

3GPP2 S.R0017

Version Date: December 13, 1999



3RD GENERATION
PARTNERSHIP
PROJECT 2
"3GPP2"

3G Wireless Network Management System High Level Requirements

Revision: 0

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3rd Generation Partnership Project (3GPP2)

3G Wireless Network Management System High Level Requirements Including: OAM&P TMN Applications, Required Network and Systems Management Processes and Network Reference Model (NRM)

1 3G OAM&P

1.1 TMN Applications

Telecommunication management applications can be implemented in many different ways depending upon constraints such as logical and physical architecture differences, interface incompatibilities and others. Consistent operational processes are required for the management of the network irrespective of vendor equipment. A mobile operator can, because of the very heterogeneous nature of their networks, easily end up with dozens of duplicated applications for items such as alarm surveillance. Most vendors of network equipment offer dedicated network element managers and the ones not built with an open system approach will severely limit the possibility to report and manage the network in a consistent way.

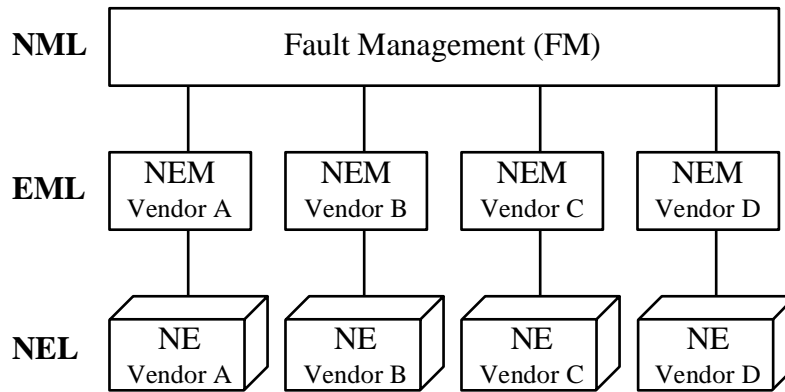
1.2 2G to 3G Wireless Management Migration

A primary goal of 3G Wireless OAM&P Standards is to preserve wireless operators' investments in current systems while facilitating the deployment of new 3G capabilities. The implication of the top-down approach in the standardizing work of 3GPP2 TSG-S WG2 is that consistent operational management processes are required irrespective of vendor equipment. Generic 3G Network Management applications are required to fulfill the requirements in Section 2 and to facilitate:

- consistent representation of basic information;
- reduced management application development costs;
- simplification of operational processes and associated reduction in costs;
- reduced time to deploy new services as management systems already exist.
- compatibility to 2G+ management systems specifications

1.2.1 Network Management Fault Management Example

Figure 1 is an example of network element fault management which represents a very common situation in the management of 2G mobile networks. Different vendors supplied their network elements (NE's) with unique network element managers (NEM's). The interfaces were mostly proprietary or unique and the information models for generic information, such as alarms, were rarely standardized. The consequences for the operators were that the network management systems became very complex, many still are. Similar information at many levels, repeated knowledge of alarms, inconsistent representation of similar information; are but a few of the difficulties the operators had to cope with, and some still do.



NML - Network Management Layer
 EML - Equipment Management Layer
 NEL - Network Element Layer

Figure 1 - 2G Unique Network Element Fault Management

Some of the more severe implications of this situation are the difficulty involved in adding more intelligence into the applications to better support the processes of the network providers. The operators who tried to break this situation had to put in a lot of effort into software development and proprietary interfaces. To make matters worse, the marketplace did not support the needs of the operators.

1.2.2 2G+ OAM&P Standards Overview

2G+ OAM&P Standards intent is to facilitate the transition from proprietary 2nd generation wireless OAM&P to standard 3rd generation wireless OAM&P. It addresses TMN interfaces so that it does not require major changes to deployed proprietary OAM&P systems. Moreover, the information model should employ capabilities that will remain applicable for the ensuing 3rd generation wireless OAM&P standards. Because the information models in IS-4108 do not meet the full complement of 3rd generation (3G) wireless OAM&P requirements, they are ascribed as 2G+ wireless OAM&P information models.

Figure 2 illustrates the TMN interfaces addressed in IS-4108. These are for Operations Support Systems (OSS) communication across the SML/NML, across the NML/EML and between SML OSs and EML OSs with no intervening NML. Element management systems (EML OSs) are regarded as executing proprietary wireless OAM&P otherwise, the OAM&P is standard. The 3G standards will not necessarily possess the restriction to only those interface identified in Figure 2. Note that the IWF in this context is for management purpose and should not be confused with NE IWF in the NRM.

