QualNet 7.1
UMTS Model Library

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Table of Contents

1 Overview of Model Library

1.1 List of Models in the Library

The models described in the UMTS Model Library are listed in Table 1-1.

TABLE 1-1. UMTS Library Models

Model Name	Model Type	Section Number
Packet Service Applications	Application Layer	Section 3.1
UMTS Call Traffic Generator	Application Layer	Section 3.2
UMTS	Multilayer	Section 2.1

Refer to Appendix A for routing information between UMTS and IP networks.

1.2 Conventions Used

1.2.1 Format for Command Line Configuration

This section describes the general format for specifying parameters in input files, the precedence rules for parameters, and the conventions used in the description of command line configuration for each model.

1.2.1.1 General Format of Parameter Declaration

The general format for specifying a parameter in an input file is:

```
[<Qualifier>] <Parameter Name> [<Index>] <Parameter Value>
```

where

`<Qualifier>` The qualifier is optional and defines the scope of the parameter declaration. The scope can be one of the following: Global, Node, Subnet, and Interface. Multiple instances of a parameter with different qualifiers can be included in an input file. Precedence rules (see Section 1.2.1.2) determine the parameter value for a node or interface.

Global: The parameter declaration is applicable to the entire scenario (to all nodes and interfaces), subject to precedence rules. The scope of a parameter declaration is global if the qualifier is not included in the declaration.

Example:

```
MAC-PROTOCOL            MACDOT11
```

Node: The parameter declaration is applicable to specified nodes, subject to precedence rules. The qualifier for a node-level declaration is a list of space-separated node IDs or a range of node IDs (specified by using the keyword `thru`) enclosed in square brackets.

Example:

```
[5 thru 10] MAC-PROTOCOL            MACDOT11
```

Subnet: The parameter declaration is applicable to all interfaces in specified subnets, subject to precedence rules. The qualifier for a subnet-level declaration is a space-separated list of subnet addresses enclosed in square brackets. A subnet address can be specified in the IP dot notation or in the QualNet N syntax.

Example:

```
[N8-1.0 N2-1.0] MAC-PROTOCOL      MACDOT11
```

Interface: The parameter declaration is applicable to specified interfaces. The qualifier for an interface-level declaration is a space-separated list of subnet addresses enclosed in square brackets.

Example:

```
[192.168.2.1 192.168.2.4] MAC-PROTOCOL MACDOT11
```

`<Parameter Name>`	Name of the parameter.
`<Index>`	Instance of the parameter to which this parameter declaration is applicable, enclosed in square brackets. This should be in the range 0 to *n* -1, where *n* is the number of instances of the parameter. The instance specification is optional in a parameter declaration. If an instance is not included, then the parameter declaration is applicable to all instances of the parameter, unless otherwise specified.
`<Parameter Value>`	Value of the parameter.

Note: There should not be any spaces between the parameter name and the index.

Examples of parameter declarations in input files are:

```
PHY-MODEL                                  PHY802.11b
[1] PHY-MODEL                              PHY802.11a
[N8-1.0] PHY-RX-MODEL                      BER-BASED
[8 thru 10] ROUTING-PROTOCOL               RIP
[192.168.2.1 192.168.2.4] MAC-PROTOCOL     GENERICMAC
NODE-POSITION-FILE                         ./default.nodes
PROPAGATION-CHANNEL-FREQUENCY[0]           2.4e9
[1 2] QUEUE-WEIGHT[1]                      0.3
```

Note In the rest of this document, we will not use the qualifier or the index in a parameter's description. Users should use a qualifier and/or index to restrict the scope of a parameter, as appropriate.

1.2.1.2 Precedence Rules

Parameters without Instances

If the parameter declarations do not include instances, then the following rules of precedence apply when determining the parameter values for specific nodes and interfaces:

Interface > Subnet > Node > Global

This can be interpreted as follows:

- The value specified for an interface takes precedence over the value specified for a subnet, if any.
- The value specified for a subnet takes precedence over the value specified for a node, if any.
- The value specified for a node takes precedence over the value specified for the scenario (global value), if any.

Parameters with Instances

If the parameter declarations are a combination of declarations with and without instances, then the following precedence rules apply (unless otherwise stated):

Interface[i] > Subnet[i] > Node[i] > Global[i] > Interface > Subnet > Node > Global

This can be interpreted as follows:

- Values specified for a specific instance (at the interface, subnet, node, or global level) take precedence over values specified without the instance.

- For values specified for the same instance at different levels, the following precedence rules apply:
  - The value specified for an interface takes precedence over the value specified for a subnet, if any, if both declarations are for the same instance.
  - The value specified for a subnet takes precedence over the value specified for a node, if any, if both declarations are for the same instance.
  - The value specified for a node takes precedence over the value specified for the scenario (global value), if any, if both declarations are for the same instance.

1.2.1.3 Parameter Description Format

In the Model Library, most parameters are described using a tabular format described below. The parameter description tables have three columns labeled “Parameter”, “Values”, and “Description”. Table 1-2 shows the format of parameter tables. Table 1-4 shows examples of parameter descriptions in this format.

TABLE 1-2. Parameter Table Format

Parameter	Values	Description
<Parameter Name> <Designation> <Scope> [<Instances>]	<Type> [<Range>] [<Default Value>] [<Unit>]	<Description>

Parameter Column

The first column contains the following entries:

- ***<Parameter Name>*****:** The first entry is the parameter name (this is the exact name of the parameter to be used in the input files).

- ***<Designation>:*** This entry can be *Optional* or *Required*. These terms are explained below.
  - ***Optional***: This indicates that the parameter is optional and may be omitted from the configuration file. (If applicable, the default value for this parameter is included in the second column.)
  - ***Required***: This indicates that the parameter is mandatory and must be included in the configuration file.

- ***<Scope>:*** This entry specifies the possible scope of the parameter, i.e., if the parameter can be specified at the global, node, subnet, or interface levels. Any combination of these levels is possible.If the parameter can be specified at all four levels, the keyword “All” is used to indicate that.

  Examples of scope specification are:

  Scope: All

  Scope: Subnet, Interface

  Scope: Global, Node

- ***<Instances>:*** If the parameter can have multiple instances, this entry indicates the type of index. If the parameter can not have multiple instances, then this entry is omitted.

Examples of instance specification are:

Instances: channel number

Instances: interface index

Instances: queue index

Values Column

The second column contains the following information:

- ***<Type>*:** The first entry is the parameter type and can be one of the following: Integer, Real, String, Time, Filename, IP Address, Coordinates, Node-list, or List. If the type is a List, then all possible values in the list are enumerated below the word “List”. (In some cases, the values are listed in a separate table and a reference to that table is included in place of the enumeration.)

  Table 1-3 shows the values a parameter can take for each type.

TABLE 1-3. Parameter Types

Type	Description
Integer	Integer value Examples: `2`, `10`
Real	Real value Examples: `15.0`, `-23.5`, `2.0e9`
String	String value Examples: `TEST`, `SWITCH1`
Time	Time value expressed in QualNet time syntax (refer to *QualNet User's Guide*) Examples: `1.5S`, `200MS`, `10US`

Filename	Name of a file in QualNet filename syntax (refer to *QualNet User's Guide*)
	Examples:
	`../../data/terrain/los-angeles-w`
	(For Windows and UNIX)
	`C:\scalable\qualnet\7.1\scenarios\WF\WF.nodes`
	(For Windows)
	`/root/scalable/qualnet/7.1/scenarios/WF/WF.nodes`
	(For UNIX)

Path	Path to a directory in QualNet path syntax (refer to *QualNet User's Guide*)
	Examples:
	`../../data/terrain` (For Windows and UNIX)
	`C:\scalable\qualnet\7.1\scenarios\default`
	(For Windows)
	`/root/scalable/qualnet/7.1/scenarios/default`
	(For UNIX)

IP Address	IPv4 or IPv6 address Examples: `192.168.2.1`, `2000:0:0:0::1`
IPv4 Address	IPv4 address Examples: `192.168.2.1`
IPv6 Address	IPv6 address Examples: `2000:0:0:0::1`
Coordinates	Coordinates in Cartesian or Lat-Lon-Alt system. The altitude is optional. Examples: `(100, 200, 2.5)`, `(-25.3478, 25.28976)`
Node-list	List of node IDs separated by commas and enclosed in "{" and "}". Examples: `{2, 5, 10}`, `{1, 3 thru 6}`
List	One of the enumerated values. Example: See the parameter `MOBILITY` in Table 1-4.

Note: If the parameter type is List, then options for the parameter available in QualNet and the commonly used model libraries are enumerated. Additional options for the parameter may be available if some other model libraries or addons are installed. These additional options are not listed in this document but are described in the corresponding model library or addon documentation.

- ***<Range>*:** This is an optional entry and is used if the range of values that a parameter can take is restricted. The permissible range is listed after the label "*Range:*" The range can be specified by giving the minimum value, the maximum value, or both. If the range of values is not restricted, then this entry is omitted.

  If both the minimum and maximum values are specified, then the following convention is used to indicate whether the minimum and maximum values are included in the range:

  `(min, max)` `min` < parameter value < `max`

  `[min, max)` `min` ≤ parameter value < `max`

  `(min, max]` `min` < parameter value ≤ `max`

  `[min, max]` `min` ≤ parameter value ≤ `max`

  `min` (or `max`) can be a parameter name, in which case it denotes the value of that parameter.

  Examples of range specification are:

  Range: ≥ `0`

  Range: `(0.0, 1.0]`

  Range: `[1, MAX-COUNT]`

  Range: `[1S, 200S]`

Note: If an upper limit is not specified in the range, then the maximum value that the parameter can take is the largest value of the type (integer, real, time) that can be stored in the system.

- ***<Default>*:** This is an optional entry which specifies the default value of an optional or conditional-optional parameter. The default value is listed after the label "*Default:*"
- ***<Unit>*:** This is an optional entry which specifies the unit for the parameter, if applicable. The unit is listed after the label "*Unit:*". Examples of units are: meters, dBm, slots.

Description Column

The third column contains a description of the parameter. The significance of different parameter values is explained here, where applicable. In some cases, references to notes, other tables, sections in the User's Guide, or to other model libraries may be included here.

Table 1-4 shows examples of parameter descriptions using the format described above.

TABLE 1-4. Example Parameter Table

Parameter	Values	Description
`MOBILITY` Optional *Scope:* Global, Node	List: • `NONE` • `FILE` • `GROUP-MOBILITY` • `RANDOM-WAYPOINT` Default: `NONE`	Mobility model used for the node. If `MOBILITY` is set to `NONE`, then the nodes remain fixed in one place for the duration of the simulation. See Table 7-11 for a description of mobility models.
`BACKOFF-LIMIT` Required *Scope:* Subnet, Interface	Integer *Range:* `[4,10)` *Unit:* slots	Upper limit of backoff interval after collision. A backoff interval is randomly chosen between 1 and this number following a collision.
`IP-QUEUE-PRIORITY-QUEUE-SIZE` Required *Scope:* All *Instances:* queue index	Integer *Range:* `[1, 65535]` *Unit:* bytes	Size of the output priority queue.
`MAC-DOT11-DIRECTIONAL-ANTENNA-MODE` Optional *Scope:* All	List • `YES` • `NO` *Default:* `NO`	Indicates whether the radio is to use a directional antenna for transmission and reception.

1.2.2 Format for GUI Configuration

The GUI configuration section for a model outlines the steps to configure the model using the GUI. The following conventions are used in the GUI configuration sections:

Path to a Parameter Group

As a shorthand, the location of a parameter group in a properties editor is represented as a path consisting of the name of the properties editor, name of the tab within the properties editor, name of the parameter group within the tab (if applicable), name of the parameter sub-group (if applicable), and so on.

Example

The following statement:

Go to **Default Device Properties Editor > Interfaces > Interface # > MAC Layer**

is equivalent to the following sequence of steps:

1. Open the Default Device Properties Editor for the node.
2. Click the **Interfaces** tab.

3. Expand the applicable Interface group.
4. Click the **MAC Layer** parameter group.

The above path is shown in Figure 1-1.

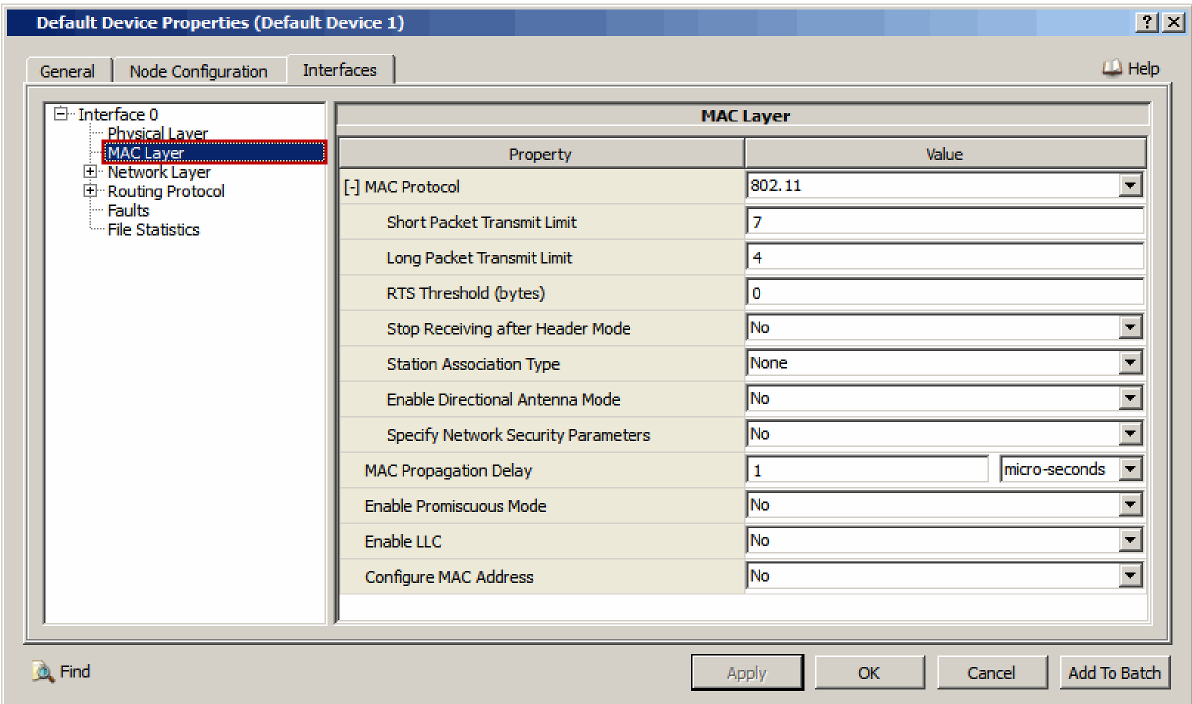

FIGURE 1-1. Path to a Parameter Group

Path to a Specific Parameter

As a shorthand, the location of a specific parameter within a parameter group is represented as a path consisting of all ancestor parameters and their corresponding values starting from the top-level parameter. The value of an ancestor parameter is enclosed in square brackets after the parameter name.

Example

The following statement:

Set **MAC Protocol** *[= 802.11]* **> Station Association Type** *[= Dynamic]* **> Set Access Point** *[= Yes]* **>** *Enable Power Save Mode* to *Yes*

is equivalent to the following sequence of steps:

1. Set **MAC Protocol** to *802.11*.
2. Set **Station Association Type** to *Dynamic.*
3. Set **Set Access Point** to *Yes*.
4. Set **Enable Power Save Mode** to *Yes*.

The above path is shown in Figure 1-2.

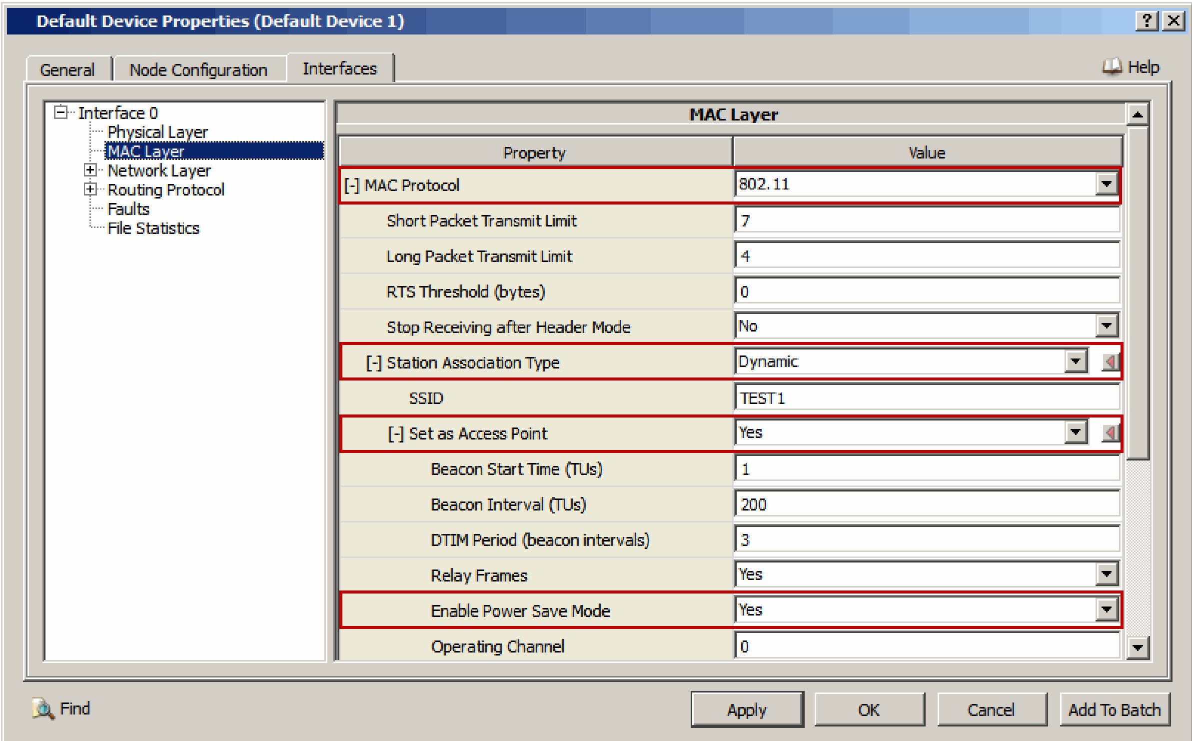

FIGURE 1-2. Path to a Specific Parameter

Parameter Table

GUI configuration of a model is described as a series of a steps. Each step describes how to configure one or more parameters. Since the GUI display name of a parameter may be different from the name in the configuration file, each step also includes a table that shows the mapping between the GUI names and command line names of parameters configured in that step. For a description of a GUI parameter, see the description of the equivalent command line parameter in the command line configuration section.

