CONNECTION AND LOCATION MANAGEMENT BASED ON A TINA-COMPLIANT ARCHITECTURE FOR UMTS

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Key words: TINA (Telecommunication Information Networking Architecture), UMTS (Universal Mobile Telecommunication System), Connection Management, Location Management (LM).

Abstract: Connection and location management are the main processes for a mobile communication network. In this paper, the next generation mobile communication network such as UMTS (Universal Mobile Telecommunication System), is proposed to integrate with a TINA-compliant architecture enabling to handle that kind of management-specific processes. The approach provides a key framework for the unified and adapted provision of connection mobility management toward roaming users using different end systems and, access networks via a core/fixed network. It can be seen as a benchmark application of TINA on UMTS.

1. INTRODUCTION

The current UMTS standardisation activities have been based on a functional type of architecture influenced by Intelligent Networks (IN). UMTS aims to address a scenario with multiple, competitive services and different connectivity providers. In this scenario, IN would take care of user and mobile controls with the related data, while B-ISDN is responsible for the basic switching. It is questionable whether the designated concepts of IN will ever provide the required powerful mechanisms needed for service provisioning, numbering, as well as connection and location management in multi-service provider domains. TINA (Telecommunications Information Networking Architecture) proposes a framework for future telecommunication systems based on distributed and object-oriented

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computing that enable fast services provisioning and management, independently of the underlying technology of the networks. TINA offers many advantages over this type of architecture. Applying TINA to UMTS can provide more flexible open system [11,12].

The motivation for studying how UMTS can take advantage of the TINA services and network management concepts is that the IN and TMN standards (the current basis for UMTS) are likely to evolve towards TINA. Here, we argue that a TINA compliant architecture, which already contains some well-developed concepts, can be used to satisfy the requirements of UMTS management such as connection and location management.

The paper is structured as follows: the next two sections present the overview of the UMTS architecture and our proposed TINA-compliant architecture includes a Business Model, Terminal Provider Domain, and Network Resource Information Model. Based on this model, the Network Topology Configuration Management, Connection Management, and Location Management are analysed and implemented.

2. UNIVERSAL MOBILE TELECOMMUNICATION SYSTEM (UMTS)

2.1 UMTS architecture

The basic UMTS network consists of three sub-networks that are radio access network, core network and service network [1,2]. The most complete configuration, the UMTS network architecture, is shown in Figure 1 and its elements are described below.

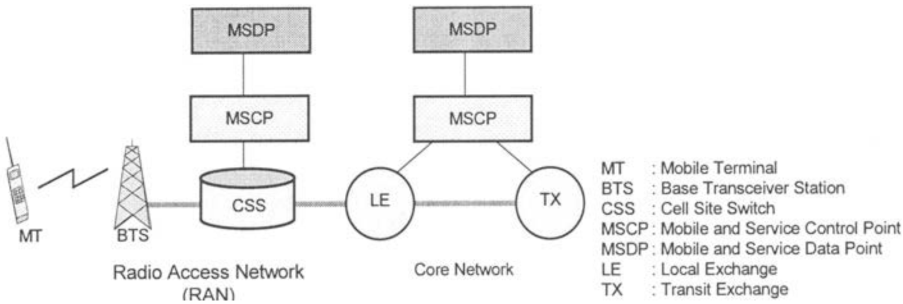


Figure 1. UMTS network architecture

- RAN (Radio Access Network) provides mainly radio-related functions including the basic local switching and transmission functions, measurement reporting, and handover.

- Core Network consists of local and transit switches of the fixed network, including the transmission system, to provide switching, call control, as well as connection control. In UMTS the prescription on the core is to be compliant with the B-ISDN. Within the current definition of B-ISDN, ATM is defined as the transport infrastructure.
- Service Network provides service and mobility control. It also supports call and connection control when the core network allows for the extraction of that functionality from the individual network elements.

2.2 UMTS mobility services

- User Registration: before a user can make outgoing and receive incoming calls, the user must register to a terminal and the terminal must register to the network.
- Location Management: when a user moves to another location area, a location updating procedure must be done to inform the network of the user's current location.
- Handover: the change of physical links (radio channels) and/or fixed terrestrial channels while maintaining a call.