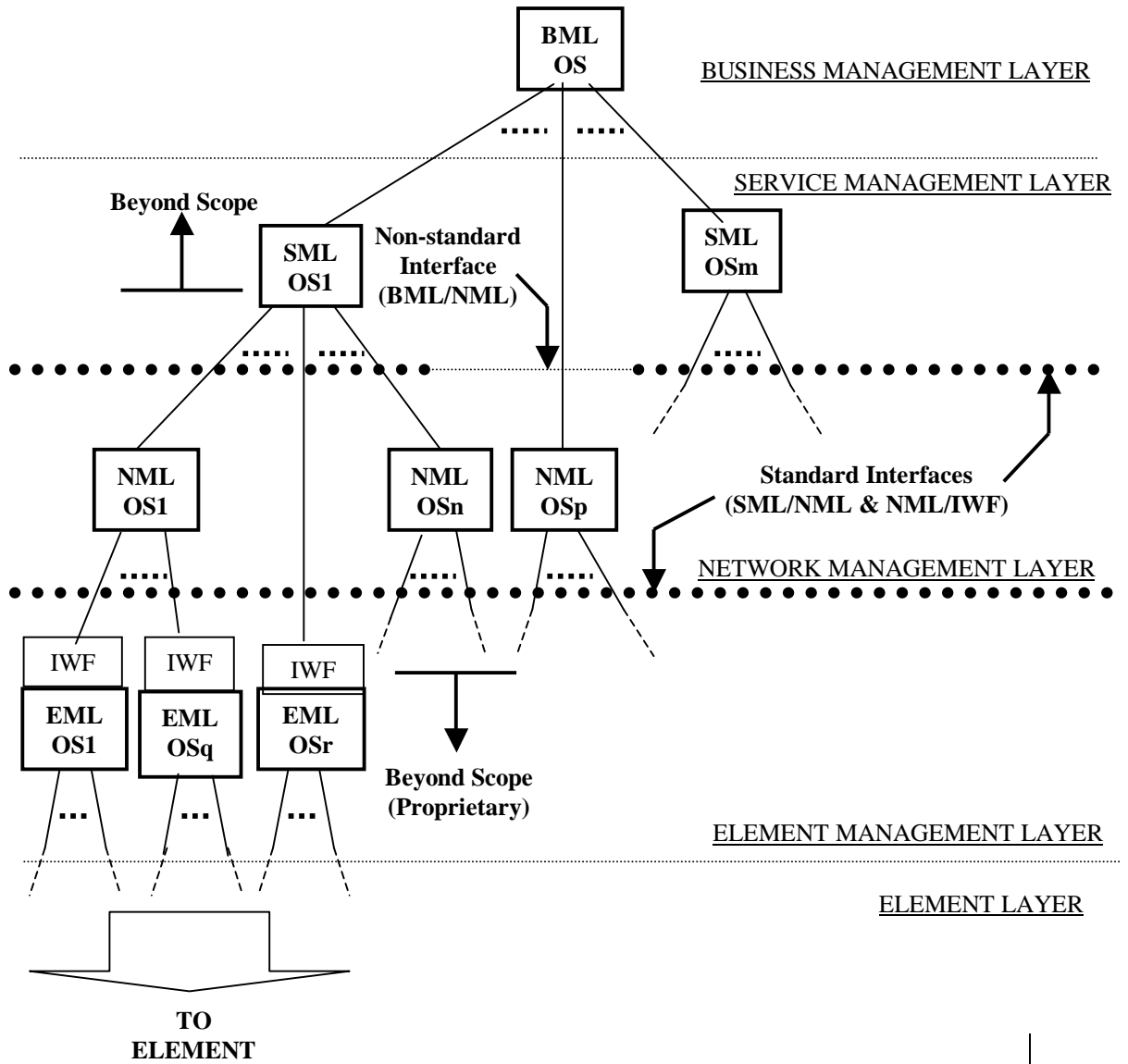


Figure 2 - TMN Layer Interfaces to be Standardized for 2G+ Wireless Systems

1.3 3G Wireless Management

Complementary to 2G+, 3G expands on it by adding 3G capabilities for applications that need to interoperate with other applications and will need to be designed employing the open systems approach in order to be part of a 3G network management system.

With a network having many different types of network elements, a common graphical user interface such as a web browser, could be an important issue in creating consistent operational processes. A consequence of this is that unlike the 2G+ transition, the OSs and

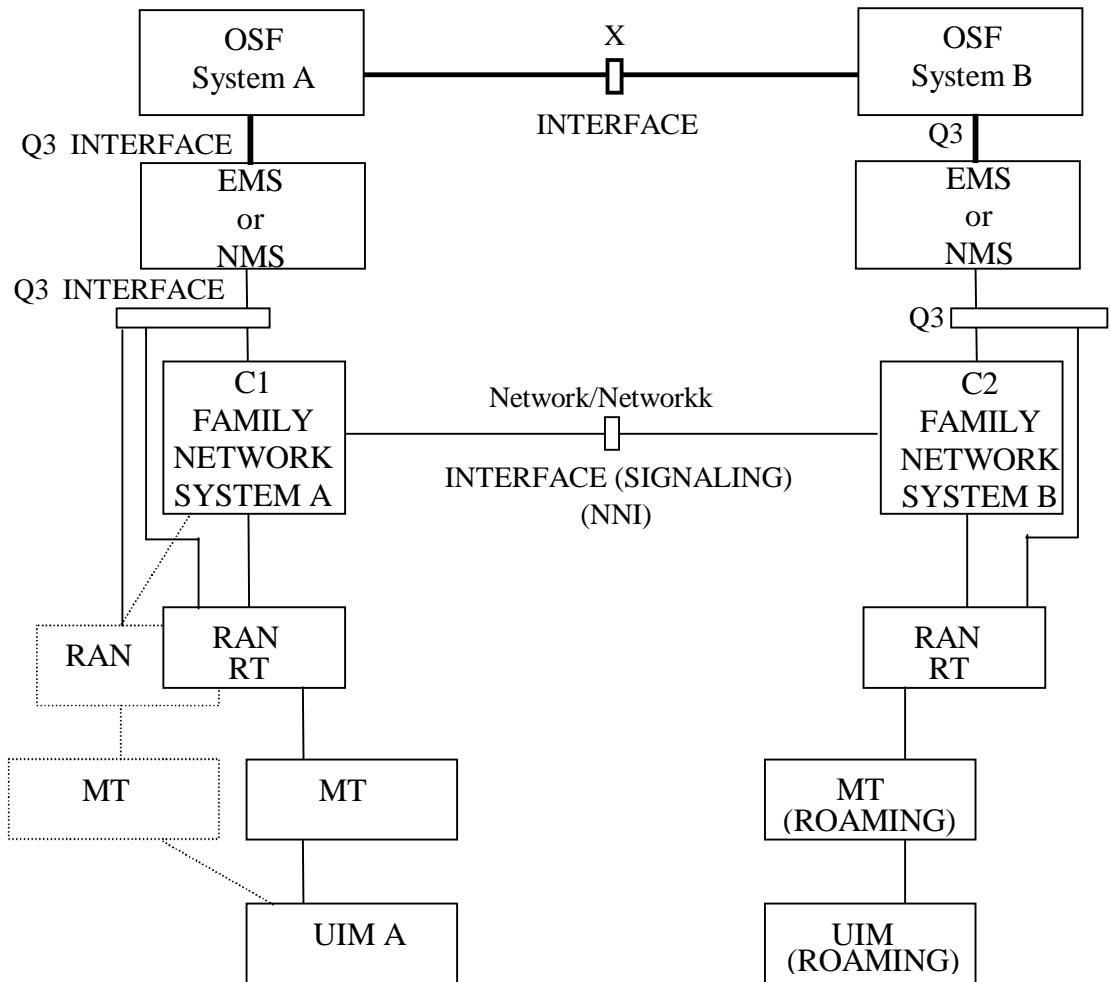
EML will need to have new operations and data requirements in order to meet the OAM&P demands of the 3G capabilities.