The format of a parameter mapping table is shown in Table 1-5.

TABLE 1-5. Mapping Table

GUI Parameter	Scope of GUI Parameter	Command Line Parameter
<GUI Display Name>	<Scope>	*<Command Line Parameter Name>*

The first column, labeled “GUI Parameter”, lists the name of the parameter as it is displayed in the GUI.

The second column, labeled “Scope of GUI Parameter”, lists the level(s) at which the parameter can be configured. *<Scope>* can be any combination of: Global, Node, Subnet, Wired Subnet, Wireless Subnet, Point-to-point Link, and Interface.

Table 1-6 lists the Properties Editors where parameters with different scopes can be set.

Notes: **1.** Unless otherwise stated, the “Subnet” scope refers to “Wireless Subnet”.

2. The scope column can also refer to Properties Editors for special devices and network components (such as ATM Device Properties Editor) which are not included in Table 1-6.

TABLE 1-6. Properties Editors for Different Scopes

Scope of GUI Parameter	Properties Editor
Global	Scenario Properties Editor
Node	Default Device Properties Editor (General and Node Configuration tabs)
Subnet Wireless Subnet	Wireless Subnet Properties Editor
Wired Subnet	Wired Subnet Properties Editor
Point-to-point Link	Point-to-point Link Properties Editor
Interface	Interface Properties Editor, Default Device Properties Editor (Interfaces tab)

The third column, labeled “Command Line Parameter”, lists the equivalent command line parameter.

Note: For some parameters, the scope may be different in command line and GUI configurations (a parameter may be configurable at fewer levels in the GUI than in the command line).

Table 1-7 is an example of a parameter mapping table.

TABLE 1-7. Example Mapping Table

GUI Parameter	Scope of GUI Parameter	Command Line Parameter
Define Area	Node	`OSPFv2-DEFINE-AREA`
OSPFv2 Configuration File	Node	`OSPFv2-CONFIG-FILE`
Specify Autonomous System	Node	N/A
Configure as Autonomous System Boundary Router	Node	`AS-BOUNDARY-ROUTER`
Inject External Route	Node	N/A
Enable Stagger Start	Node	`OSPFv2-STAGGER-START`

2 Multi-layer Models

This chapter describes features, configuration requirements and parameters, statistics, and scenarios for Multi-layer Models in the UMTS Models, and consists of the following section:

- Universal Mobile Telecommunication System (UMTS)

2.1 Universal Mobile Telecommunication System (UMTS)

The QualNet UMTS model is based on 3GPP UMTS Technical Specifications Release 7.

2.1.1 Description

The Universal Mobile Telecommunication System (UMTS) is a third generation (3G) mobile communication system that provides a range of broadband wireless and mobile communication services. UMTS maintains the global roaming capability of the second generation (2G) GSM system and its packet-switch mode enhancement (GPRS system) and provides enhanced capabilities. Compared with 2G telecommunication systems, UMTS is able to support multimedia services including graphics, pictures, and video communications, as well as voice and data at a higher data rate and with better quality of service.

UMTS targets to build an all-IP network by extending the second generation GSM/GPRS system and using complex technologies including Code Division Multiple Access (CDMA), Asynchronous Transfer Mode (ATM), and Internet Protocol (IP). GPRS is the convergence point between the 2G technologies and the packet-switch domain of UMTS. The architecture for a typical third generation telecommunication system is illustrated in Figure 2-1. There are three major categories of network elements:

- **GSM Core Network Elements**: Mobile Service Center (MSC), Visitor Location Register (VLR), Home Location Register (HLR), Authentication Center (AuC), and Equipment Identity Register (EIR).
- **GPRS Network Elements**: Serving GPRS Support Node (SGSN), and Gateway GPRS Support Node (GGSN).
- **UMTS-specific Network Elements**: User equipment (UE), and UMTS Terrestrial Radio Access Network (UTRAN) elements.

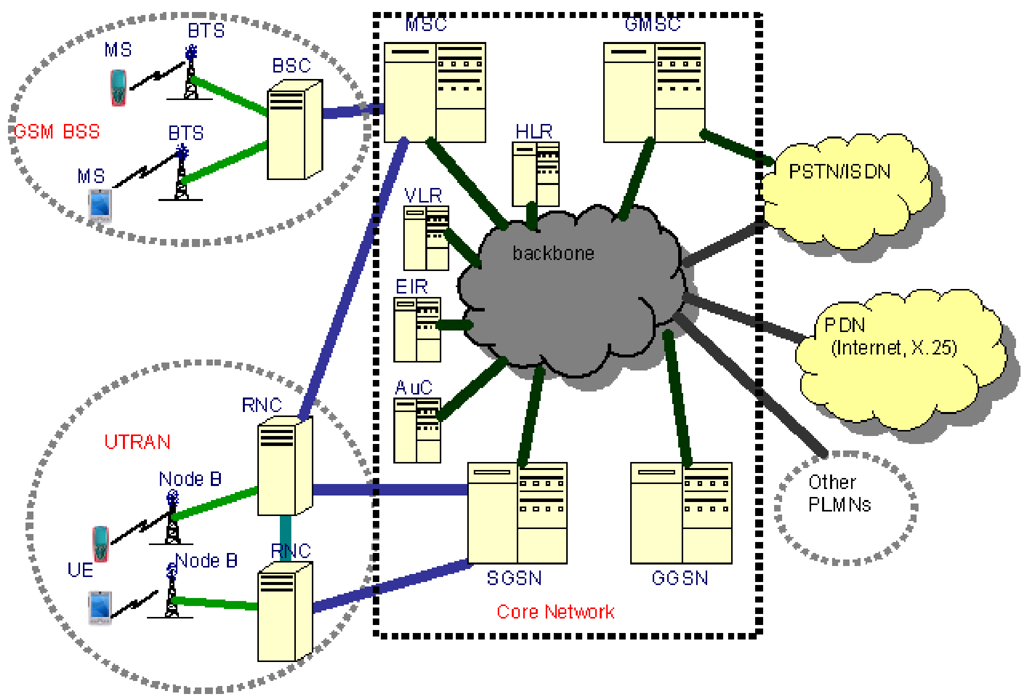

FIGURE 2-1. UMTS Architecture

The core network is based on GSM/GPRS, but uses ATM or IP as the transport network. The ATM-based UMTS network is more popular since it ensures various QoS and classes-of-service to the end users. The functions of core networks include switching, routing, transporting, and maintaining a database for user traffic. It contain the circuit-switch domain that includes MSCs, VLRs, and GMSCs, and the packet-switch domain that includes SGSNs and GGSNs. The EIR, HLR, and AuC are part of both domains. In an ATM-based UMTS network, ATM adaptation layer type 2 (ALL2) can handle circuit-switch connections, while ALL5 can handle packet-switched connections.

2.1.1.0.1 Architecture of the QualNet UMTS Model

The QualNet UMTS model is intended to model the network architecture illustrated in Figure 2-2. The Public Land Mobile Network (PLMN) contains different node types, such as UE, Node B, RNC, SGSN, GGSN, and HLR nodes. The SGSN, GGSN, and HLR nodes form the Core Network (CN). It is assumed that the SGSN and GGSN have the capability to handle both circuit switched services and packet switched services. That is, the SGSN also implements the capability of a MSC and the GGSN also implements the capability of a GMSC. Such a SGSN is also called UMTS MSC (UMSC).

Each Node B is connected via a single-hop connection to a RNC and each RNC is connected via a single-hop connection to a SGSN. The RNCs can be connected to each other via single-hop connections. The connections among SGSNs, GGSNs, and HLRs can be any type of backbone network. No special connections are required among them (i.e., they need not be one hop away from each other). It is assumed that each SGSN has one Visitor Location Register (VLR) co-located with it. In the QualNet UMTS model, the SGSN node also implements the functionality of the VLR.

The GGSN node is a special SGSN node, which acts as a gateway node to interconnect the PLMN with other type of networks such as PSTN, ISDN, or Packet Data Networks (PDNs) such as the Internet. It is also the gateway node that interconnects different PLMNs. One PLMN can have multiple GGSNs to interconnect with different networks. However, it is assumed that one PLMN can only have one Home Location Register (HLR).

As illustrated in Figure 2-2, the PLMN can be divided into three parts, namely User Equipment (UE), Access Network (AN), and Core Network (CN). The Access Network can more precisely be called the UMTS Terrestrial Radio Access Network (UTRAN). A UE most commonly refers to a user handset. The access network provides radio access to UEs. The core network implements functions such as location registration, handover, session management, call management, etc.

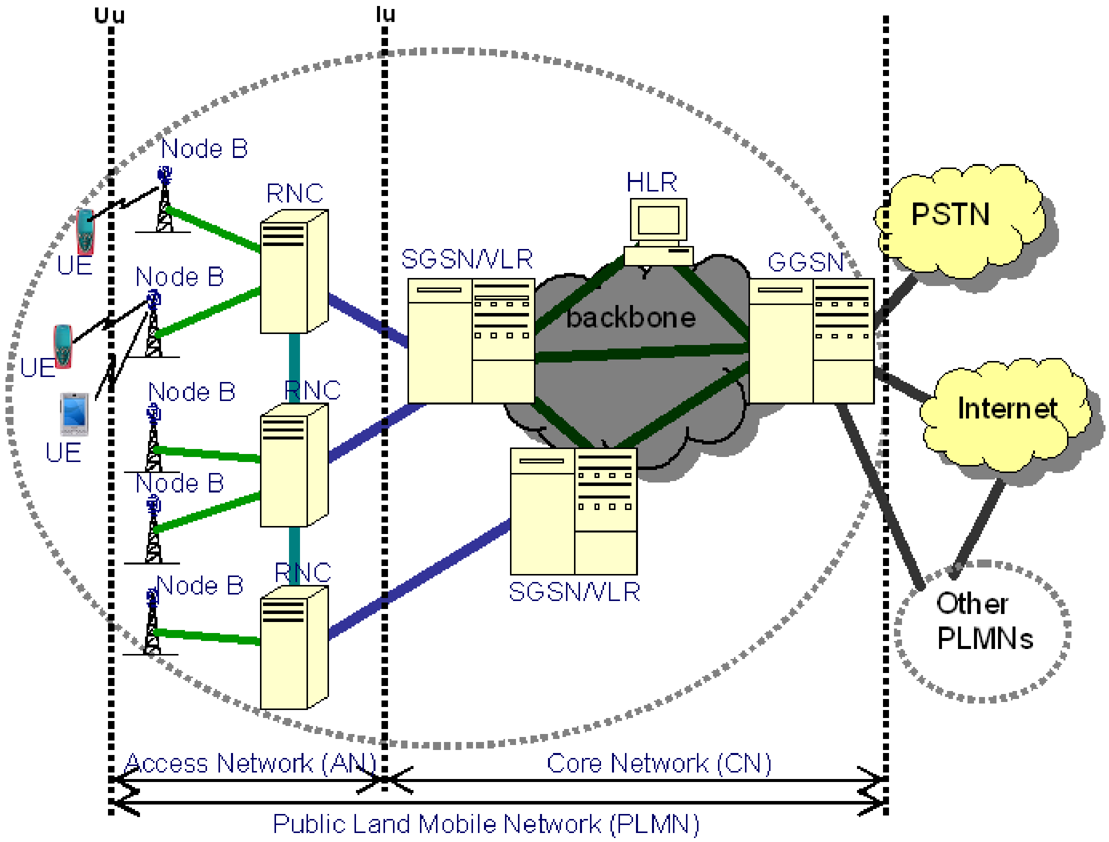

FIGURE 2-2. Architecture of the QualNet UMTS Model

2.1.2 Features and Assumptions

This section describes the implemented features, omitted features, assumptions and limitations of the UMTS model.

2.1.2.1 Implemented Features

2.1.2.1.1 Implemented General Features

- UMTS FDD (Frequency Division Duplex)
- UE, Node B, RNC, SGSN, GGSN, and HLR node types
- Support for four QoS classes: Background, Interactive, Streaming, and Conversational
- Open source admission control

2.1.2.1.2 Implemented Physical Layer Features

- WCDMA PHY
- Cell search
- Radio link monitoring and measurement
- Closed-loop power control

2.1.2.1.3 Implemented Layer 2 Features

MAC Sublayer of Layer 2

- Mapping between logical channels and transport channels
- Selection of appropriate transport format for each transport channel depending on traffic rate
- Identification of UEs on common transport channels
- Multiplexing/demultiplexing of upper layer PDUs into/from transport blocks delivered to/from the physical layer on common transport channels
- Multiplexing/demultiplexing of upper layer PDUs into/from transport blocks delivered to/from the physical layer on dedicated transport channels
- Access service class selection for RACH transmission

RLC Sublayer of Layer 2

- TM transmission
  - No discard configuration for SDU discard function
  - Segmentation and reassembly
- UM transmission
  - No discard configuration for SDU discard function
  - Segmentation, padding, and reassembly
  - Add/remove RLC header (sequence number and length indicator)
- AM transmission
  - Segmentation, padding, and reassembly
  - Add/remove RLC header (sequence number, length indicator, D/T bit, P bit, PDU type, SUFI)
  - LAST_PDU triggered polling function
  - STATUS PDU transmission function

2.1.2.1.4 Implemented Layer 3 Features

Connection Management (CM)

- Call Control (CC)
  - Call establishment for normal calls
  - Call maintenance
  - Call termination
- Session Management (SM)
  - PDP context activation
  - PDP context deactivation

Mobility Management (MM) and GPRS Mobility Management (GMM)

- VLR and HLR
- GPRS attach
- IMSI attach
- MM connection management
- GMM connection management
- Combined routing area update and location update

Radio Resource Control (RRC)

- Initial cell selection and cell reselection
- Broadcast of system information blocks (complete combination type only)
- Establishment, maintenance, and release of the RRC connection
- Establishment and release of radio bearers
- Assignment and release of radio resources
- RRC connection mobility functions
- UE measurement reporting and control of reporting
- Paging

Handovers

- Soft handover (break after handover)
- Intra-SGSN handover
- Inter-SGSN handover

2.1.2.1.5 Implemented GPRS Tunneling Protocol (GTP) Features

- GTP header format
- GTP tunnel establishment
- GTP-U control and data service

2.1.2.1.6 Implemented High Speed Downlink Packet Access (HSDPA) Features

- HS-DSCH channel with the following characteristics: 2 ms TTI, SF =16, QPSK/QAM 16 modulation, transport block size derivation
- HS-SCCH with transport format information transmission
- HS-DPCCH with transmission of CQI
- Queue distribution in UTRAN MAC-hs
- Scheduling/priority handling in UTRAN MAC-hs
- Reordering function
- Disassembly function

2.1.2.2 Omitted Features

2.1.2.2.1 Omitted General Features

- No security related features are implemented
- Only one GGSN is supported in each PLMN
- No roaming support across different PLMNs

2.1.2.2.2 Omitted Physical Layer Features

- Enhanced DCH is not implemented, thus no E-DCH related physical channels, transport channels and procedures are defined
- Downlink power control
- Synchronization (frequency/timing adjustment)

2.1.2.2.3 Omitted Layer 2 Features

RLC Sublayer of Layer 2

- NO_SDU discard after MaxDAT number of transmissions (trigger reset)
- Reset procedure

2.1.2.2.4 Omitted Layer 3 Features

Connection Management (CM)

- MBMS context activation and de-activation of Session Management (SM)
- Call establishment for emergency calls of Call Control (CC)
- Supplementary Services (SS) support
- Short Message Service (SMS) support
- GRPS Short Message Service (GSMS) support
- Group Call Control (GCC)
- Broadcast Call Control (BCC)
- Connection management of packet data on signaling channels

Mobility Management (MM) and GPRS Mobility Management (GMM)

- Security-related procedures, such as IMSI reallocation, authentication, identification, P-TMSI (re-) allocation, GPRS authentication and ciphering, and GPRS identification
- MM information procedure
- GPRS information
- Periodic routing area/location update
- Combined GPRS attach and IMSI attach

Radio Resource Control (RRC)

- Security mode control (ciphering and message integrity protection)
- Slow DCA (TDD mode)
- Arbitration of radio resources on uplink DCH
- Timing advance (TDD mode)
- Support for Cell Broadcast Services (CBS)
- MBMS control
- Control of requested QoS
- Outer loop power control
- Cell update
- Radio bearer reconfiguration
- Measurement control

Handover

- Softer handover
- Hard handover (inter-frequency as it needs more hardware)
- Inter-system handover

2.1.2.3 Assumptions and Limitations

- Each carrier network has only one HLR.
- The VLR is co-located with the SGSN node.
- A SGSN node has both the SGSN module and MSC module. Thus, effectively it acts as a UMSC node.
- A GGSN node has both the GGSN module and GMSC module.
- A RNC can connect to only one SGSN.
- The mobile node (UE) is assumed to be a fully functional UMTS terminal. There is no modeling of different classes.
- Cordless Telephony Service (CTS) related services/functions/protocols are not supported.
- Only UTRAN radio access network is supported. Support for GSM BSS radio access network is not implemented.

2.1.3 Supplemental Information

None.

