (or CCITT Recommendation X.213 [9]) 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 will only be specified as a network performance figure.

D.2.8.3 NC protection

Refer to ISO.8348 [12] (or CCITT Recommendation X.213 [9]) 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.

D.2.8.4 NC priority

Refer to ISO.8348 [12] (or CCITT Recommendation X.213 [9]) 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 is required to accept new requests for NCs with a high priority type a) if it can, even if NCs with a lower priority b) have to be 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) are to have their requests serviced within the required QoS first and remaining resources are then used to satisfy requests on lower priority NCs.

D.2.9 Maximum acceptable cost

Refer to ISO.8348 [12] (or CCITT Recommendation X.213 [9]) 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.

D.2.10 Air interface parameters

These parameters do not appear in ISO.8348 [12] or CCITT Recommendation X.213 [9]. Therefore they are only applicable to circuit-mode services.

D.2.10.1 Duration of interruption of user traffic due to call restoration

The duration of interruption of user traffic due to call restoration is the total time for which a traffic channel is interrupted due to a single call restoration event. If there are several short interruptions during this process, the sum total of all these interruptions shall apply.

Different figures may apply depending on the type of the call restoration. The following different cases are identified:

- change of cell;
- change of RF carrier at the same cell (with or without a change of slot position);
- change of slot position on the same RF carrier at the same cell.

D.2.10.2 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.

D.2.10.3 Interruption of user traffic due to slot stealing

This parameter should shall only apply to circuit-mode services.

This parameter should specify the duration of any single continuous interruption of user traffic due to slot stealing, and the interval between successive interruptions.

D.2.11 Supplementary service parameters

D.2.11.1 Maximum time to activate a supplementary service

This parameter does not appear in ISO.8348 [12] or CCITT Recommendation X.213 [9].

This parameter should only apply to circuit mode services.

The maximum time to activate a supplementary service is the time from the issuing of the service request to the time when the service has become available.

D.2.12 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.

D.2.13 QoS parameter set for connectionless services

D.2.13.1 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 D.3: Classification of performance QoS-parameters

Phase	Performance Criterion	
	Speed	Accuracy/Reliability
Data transfer	Transit delay	Residual error probability

Table D.4: QoS-parameters not associated with performance

Protection from unauthorised access Cost determinants Priority

D.2.13.2 Transit delay

Refer to ISO.8348/Addendum 1 [12], 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.

D.2.13.3 Protection from unauthorised access

Refer to ISO.8348/Addendum 1 [12], 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).

D.2.13.4 Cost determinants

Refer to ISO.8348/Addendum 1 [12], 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.

D.2.13.5 Residual error probability

Refer to ISO.8348/Addendum 1 [12], 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.

D.2.13.6 Priority

Refer to ISO.8348/Addendum 1 [12], 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.

D.2.13.7 Connectionless QoS negotiation

Not applicable.

D.3 Applicability of QoS parameters to TETRA services

Table D.5: Applicability of connection oriented QoS-parameters

	CONS	cct data protected	cct data unprotected	voice
NC establishment delay	n	n	n	f
NC establishment failure probability	s	s	s	s
Throughput	N	N	N	f
Transit delay	n	f	f	f
Residual error rate	n	n1	f	f
Transfer failure prob.	s	s	s	s
NC resilience	s	s	s	s
NC release delay	s	s	s	s
NC release failure prob.	s	s	s	s
NC protection	N note 2	N note 2	N note 2	N notes 2 and 3
NC priority	n note 4	n note 4	n note 4	n note 4
Maximum acceptable cost	n note 2	n note 2	n note 2	n note 2

Table D.6: Applicability of connectionless QoS-parameters

	S-CLNS	SDS
Transit delay	s	s
Protection from unauthorised access	n	n
Cost determinants	n note 2	n note 2
Residual error probability	s	s
Priority	n notes 4 and 5	n note 4

Key and notes:

- f fixed relative to type of call;
- n negotiable only between NS user and NS provider;
- N negotiable between NS users (calling and called) and NS provider;
- s network performance figure;
- x not applicable/not specified.

NOTE 1: Not applicable to unprotected services.

NOTE 2: May not be implemented on all systems.

NOTE 3: Negotiable only between calling NS user and NS provider for point-to-multipoint calls. Called NS users not able to meet protection requirements will be excluded from the call.

NOTE 4: The negotiation only uses a limited set of parameters (see subclause D.2.8.4).

NOTE 5: Negotiation only supported by full version of S-CLNS.

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