1.4 Wireless Management Requirements from 3G Capabilities
TBD

2 3G Network Management Requirements

2.1 3G Network Management Scope

The 3G NM Scope is the interface between the NML and EML. Both the TMN architectural interface "X", which is the interface between Operations System (OSs) of two family members, and interface "Q3", which is the interface between OS's and its Core Network (CN), as shown in Figure 3, should be targeted as initial work of 3GPP2 OAM&P standardization.



Legend:

MT = Mobile Terminal

RAN = Radio Access

NNI = Network-to-Network

RTT = Radio Transmission Technology

OSF = Operations Systems Functions UIM = User Identity Module

Heavy line indicates interface for standardization

Figure 3 - IMT-2000 Family Management Interfaces

2.1.1 3G Network Management Goals

3G Network Management goals are:

1. To provide 3G configuration capabilities that are flexible enough to allow rapid deployment of services;
2. To be scaleable which will enable the support and control of a growing number of resources. This will allow the 3G system to start from a small and simple configuration and be able to grow as needed in both size and complexity;
3. To address the management and assessment of system performance and operation through the use of common measurements, etc., which will enable a 3G Network Operator/Service Provider to be able to assess actual performance against planned targets;

2.2 3G General Requirements

1. 3GPP2 OAM&P should, to the maximum extent possible, be compatible to the IS-4108 TR-45.7 Wireless Network Management Standard that is being addressed by TR-45.7 which currently targets 2G+ networks. Additional management functionality may be required to support Authorization, Authentication and Accounting (AAA) for packet capabilities.
2. To be capable of managing 3G/2G element management systems in a multi-vendor environment supplied by different vendors including the management systems themselves.
3. 3GPP2 OAM&P should be designed to manage multiple 3G radio technologies at the NML-EML interface.
4. NML to EML interfaces should be developed in a protocol-neutral manner like UML, based on the methodology outlined in ITU-T M.3020 and be capable of supporting multiple management protocol implementations.
5. In packet data services two inter-network management models may be supported; Broker Management and Proxy Management. The Broker Management model allows for communication with a trusted third party which can access messaging content for information, examination, retention, selective filtering and relaying on to other networks' management systems. The Proxy Management model allows for communication with a trusted third party which can only forward the message to other network's management systems without accessing the message content. Broker management and proxy management are realizable via time-tested and well-known

concepts called event forwarding discriminators and filters and mediation devices, in the management world.

2.3 3G Fault Management (FM) Requirements

1. To provide information related to integrated fault management capabilities that are intended to determine the root cause.

2.4 3G Configuration Management (CM) Requirements

1. To require retrieval and disclosure of information only once. For example, if an operator wants to change one parameter in a cell, then all occurrences of this parameter (e.g., transceiver frequency, hand-over relationships, frequency hopping control, performance measurements, etc.) should be changed by only one action, as required.
2. To support the management of end-to-end services, in the wireless domain.
3. The OAM&P design should continue to be driven by an architecture-independent allocation strategy. In general, it must be ensured that architectural changes in a particular network element will only affect that element and manager, not the OAM&P or OSS in general, nor adversely affect the data model.

2.5 3G Performance Management (PM) Requirements

1. Management within a technology domain should be consistent regardless of where the management action is being performed (e.g., from the NOC or remotely) or of the application of the network element within that domain (i.e., BTS, RNCs, router, switch, etc.). For example, event control will operate the same for all network elements within a technology domain;
2. The OAM&P systems should not be required for proper services operation. In other words, the OAM&P systems should not have a master-slave relationship with the network, causing service outages if the OAM&P systems are down or experiencing difficulty.

2.6 3G Accounting Management (AM) Requirements

1. To provide interoperability between wireless Network Operators/Service Providers for the exchange of management/charging information.