2.1.4 Command Line Configuration

Configuring a UMTS scenario in command line requires the following steps:

1. Enable UMTS at all nodes that constitute the UMTS network and specify the node type for each UMTS node (see Section 2.1.4.1).
2. Configure the different nodes in the UMTS network. Layer 3 parameters need to be specified for all UMTS nodes. Additionally, UMTS layer 2 and physical layers need to be configured for UE and Node B nodes (see Section 2.1.4.2).
3. Configure the wireless interface between UE and Node B nodes (see Section 2.1.4.3).
4. Configure the backbone network (see Section 2.1.4.4).
5. Enable statistics collection (see Section 2.1.5.4).
6. Set up traffic between nodes. See Chapter 3 for details of configuring traffic generators for a UMTS scenario.

In addition to UMTS-specific parameters, some other QualNet parameters need to be set appropriately for a UMTS scenario. These parameters are described in Section 2.1.4.5.

See Section 1.2.1.3 for an explanation of the format used for parameter tables in this section.

2.1.4.1 General UMTS Parameters

To enable the UMTS model, include the following parameters in the scenario configuration (.config) file:

```
[<Qualifier>]   NETWORK-PROTOCOL                CELLULAR-LAYER3
[<Qualifier>]   CELLULAR-LAYER3-PROTOCOL        UMTS-LAYER3
```

The scope of `NETWORK-PROTOCOL` can be Global, Node, Subnet, or Interface, and of `CELLULAR-LAYER3-PROTOCOL` can be Global or Node. See Section 1.2.1.1 for a description of `<Qualifier>` for each scope.

Table 2-1 lists the general configuration parameters for UMTS.

TABLE 2-1. General UMTS Parameters

Parameter	Value	Description
`UMTS-NODE-TYPE` *Optional* *Scope:* Global, Node	List • `GGSN` • `HLR` • `NodeB` • `RNC` • `SGSN` • `UE` *Default:* `UE`	Indicates the type of UMTS node. `GGSN` : Node is a Gateway GPRS Support Node which connects the PLMN to other PLMNs or other types of networks, such as the Internet. To configure a GGSN node, see Section 2.1.4.2.4. `HLR` : Node is a Home Location Register. There are no additional configuration parameters for an HLR node. `NodeB` : Node is a Node B (UMTS version of Base Transceiver Station). To configure a Node B node, see Section 2.1.4.2.1. `RNC` : Node is a Radio Network Controller. To configure a RNC node, see Section 2.1.4.2.2. `SGSN` : Node is a Serving GPRS Support Node. To configure a SGSN node, see Section 2.1.4.2.3. `UE` : Node is a User Equipment. To configure a UE node, see Section 2.1.4.2.1. **Note:** Although this parameter is optional, it is recommended that it be specified for each UMTS node.
`CELLULAR-STATISTICS` *Optional* *Scope:* Global, Node	List • `YES` • `NO` *Default:* `YES`	Indicates whether statistics collection is enabled for cellular protocols, including UMTS. If statistics collection is enabled, then statistics are collected for UMTS layer 3, UMTS layer 2, and UMTS physical layer.
`UMTS-PRINT-DETAILED-STATISTICS` *Optional* *Scope:* Global, Node	List • `YES` • `NO` *Default:* `NO`	Indicates whether detailed UMTS layer 3 statistics are collected.

2.1.4.2 Configuring UMTS Nodes

This section describes the additional parameters that need to be configured for each UMTS node type.

2.1.4.2.1 UE and Node B Configuration

In addition to layer 3, the MAC and physical layers also need to be configured for UE and Node B nodes.

2.1.4.2.1.1 UMTS Layer 3 Configuration for UE and Node B Nodes

Table 2-2 lists the layer 3 parameters that need to be configured for Node B and UE nodes.

TABLE 2-2. UMTS Layer 3 Parameters for Node B and UE Nodes

Parameter	Value	Description
UMTS-CELL-SELECTION-MIN-RX-LEVEL *Dependency:* UMTS-NODE-TYPE = NodeB or UE *Optional* *Scope:* Global, Node	Real *Range:* [-115.0, -80.0] *Default:* -95.0 *Unit:* dBm	Minimum received signal strength for initial cell selection and reselection. A UE uses this value for the initial cell selection after powering on. Each Node B node can be configured with a different value for this parameter. Node B nodes include this value in their system information messages.
UMTS-CELL-SEARCH-THRESHOLD *Dependency:* UMTS-NODE-TYPE = NodeB or UE *Optional* *Scope:* Global, Node	Real *Range:* [-115.0, -70.0] *Default:* -80.0 *Unit:* dBm	Threshold for searching and ranking cells. When the measured cell quality, i.e., the quality of the signal received from Node B, is below this threshold, cell search is initiated using the rules specified in the UMTS specification. This threshold triggers both intra-frequency and inter-frequency cell searches. However, intra-frequency search is performed first and inter-frequency search is initiated only if intra-frequency search fails.
UMTS-CELL-RESELECTION-HYSTERESIS *Dependency:* UMTS-NODE-TYPE = NodeB or UE *Optional* *Scope:* Global, Node	Real *Range:* [0.0, 40.0] *Default:* 4.0 *Unit:* dBm	Hysteresis value for cell quality used during cell reselection. UMTS has specific algorithms for cell selection and reselection. In general, increasing the value of this parameter gives a higher priority to the serving cell. Decreasing this value makes the cell reselection more sensitive to cell quality.
UMTS-UE-POWER-ON-TIME *Dependency:* UMTS-NODE-TYPE = UE *Optional* *Scope:* Global, Node	Time *Range:* ≥ 0S *Default:* 0S	Specifies the time when the UE is powered on.

TABLE 2-2. UMTS Layer 3 Parameters for Node B and UE Nodes (Continued)

Parameter	Value	Description
UMTS-NodeB-DOWNLINK-CHANNEL *Dependency:* UMTS-NODE-TYPE = NodeB *Required* *Scope:* Global, Node	Integer or string *Range:* ≥ 0 (if channel index is used)	Index or name of the downlink channel. If a channel index is used to specify the downlink channel, then it must correspond to the index of the parameter PROPAGATION-CHANNEL-FREQUENCY. See note below table. **Note:** For FDD UMTS, the downlink and uplink channels should be different. For TDD UMTS, the downlink and uplink channels should be the same.
UMTS-NodeB-UPLINK-CHANNEL *Dependency:* UMTS-NODE-TYPE = NodeB *Required* *Scope:* Global, Node	Integer or string *Range:* ≥ 0 (if channel index is used)	Index or name of the uplink channel. If a channel index is used to specify the uplink channel, then it must correspond to the index of the parameter PROPAGATION-CHANNEL-FREQUENCY. See note below table. **Note:** For FDD UMTS, the downlink and uplink channels should be different. For TDD UMTS, the downlink and uplink channels should be the same.

Note: For a Node B node, the index of the uplink and downlink channels (specified by parameters UMTS-NodeB-UPLINK-CHANNEL and UMTS-NodeB-DOWNLINK-CHANNEL, respectively) must match the indices used in the specification of channel frequencies (specified by the parameter PROPAGATION-CHANNEL-FREQUENCY).

Consider an example in which two channels are configured as follows in the scenario configuration (.config) file:

```
PROPAGATION-CHANNEL-FREQUENCY[0]      2500000000
PROPAGATION-CHANNEL-FREQUENCY[1]      2400000000
PROPAGATION-CHANNEL-NAME[0]           uplink
PROPAGATION-CHANNEL-NAME[1]           downlink
```

If a Node B node with node ID 10 is to use the 2.5 GHz frequency as its uplink channel and the 2.4 GHZ frequency as its downlink channel, then one (but not both) of the following sets of parameters should be included in the scenario configuration (.config) file:

```
[10] UMTS-NodeB-UPLINK-CHANNEL        0
[10] UMTS-NodeB-DOWNLINK-CHANNEL      1
```

or

```
[10] UMTS-NodeB-UPLINK-CHANNEL        uplink
[10] UMTS-NodeB-DOWNLINK-CHANNEL      downlink
```

2.1.4.2.1.2 UMTS Layer 2 Configuration for UE and Node B Nodes

UMTS layer 2 needs to be configured only for UE and Node B nodes.

UMTS layer 2 includes both the RLC and MAC sublayers. To enable UMTS layer 2, include the following parameters in the scenario configuration (.config) file:

```
[<Qualifier>]  MAC-PROTOCOL                  CELLULAR-MAC
[<Qualifier>]  CELLULAR-MAC-PROTOCOL         UMTS-LAYER2
```

The scope of MAC-PROTOCOL can be Global, Node, Subnet, or Interface and of CELLULAR-MAC-PROTOCOL can be Global or Node. See Section 1.2.1.1 for a description of <Qualifier> for each scope.

No other parameters are needed to configure UMTS layer 2.

2.1.4.2.1.3 UMTS Physical Layer Configuration for UE and Node B Nodes

The physical layer needs to be configured only for UE and Node B nodes.

To enable the UMTS physical layer, include the following parameters in the scenario configuration (.config) file:

```
[<Qualifier>] PHY-MODEL                 PHY-CELLULAR
[<Qualifier>] CELLULAR-PHY-MODEL        PHY-UMTS
[<Qualifier>] PHY-RX-MODEL              PHY-UMTS
```

The scope of these parameter declarations can be Global, Node, Subnet, or Interface. See Section 1.2.1.1 for a description of <Qualifier> for each scope.

Table 2-3 lists the configuration parameters for the UMTS physical layer for both Node B and UE nodes. Table 2-4 lists the additional configuration parameters for the UMTS physical layer for Node B nodes.

TABLE 2-3. UMTS Physical Layer Parameters for Node B and UE Nodes

Parameter	Value	Description
PHY-UMTS-MAX-TX-POWER *Optional* *Scope:* All	Real *Default:* 30 *Unit:* dBm	Maximum transmitter power. This is the initial transmitter power as well as the bound for the maximum transmitter power. The transmitter power can not get higher than this value even if a command is received to increase the transmit power.
PHY-UMTS-MIN-TX-POWER *Optional* *Scope:* All	Real *Default:* -30 *Unit:* dBm	Minimum transmitter power. The transmitter power can not get lower than this value even if a command is received to decrease the transmit power.
PHY-UMTS-HSDPA-CAPABLE *Optional* *Scope:* All	List: • YES • NO *Default:* NO	Specifies whether the node supports High-Speed Downlink Packet Access (HSDPA).

TABLE 2-4. Additional UMTS Physical Layer Parameters for Node B Nodes

Parameter	Value	Description
PHY-UMTS-NodeB-SCRAMBLING-CODE-SET-INDEX *Optional* *Scope:* All	Integer *Range:* [0, 511] *Default:* See note below.	Scrambling code set index assigned to a Node B node for downlink transmissions. There are a total of 8192 downlink scrambling codes available. These codes are grouped into 512 sets of 16 codes each. In each set, the first code is called the primary scrambling code and the rest are called secondary scrambling codes. The 512 code sets are further divided into 64 groups with 8 sets each. If *val* is the value of this parameter, the group index can be computed as the quotient of the integer division *val* / 8, and the index within the group can be computed as *val* mod 8. **Note:** Neighboring Node B nodes should use different scrambling code sets in order to minimize interference.

Note: The default value of PHY-UMTS-NodeB-SCRAMBLING-CODE-SET-INDEX is *node-ID* mod 512, where *node-ID* is the node ID of the Node B node.

For large networks, if the default value of PHY-UMTS-NodeB-SCRAMBLING-CODE-SET-INDEX is used, then the same scrambling code set index may get assigned to multiple Node B nodes. To guard against such a conflict, it is recommended that Node B nodes be assigned node IDs less than 512.

2.1.4.2.2 RNC Configuration

Table 2-5 lists the parameters that need to be configured for an RNC node.

TABLE 2-5. UMTS Layer 3 Parameters for RNC Nodes

Parameter	Value	Description
UMTS-RNC-SHO-AS-THRESHOLD *Dependency:* UMTS-NODE-TYPE = RNC *Optional* *Scope:* Global, Node	Real *Range:* > 0.0 *Default:* 3.0 *Unit:* dBm	Soft handoff threshold. This is the threshold for macro diversity which is used for deciding whether to add a new cell into or remove a cell from the active set of a UE. If the measured signal quality of the best cell not in the current active set is greater than the signal quality of the best cell in the active set minus (UMTS-RNC-SHO-AS-THRESHOLD + UMTS-RNC-SHO-AS-THRESHOLD-HYSTERESIS), and if the active set is not full, then that cell is added to the active set. In addition, if the signal quality of the worst cell in the active set is below that of the best cell minus (UMTS-RNC-SHO-AS-THRESHOLD + UMTS-RNC-SHO-AS-THRESHOLD-HYSTERESIS), then the worst cell is removed from the active set.
UMTS-RNC-SHO-AS-THRESHOLD-HYSTERESIS *Dependency:* UMTS-NODE-TYPE = RNC *Optional* *Scope:* Global, Node	Real *Range:* > 0.0 *Default:* 1.0 *Unit:* dBm	Hysteresis value for soft handoff threshold. See the description for UMTS-RNC-SHO-AS-THRESHOLD.
UMTS-RNC-SHO-AS-REPLACE-HYSTERESIS *Dependency:* UMTS-NODE-TYPE = RNC *Optional* *Scope:* Global, Node	Real *Range:* > 0.0 *Default:* 1.0 *Unit:* dBm	Hysteresis value for replacing cells in the active set. If the active set is full, a new cell will replace the worst one in the active set if its signal quality is greater than that of the worst one plus the value of this parameter.

2.1.4.2.3 SGSN Configuration

Table 2-6 lists the parameters that need to be configured for a SGSN node.

TABLE 2-6. UMTS Layer 3 Parameters for SGSN Nodes

Parameter	Value	Description
`UMTS-HLR-SERVER` *Dependency:* `UMTS-NODE-TYPE = GGSN` or `SGSN` *Required* *Scope:* Global, Node	Integer *Range:* `> 0`	Node ID of the HLR node of the PLMN. **Note:** It is assumed that a PLMN maintains only one HLR server.
`UMTS-PRIMARY-GGSN` *Dependency:* `UMTS-NODE-TYPE = SGSN` *Required* *Scope:* Global, Node	Integer *Range:* `> 0`	Primary GGSN for a SGSN node. This parameter must be set to the node ID of a GGSN node of the PLMN. The SGSN needs to communicate with the GGSN for PDP context-related functions. However, since the backbone network among SGSNs and GGSNs can have multiple hops, a SGSN may not have enough information about the GGSN for a specific PDP context. A SGSN can always communicate with its primary GGSN.

2.1.4.2.4 GGSN Configuration

Table 2-7 lists the parameters that need to be configured for a GGSN node.

TABLE 2-7. UMTS Layer 3 Parameters for GGSN Nodes

Parameter	Value	Description
`UMTS-HLR-SERVER` *Dependency:* `UMTS-NODE-TYPE = GGSN` or `SGSN` *Required* *Scope:* Global, Node	Integer *Range:* `> 0`	Node ID of the HLR node of the PLMN. **Note:** It is assumed that a PLMN maintains only one HLR server.

2.1.4.2.5 HLR Configuration

No additional parameters are required to configure an HLR node.

2.1.4.3 Configuring the Air Interface

An uplink channel and a downlink channel need to be defined for each SGSN control area.

Specify the listenable channels of UE and Node B nodes as follows:

- All UE nodes should be able to listen to the downlink channel.
- All Node B nodes should be able to listen to the uplink channel.

2.1.4.4 Building the Backbone Network

The Node B, RNC, SGSN, HLR, and GGSN nodes in a scenario should be connected as follows:

- There should be a single-hop connection (point-to-point wired link or a hub) between a Node B node and a RNC node and between a RNC node and a SGSN node.
- The HLR, SGSN, and GGSN nodes should form a connected network, i.e., they should be able to exchange packets with each other. The connection between any two of these nodes can be a single-hop connection or a multi-hop network connection.

2.1.4.5 Configuring Related Parameters

Several other parameters need to be specified to configure a UMTS scenario (refer to *QualNet User's Guide*). For a UMTS scenario, the following parameters should set as described below:

- `PROPAGATION-CHANNEL-FREQUENCY`

  This parameter is used to create wireless channels. The UMTS models implements WCDMA FDD. Thus, two wireless channels should be created for a UMTS scenario, one for the uplink channel and one for the downlink channel. If the scenario has other wireless networks, additional channels may be needed.

- `PROPAGATION-LIMIT`

  This parameter controls the precision of the wireless signal propagation. To optimize runtime performance of wireless propagation, if the effective power of a transmitted signal at a receiving node is below `PROPAGATION-LIMIT`, that signal is considered as not received by the node. The default value of this parameter is based on normal wireless networks, such as 802.11 networks. However, the default value may not be suitable for a UMTS radio network. This is because UMTS PHY is based on CDMA and a CDMA radio spreads the useful signal in a narrow band to a wide band resulting in a small signal power. In extreme cases, it may even able to hide the desired signal among the background noise. In order to properly propagate weak signals, this parameter should be set to a small value for the wireless channels used by UMTS radios.

  We recommend to set the propagation limit to -150 dBm for channels used by the UMTS radio access network.

- `PHY-LISTENABLE-CHANNELS`

  This parameter specifies the wireless channels that a node can potentially listen to during the simulation. This parameter is configured for UE and Node B nodes and should be set such that UE nodes can listen to the downlink channel and Node B nodes can listen to the uplink channel.

- `ROUTING-PROTOCOL`

  A routing protocol should be configured for the UMTS Core Network (CN) which consists of SGSN, GGSN, and HLR nodes.

  When connecting the UMTS network to an IP-based Packet Data Network (PDN), configuring routing protocols to allow proper packet forwarding from the PDN to the PLMN is critical. For data packets addressed to destinations in the UMTS PLMN, the IP routers in the PDN should route those packets towards the GGSN node of that PLMN. This information can be configured statistically via static routing or by using a default gateway, or can be built up dynamically by routing protocols. See Appendix A for more information.

- `DEFAULT-GATEWAY`

  This parameter configures a default gateway for a node. When there is no routing information available to forward a packet, that packet is forwarded to the default gateway. This parameter can be used to direct packets from PDNs to the GGSN node of the destination PLMN. See Appendix A for more information.