3. THE TINA-COMPLIANT MODEL

3.1 The TINA-compliant business model

TINA-C defines the Business Model [3], which aims at giving an additional structure that eases the application of TINA in a multi-stakeholder, multi-vendor environment. It does so by defining the interaction between business administrative domains in terms of contracts, business roles and business administrative domains. The following entities are to be defined.

- *Consumer* uses various kinds of services provided by a TINA system. A consumer can use services from retailers after subscripting to them.
- *Retailer* provides different kinds of service to customers. In order to a Retailer to provide its services, support from providers playing other roles might be used, e.g. Broker, third party provider and connectivity provider roles.
- *Broker* provides stakeholders information that enables them to find other stakeholders and services in the TINA system.

- *Third party service provider* supports services to retailers or other third party service providers. Unlike a retailer, a third party service provider does not have any contractual relationship with customers.
- *Connectivity provider* owns and manages a network infrastructure which can contribute a transport network to support stream binding in a TINA system or a kTN (kernel Transport Network) supporting a DPE node interconnection.

Their business model then defines how the above roles translate into object domains with precise boundaries and well-defined interfaces, called reference points, between them. The model contains a set of concepts and guidelines to specify reference point, which in turn specify conformance requirements for the TINA system. However, in an environment supporting personal mobility and a multi-provider domain, the relation between user and terminal is not a fixed one-to-one association, but user may register to different terminals for different services, thus allowing a terminal to be shared by different users. Therefore, in the current TINA business model, the consumer role implicitly incorporates a terminal and this modelling does not support all functional of personal mobility because there is no clear separation between terminal and user.

In DOLMEN-AC036 Project [8,9], the new concept of Terminal Provider is defined to solve that problem. It is a stakeholder that owns and manages the terminal equipment information. Its introduction has been recently accepted within the TINA Next Generation Mobile Workshop.

In the context of the third-generation mobile communication network, the connectivity provider owns a set of base stations, an associated access network, and a part of the core network covering a certain geographical region. A retailer may have contracts with several connectivity providers, and each connectivity provider may serve several retailers. Consequently, the coverage area of a retailer may consist of many connectivity provider networks. Figure 2 shows our proposal of some main business roles to model mobility management functionality for the UMTS network by using the DOLMEN-TINA business model. This model includes some additional computational objects (COs) in the computational model in connectivity provider and network topology configuration management domain that can be considered as a TINA-compliant model to implement connection and location management for UMTS.

- *User registration/deregistration* business role allows a user in the *customer domain* to inform a service provider in the *retailer domain* about the terminal from which a user wants to receive or activate services. Deregistration is used to reset an association between user and terminal previously established through registration. These procedures require *access*, *identification,* and *authentication* procedures to be carried out before or in conjunction with them. In order to be successfully carried out, registration procedures require that the owner of the terminal has allowed access to the terminal. This knowledge can be retrieved from the terminal profile data.

- *User subscription* allows a user (*customer domain*) to subscribe to services provided by the service provider (*retailer domain*). It is split into different subprocedures which include online or offline subscription, changing the previous service setting, dynamic service updating and dynamic subscription of the new-third party service.
- *Location update* allows the network provider (*connectivity provider domain*) to update and store the new location area of the mobile terminal (*terminal provider domain*). Location monitoring operations are started automatically by the mobile terminals on behalf of the users. The concept of terminal location depends on the cellular structure of the area covered by the mobile system. Each mobile terminal continuously receives the location information broadcast by the base stations and compares the received location information with the location information stored in the terminal.
- *Domain update* is similar to location update, but it will be done at the retailer domain. A domain is an administrative area in which a UMTS provider offers a set of UMTS services. Domain update is the part of location monitoring that ensures that the system has up-to-date location knowledge of the terminals and associated users. When the terminal decides to access a new administrative domain, it can execute the domain update procedure.
- *Handover/Paging* are procedures that take place between the terminal provider domain and connectivity provider domain to perform the functionality of terminal mobility. These procedures will be used to support terminal mobility that is out of scope of this paper.