2.7 3G Security Management (SM) Requirements

1. To support the security management of 3G systems (e.g., key management, access control management, operation and administration of security mechanisms, etc.) with

particular emphasis on new features such as packet switched services and methods and mechanisms for packet switching elements including CM, FM and PM at a minimum. For example:

- **Fault management:**
Alarms and event notifications from packet switched elements and circuit-switched elements will conform to a similar style and have the same semantics and information elements.
- **Configuration management:**
Operational states (enabled and disabled) will be supported in a consistent manner by both packet switched and circuit switched elements in the 3G wireless environment.
- **Performance management:**
Since a call may be composed of different sessions, the performance data should be measured piece-meal and as well as a whole. (For example, DATA and VOICE sessions are measured for success and failures and also included in USER SUCCESS and FAILURE rates. (Note this will transcend both circuit and packet switched elements)

3. 3G Management Processes

The purpose of this section is to aid in requirements, so the following descriptions should also result in requirements such as:

- Network performance data for handovers shall be derived from element management system notifications from element management systems for (e.g.) BTS and PDSN.
- Network performance data for authentication failures shall be derived from multiple element management systems for (say) AAA and HLR or HSS.

Figure 4 illustrates the full extent of telecommunication management processes:

- planning/development;
- provisioning;
- inventory management - equipment installation
- maintenance and restoration - operation
- data management - optimization

These management processes are based on the widely accepted Telecom Operations Map (TOM) from the TeleManagement Forum (TMF) and map onto the Service and Network Management Layers as defined in ITU-T Recommendation M.3010 Appendix II. This document further refines the subset of processes that are applicable to the 3G requirements. The customer Care Processes and Service Development and Operation Processes are outside the scope of this document so they are not discussed here.

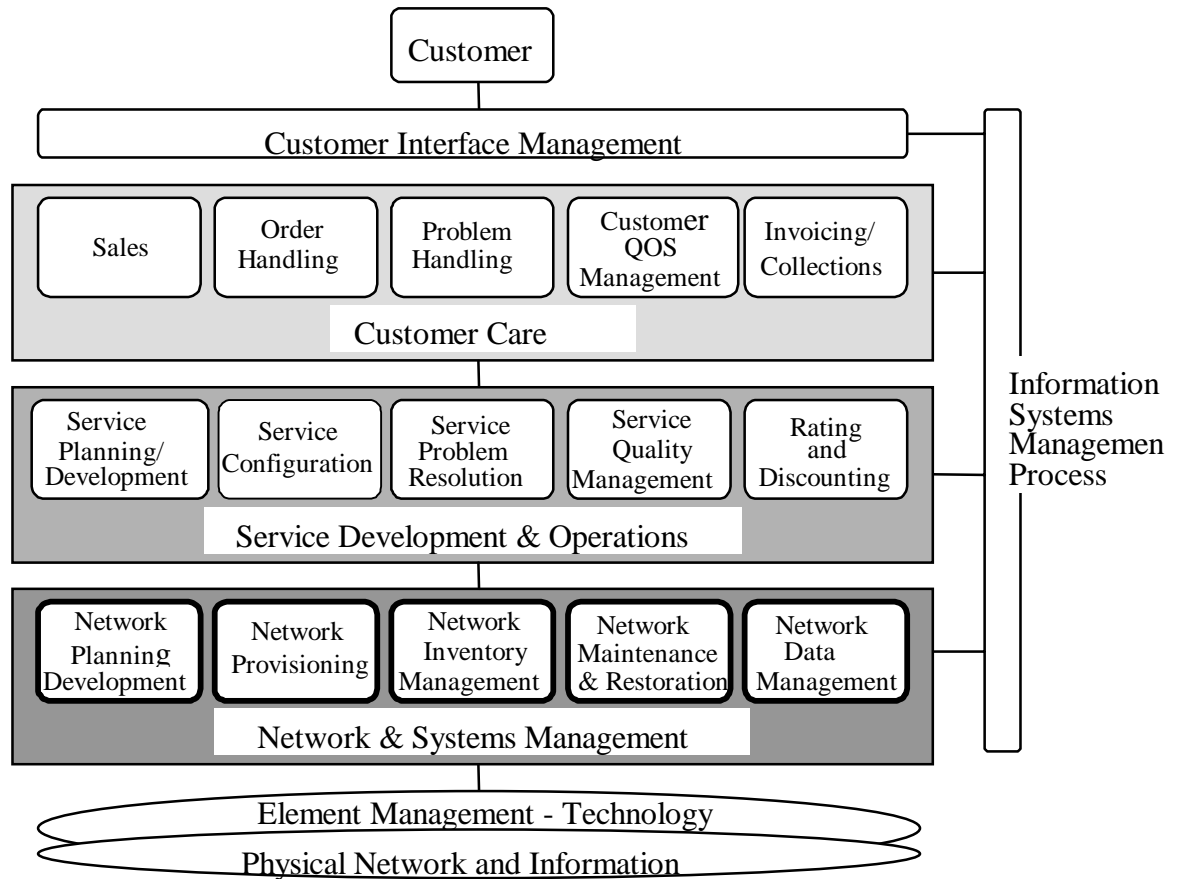


Figure 4 - Telecomm Operations Map (TOM) Business Process Model

"Network & Systems Management" functions are driven from "Service Development & Operations" functions.

These processes may be viewed as forming a life cycle that is repeated at the various stages of network evolution.