2.1.5 GUI Configuration

The QualNet GUI provides preconfigured device types for the different UMTS nodes. For these device types, the network, layer 2, and physical layer parameters are set to their default values. (The parameters can be assigned values other than the default values, as described in Section 2.1.5.3)

The preconfigured UMTS device types can be selected from the UMTS Devices toolbar (see Figure 2-3). These device types are: UMTS-UE, UMTS-NodeB, UMTS-RNC, UMTS-SGSN, UMTS-HLR, and UMTS-GGSN.

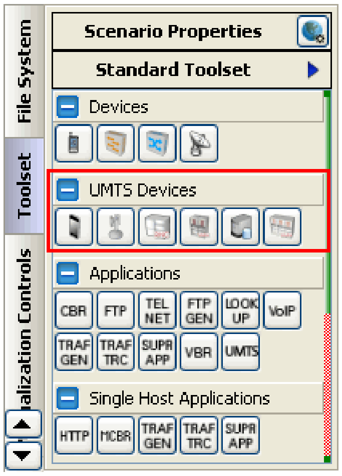

FIGURE 2-3. UMTS Devices Toolbar

Figure 2-4 shows the icons placed on the canvas for the different UMTS devices.

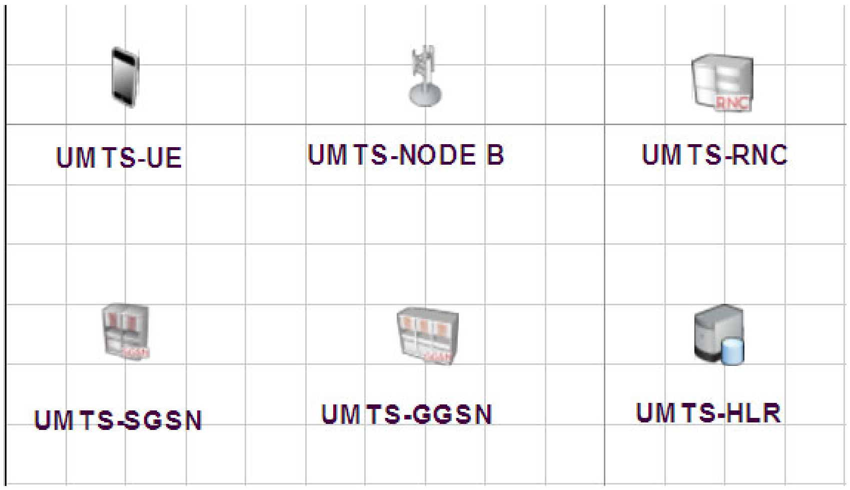

FIGURE 2-4. Canvas Icons for UMTS Devices

Configuring a UMTS scenario in the GUI requires the following steps:

- Configuring the air interface (see Section 2.1.5.1).
- Configuring the backbone network (see Section 2.1.5.2).
- Configuring the UMTS nodes (see Section 2.1.5.3).
- Enabling statistics collection (see Section 2.1.5.4).
- Setting up traffic between nodes. See Chapter 3 for details of configuring traffic generators for a UMTS scenario.

2.1.5.1 Configuring the Air Interface

Configuring the air interface between the UEs and Node Bs consists of the following steps:

- Configuring channels
- Creating wireless interfaces
- Configuring UMTS Layer 2 and Physical Layer Properties

2.1.5.1.1 Configuring Channels

An uplink channel and a downlink channel need to be defined for each SGSN control area. To configure channels, do the following:

1. Go to **Scenario Properties Editor > Channel Properties**.
2. Set **Number of Channels** to the desired value as shown in Figure 2-5.

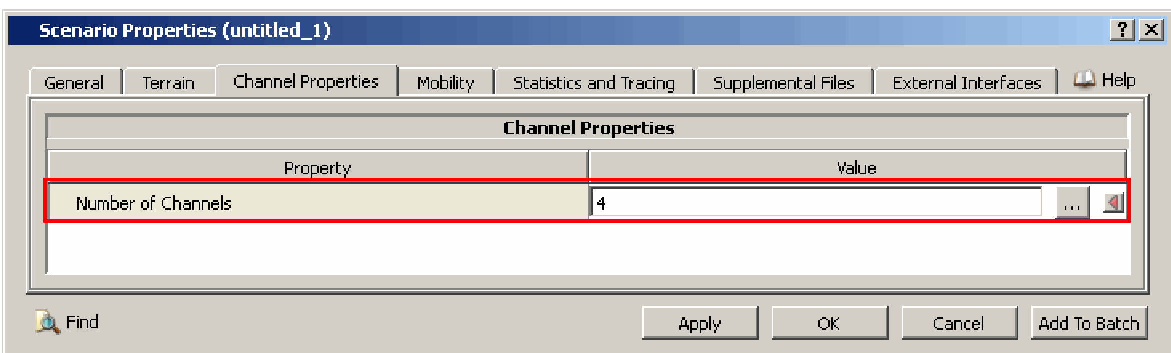

FIGURE 2-5. Setting Number of Channels

3. Click on the **Open Array Editor**  button in the **Value** column. This opens the Array Editor.

4. In the left panel of the Array Editor, select the index of the channel to be configured. In the right panel, set the parameters listed in Table 2-8.

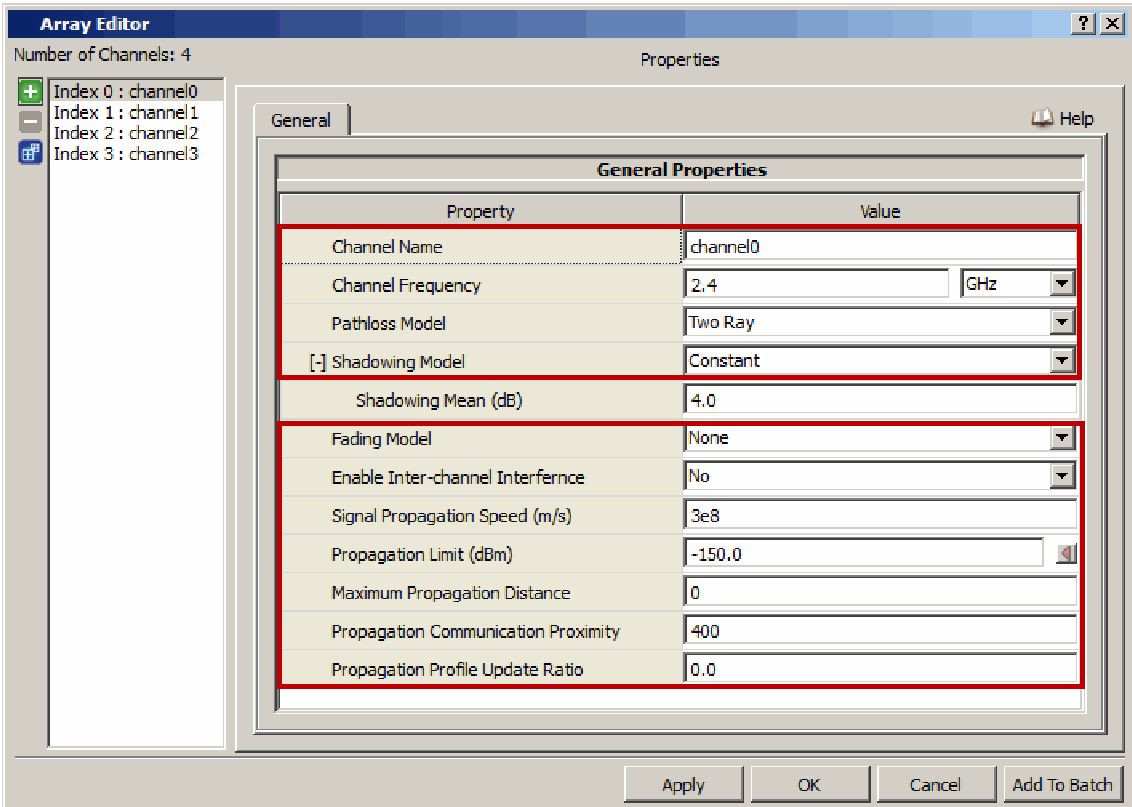

FIGURE 2-6. Configuring Channel Properties

TABLE 2-8. Command Line Equivalent of Channel Parameters

GUI Parameter	Scope of GUI Parameter	Command Line Parameter
Channel Name	Global	PROPAGATION-CHANNEL-NAME
Channel Frequency	Global	PROPAGATION-CHANNEL-FREQUENCY
Pathloss Model	Global	PROPAGATION-PATHLOSS-MODEL
Shadowing Model	Global	PROPAGATION-SHADOWING-MODEL
Fading Model	Global	PROPAGATION-FADING-MODEL
Propagation Limit	Global	PROPAGATION-LIMIT
Maximum Propagation Distance	Global	PROPAGATION-MAX-DISTANCE
Propagation Communication Proximity	Global	PROPAGATION-COMMUNICATION-PROXIMITY
Propagation Profile Update Ratio	Global	PROPAGATION-PROFILE-UPDATE-RATIO

Setting Parameters

- Refer to *Wireless Model Library* for configuring the channel parameters.

- The default value for the parameter *Propagation limit* (-110.0 dB) is too large for the UMTS air interface. This parameter should be set to a lower value (e.g., -150.0 dB).

2.1.5.1.2 Creating Wireless Interfaces

To create the wireless interfaces between UEs and Node Bs, do the following:

1. Place one or more wireless subnet icons on the canvas. Place UE and Node B nodes on the canvas.
2. Connect the UE and Node B nodes to the appropriate wireless subnet.
3. Specify the listenable and listening channels for each interface. The list of listenable channels for all UE nodes should include the downlink channel. The list of listenable channels for all NodeB nodes should include the uplink channel.

   Since, typically, there are many more UEs in a scenario than Node Bs, it may be convenient to configure the listenable and listening channels for UEs by configuring the channels for the wireless subnet that the UEs are connected to, and configure the channels for Node Bs at the individual interfaces.

   To configure the listenable and listening channels for a wireless subnet, go to **Wireless Subnet Properties Editor > Physical Layer**, and include the downlink channel in **Listenable Channels** and **Listening Channels**.

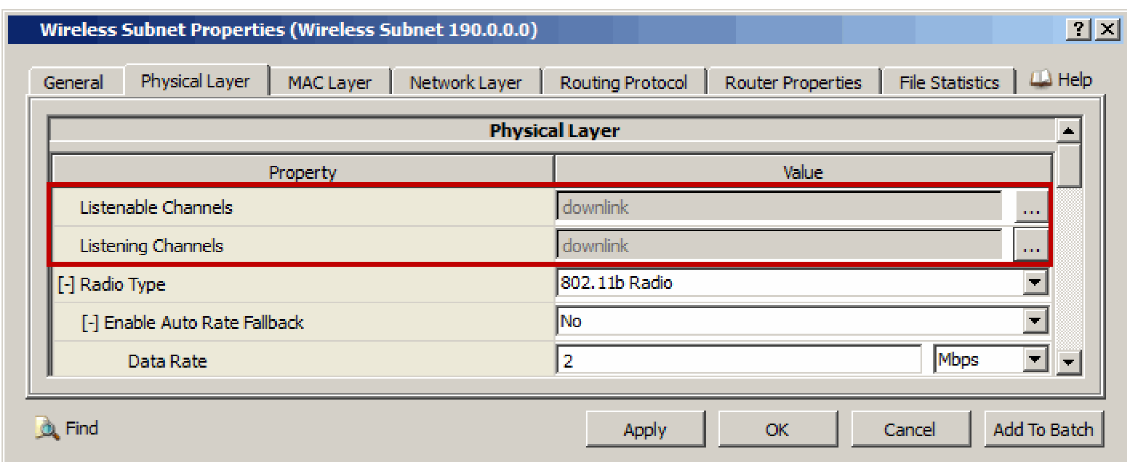

FIGURE 2-7. Setting Listenable Channels for UEs

4. To specify listenable and listening channels for Node B nodes, see Section 2.1.4.2.1.

2.1.5.1.3 Configuring UMTS Layer 2 and Physical Layer Properties

Since UMTS layer 2 and physical layer parameters are set to the same values for all UEs and Node Bs in a SGSN control area, it is most convenient to configure these parameters for the wireless subnet connecting the UEs and Node Bs.

Layer 2 Configuration

To configure the UMTS layer 2 parameters, perform the following steps:

1. Go to **Wireless Subnet Properties Editor > MAC Layer**.
2. Set **MAC Protocol** *[= Cellular MAC]* **> Cellular MAC Protocol** to *UMTS Layer 2* as shown in Figure 2-8).

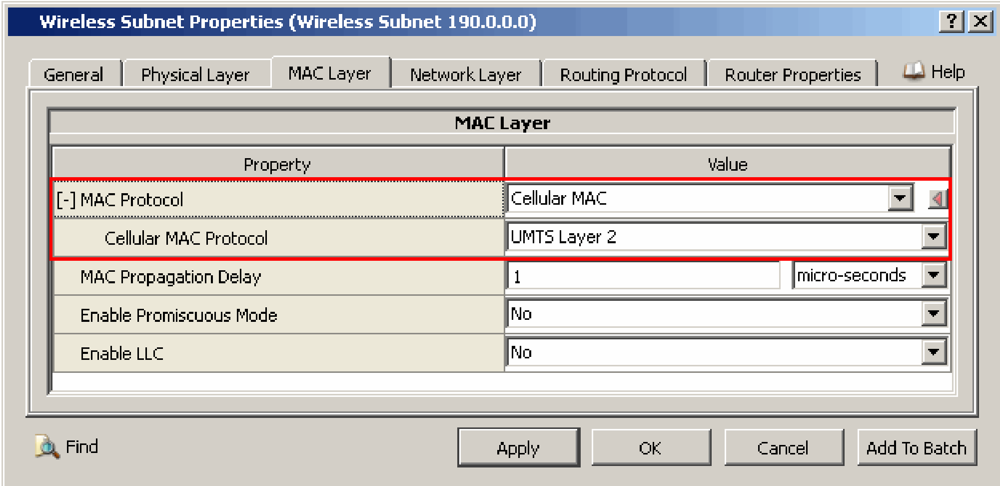

FIGURE 2-8. Specifying UMTS MAC Protocol

Physical Layer Configuration

To configure physical layer parameters, perform the following steps:

1. Go to **Wireless Subnet Properties Editor > Physical Layer**.
2. Set **Radio Type** *[= Cellular PHY]* **> Cellular PHY Model** to *UMTS PHY Model* and set the dependent parameters listed in Table 2-9.

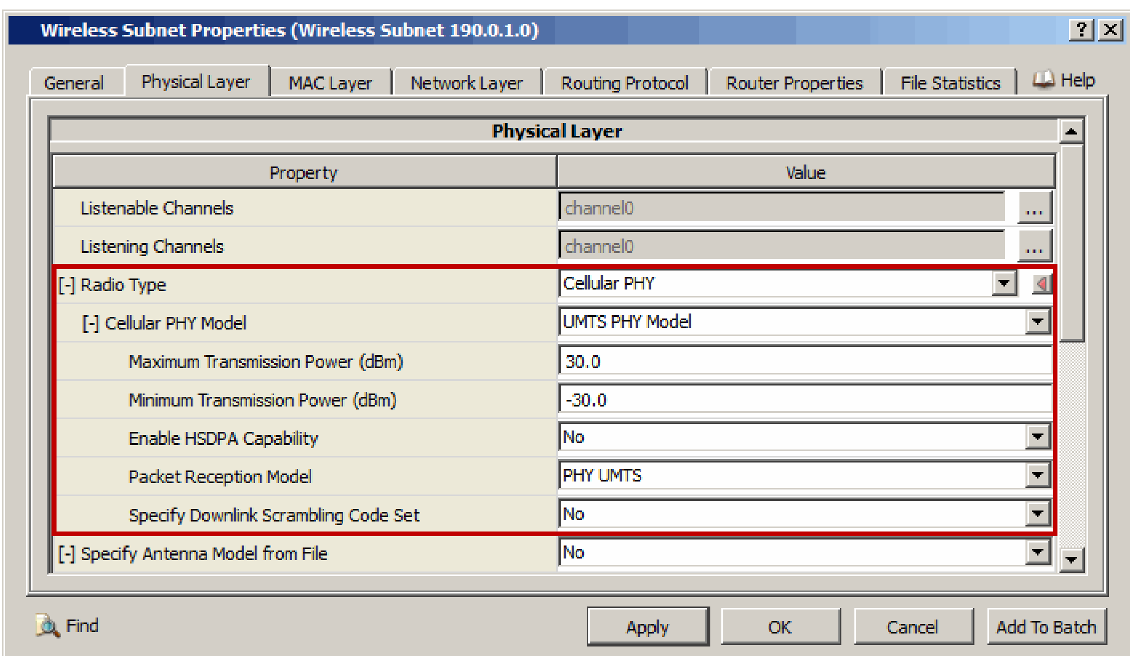

FIGURE 2-9. Specifying UMTS PHY Protocol

TABLE 2-9. Command Line Equivalent of UMTS Physical Layer Parameters

GUI Parameter	Scope of GUI Parameter	Command Line Parameter
Maximum Transmission Power	Subnet, Interface	`PHY-UMTS-MAX-TX-Power`
Minimum Transmission Power	Subnet, Interface	`PHY-UMTS-MIN-TX-Power`
Enable HSDPA Capability	Subnet, Interface	`PHY-UMTS-HSDPA-CAPABLE`
Packet Reception Model	Subnet, Interface	`PHY-RX-MODEL`
Specify Downlink Scrambling Code Set	Subnet, Interface	`N/A`

Setting Parameters

- To enable HSDPA capability, set **Enable HSDPA Capability** to *Yes*; otherwise, set **Enable HSDPA Capability** to *No*.
- To enable Downlink Scrambling Code Set, set **Specify Downlink Scrambling Code Set** to *Yes*; otherwise set **Specify Downlink Scrambling Code Set** to *No*. This parameter has to be specified for Node B. To enable downlink scrambling code set for Node B, see Section 2.1.5.3.2.