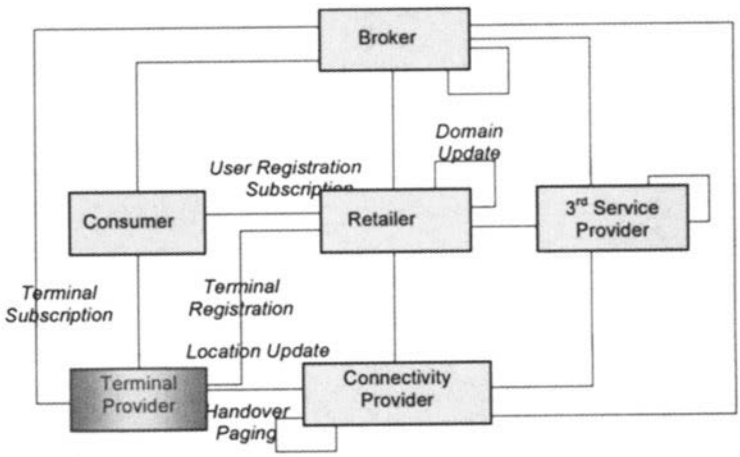


Figure 2. TINA-DOLMEN Business Model for UMTS

3.2 Terminal provider domain

To support personal mobility in a multi-retailer domain environment, the concept of terminal provider has been introduced as that a stakeholder owns and manages the terminal. The reasons for this choice are strongly related to the distinction between user and terminal that characterises personal mobility services. The Terminal Provider requires some new computational objects (COs) representing that role both inside the system and the terminal itself [8]. As can be seen in Figure 3, we suggest an agent associated with the terminal representing the terminal into the system, referred to as a *Terminal Agent* (TA) object. This TA is fixed, even if the terminal is roaming, and should be located in the domain where the owner of the terminal has subscribed. Thus it can always be retrieved through the terminal provider identity with the support of the broker.

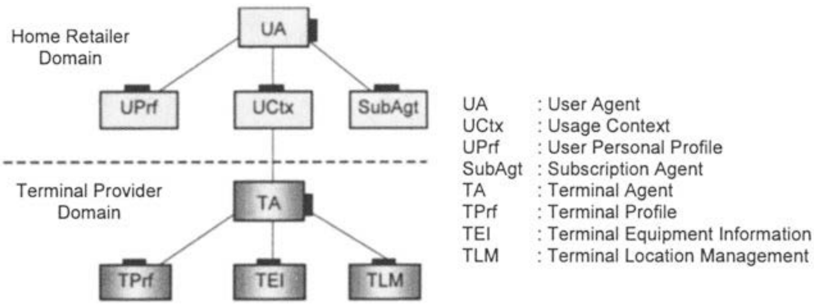


Figure 3. User Agent and Terminal Agent

The dynamic associations between a user and the terminal he has registered on for the different services are maintained in the UCtx (User Context) that points to the TA related with the terminal in the terminal provider. The TA in the Terminal Provider holds the required information to access and use a terminal. In addition to regular consumer information, a terminal provider should maintain the following information: terminal location (in terms of connectivity provider domain), registration policies, and terminal capability. The information needs to be maintained inside the network by the *Terminal Equipment Information* (TEI) in order to support remote registration and subscription procedures. Relating this information to the Terminal Provider makes it possible to locate the terminal without any knowledge of the users registered on it. The *Terminal Personal Profile* (TPrf) manages specific owner preferences and restrictions that can be used to handle the access, identify procedures before the user can use the terminal for receiving and activating services. The information of a list of end-users registered at the terminal could, alternatively, be stored in the terminal itself.

However, it would be more efficient to maintain this information inside the network, thus reducing the traffic on the terminal access link.

Moreover, in order to perform location updating of the mobile terminal when roaming, a new object is also proposed in the terminal, namely Terminal Location Management (TLM). A TLM always listens to the broadcast channel, and each time the TLM recognises a new location area, it initialises a location update by invoking a corresponding operation at the TA.

3.3 Network Resource Information Model (NRIM)

The TINA NRIM [6,13] is a technology-independent network-level resource model that provides a view of the information bearing entities, their relations to each other, as well as the constraints and rules governing their behaviour. In order to master complexity, the model is divided into *fragments*, each defining object classes related to a specific domain that will be described in the following subsections.

3.3.1 Network fragment

A network as viewed by a specific stakeholder who offers connectivity services in Connectivity Provider Domain is called a Connectivity Layer Network (CLNW). A network architecture is an overlay architecture on top of CLNW and is organised by co-operating connectivity providers. The CLNW represents the highest level of abstraction and assembles all resources (e.g. switches, links, adapters, inter-working units and bridges) available to provide network connectivity between access-points of a worldwide transport network.