3.1.3 Network Planning/Development

Network planning involves developing a plan that:

- Supplies services at the desired QOS
- Allows for network growth
- Maximizes profit

The Network Planning process can be divided into three phases:

- Preparation
- Estimation of cell count
- Detailed network planning

In the preparation phase, coverage and capacity objectives are established, network planning strategy defined, and initial design and operating parameters determined. In the estimation of cell count phase, the number of wireless users in a given area is obtained by multiplying the population by the penetration. The number of users and offered traffic per user determines the overall offered traffic. Detailed network planning, taking into account the exact radio environment where each cell is deployed, can start after the cell count has been obtained. Due to cost reasons, zoning laws, building restrictions, or some other impediment, it is not possible to obtain optimum cell site in a real network. This will impact the coverage plan.

3.1.3 Network Provisioning

This process encompasses the configuration of the network to ensure that network capacity is ready for provisioning of 3G services. It carries out network provisioning, as required, to fulfill specific service requests and configuration changes to address network problems. This process must assign and administer identifiers for provisioned resources and make them available to other processes.

3.1.4 Network Inventory Management

This process encompasses tracking of hardware and software network resources that are managed by an element management system (EMS) (in the EML).

3.1.5 Network Maintenance and Restoration

This process involves communicating network information so the operational quality of the network is maintained in accordance with required network performance goals. Network maintenance activities can be preventative, such as scheduled routine maintenance, or corrective. Corrective maintenance can be in response to faults or to indications that problems may be developing (proactive maintenance - fault avoidance).

3.1.6 Network Data Management

This process, performed by network managers, operators, and service providers, is responsible for the collection of performance/usage data and events for the purpose of network performance, usage, and traffic analysis and accounting. The Network Data Management process must also provide sufficient and relevant information to Customer QOS Management to allow verification (compliance/non-compliance) of Service Level Agreements (SLA's). The SLA's themselves' are not known at the Network Management Layer (NML).

This process must ensure that the Network Performance goals are tracked, and that notification is provided when they are not met (e.g., threshold exceeded or performance degraded).

4 3G Network Reference Model (NRM)

4.1 3GPP2 Wireless Network Reference Model

Figure 5 presents the network entities and associated reference points that comprise a wireless network. The network entities are represented by squares, triangles and rounded corner rectangles; the reference points are represented by circles. The network reference model in this document is the compilation of several reference models currently in use in 3GPP2 wireless recommendations.

- **The network reference model is a functional block diagram.**
- **A network entity represents a group of functions, not a physical device. For example, a Mobile Switching Center (MSC) is a physical device; it comprises frames, shelves, circuit packs, etc. The physical device may comprise a single network entity such as the MSC, or it may comprise some combination such as the MSC, the Visitor Location Register (VLR), the Home Location Register (HLR), and the Authentication Center (AC). The physical realization is an implementation issue; a manufacturer may choose any physical implementation of network entities, either individually or in combination, as long as the implementation meets the functional requirements. Sometimes, for practical reasons, the functional network entity is a physical device. The Mobile Station (MS) is an excellent example.**
- **A reference point is a conceptual point that divides two groups of functions. It is not necessarily a physical interface. A reference point only becomes a physical interface when the network entities on either side of it are contained in different physical devices.**
- **A “Collective Entity” contains encompassed network entities that are an instance of the collective.**
- **A “Composite Entity” contains encompassed network entities that are part of the composite.**