2.1.5.2 Configuring the Backbone Network

The Node B, RNC, SGSN, HLR, and GGSN nodes in a scenario should be connected as follows:

- There should be a single-hop connection (point-to-point wired link or a hub) between a Node B node and a RNC node and between a RNC node and a SGSN node.
- The HLR, SGSN, and GGSN nodes should form a connected network, i.e., they should be able to exchange packets with each other. The connection between any two of these nodes can be a single-hop connection or a multi-hop network connection.

Even though UMTS layer 3 is enabled for all preconfigured UMTS devices, UMTS layer 3 should be explicitly enabled at all UMTS interfaces. This is because the network protocol for point-to-point links and subnets is configured to be IPv4 by default, and these settings take precedence over the node-level settings.

- If two UMTS nodes (Node B, RNC, SGSN, HLR, or GGSN) are directly connected via a point-to-point link or a hub, then enable UMTS layer 3 for the link or subnet. For example, to enable UMTS layer 3 for a point-to-point link, perform the following steps:

  1. Go to **Interface Properties Editor > Interfaces > Interface # > Network Layer**.
  2. Set **Network Protocol** *[= Cellular Layer3]* **> Cellular Layer3 Protocol** to *UMTS Layer 3* as shown in Figure 2-10.

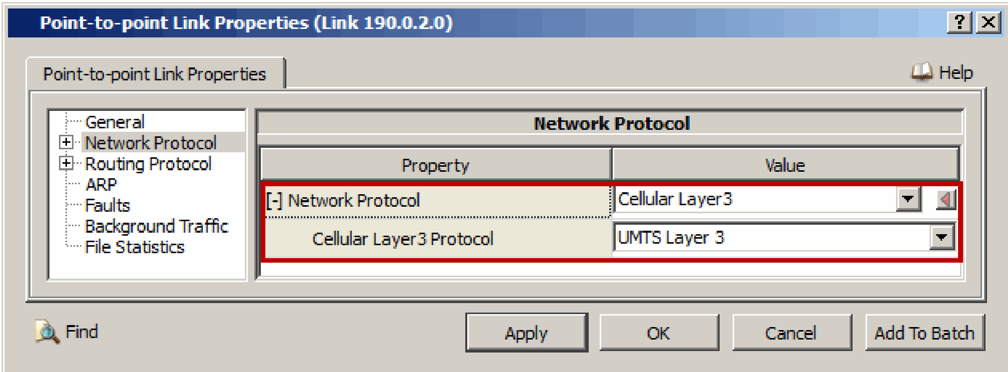

FIGURE 2-10. Enabling UMTS Layer 3 for Point-to-point Link

- If two UMTS nodes (SGSN, HLR, or GGSN) are connected via a network of IP nodes, then configure the network layer at the interfaces. For the UMTS node, enable UMTS layer 3 at the interface to the IP node. For the IP node, configure network layer to be IPv4 or IPv6, as the case may be.

2.1.5.3 Configuring UMTS Nodes

Preconfigured device types for the different types of UMTS nodes are available from the Devices tab. The parameters for each node type are set to their default values. This section describes how to change the values of the parameters from their default values.

UMTS Node Type can be one of UMTS device Types, viz. UE, NodeB, RNC, SGSN, GGSN or HLR.

2.1.5.3.1 UE Configuration

To configure UMTS layer 3 parameters for a UE in the Scenario Designer, perform the following steps:

1. Go to **Default Device Properties Editor > Node Configuration > Network Layer**.
2. Set **Network Protocol** *[= Cellular Layer3]* **> Cellular Layer3 Protocol** *[= UMTS Layer 3]* **> UMTS Node Type** to UE and set the dependent parameters listed in Table 2-10.

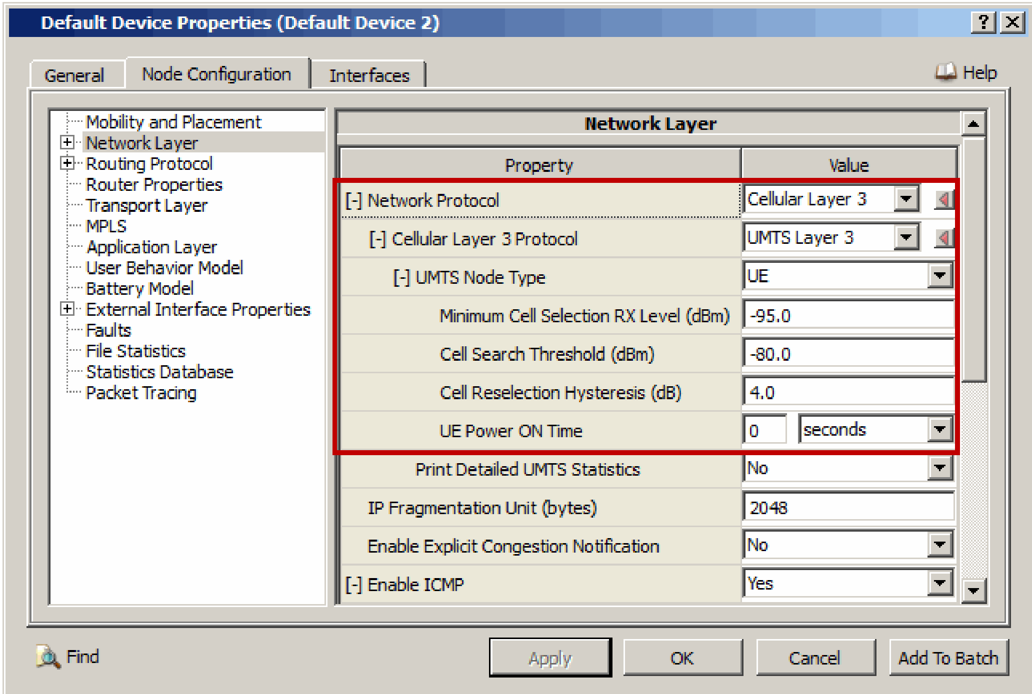

FIGURE 2-11. Configuring UE Layer 3 Parameters

TABLE 2-10. Command Line Equivalent of UE Layer 3 Parameters

GUI Parameter	Scope of GUI Parameter	Command Line Parameter
Minimum Cell Selection RX Level	Node	`UMTS-CELL-SELECTION-MIN-RX-LEVEL`
Cell Search Threshold	Node	`UMTS-CELL-SEARCH-THRESHOLD`
Cell Reselection Hysteresis	Node	`UMTS-CELL-RESELECTION-HYSTERESIS`
UE Power ON Time	Node	`UMTS-UE-POWER-ON-TIME`

Note: UMTS layer 2 and physical layer properties for UEs should be configured at the subnet level (see Section 2.1.5.1.3).

2.1.5.3.2 Node B Configuration

To configure UMTS layer 3 parameters for a Node B, perform the following steps:

1. Go to **Default Device Properties Editor > Node Configuration > Network Layer**.
2. Set **Network Protocol** *[= Cellular Layer3]* **> Cellular Layer3 Protocol** *[= UMTS Layer 3]* **> UMTS Node Type** to *NodeB* and set the dependent parameters listed in Table 2-11.

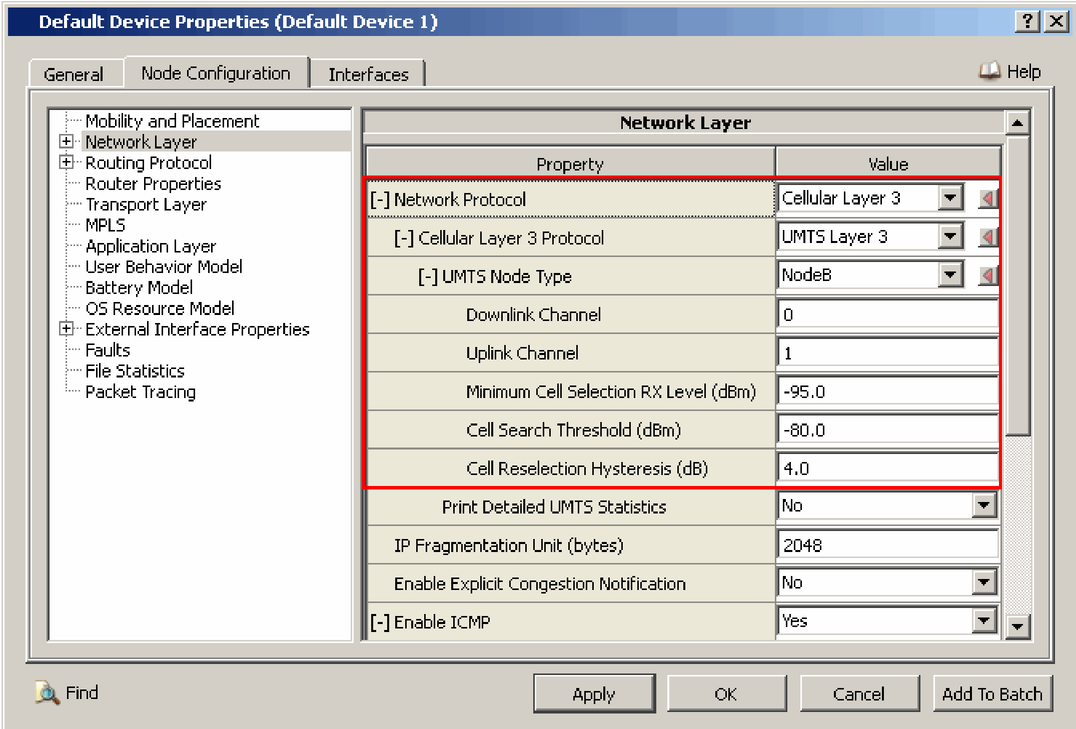

FIGURE 2-12. Configuring Node B Layer 3 Parameters

TABLE 2-11. Command Line Equivalent of Node B Layer 3 Parameters

GUI Parameter	Scope of GUI Parameter	Command Line Parameter
Downlink Channel	Node	`UMTS-NodeB-DOWNLINK-CHANNEL`
Uplink Channel	Node	`UMTS-NodeB-UPLINK-CHANNEL`
Minimum Cell Selection RX Level	Node	`UMTS-CELL-SELECTION-MIN-RX-LEVEL`
Cell Search Threshold	Node	`UMTS-CELL-SEARCH-THRESHOLD`
Cell Reselection Hysteresis	Node	`UMTS-CELL-RESELECTION-HYSTERESIS`

3. To configure the downlink scrambling code set for Node B, go to one of the following locations:
    - **Interface Properties Editor > Interfaces > Interface # > Physical Layer**.
    - **Default Device Properties Editor > Interfaces > Interface # > Physical Layer**.

    Set **Radio Type** *[= Cellular PHY]* **> Cellular PHY Model** *[= UMTS PHY Model]* **> Specify Downlink Scrambling Code Set** to *Yes* and set the dependent parameters listed in Table 2-12.

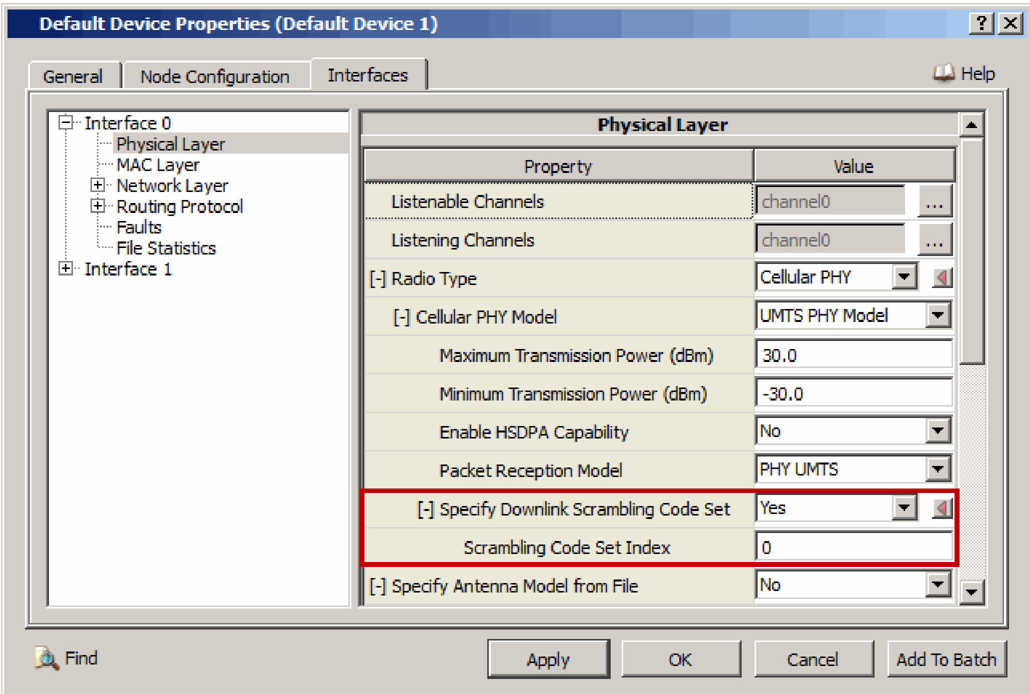

FIGURE 2-13. Setting Scrambling Code Set Index for a Node B

TABLE 2-12. Command Line Equivalent of Scrambling Code Set Index Parameters

GUI Parameter	Scope of GUI Parameter	Command Line Parameter
Scrambling Code Set Index	Subnet, Interface	`PHY-UMTS-NodeB-SCRAMBLING-CODE-SET-INDEX`

4. To specify the listenable and listening channels for Node B, go to one of the following locations:
    - **Interface Properties Editor > Interfaces > Interface # > Physical Layer**.
    - **Default Device Properties Editor > Interfaces > Interface # > Physical Layer**.

Set **Listenable Channels** and **Listening Channels** appropriately so that the uplink channel is included in the list of listenable and listening channels.

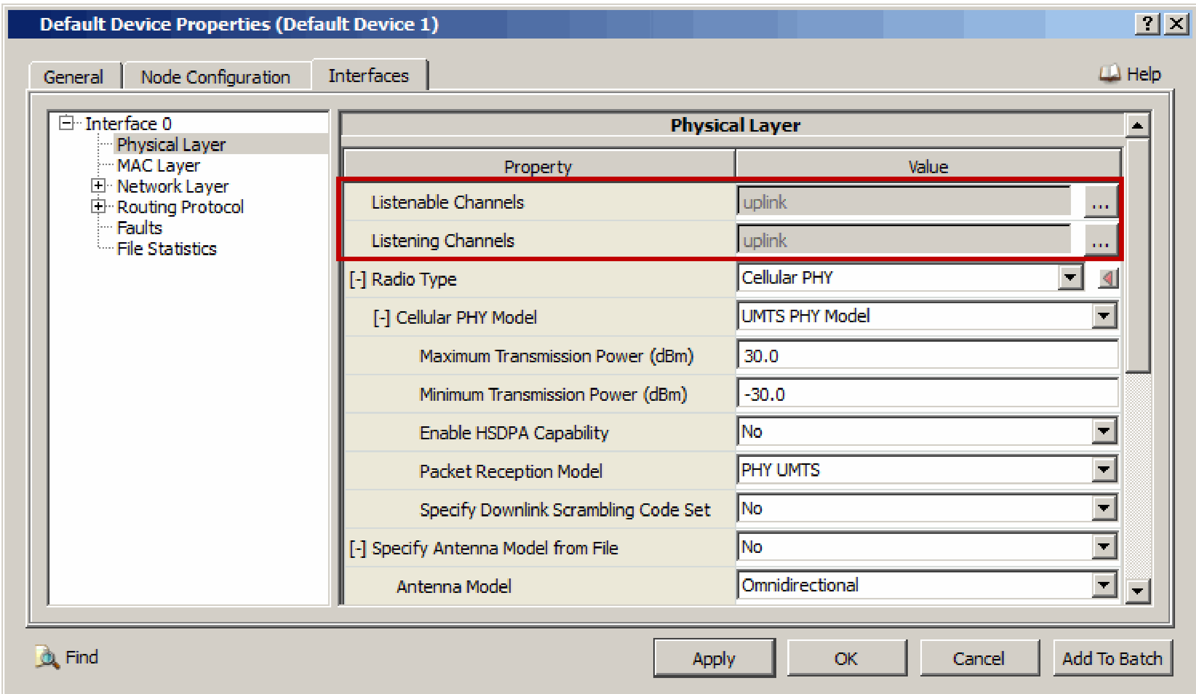

FIGURE 2-14. Setting Listenable and Listening Channels for Node B

2.1.5.3.3 RNC Configuration

To configure UMTS layer 3 parameters for a RNC in the Scenario Designer, perform the following steps:

1. Go to **Default Device Properties Editor > Node Configuration > Network Layer**.
2. Set **Network Protocol** *[= Cellular Layer3]* **> Cellular Layer3 Protocol** *[= UMTS Layer 3]* **> UMTS Node Type** to *RNC* and set the dependent parameters listed in Table 2-13.