- *Layer Network* (LNW): A CLNW is structured in terms of LNWs, with possibly *adapters* between them. The layer network represents all resources involved in the delivery of certain characteristic information in a given format. In the case of a mobile network, some additional control aspects should be supported by a LNW within the mobile environment such as multi-bearer capabilities, macro-diversity, and handover.
- *Adapter* represents a resource that enables a peer-to-peer relation between layer networks that convert the data format and control message used in one layer network to the other.
- *Layer Network Domain* (LND) represents the part of a layer network that is under the control of one administrative domain. From a connectivity provider perspective, a LNW is seen as being made up of one or more LNDs. For the sake of performing and controlling

connection management within a LND, the concepts of *Local Layer Network Domains (LLNDs)* and *Foreign Layer Network Domains (FLNDs)* are introduced. Establishment of a connection crossing different LNDs within the same administrative domain requires co-operation (*federation*) between different LNDs.

- *Subnetwork* (SNW): A LND consists of a subnetwork (referred to as the top-level subnetwork) on which one or more links terminate. Each such link interconnects the top-level subnetwork of a LND with either the top-level subnetwork of another LND or Customer Premises Equipment (CPE). The top-level subnetwork of a LND may in turn be composed of two or more subnetworks (referred to as lower level subnetworks) interconnected by links. This subnetwork decomposition may occur in multiple levels until the subnetwork maps directly to a network element (NE).
- *Link and Topological Link* (TL) are topological components used for representing an interconnection between a subnetwork and either another subnetwork or a CPE. A Topological Link is a logical or physical transmission path interconnecting two NEs (more generally two subnetworks) and it is supported by a Trail in the server layer network. A topological link has a specific bandwidth capacity that is determined by the bandwidth of the server layer trail. A link can be configured by assigning either a portion of the bandwidth or the entire bandwidth of one or more topological links.

3.3.2 Connectivity fragment

The connectivity fragment describes the information objects and relationships used to model connectivity resources across a TINA network.

- *Network Flow Connection* (NFC) models the end-to-end connection between CPEs across a CLNW.
- *Terminal Flow Connections* (TFC) models the terminal part of Stream Flow Connection.
- *Trail* models an end-to-end connection within a layer network.
- *Subnetwork Connection* (SNC) models a switched connectivity across a sub-network (point-to-point or involving multi-point topologies).
- *Link Connection* (LC*)* is a connection between either subnetworks or between a sub-network and a CPE.
- *Tandem Connection* (TC) is a chain of subnetworks and link connections.
- *Edge* is a leg of a subnetwork connection. Root and branch relations to model multi-point connectivity.

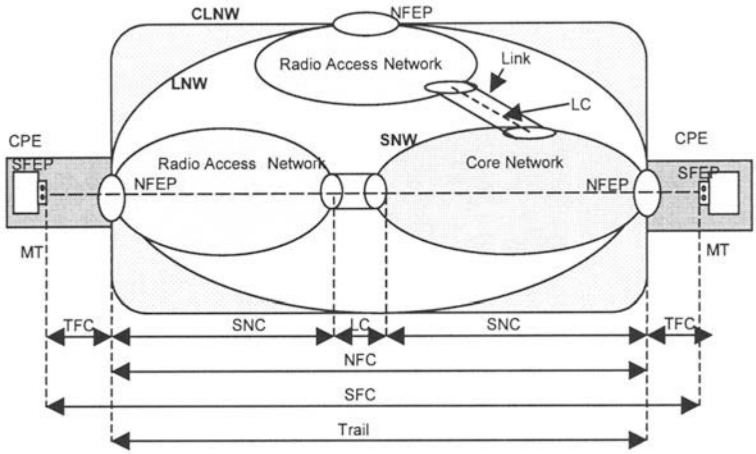
3.3.3 Termination Point Fragment

Termination end points in a CLNW are modelled in a separate fragment. This fragment includes Network Flow End Point (NFEP), Trail Termination Point (TTP), Network Trail Termination Point (NWTTP), Network Connection Termination Point (NWCTP), Link Termination Point (LTP), and Topological Link Termination Point (TLTP). These concepts are used to model end points between CPEs across a CLNW, trails, subnetwork connections, links and topological links, respectively. The Stream Flow End Point (SFEP) is also defined, to model the sources and sinks of the information flows.