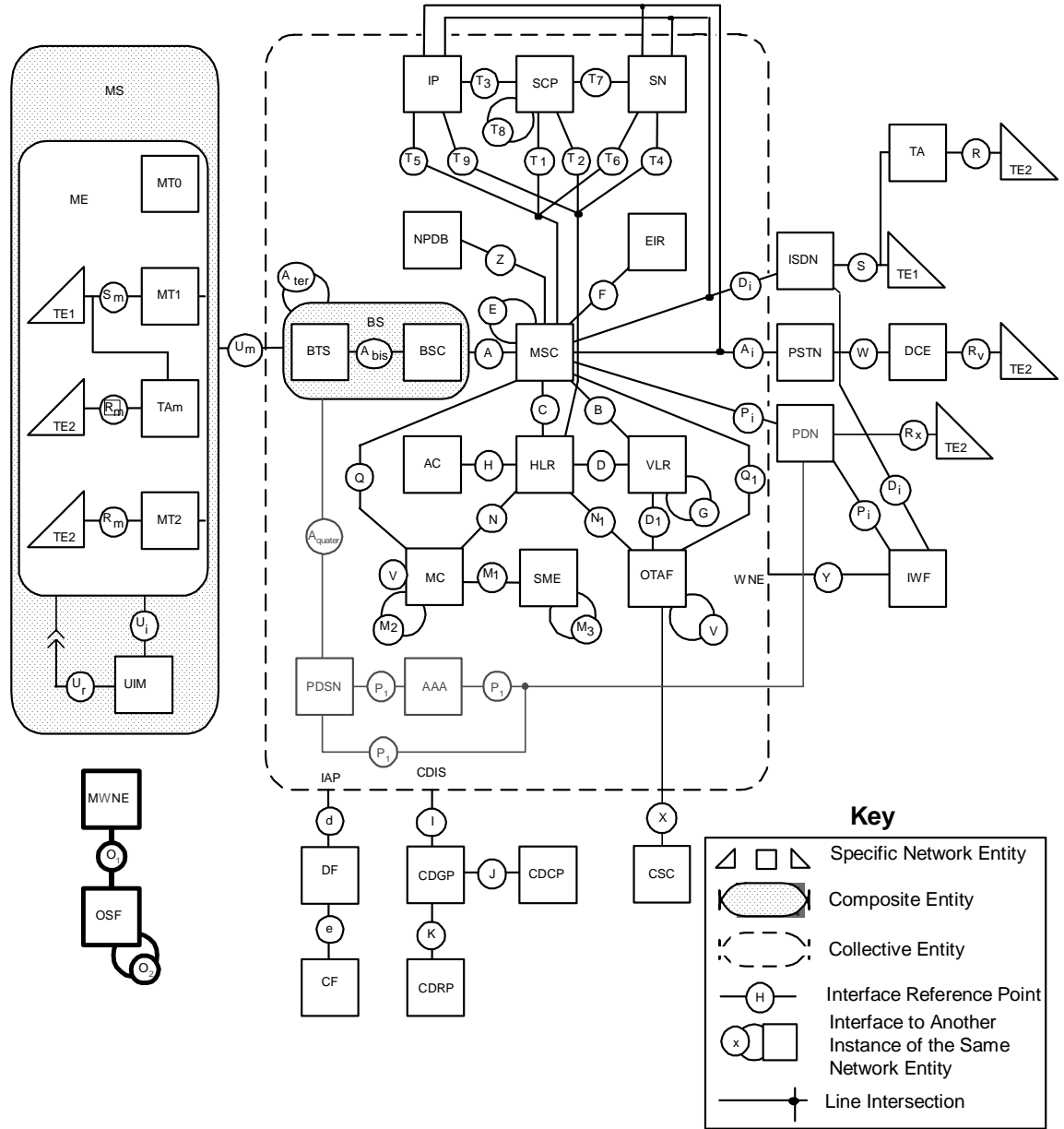


Figure 5 - 3GPP2 Wireless Network Reference Model

AAA	Authentication, Authorization, and Accounting	MWNE	Managed Wireless_Network Entity
AC	Authentication Center	MC	Message Center
BS	Base Station	MS	Mobile Station
BSC	Base Station Controller	MSC	Mobile Switching Center
BTS	Base Transceiver System	MT	Mobile Terminal
CDGP	Call Data Collection Point	NPDB	Number Portability Data Base
CDGP	Call Data Generation Point	OSF	Operations Systems Function
CDIS	Call Data Information Source	OTAF	Over-The-Air Service Provisioning Function
CDRP	Call Data Rating Point	PDSN	Public Data Serving Node
CF	Collection Function	PDN	Packet Data Network
CSC	Customer Service Center	PSTN	Public Switched Telephone Network
DCE	Data Circuit Equipment	SCP	Service Control Point
DF	Delivery Function	SN	Service Node
EIR	Equipment Identity Register	SME	Short Message Entity
HLR	Home Location Register	TA	Terminal Adapter
ISDN	Integrated Services Digital Network	TE	Terminal Equipment
IP	Intelligent Peripheral	UIM	User Identity Module
IAP	Intercept Access Point	VLR	Visitor Location Register
IWF	Interworking Function	WNE	Wireless Network Entity

4.2 Network Entities

The only network entity that is by definition a physical device is the MS. Each of the others may be a physical device, it may form part of a physical device, or it may be distributed over a number of physical devices.

Authentication, Authorization and Accounting (AAA)

The AAA is an entity that provides Internet Protocol functionality to support the functions of Authentication, Authorization, and Accounting. These IP functions are defined in the Internet Engineering Task Force (IETF) documents. The AAA interacts with the PDSN to perform AAA functions in support of the PDSN for requesting Mobile Stations. The AAA interacts with other AAA entities to perform AAA functions where the Home AAA is outside the serving mobile network.

Authentication Center (AC)

The AC is an entity that manages the authentication information related to the MS. The AC may, or may not be located within, and be indistinguishable from an HLR. An AC may serve more than one HLR.

Base Station (BS)

A BS is an entity that provides the means for MSs to access network services using radio. It includes a BSC and a BTS.

Base Station Controller (BSC)

The BSC is an entity that provides control and management for one or more BTSs. The BSC exchanges messages with both the BTS and the MSC. Traffic and signaling

concerned with call control, mobility management, and MS management may pass transparently through the BSC.

Base Transceiver System (BTS)

The BTS is an entity that provides transmission capabilities across the U_m reference point. The BTS consists of radio devices, antenna and equipment.

Call Data Collection Point (CDCP)

The CDCP is the entity that collects the *IS-124* format call detail information.

Call Data Generation Point (CDGP)

The CDGP is an entity that provides call detail information to the CDCP in *IS-124* format. This may be the entity which converts call detail information from a proprietary format into the *IS-124* format. All information from the CDGP to the CDCP must be in *IS-124* format.

Call Data Information Source (CDIS)

The CDIS is an entity that can be the source of call detail information. This information may be in proprietary format. It is not required to be in *IS-124* format.

Call Data Rating Point (CDRP)

The CDRP is the entity that takes the unrated *IS-124* format call detail information and applies the applicable charge and tax related information. The charge and tax information is added using *IS-124* format.

Collection Function (CF) - [Intercept]

The CF is an entity that is responsible for collecting intercepted communications for a lawfully authorized law enforcement agency.

The CFs typically include:

- the ability to receive and process call contents information for each intercept subject.
- the ability to receive information regarding each intercept subject (e.g., call associated or non-call associated) from the Delivery function and process it.

Customer Service Center (CSC)

The CSC is an entity where service provider representatives receive telephone calls from customers wishing to subscribe to initial wireless service or request a change in the customer's existing service. The CSC interfaces proprietarily with the OTAF to perform network and MS related changes necessary to complete the service provisioning request.

Data Circuit Equipment (DCE)

A termination that provides a non-ISDN user-network interface (e.g., ITU-T [CCITT] V series, ITU-T [CCITT] X series).