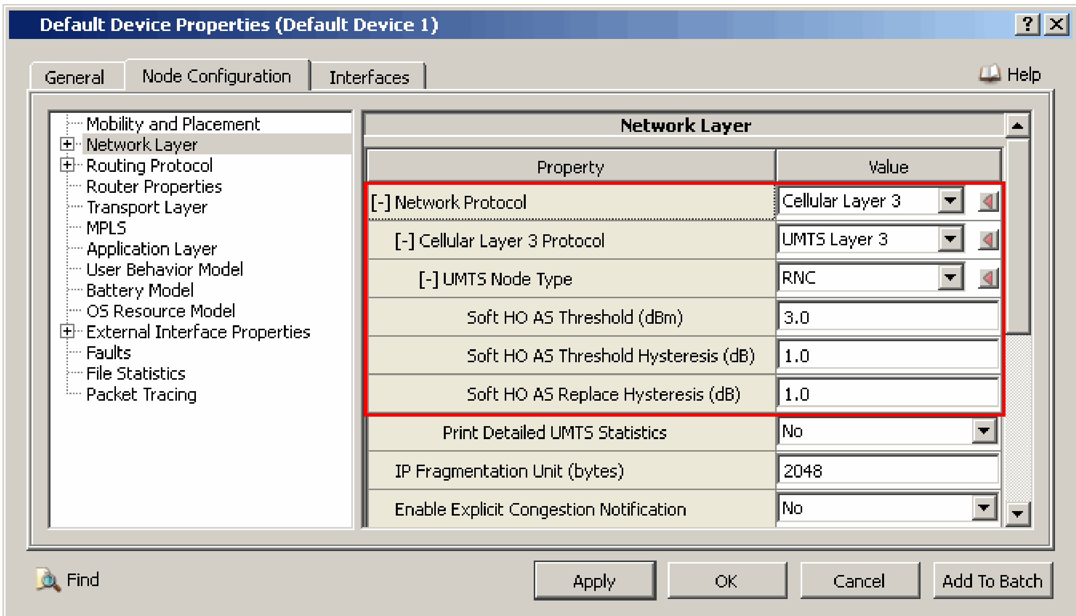

FIGURE 2-15. Configuring RNC Parameters

TABLE 2-13. Command Line Equivalent of RNC Parameters

GUI Parameter	Scope of GUI Parameter	Command Line Parameter
Soft HO AS Threshold	Node	`UMTS-RNC-SHO-AS-THRESHOLD`
Soft HO AS Threshold Hysteresis	Node	`UMTS-RNC-SHO-AS-THRESHOLD-HYSTERESIS`
Soft HO AS Replace Hysteresis	Node	`UMTS-RNC-SHO-AS-REPLACE-HYSTERESIS`

2.1.5.3.4 SGSN Configuration

To configure UMTS layer 3 parameters for a SGSN in the Scenario Designer, perform the following steps:

1. Go to **Default Device Properties Editor > Node Configuration > Network Layer**.
2. Set **Network Protocol** *[= Cellular Layer3]* **> Cellular Layer3 Protocol** *[= UMTS Layer 3]* **> UMTS Node Type** to *SGSN* and set the dependent parameters listed in Table 2-14.

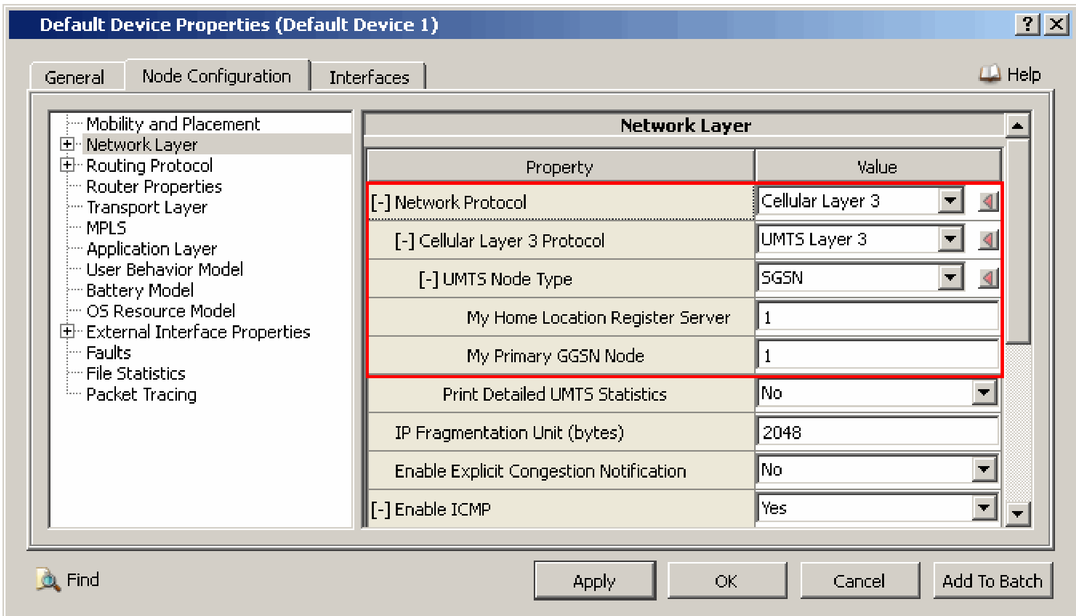

FIGURE 2-16. Configuring SGSN Parameters

TABLE 2-14. Command Line Equivalent of SGSN Parameters

GUI Parameter	Scope of GUI Parameter	Command Line Parameter
My Home Location Register Server	Node	`UMTS-HLR-SERVER`
My Primary GGSN Node	Node	`UMTS-PRIMARY-GGSN`

2.1.5.3.5 GGSN Configuration

To configure UMTS layer 3 parameters for a GGSN in the Scenario Designer, perform the following:

1. Go to **Default Device Properties Editor > Node Configuration > Network Layer**.
2. Set **Network Protocol** *[= Cellular Layer3]* **> Cellular Layer3 Protocol** *[= UMTS Layer 3]* **> UMTS Node Type** to *GGSN* and set the dependent parameters listed in Table 2-15.

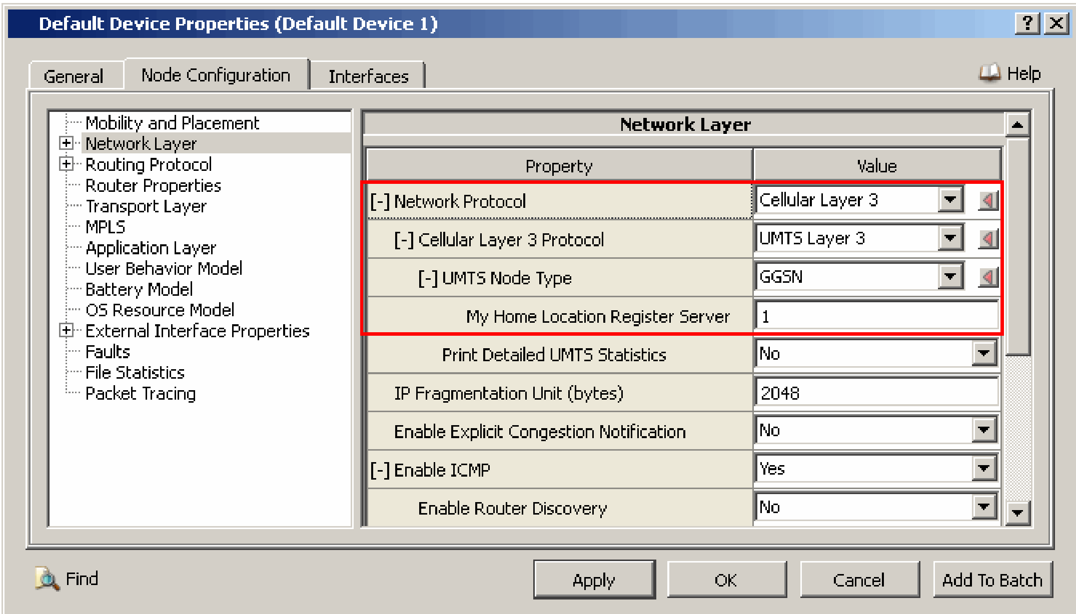

FIGURE 2-17. Configuring GGSN Parameters

TABLE 2-15. Command Line Equivalent of GGSN Parameters

GUI Parameter	Scope of GUI Parameter	Command Line Parameter
My Home Location Register Server	Node	`UMTS-HLR-SERVER`

2.1.5.3.6 HLR Configuration

To configure UMTS layer 3 parameters for a HLR in the Scenario Designer, perform the following steps:

1. Go to **Default Device Properties Editor > Node Configuration > Network Layer**.
2. Set **Network Protocol** *[= Cellular Layer3]* **> Cellular Layer3 Protocol** *[= UMTS Layer 3]* **> UMTS Node Type** to *HLR*.

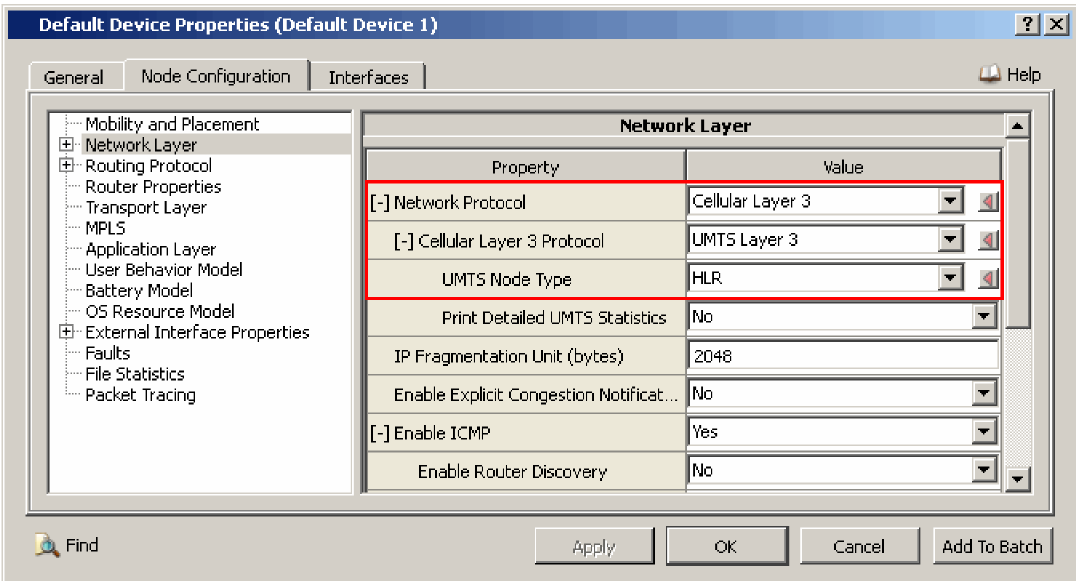

FIGURE 2-18. Configuring HLR

No additional parameters are required to be configured for an HLR node.

2.1.5.4 Enabling Statistics Collection

To enable statistics collection for a UMTS scenario, perform the following steps:

1. To enable collection of basic UMTS statistics, do one of the following:
   - To collect statistics at the global level, go to **Scenario Properties Editor > Statistics and Tracing > File Statistics**, and enable *Cellular*.
   - To collect statistics at the node level, go to **Default Device Properties Editor > Node Configuration > File Statistics**, and enable *Cellular*.

   This parameter enables statistics for all cellular protocols, including UMTS. If statistics collection is enabled, statistics are collected for UMTS layer 3, UMTS layer 2, and UMTS physical layer.
2. Collection of detailed UMTS layer 3 statistics can be enabled for each UMTS node. For example, to enable detailed statistics collection for a UE node, go to **Default Device Properties Editor > Node Configuration > Network Layer** and set **Network Protocol** *[= Cellular Layer3]* **> Cellular Layer3 Protocol** *[= UMTS Layer 3]* **> Print Detailed UMTS Statistics** to *Yes* as shown in Figure 2-19.

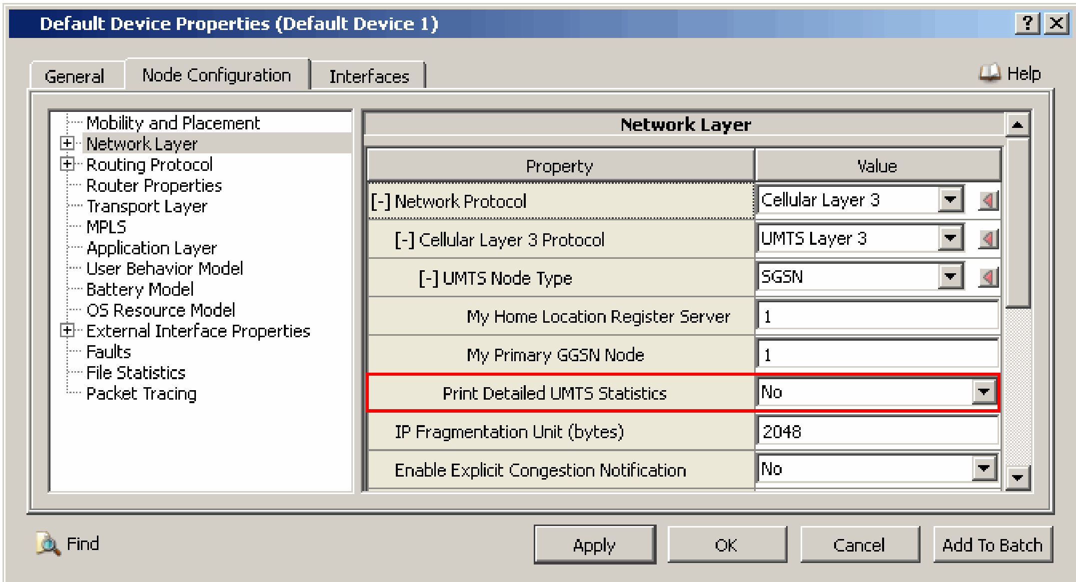

FIGURE 2-19. Enabling Detailed Layer 3 Statistics

2.1.6 Statistics

This section describes the file and dynamic statistics of the UMTS model.

2.1.6.1 File Statistics

This section lists the statistics collected for UMTS layer 3. Section 2.1.6.1 describes the statistics that are printed to the statistics (.stat) file at the end of simulation. Section 2.1.6.2 describes the dynamic statistics that can be displayed in the GUI during the simulation.

2.1.6.1.1 Physical Layer Statistics

Table 2-16 lists the UMTS physical layer statistics. (UMTS physical layer statistics are collected only for Node B and UE nodes.)

TABLE 2-16. UMTS Physical Layer Statistics for Node B and UE Nodes

Statistic	Description
Signals transmitted	Number of WCDMA signals transmitted.
Signals received and forwarded to MAC	Number of WCDMA signals received correctly and forwarded to upper layer.
Signals locked on by PHY	Number of WCDMA signals the radio has synchronized with and locked on for reception.
Signals received but with errors	Number of WCDMA signals with errors that the radio has received.
CDMA bursts received and forwarded to MAC	Number of WCDMA bursts received successfully and forwarded to upper layer.
CDMA bursts received but with errors	Number of WCDMA bursts received with errors.
Energy consumption (in mWhr)	Energy consumed by this radio (in mWhr).

2.1.6.1.2 Layer 2 Statistics

Table 2-17 lists the UMTS layer 2 statistics. (UMTS layer 2 statistics are collected only for Node B and UE nodes.)

In Table 2-17, SDU stands for Service Data Unit and PDU stands for Protocol Data Unit. A SDU is a data packet exchanged with the upper layer/sublayer to which this layer/sublayer provides service. A PDU is a data unit exchanged between this layer/sublayer and the lower layer/sublayer.

TABLE 2-17. UMTS Layer 2 Statistics for Node B and UE Nodes

Statistic	Description
Number of SDUs received from upper layer	Number of SDUs the RLC sublayer received from the upper layer.
Number of SDUs sent to upper layer	Number of SDUs the RLC sublayer passed to the upper layer.
Number of SDUs discarded	Number of SDUs dropped by RLC sublayer.
Number of data PDUs sent to MAC sublayer	Number of data PDUs the RLC sublayer passed to the MAC sublayer.
Number of data PDUs received from MAC sublayer	Number of data PDUs the RLC sublayer received from the MAC sublayer.
Number of AM STATUS PDUs sent to MAC sublayer	Number of STATUS control PDUs sent to the MAC sublayer for AM mode.
Number of AM STATUS PDUs received from MAC sublayer	Number of STATUS control PDUs received from the MAC sublayer for AM mode.
Number of AM RESET PDUs sent to MAC sublayer	Number of RESET control PDUs sent to the MAC sublayer for AM mode.
Number of AM RESET PDUs received from MAC sublayer	Number of RESET control PDUs received from the MAC sublayer for AM mode.
Number of AM RESET ACK PDUs sent to MAC sublayer	Number of RESET ACK PDUs sent to the MAC sublayer for AM mode.
Number of AM RESET ACK PDUs received from MAC sublayer	Number of RESET ACK PDUs received from the MAC sublayer for AM mode.

2.1.6.1.3 Layer 3 Statistics

This section describes the UMTS layer 3 statistics collected for each UMTS node type.

UE Statistics

Table 2-18 lists the basic UMTS layer 3 statistics for a UE node. (These statistics are printed if the parameter `CELLULAR-STATISTICS` is set to `YES`.)

TABLE 2-18. Basic UMTS Layer 3 Statistics for a UE Node

Statistic	Description
Number of cell search performed	Number of cell searches that the UE has performed in order to enter the UMTS network.
Number of initial cell selections	Number of initial cell selections that the UE has performed to select the best cell to camp on.
Number of cell reselections	When a UE is in idle mode and moves, it may reselect a better cell to camp on. This statistic indicates the number of cell reselections that this UE has performed.