A topological point on the boundary of a connectivity layer network (i.e., resident in a CPE) that represents the potential for several network flow terminations to occur at the point is called a Network Flow Endpoint Pool (NFEPPool). A NFEPPool is a collection of LTPs, and the LTPs grouped under a NFEPPool may span different layer network domains of the same connectivity provider.

3.3.4 NRIM of UMTS network

The complete NRIM for the UMTS system is shown in Figure 4. The Mobile Terminal is modelled as a CPE object. This object has been introduced so that end-to-end connectivity, stream flow connection (SFC) and stream bindings can be represented in the view of a connectivity provider. It is not suggested that a connectivity provider is aware of all CPEs included in the UMTS network. However, when the mobile terminal roams to the visited connectivity provider domain, it triggers a procedure to update the new location to the current connectivity provider and inform the position change to the home domain. Such foreign CPEs will dynamically appear and disappear (i.e., they are transient objects) in the view of the connectivity provider. In accordance with [7], CPE object contains SFEPs, which are mapped dynamically onto NFEPs in the CNLW by TFCs. The RANs and Core Networks are modelled as layer network or subnetwork objects independently of the technology used in the real networks. The features of macro-diversity and multi-bearer of UMTS will be supported by adding the control aspects of LNW and SNW. Details of NRIM for UMTS that completely supports functionality of multi-bearer and macro-diversity can be found in [10,13].



Connection		Network & Terminal		End Point	
TFC:	Terminal Flow Connection	CLNW:	Connectivity Layer Network	NFEP:	Network Flow End Point
SNC:	Subnetwork Connection	LNW:	Layer Network	SFEP:	Stream Flow End Point
LC:	Link Connection	SNW:	Subnetwork		
NFC:	Network Flow Connection	CPE:	Customer Premises Equipment		
SFC:	Stream Flow Connection	MT:	Mobile Terminal		

Figure 4. NRIM Model of UMTS Network

4. NETWORK TOPOLOGY CONFIGURATION AND CONNECTION MANAGEMENT

According to TINA [4,5], Network Configuration Management consists of Network Topology Configuration Management (NTCM), which deals with *static network resources*, and Connection Management, which deals with *dynamic network resources*. The following subsections describe these in detail.

4.1 Connection Management

Connection management is the activity of co-ordinating allocation and release of the telecommunication services (distributed applications) of connectivity network resources on behalf of a manager. Connection Management functions may also support other management services (for instance, a fault management application that needs a connection through a specific trunk in order to test that trunk), and the interconnection of DPE nodes. The Connection Management Architecture is based on the TINA Network Computational Model that is divided into a number of conceptual levels such as communication, connectivity, layer network, and subnetwork level (Fig. 5). This grouping is also used to explain the functionality of each object and its relationship with other objects. The proper behaviours of COs are added in order to minimise the set of operations (with parameters) and coherently setup and release connections.