Delivery Function (DF) - [Intercept]

The DF is an entity that is responsible for delivering intercepted communications to one or more collection functions.

The DFs typically include:

- the ability to accept call contents for each intercept subject over one or more channels from each Access function.
- the ability to deliver call contents for each intercept subject over one or more channels to a Collection function as authorized for each law enforcement agency.
- the ability to accept information over one or more data channels and combine that information into a single data flow for each intercept subject.
- the ability to filter or select information on an intercept subject before delivery to a Collection function as authorized for a particular law enforcement agency.
- the optional ability to detect audio in-band DTMF digits for translation and delivery to a Collection function as authorized for a particular law enforcement agency.
- the ability to duplicate and deliver information on the intercept subject to one or more Collection functions as authorized for each law enforcement agency.
- the ability to provide security to restrict access.

Equipment Identity Register (EIR)

The EIR is an entity that is the register to which user equipment identity may be assigned for record purposes. The nature, purpose, and utilization of this information is an area for further study.

Home Location Register (HLR)

The HLR is the location register to which a user identity is assigned for record purposes such as subscriber information (e.g. Electronic Serial Number (ESN), Mobile Directory Number (MDN), Profile Information, Current Location, Authorization Period).

Integrated Services Digital Network (ISDN)

The ISDN is defined in accordance with the appropriate *ANSI T1* Standards.

Intelligent Peripheral (IP)

The IP is an entity that performs specialized resource functions such as playing announcements, collecting digits, performing speech-to-text or text-to-speech conversion, recording and storing voice messages, facsimile services, data services, etc.

Intercept Access Point (IAP)

The IAP is an entity that provides access to the communications to, or from, the equipment, facilities, or services of an intercept subject.

Interworking Function (IWF)

The IWF is an entity that provides information conversion for one or more WNEs. An IWF may have an interface to a single WNE providing conversion services. An IWF may augment an identified interface between two WNEs, providing conversion services to both WNEs.

Managed Wireless Network Entity (MWNE)

A wireless network entity with OS management needs.

Message Center (MC)

The MC is an entity that stores and forwards short messages. The MC may also provide supplementary services for Short Message Service (SMS).

Mobile Station (MS)

A wireless terminal used by subscribers to access network services over a radio interface. MSs include portable units (e.g., hand-held units), units installed in vehicles, and somewhat paradoxically, fixed location MSs. The MS is the interface equipment used to terminate the radio path at the subscriber.

Mobile Switching Center (MSC)

The MSC switches MS originated or MS terminated traffic. An MSC is usually connected to at least one BS. It may connect to the other public networks (PSTN, ISDN, etc.), other MSCs in the same network, or MSCs in different networks. The MSC may store information to support these capabilities.

Mobile Terminal 0 (MT0)

A self-contained data capable MS termination that does not support an external interface.

Mobile Terminal 1 (MT1)

A MS termination that provides an ISDN user-network interface.

Mobile Terminal 2 (MT2)

A MS termination that provides a non-ISDN user-network interface (e.g., ITU-T [CCITT] V series, ITU-T [CCITT] X series).

Number Portability DataBase (NPDB)

The NPDB is an entity which provides portability information for portable Directory Numbers.

Operations Systems Function (OSF)

The OSF is defined by the Telecommunications Management Network (TMN) OSF. These functions include Element Management Layer (EML), Network Element Layer, Service Management Layer (SML), and Business Management Layer (BML) functions spanning across all operations systems functions (e.g., Fault Management, Performance Management, Configuration management, Accounting management and Security Management).

Over-The-Air Service Provisioning Function (OTAF)

The OTAF is an entity that interfaces proprietarily to CSCs to support service provisioning activities. The OTAF interfaces with the MSC to send MS orders necessary to complete service provisioning requests.

Packet Data Serving Node (PDSN)

The PDSN is an entity that provides Internet Protocol functionality to the mobile network. A PDSN establishes, maintains and terminates link layer sessions to the Mobile Station. A PDSN routes IP datagrams to the PDN. A PDSN may act as a Mobile IP foreign agent in the mobile network. A PDSN may have interface to one or more Base Stations to provide the link layer session. A PDSN interacts with the AAA to provide IP authentication, authorization, and accounting support. A PDSN may interface to one or more IP networks either public or Intranet to provide IP network access.

Packet Data Network (PDN)

A PDN, such as the Internet, provides a packet data transport mechanism between processing network entities capable of using such services.

Public Switched Telephone Network (PSTN)

The PSTN is defined in accordance with the appropriate *ANSI T1* Standards.

Service Control Point (SCP)

The SCP is an entity that acts as a real-time database and transaction processing system that provides service control and service data functionality.

Service Node (SN)

The SN is an entity that provides service control, service data, specialized resources and call control functions to support bearer-related services.

Short Message Entity (SME)

The SME is an entity that composes and decomposes short messages. A SME may, or may not be located within, and be indistinguishable from, an HLR, MC, VLR, MS, or MSC.

Terminal Adapter (TA)

An entity that converts signaling and user data between a non-ISDN and an ISDN interface.

Terminal Adapter m (TAm)

An entity that converts signaling and user data between a non-ISDN and an ISDN interface.

Terminal Equipment 1 (TE1)

A data terminal that provides an ISDN user-network interface.

Terminal Equipment 2 (TE2)

A data terminal that provides a non-ISDN user-network interface (e.g., ITU-T [CCITT] V series, ITU-T [CCITT] X series).

User Identity Module (UIM)

The UIM contains subscription information such as the NAM and may contain subscription feature information. The UIM can be integrated into any mobile terminal or it may be removable.