TABLE 2-18. Basic UMTS Layer 3 Statistics for a UE Node (Continued)

Statistic	Description
Number of PAGING messages received	Number of PAGING messages that the UE has received from the core network.
Number of ROUTING AREA UPDATE REQUEST messages sent	Number of ROUTING AREA UPDATE messages the UE has sent to the core network.
Number of ROUTING AREA UPDATE ACCEPT messages received	Number of ROUTING AREA UPDATE ACCEPT messages that the UE has received from the core network.
Number of ROUTING AREA UPDATE REJECT messages received	Number of ROUTING AREA UPDATE REJECT messages that the UE has received from the core network.
Number of ATTACH REQUEST messages sent	Number of GPRS ATTACH REQUEST messages that the UE has sent to the core network.
Number of ATTACH ACCEPT messages received	Number of GRPS ATTACH ACCEPT messages that the UE has received from the core network.
Number of ATTACH REJECT messages received	Number of GPRS ATTACH REJECT messages that the UE has received from the core network.
Number of ATTACH COMPLETE messages sent	Number of GPRS ATTACH COMPLETE messages that the UE has sent to the core network.
Number of SERVICE REQUEST messages sent	Number of SERVICE REQUEST messages that the UE has sent to the core network.
Number of SERVICE ACCEPT messages received	Number of SERVICE ACCEPT messages that the UE has received from the core network.
Number of MEASUREMENT COMMAND messages received	Number of MEASUREMENT COMMAND messages that the UE has received form core network.
Number of MEASUREMENT REPORT messages sent	Number of MEASUREMENT REPORT messages that the UE has sent to the core network.
Number of CPICH MEASUREMENT reports received from PHY	Number of CPICH MEASUREMENT reports that the layer 3 has received from physical layer at a UE.
Number of ACTIVE SET UPDATE messages received	Number of ACTIVE SET UPDATE messages that the UE has received from core network. This statistic reflects soft handover of the UE.
Number of ACTIVE SET UPDATE COMPLETE messages sent	Number of ACTIVE SET UPDATE COMPLETE messages that the UE has sent to the core network. This statistic reflects soft handover of the UE.
Number of PS domain data packets received from upper layer	Number of packet service domain data packets that layer 3 has received from the upper layer.
Number of PS domain data packets sent to lower layer	Number of packet service domain data packets that layer 3 has sent to the lower layer.
Number of PS domain data packet dropped	Number of packet service domain data packets dropped at layer 3.
Number of PS domain data packets received from lower layer	Number of packet service domain data packets that layer 3 has received from the lower layer.
Number of packets (data & ctrl) received from lower layer	Number of control and data packets that layer 3 received from the lower layer.
Number of mobile terminated flows requested	Number of mobile terminated flows requested for service.
Number of mobile terminated flows admitted	Number of mobile terminated flows successfully admitted for service.
Number of mobile terminated flows rejected	Number of mobile terminated flows rejected due to various reasons, such as lack of resources.

TABLE 2-18. Basic UMTS Layer 3 Statistics for a UE Node (Continued)

Statistic	Description
Number of mobile terminated flows dropped	Number of mobile terminated flows admitted, but dropped in the middle of service.
Number of mobile terminated flows completed	Number of mobile terminated flows completed successfully.
Number of mobile originated flows requested	Number of mobile originated flows requested for service.
Number of mobile originated flows admitted	Number of mobile originated flows successfully admitted for service.
Number of mobile originated flows rejected	Number of mobile originated flows rejected due to various reasons, such as lack of resources.
Number of mobile originated flows dropped	Number of mobile originated flows admitted, but dropped in the middle of service.
Number of mobile originated flows completed	Number of mobile originated flows completed successfully.

Table 2-19 lists the detailed UMTS layer 3 statistics for a UE node. (These statistics are printed if the parameter `UMTS-PRINT-DETAILED-STATISTICS` is set to `YES`.)

TABLE 2-19. Detailed UMTS Layer 3 Statistics for a UE Node

Statistic	Description
Number of Master System Information messages received	Number of Master System Information messages that the UE has received.
Number of System Information Type 1 messages received	Number of System Information Type 1 messages that the UE has received.
Number of System Information Type 2 messages received	Number of System Information Type 2 messages that the UE has received.
Number of System Information Type 3 messages received	Number of System Information Type 3 messages that the UE has received.
Number of System Information Type 5 messages received	Number of System Information Type 5 messages that the UE has received.
Number of RRC CONN REQUEST messages sent	Number of RRC CONNECTION REQUEST messages that the UE has sent.
Number of RRC CONN SETUP messages received	Number of RRC CONNECTION SETUP messages that the UE has received.
Number of RRC CONN SETUP COMPLETE messages sent	Number of RRC CONNECTION SETUP COMPLETE messages that the UE has sent.
Number of RRC CONN SETUP REJECT messages received	Number of RRC CONNECTION SETUP REJECT messages that the UE has received.
Number of RRC CONN RELEASE messages received	Number of RRC CONNECTION RELEASE messages that the UE has received.
Number of RRC CONN RELEASE COMPLETE messages sent	Number of RRC CONNECTION RELEASE COMPLETE messages that the UE has sent.
Number of DL Direct Transfer messages received	Number of DL Direct Transfer messages that the UE has received.
Number of RADIO BEARER SETUP messages received	Number of RADIO BEARER SETUP messages that the UE has received.
Number of RADIO BEARER RELEASE messages received	Number of RADIO BEARER RELEASE messages that the UE has received.

TABLE 2-19. Detailed UMTS Layer 3 Statistics for a UE Node (Continued)

Statistic	Description
Number of SIGNALLING CONN RELEASE messages received	Number of SIGNALLING CONNECTION RELEASE messages that the UE has received.
Number of SIGNALLING CONN RELEASE INDICATION messages sent	Number of SIGNALLING CONNECTION RELEASE INDICATION messages that the UE has sent.
Number of ACTIVATE PDP CONTEXT REQUEST messages sent	Number of ACTIVATE PDP CONTEXT REQUEST message that the UE has sent.
Number of ACTIVATE PDP CONTEXT ACCEPT messages received	Number of ACTIVATE PDP CONTEXT ACCEPT messages that the UE has received.
Number of ACTIVATE PDP CONTEXT REJECT messages received	Number of ACTIVATE PDP CONTEXT REJECT messages that the UE has received.
Number of REQUEST PDP CONTEXT ACTIVATION messages received	Number of REQUEST PDP CONTEXT ACTIVATION messages that the UE has received.
Number of DEACTIVATE PDP CONTEXT REQUEST messages sent	Number of DEACTIVATE PDP CONTEXT REQUEST messages that the UE has sent.
Number of DEACTIVATE PDP CONTEXT ACCEPT messages received	Number of DEACTIVATE PDP CONTEXT ACCEPT messages that the UE has received.
Number of DEACTIVATE PDP CONTEXT REQUEST messages received	Number of DEACTIVATE PDP CONTEXT REQUEST messages that the UE has received.
Number of DEACTIVATE PDP CONTEXT ACCEPT messages sent	Number of DEACTIVATE PDP CONTEXT ACCEPT messages that the UE has sent.
Number of mobile terminated conversational flows requested	Number of mobile terminated conversational flows requested for service.
Number of mobile terminated conversational flows admitted	Number of mobile terminated conversational flows admitted for service.
Number of mobile terminated conversational flows rejected	Number of mobile terminated conversational flows rejected due to various reasons, such as lack of resources.
Number of mobile terminated conversational flows dropped	Number of mobile terminated conversational flows admitted but dropped in the middle of service.
Number of mobile terminated conversational flows completed	Number of mobile terminated conversational flows successfully completed.
Number of mobile terminated streaming flows requested	Number of mobile terminated streaming flows requested for service.
Number of mobile terminated streaming flows admitted	Number of mobile terminated streaming flows admitted for service.
Number of mobile terminated streaming flows rejected	Number of mobile terminated streaming flows rejected due to various reasons such as lack of resources.
Number of mobile terminated streaming flows dropped	Number of mobile terminated streaming flows admitted but dropped in the middle of service.
Number of mobile terminated streaming flows completed	Number of mobile terminated streaming flows successfully completed.
Number of mobile terminated interactive flows requested	Number of mobile terminated interactive flows requested for service.
Number of mobile terminated interactive flows admitted	Number of mobile terminated interactive flows admitted for service.
Number of mobile terminated interactive flows rejected	Number of mobile terminated interactive flows rejected due to various reasons, such as lack of resources.

TABLE 2-19. Detailed UMTS Layer 3 Statistics for a UE Node (Continued)

Statistic	Description
Number of mobile terminated interactive flows dropped	Number of mobile terminated interactive flows admitted but dropped in the middle of service.
Number of mobile terminated interactive flows completed	Number of mobile terminated interactive flows successfully completed.
Number of mobile terminated background flows requested	Number of mobile terminated background flows requested for service.
Number of mobile terminated background flows admitted	Number of mobile terminated background flows admitted for service.
Number of mobile terminated background flows rejected	Number of mobile terminated background flows rejected due to various reasons, such as lack of resources.
Number of mobile terminated background flows dropped	Number of mobile terminated background flows admitted but dropped in the middle of service.
Number of mobile terminated background flows completed	Number of mobile terminated background flows successfully completed.
Number of mobile originated conversational flows requested	Number of mobile originated conversational flows requested for service.
Number of mobile originated conversational flows admitted	Number of mobile originated conversational flows admitted for service.
Number of mobile originated conversational flows rejected	Number of mobile originated conversational flows rejected due to various reasons, such as lack of resources.
Number of mobile originated conversational flows dropped	Number of mobile originated conversational flows admitted but dropped in the middle of service.
Number of mobile originated conversational flows completed	Number of mobile originated conversational flows successfully completed.
Number of mobile originated streaming flows requested	Number of mobile originated streaming flows requested for service.
Number of mobile originated streaming flows admitted	Number of mobile originated streaming flows admitted for service.
Number of mobile originated streaming flows rejected	Number of mobile originated streaming flows rejected due to various reasons, such as lack of resources.
Number of mobile originated streaming flows dropped	Number of mobile originated streaming flows admitted but dropped in the middle of service.
Number of mobile originated streaming flows completed	Number of mobile originated streaming flows successfully completed.
Number of mobile originated interactive flows requested	Number of mobile originated interactive flows requested for service.
Number of mobile originated interactive flows admitted	Number of mobile originated interactive flows admitted for service.
Number of mobile originated interactive flows rejected	Number of mobile originated interactive flows rejected due to various reasons, such as lack of resources.
Number of mobile originated interactive flows dropped	Number of mobile originated interactive flows admitted but dropped in the middle of service.
Number of mobile originated interactive flows completed	Number of mobile originated interactive flows successfully completed.
Number of mobile originated background flows requested	Number of mobile originated background flows requested for service.

TABLE 2-19. Detailed UMTS Layer 3 Statistics for a UE Node (Continued)

Statistic	Description
Number of mobile originated background flows admitted	Number of mobile originated background flows admitted for service.
Number of mobile originated background flows rejected	Number of mobile originated background flows rejected due to various reasons, such as lack of resources.
Number of mobile originated background flows dropped	Number of mobile originated background flows admitted but dropped in the middle of service.
Number of mobile originated background flows completed	Number of mobile originated background flows successfully completed.
Number of mobile originated CS domain flows requested	Number of mobile originated circuit service domain data packets that the UE has requested for service.
Number of mobile originated CS domain flows admitted	Number of mobile originated circuit service domain data packets that the UE has admitted for service.
Number of mobile originated CS domain flows rejected	Number of mobile originated circuit service domain data packets that the UE has rejected due to various reasons, such as lack of resources.
Number of mobile originated CS domain flows dropped	Number of mobile originated circuit service domain data packets that the UE has dropped in the middle of service.
Number of mobile originated CS domain flows completed	Number of mobile originated circuit service domain data packets that the UE has successfully completed.

Node B Statistics

No UMTS layer 3 statistics are collected for Node B nodes.

RNC Statistics

Table 2-20 lists the basic UMTS layer 3 statistics for a RNC node. (These statistics are printed if the parameter `CELLULAR-STATISTICS` is set to `YES`.)

TABLE 2-20. Basic UMTS Layer 3 Statistics for a RNC Node

Statistic	Description
Average UL radio resource allocated at NodeB #	Time-averaged uplink radio resources allocated at the specified Node B.
Peak UL radio resource allocated at NodeB #	Peak uplink radio resources allocated at the specified Node B.
Average DL radio resource allocated at NodeB #	Time-averaged downlink radio resources allocated at the specified Node B.
Peak DL radio resource allocated at NodeB #	Peak downlink radio resources allocated at the specified Node B.
Number of RRC CONN REQUEST messages received	Number of RRC CONNECTION REQUEST messages that the RNC has received.
Number of RRC CONN SETUP messages sent	Number of RRC CONNECTION SETUP messages that the RNC has sent.
Number of RRC CONN SETUP COMPLETE messages received	Number of RRC CONNECTION SETUP COMPLETE messages that the RNC has received.
Number of RRC CONN REJECT messages sent	Number of RRC CONNECTION REJECT messages that the RNC has sent.

TABLE 2-20. Basic UMTS Layer 3 Statistics for a RNC Node (Continued)

Statistic	Description
Number of data packets from UE dropped due to no RRC	Number of data packets received from UE that the RNC node has dropped because it was unable to find the corresponding RRC connection.
Number of data packets from UE dropped due to no RAB	Number of data packets received from UE that the RNC node has dropped because it was unable to find the corresponding radio access bearer.
Number of CS domain data packets forwarded to SGSN	Number of circuit service domain data packets that the RNC node has forwarded to its SGSN.
Number of data packets from SGSN dropped due to no RRC	Number of data packets received from SGSN that the RNC node has dropped because it was unable to find the corresponding RRC connection.
Number of data packets from SGSN dropped due to no RAB	Number of data packets received from SGSN that the RNC node has dropped because it was unable to find the corresponding radio access bearer.
Number of CS domain data packets forwarded to UE (via NodeB)	Number of circuit service domain data packets that the RNC node has forwarded to UEs under its control via Node Bs.
Number of CS domain packets forwarded to GGSN	Number of circuit service domain packets that the SGSN has forwarded to its GGSN.
Number of CS domain packets forwarded to UE	Number of circuit service domain packets that the SGSN has forwarded to UE.
Number of CS domain packets dropped	Number of circuit service domain packets that the SGSN has dropped due to lack of resources.
Number of data packets received from SGSN	Number of data packets that the RNC node has received from its SGSN node.
Number of data packets forwarded to SGSN	Number of data packets that the RNC node has forwarded to its SGSN node.
Number of PS domain data packets received from UE (via Node B)	Number of packet service domain data packets that the RNC node has received from UEs under its control via Node Bs.
Number of PS domain data packets forwarded to UE (via Node B)	Number of packet service domain data packets that the RNC node has forwarded to UEs under its control via Node Bs.

SGSN Statistics

Table 2-21 lists the basic UMTS layer 3 statistics for a SGSN node. (These statistics are printed if the parameter `CELLULAR-STATISTICS` is set to `YES`.)

TABLE 2-21. Basic UMTS Layer 3 Statistics for a SGSN Node

Statistic	Description
Number of GTP tunneled packets forwarded to GGSN	Number of GTP tunneled packets forwarded to GGSN.
Number of GTP tunneled packets forwarded to UE	Number of GTP tunneled packets forwarded to UE.
Number of GTP tunneled packets dropped	Number of GTP tunneled packets dropped at SGSN due to lack of flow information at the SGSN.
Number of CS domain packets forwarded to GGSN	Number of circuit service domain packets that the SGSN has forwarded to its GGSN.
Number of CS domain packets forwarded to UE	Number of circuit service domain packets that the SGSN has forwarded to UE.

TABLE 2-21. Basic UMTS Layer 3 Statistics for a SGSN Node (Continued)

Statistic	Description
Number of CS domain packets dropped	Number of circuit service domain packets that the SGSN has dropped due to lack of resources.
Number of ROUTING AREA UPDATE messages received	Number of ROUTING AREA UPDATE messages received from UEs.
Number of ROUTING AREA UPDATE ACCEPT messages sent	Number of ROUTING AREA UPDATE ACCEPT messages sent to UEs.
Number of ATTACH REQUEST messages received	Number of GPRS ATTACH REQUEST messages received from UEs.
Number of ATTACH ACCEPT messages sent	Number of GPRS ATTACH ACCEPT messages sent to UEs.
Number of ATTACH REJECT messages sent	Number of GPRS ATTACH REJECT messages sent to UEs.
Number of ATTACH COMPLETE messages received	Number of GPRS ATTACH COMPLETE messages received from UEs.
Number of PAGING messages sent	Number of PAGING messages sent.
Number of SERVICE REQUEST messages received	Number of SERVICE REQUEST messages received from UEs.
Number of SERVICE ACCEPT messages sent	Number of SERVICE ACCEPT messages sent to UEs.
Number of SERVICE REJECT messages sent	Number of SERVICE REJECT messages sent to UEs.
Number of VLR entries added	Number of entries inserted into the VLR.
Number of VLR entries removed	Number of entries removed from the VLR.
Number of HLR updates performed	Number of updates sent to the HLR for updating routing information for UEs.

Table 2-22 lists the detailed UMTS layer 3 statistics for a SGSN node. (These statistics are printed if the parameter `UMTS-PRINT-DETAILED-STATISTICS` is set to `YES`.)

TABLE 2-22. Detailed UMTS Layer 3 Statistics for a SGSN Node

Statistic	Description
Number of ACTIVATE PDP CONTEXT REQUEST messages received	Number of ACTIVATE PDP CONTEXT REQUEST messages received from UEs.
Number of ACTIVATE PDP CONTEXT ACCEPT messages sent	Number of ACTIVATE PDP CONTEXT ACCEPT messages sent to UEs.
Number of ACTIVATE PDP CONTEXT REJECT messages sent	Number of ACTIVATE PDP CONTEXT REJECT messages sent to UEs.
Number of REQUEST PDP CONTEXT ACTIVATION messages sent	Number of REQUEST PDP CONTEXT ACTIVATION messages sent to UEs.
Number of DEACTIVATE PDP CONTEXT REQUEST messages received	Number of DEACTIVATE PDP CONTEXT REQUEST messages received from UEs.
Number of DEACTIVATE PDP CONTEXT ACCEPT messages sent	Number of DEACTIVATE PDP CONTEXT ACCEPT messages sent to UEs.
Number of DEACTIVATE PDP CONTEXT REQUEST messages sent	Number of DEACTIVATE PDP CONTEXT REQUEST messages sent to UEs.
Number of DEACTIVATE PDP CONTEXT ACCEPT messages received	Number of DEACTIVATE PDP CONTEXT ACCEPT messages received from UEs.
Number of CREATE PDP CONTEXT REQUEST messages sent	Number of CREATE PDP CONTEXT REQUEST messages sent to the GGSN.