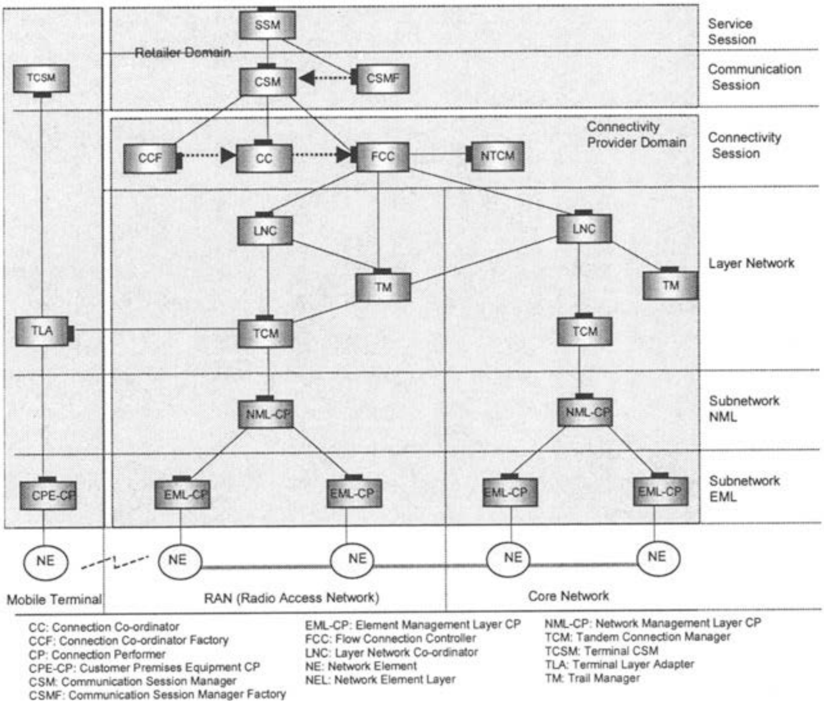


Figure 5. Computational model for Connection Management

Whenever a communication session is required, the CSM (Communication Session Manager) should be contacted in the retailer domain. As a result, a stream binding is setup at the service level and a set of Stream Flow Connections (SFCs) is established in order to accomplish the service session demands. The CSM uses the Stream Flow End Point (SFEP) descriptions to determine the associated Terminal CSM (TCSM) to negotiate with the terminal involved the information needed to perform that communication session. The CSM contacts each TCSM associated with the SFC so that the terminal and network parts of the SFC can be connected. The CSM translates the SFCs to Network Flow Connections (NFCs) and uses the connectivity session to establish these connections.

The connectivity session presents a technology-independent network view that is independent of complications such as multiple connectivity provider domains or establishing connections over different network technologies. This view is supported by the NFCs, which are modelled by the Physical Connection Graph (PCG). However, to establish connections, this abstract view must be translated to a suitable technology-dependent layer network view. The connectivity session is responsible for connecting NFEPs and realises this by partitioning the NFC into *trails* and determining the layer networks that can support the characteristics of these trails. A total of three COs reside in the connectivity session. They are CCF (Connection Co-ordinator Factory), which serves as a factory object for connectivity session; CC (Connection Co-ordinator) which acts as session control; and FCC (Flow Connection Controller) which acts as connection control. An important selection criterion for choosing a certain layer network is whether the layer network can support the QoS requirements as captured in the description of the NFC.

The LNC (Layer Network Coordinator) and subordinate objects (NML-CP and EML-CP) present an end-to-end view of a network technology, and offers services to establish *trails* across the entire network. Upon connectivity session setup, the FCC contacts the NRCM (Network Topology configuration Management) domain to determine the layer networks that can support the characteristics of the required trails. The layer networks are managed and controlled by LNCs, such that the FCC requests LNCs to set up the trail. The LNC consequently creates a TM (Trail Manager) that is held responsible for providing manipulations on the trail. A TM instance exists for each trail within a layer network and its reference is forwarded to the FCC such that this object can invoke actions. To a peer layer concept (components acting on behalf of other domains of the same layer network), the LNC offers services to setup *tandem connections* to complete trails that are terminated outside their domain. A CO called TCM (Tandem Connection Manager) is created by TM to manage the above tandem connections.

The side of the layer network that resides in the MT (mobile terminal) is managed and controlled by the TLA (Terminal Layer Adapter). This computational object provides functions for creating, manipulating and deleting NFEPs. The CPE stores one TLA for each network technology it supports. This object is created upon configuration of the terminal and has a maximum lifetime coinciding with the lifetime of the terminal. Upgrading a terminal may result in changing the TLA. The TM and TLA exchange details of the NFEPs that will be used for the network connection.

4.2 Network Topology Configuration Management

The Network Topology Configuration Management (NTCM) [4] introduces some aspects of connectivity resource configuration (connection management) in order to help understanding the distinction of topology resource configuration management and connectivity resource configuration management. The main goal of NTCM is to administrate the life cycle of the installed topology resources (create, delete, update and status change of the resources). The functions that should be provided by the NTCM can be defined as follows:

- Maintaining the resource map of the network resources, in the viewpoints of inventory of all resources and network topology (the relationships between resources).
- Allowing activation, deactivation, reservation and release of resources.
- Installation support that can support the installation and removal of network resources.