Visitor Location Register (VLR)

The VLR is the location register other than the HLR used by an MSC to retrieve information for handling of calls to or from a visiting subscriber. The VLR may, or may not be located within, and be indistinguishable from an MSC. The VLR may serve more than one MSC.

Wireless Network Entity (WNE)

A Network Entity in the wireless Collective Entity

4.3 Reference Points

The U_m reference point is the only reference point that is by definition a physical interface. The other reference points will be physical interfaces if network entities on either side them are contained in different physical devices.

An interface exists when two Network Entities are interconnected through exactly one Reference Point.

Reference Point A

Reference Point A is the interface between the BSC and the MSC.

Reference Point A_i

Reference Point A_i is the interface between the IP and the PSTN, plus the interface between the MSC and the PSTN, plus the interface between the SN and the PSTN.

Reference Point A_{bis}

Reference Point A_{bis} is the interface between the BSC and the BTS.

Reference Point A_{ter}

Reference Point A_{ter} is the BS to BS interface.

A_{quater} Interface

Reference Point A_{quater} is the interface between the PDSN and the BS. The operations supported by this interface are described in TSB 4286.

Reference Point B

Reference Point B is the interface between the MSC and the VLR.

Reference Point C

Reference Point C is the interface between the MSC and the HLR.

Reference Point D

Reference Point D is the interface between the VLR and the HLR.

Reference Point d

Reference Point d is the interface between an IAP and the DF.

Reference Point D₁

Reference Point D₁ is the interface between the OTAF and the VLR.

Reference Point D_i

Reference Point D_i is the interface between the IP and the ISDN, the IWF and the ISDN, the interface between the MSC and the ISDN, plus the interface between the SN and the ISDN.

Reference Point E

Reference Point E is the interface between the MSC and the MSC.

Reference Point e

Reference Point e is the interface between the CF and the DF.

Reference Point F

Reference Point F is the interface between the MSC and the EIR.

Reference Point G

Reference Point G is the interface between the VLR and the VLR.

Reference Point H

Reference Point H is the interface between the HLR and the AC.

Reference Point I

Reference Point I is the interface between the CDIS and the CDGP. The operations supported by this interface are described in *IS-124*.

Reference Point J

Reference Point J is the interface between the CDGP and the CDCP. The operations supported by this interface are described in *IS-124*.

Reference Point K

Reference Point K is the interface between the CDGP and the CDRP. The operations supported by this interface are described in *IS-124*.

Reference Point L
Reserved.

Reference Point M₁
Reference Point M₁ is the interface between the SME and the MC.

Reference Point M₂
Reference Point M₂ is the MC to MC interface.

Reference Point M₃
Reference Point M₃ is the SME to SME interface.

Reference Point N
Reference Point N is the interface between the HLR and the MC.

Reference Point N₁
Reference Point N₁ is the interface between the HLR and the OTAF.

Reference Point O₁
Reference Point O₁ is the interface between an Operations Systems Function (OSF) and a Managed Wireless Network Entity (MWNE).

Reference Point O₂
Reference Point O₂ is the interface between two Operations Systems Functions (OSF's).

Reference Point P_i
Reference Point P_i is the interface between the MSC, the IWF, the PDSN, the AAA, and the PDN. This reference point is also the interface between the PDSN and the AAA.

Reference Point Q
Reference Point Q is the interface between the MC and the MSC.

Reference Point Q₁
Reference Point Q₁ is the interface between the MSC and the OTAF.

Reference Point R
Reference Point R is the interface between the TA and the TE2.

Reference Point R_m
Reference Point R_m is the interface between the TE2 and the TA_m plus the interface between the TE2 and the MT2.

Reference Point R_v

Reference Point R_v is the interface between the DCE and the TE2.

Reference Point R_x

Reference Point R_x is the interface between the PPDN and the TE2.

Reference Point S

Reference Point S is the interface between the ISDN and the TE1.

Reference Point S_m

Reference Point S_m is the interface between the TE1 and the MT1 plus the interface between the TE1 and the TAm.

Reference Point T₁

Reference Point T₁ is the interface between the MSC and the SCP.

Reference Point T₂

Reference Point T₂ is the interface between the HLR and the SCP.

Reference Point T₃

Reference Point T₃ is the interface between the IP and the SCP.

Reference Point T₄

Reference Point T₄ is the interface between the HLR and the SN.

Reference Point T₅

Reference Point T₅ is the interface between the IP and the MSC.

Reference Point T₆

Reference Point T₆ is the interface between the MSC and the SN.

Reference Point T₇

Reference Point T₇ is the interface between the SCP and the SN.

Reference Point T₈

Reference Point T₈ is the interface between the SCP and the SCP.

Reference Point T₉

Reference Point T₉ is the interface between the HLR and the IP.

Reference Point U_i

Reference Point U_i is the interface between the integrated UIM and a MT.

Reference Point U_m

Reference Point U_m is the interface between the BS and the MS, which corresponds to the air interface.

Reference Point U_r

Reference Point U_r is the interface between the Removable-UIM and a MT.

Reference Point V

Reference Point V is the interface between the OTAF and the OTAF.

Reference Point W

Reference Point W is the interface between the DCE and the PSTN.

Reference Point X

Reference Point X is the interface between the CSC and the OTAF.

Reference Point Y

Reference Point Y is the interface between a Wireless Network Entity (WNE) and the IWF. See *IS-634* or *IS-658*.

Reference Point Z

Reference Point Z is the interface between the MSC and the NPDB.