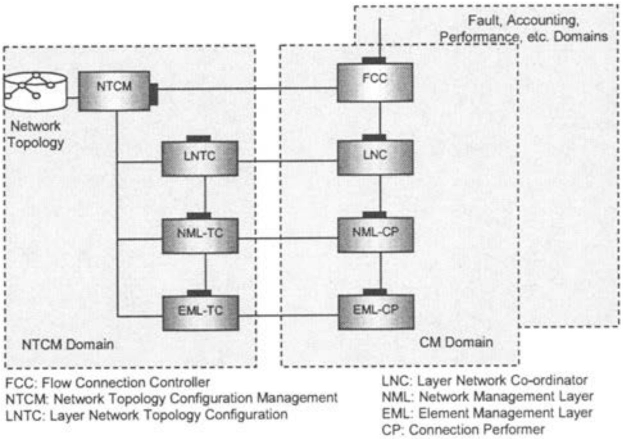


Figure 6. Computational model of Network Topology Configuration and Connection Management

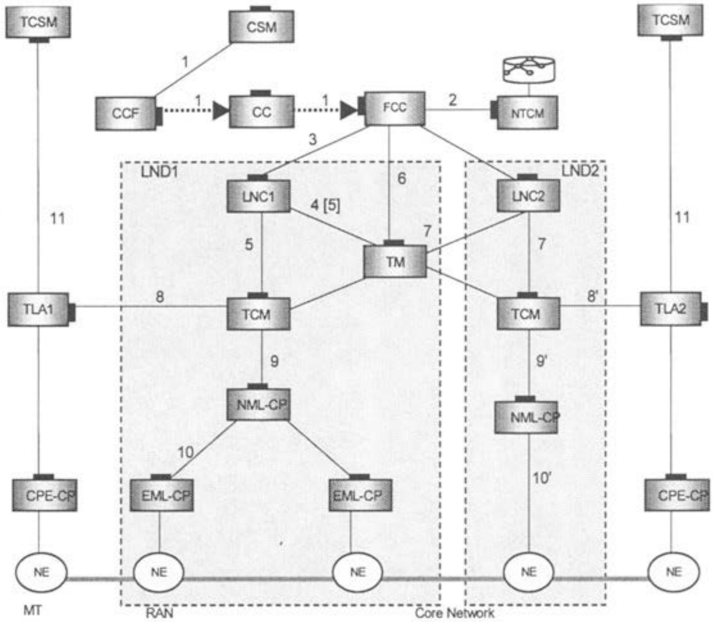
Routing function that can support the procedure for routing information exchange between LNDs and connectivity provider domains. Routing information can be used (by FCC) to choose a route within the layer network or federate with the neighbouring domains to create tandem connections.

The Network Topology Configuration Management is modelled as a computational object (CO) named as NTCM (Network Topology Configuration Manager) as described in Figure 6. The interfaces among NTCM and other management domains (Fault, Configuration, Accounting, Performance and Security – FCAPS Management) are considered and COs within NTCM are defined. For the scope of this paper, we consider only the Connection Management that addresses the management of *dynamically* allocated connectivity resources. Other Subordinate COs are defined in the NTCM domain as follows:

- Layer Network Topology Configuration (LNTC)
- Network Management Layer Topology Configuration (NML-TC)
- Element Management Layer Topology Configuration (EML-TC)

They configure the topology resources of the layer network, network management layer and element management layer levels respectively. The

Network Topology database is an inventory of network resources and the relationship between them that should be maintained by NTCM.



CC: Connection Co-ordinator
CCF: Connection Co-ordinator Factory
CP: Connection Performer
CPE-CP: Customer Premises Equipment CP
CSM: Communication Session Manager
CSMF: Communication Session Manager Factory
EML-CP: Element Management Layer CP
FCC: Flow Connection Controller
LNC: Layer Network Co-ordinator
NE: Network Element
NEL: Network Element Layer
NML-CP: Network Management Layer CP
TCM: Tandem Connection Manager
TCSM: Terminal CSM
TLA: Terminal Layer Adapter
TM: Trail Manager

Figure 7. Connection management scenario

5. CONNECTIVITY SESSION SETUP SCENARIO

This section describes the procedure that is necessary to setup a connection in a UMTS system, between a mobile terminal and another terminal, either mobile or fixed. In order to make clear the control of the connections a simple network configuration will be considered where only one connectivity provider domain with two LNDs are involved. In this scenario, a computational diagram (Figure 7) is provided where the interactions between the different COs involved are shown. This representation is more focused on high-level mechanisms rather than on technology specific ones. In addition, the LND federation relationship is not further described here due to its complexity. Details concerning this issue can be found in [15].

1. CSM requests the CCF to setup a new connectivity session; CCF creates a new CC for that connectivity session; then for each NFC in the connectivity session CC creates a FCC to manage it.
2. FCC requests NTCM for the current information of network topology to make a decision which is initiated layer network domain for the trail associated with that NFC (FCC translates NFC into NWTTPs of the trail).
3. FCC locates the LNC1 (initiated layer network object described in step 2) of LND1 and requests a trail setup.
4. LNC creates a TM to manage the new trail; then LNC requests TM to add branches to the new trail.
5. To attend this request, TM requests the creation of a tandem connection within LND1 to LNC1 and LNC1 creates a TCM1 for the tandem connection.
6. As the above assumption, one of NWTTPs may in this scenario not belong to the LND1 that TM should request FCC to solve which LND is involved in the trail. This is performed by the federation between FCCs in multidomains. Then the reference of LNC2 is solved and returned to TM.
7. TM requests LNC2 to add a tandem connection for the trail; LNC2 creates TCM2 for that additional tandem connection.
8. (8') TCM requests the setup of NFEPs from the TLA in the consumer's domain, including the negotiation of connection parameters such as QoS and the bandwidth that can be supported by the terminal to that connection.
9. (9') TCM then requests to its top NML-CP object to create a subnetwork connection among the identified NWTTPs. Each NML-CP deals with routing functionality by interacting with the respective NML-TP in the NTCM domain.
10. (10') Each NML-CP determines the lower CP objects (finally, at EML-CP) to request the connectivity for the subnetworks in the domain. EML-CP objects keep control of the use and reservation of the resources associated with a certain subnetwork (i.e. termination points and bandwidth associated to the subnetwork).
11. TLA selects and requests the corresponding NFEPs and the association of TFC from TCSM; TCSM performs the association request. It is assumed that the nodal binding has been established and the internal interactions of the terminal are not described here

6. LOCATION MANAGEMENT

This scenario, as seen in Figure 8, is used to monitor, detect and update the location when the mobile terminal changes from the current location area (LA) to the new one. The concept of LA depends on the cellular structure area covered by the mobile system that can be identified by its Location Area Identifier (LAI). It is broadcast to all associated cells by a Location Management (LM) computational object in the connectivity provider domain. That procedure is triggered whenever a terminal moves from one LA to another and forces the TA to update the location information of the terminal stored in the TEI. That information will be used by NTCM to solve the location of the terminal when FCC requests to make a connection with. Depending on the network configuration and behaviour of the mobility user, the terminal location information will be maintained and stored in the Terminal Provider or in the NTCM domain. This issue is opened for further study.

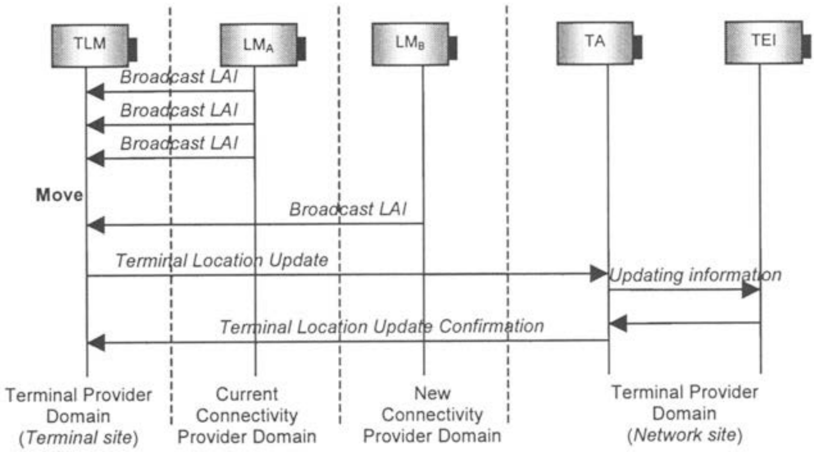


Figure 8. Location Management

7. CONCLUSION

In this paper, we present a TINA compliant architecture as an interesting candidate to perform connection, network topology configuration and location management for UMTS. The proposed TINA-compliant architecture (comprising of Business Model, NRIM and Computational Model) is suitable for model the UMTS network to handle diverse kinds of UMTS requirements. The Business Model defines the main stakeholder roles and clarifies their relationships to each other, as well as the extension of the new role of Terminal Provider that can support personal mobility and location management. The network topology configuration management with the proposed routing functionality can be used for fast setup and managing a connection. Further work will concentrate on how to maintain the stream and operational bindings during handover and how to realise a virtual home environment (VHE) to fulfil entirely mobility management supporting UMTS.

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