TABLE 2-22. Detailed UMTS Layer 3 Statistics for a SGSN Node (Continued)

Statistic	Description
Number of CREATE PDP CONTEXT RESPONSE messages received	Number of CREATE PDP CONTEXT RESPONSE messages received from the GGSN.
Number of PDU NOTIFICATION REQUEST messages received	Number of PDU NOTIFICATION REQUEST messages received from the GGSN.
Number of PDU NOTIFICATION RESPONSE messages sent	Number of PDU NOTIFICATION RESPONSE messages sent to the GGSN.
Number of DELETE PDP CONTEXT REQUEST messages sent	Number of DELETE PDP CONTEXT REQUEST messages sent to the GGSN.
Number of DELETE PDP CONTEXT RESPONSE messages received	Number of DELETE PDP CONTEXT RESPONSE messages received from the GGSN.
Number of DELETE PDP CONTEXT REQUEST messages received	Number of DELETE PDP CONTEXT REQUEST messages received from the GGSN.
Number of DELETE PDP CONTEXT RESPONSE messages sent	Number of DELETE PDP CONTEXT RESPONSE messages sent to the GGSN.
Number of call control SETUP messages sent	Number of call control SETUP messages that the SGSN has sent.
Number of call control CALL CONFIRM messages received	Number of call control CALL CONFIRM messages that the SGSN has received.
Number of call control ALERTING messages received	Number of call control ALERTING messages that the SGSN has received.
Number of call control CONNECT messages received	Number of call control CONNECT messages that the SGSN has received.
Number of call control CONNECT ACKNOWLEDGE messages sent	Number of call control CONNECT ACKNOWLEDGE messages that the SGSN has sent.
Number of call control DISCONNECT messages sent	Number of call control DISCONNECT messages that the SGSN has sent.
Number of call control RELEASE messages received	Number of call control RELEASE messages that the SGSN has received.
Number of call control RELEASE COMPLETE messages sent	Number of call control RELEASE COMPLETE messages that the SGSN has sent.
Number of call control SETUP messages received	Number of call control SETUP messages that the SGSN has received.
Number of call control CALL PROCEEDING messages sent	Number of call control CALL PROCEEDING messages that the SGSN has sent.
Number of call control ALERTING messages sent	Number of call control ALERTING messages that the SGSN has sent.
Number of call control CONNECT messages sent	Number of call control CONNECT messages that the SGSN has sent.
Number of call control CONNECT ACKNOWLEDGE messages received	Number of call control CONNECT ACKNOWLEDGE messages that the SGSN has received.
Number of call control DISCONNECT messages received	Number of call control DISCONNECT messages that the SGSN has received.
Number of call control RELEASE messages sent	Number of call control RELEASE messages that the SGSN has sent.
Number of call control RELEASE COMPLETE messages received	Number of call control RELEASE COMPLETE messages that the SGSN has received.

GGSN Statistics

Table 2-23 lists the basic UMTS layer 3 statistics for a GGSN node. (These statistics are printed if the parameter `CELLULAR-STATISTICS` is set to `YES`.)

TABLE 2-23. Basic UMTS Layer 3 Statistics for a GGSN Node

Statistic	Description
Number of mobile terminated flows requested	Number of mobile terminated flows requested for service.
Number of mobile terminated flows admitted	Number of mobile terminated flows successfully admitted for service.
Number of mobile terminated flows rejected	Number of mobile terminated flows rejected due to various reasons, such as lack of resources.
Number of mobile terminated flows dropped	Number of mobile terminated flows admitted, but dropped in the middle of service.
Number of mobile terminated flows completed	Number of mobile terminated flows completed successfully.
Number of mobile originated flows requested	Number of mobile originated flows requested for service.
Number of mobile originated flows admitted	Number of mobile originated flows successfully admitted for service.
Number of mobile originated flows rejected	Number of mobile originated flows rejected due to various reasons, such as lack of resources.
Number of mobile originated flows dropped	Number of mobile originated flows admitted, but dropped in the middle of service.
Number of mobile originated flows completed	Number of mobile originated flows completed successfully.
Number of PS domain data packets dropped (unsupported format)	Number of PS domain data packets dropped at the GGSN node due to unsupported format.
Number of CS domain data packets routed to my PLMN	Number of CS domain data packets forwarded to the GGSN's PLMN.
Number of CS domain data packets from my PLMN	Number of CS domain data packets that come from inside of the GGSN's PLMN.
Number of CS domain data packets routed to outside of my PLMN	Number of CS domain data packets forwarded to outside of the GGSN's PLMN.
Number of CS domain data packets dropped	Number of CS domain data packets dropped at the GGSN node.
Number of PS domain data packets from outside of my PLMN	Number of PS domain data packets that come from outside of the GGSN's PLMN.
Number of PS domain data packets routed to my PLMN	Number of PS domain data packets forwarded to the GGSN's PLMN.
Number of PS domain data packets from my PLMN	Number of PS domain data packets that come from inside of the GGSN's PLMN.
Number of PS domain data packets routed to outside of my PLMN	Number of PS domain data packets forwarded to outside of the GGSN's PLMN.
Number of PS domain data packets dropped	Number of PS domain data packets dropped at the GGSN node.
Number of routing information queries sent to HLR	Number of queries sent to the HLR for routing information for UEs.
Number of routing info replies with success status received	Number of replies received from the HLR containing routing information for the queried UE.
Number of routing info replies with failure status received	Number of replies received from the HLR indicating that routing information was not found for the queried UE.

Table 2-24 lists the detailed UMTS layer 3 statistics for a GGSN node. (These statistics are printed if the parameter `UMTS-PRINT-DETAILED-STATISTICS` is set to `YES`.)

TABLE 2-24. Detailed UMTS Layer 3 Statistics for a GGSN Node

Statistic	Description
Number of mobile terminated conversational flows requested	Number of mobile terminated conversational flows requested for service.
Number of mobile terminated conversational flows admitted	Number of mobile terminated conversational flows admitted for service.
Number of mobile terminated conversational flows rejected	Number of mobile terminated conversational flows rejected due to various reasons, such as lack of resources.
Number of mobile terminated conversational flows dropped	Number of mobile terminated conversational flows admitted but dropped in the middle of service.
Number of mobile terminated conversational flows completed	Number of mobile terminated conversational flows successfully completed.
Number of mobile terminated streaming flows requested	Number of mobile terminated streaming flows requested for service.
Number of mobile terminated streaming flows admitted	Number of mobile terminated streaming flows admitted for service.
Number of mobile terminated streaming flows rejected	Number of mobile terminated streaming flows rejected due to various reasons, such as lack of resources.
Number of mobile terminated streaming flows dropped	Number of mobile terminated streaming flows admitted but dropped in the middle of service.
Number of mobile terminated streaming flows completed	Number of mobile terminated streaming flows successfully completed.
Number of mobile terminated interactive flows requested	Number of mobile terminated interactive flows requested for service.
Number of mobile terminated interactive flows admitted	Number of mobile terminated interactive flows admitted for service.
Number of mobile terminated interactive flows rejected	Number of mobile terminated interactive flows rejected due to various reasons, such as lack of resources.
Number of mobile terminated interactive flows dropped	Number of mobile terminated interactive flows admitted but dropped in the middle of service.
Number of mobile terminated interactive flows completed	Number of mobile terminated interactive flows successfully completed.
Number of mobile terminated background flows requested	Number of mobile terminated background flows requested for service.
Number of mobile terminated background flows admitted	Number of mobile terminated background flows admitted for service.
Number of mobile terminated background flows rejected	Number of mobile terminated background flows rejected due to various reasons, such as lack of resources.
Number of mobile terminated background flows dropped	Number of mobile terminated background flows admitted but dropped in the middle of service.
Number of mobile terminated background flows completed	Number of mobile terminated background flows successfully completed.
Number of mobile originated conversational flows requested	Number of mobile originated conversational flows requested for service.
Number of mobile originated conversational flows admitted	Number of mobile originated conversational flows admitted for service.

TABLE 2-24. Detailed UMTS Layer 3 Statistics for a GGSN Node (Continued)

Statistic	Description
Number of mobile originated conversational flows rejected	Number of mobile originated conversational flows rejected due to various reasons, such as lack of resources.
Number of mobile originated conversational flows dropped	Number of mobile originated conversational flows admitted but dropped in the middle of service.
Number of mobile originated conversational flows completed	Number of mobile originated conversational flows successfully completed.
Number of mobile originated streaming flows requested	Number of mobile originated streaming flows requested for service.
Number of mobile originated streaming flows admitted	Number of mobile originated streaming flows admitted for service.
Number of mobile originated streaming flows rejected	Number of mobile originated streaming flows rejected due to various reasons, such as lack of resources.
Number of mobile originated streaming flows dropped	Number of mobile originated streaming flows admitted but dropped in the middle of service.
Number of mobile originated streaming flows completed	Number of mobile originated streaming flows successfully completed.
Number of mobile originated interactive flows requested	Number of mobile originated interactive flows requested for service.
Number of mobile originated interactive flows admitted	Number of mobile originated interactive flows admitted for service.
Number of mobile originated interactive flows rejected	Number of mobile originated interactive flows rejected due to various reasons, such as lack of resources.
Number of mobile originated interactive flows dropped	Number of mobile originated interactive flows admitted but dropped in the middle of service.
Number of mobile originated interactive flows completed	Number of mobile originated interactive flows successfully completed.
Number of mobile originated background flows requested	Number of mobile originated background flows requested for service.
Number of mobile originated background flows admitted	Number of mobile originated background flows admitted for service.
Number of mobile originated background flows rejected	Number of mobile originated background flows rejected due to various reasons, such as lack of resources.
Number of mobile originated background flows dropped	Number of mobile originated background flows admitted but dropped in the middle of service.
Number of mobile originated background flows completed	Number of mobile originated background flows successfully completed.
Number of PDU NOTIFICATION REQUEST messages sent	Number of PDU NOTIFICATION REQUEST messages sent to SGSNs.
Number of PDU NOTIFICATION RESPONSE messages received	Number of PDU NOTIFICATION RESPONSE messages received from SGSNs.
Number of CREATE PDP CONTEXT REQUEST messages received	Number of CREATE PDP CONTEXT REQUEST messages received from SGSNs.
Number of CREATE PDP CONTEXT RESPONSE messages sent	Number of CREATE PDP CONTEXT RESPONSE messages sent to SGSNs.
Number of DELETE PDP CONTEXT REQUEST messages received	Number of DELETE PDP CONTEXT REQUEST messages received from SGSNs.

TABLE 2-24. Detailed UMTS Layer 3 Statistics for a GGSN Node (Continued)

Statistic	Description
Number of DELETE PDP CONTEXT RESPONSE messages sent	Number of DELETE PDP CONTEXT RESPONSE messages sent to SGSNs.
Number of DELETE PDP CONTEXT REQUEST messages sent	Number of DELETE PDP CONTEXT REQUEST messages sent to SGSNs.
Number of DELETE PDP CONTEXT RESPONSE messages received	Number of DELETE PDP CONTEXT RESPONSE messages received from SGSNs.

HLR Statistics

Table 2-25 lists the basic UMTS layer 3 statistics for an HLR node. (These statistics are printed if the parameter `CELLULAR-STATISTICS` is set to `YES`.)

TABLE 2-25. Basic UMTS Layer 3 Statistics for an HLR Node

Statistic	Description
Number of Routing Area updates received	Number of routing information updates received.
Number of Routing Area queries received	Number of routing information queries received.
Number of successful Routing Area query replied	Number of query replies sent with routing information for the queried UE.
Number of Routing Area query failures sent	Number of query replies sent without routing information because the HLR was unable to find the queried UE in the database.

2.1.6.2 Dynamic Statistics

This section describes the statistics that can be displayed in the GUI during the simulation. Refer to Chapter 5 of *QualNet User's Guide* for instructions for enabling dynamic statistics in the GUI.

UE Statistics

Table 2-26 lists the dynamic statistics for a UE node.

TABLE 2-26. Dynamic Statistics for a UE Node

Statistic	Description
Transmission Power (dBm)	UE's Transmission power at the physical layer (in dBm).
DownLink Throughput (bps)	UE's downlink throughput at layer 2 (in bps).
UpLink Throughput (bps)	UE's uplink throughput at layer 2 (in bps).
Primary NodeB CPICH RSCP (dBm)	UE's Received Signal Code Power (RSCP) of CPICH signal from the primary Node B (in dBm).
Primary NodeB CPICH Ec/No (dB)	UE's Energy Per Chip Noise Ratio (Ec/No) of CPICH signal from the primary Node B (in dBm).
Primary NodeB CPICH BER	UE's Bit Error Rate (BER) of CPICH signal from the primary Node B.
Size of Active Set	Size of UE's active set

Node B Statistics

Table 2-27 lists the dynamic statistics for a Node B node.

TABLE 2-27. Dynamic Statistics for a Node B Node

Statistic	Description
Transmission Power (dBm)	Node B's Transmission power at the physical layer (in dBm).
Number of Active HSDPA Channels	Number of HSDPA channel in use at the physical layer
DownLink Throughput (bps)	Node B's downlink throughput at layer 2 (in bps).
UpLink Throughput (bps)	Node B's uplink throughput at layer 2
Number of UEs in Connected Mode in the Cell	Number of UEs in connected mode in the cell at layer 3 (in bps).

RNC Statistics

No dynamic statistics are enabled for a RNC node.

SGSN Statistics

Table 2-28 lists the dynamic statistics for a SGSN Node.

TABLE 2-28. Dynamic Statistics for a SGSN Node

Statistic	Description
Number of Registered UEs	Number of UEs registered with this SGSN

GGSN Statistics

Table 2-29 lists the dynamic statistics for a GGSN node.

TABLE 2-29. Dynamic Statistics for a GGSN Node

Statistic	Description
Egress Throughput (bps)	Egress throughput from this PLMN (in bps).
Ingress Throughput (bps)	Ingress throughput to this PLMN (in bps).

HLR Statistics

No dynamic statistics are enabled for an HLR node.

2.1.7 Sample Scenario

2.1.7.1 Scenario Description

The sample scenario consists of one PLMN connected to a small IP network. There are 14 nodes in the UMTS PLMN: six UEs, three Node Bs, two RNCs, one SGSN, one GGSN, and one HLR server. Two of the Node Bs are connected to one of the RNCs while the third Node B is connected to the other RNC. The SGSN, GGSN, and HLR are connected by point-to-point links and form the core network.

The IP network consists of three nodes, one of which is connected to the GGSN and the other two IP nodes.

Topology

Figure 2-20 shows the topology of the sample scenario.

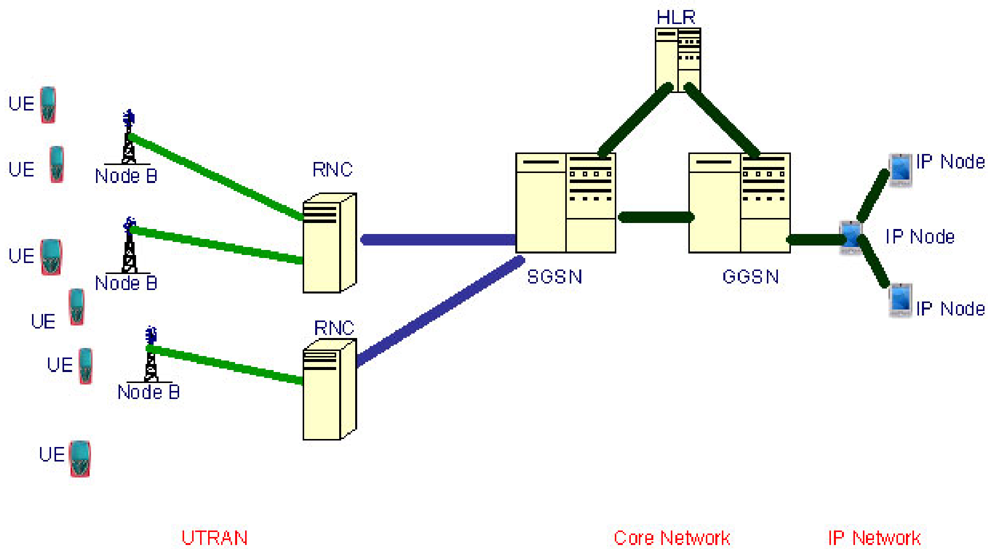

FIGURE 2-20. Sample Scenario Topology

2.1.7.2 Command Line Configuration

To configure the sample scenario in command line, enter the lines described in the following steps in the scenario configuration (.config) file.

Note: Only the configuration steps specific to UMTS are described here. To configure a complete scenario, additional scenario components need to be configured, as described in *QualNet User's Guide*

1. Define a subnet with all UEs (nodes 1 through 6) and NodeBs (nodes 7 through 9). Connect the NodeBs to the corresponding RNCs (nodes 10 and 11) and connect the RNCs to the SGSN (node 12). Connect the SGSN to the GGSN (node 13) and the HLR (node 14). Connect the GGSN to the HLR.

```
SUBNET N8-192.0.0.0 {1 thru 9}    // 6 UEs and 3 NodeBs in one subnet
LINK N8-192.0.1.0 {7, 10}   // Connect NodeB node 7 to RNC node 10
LINK N8-192.0.2.0 {8, 10}   // Connect NodeB node 8 to RNC node 10
LINK N8-192.0.3.0 {9, 11}   // Connect NodeB node 9 to RNC node 11
LINK N8-192.0.4.0 {10, 12}  // Connect RNC node 10 to SGSN node 12
LINK N8-192.0.5.0 {11, 12}  // Connect RNC node 11 to SGSN node 12
LINK N8-192.0.6.0 {12, 13}  // Connect SGSN node 12 to GGSN node 13
LINK N8-192.0.7.0 {12, 14}  // Connect SGSN node 12 to HLR node 14
LINK N8-192.0.8.0 {13, 14}  // Connect GGSN node 13 to HLR node 14
```

2. Configure UMTS layer 3 as the network protocol of all nodes.

```
[ 1 thru 14] NETWORK-PROTOCOL           CELLULAR-LAYER3
[ 1 thru 14] CELLULAR-LAYER3-PROTOCOL   UMTS-LAYER3
```

3. Configure nodes 1 through 6 as UEs, nodes 7 through 9 as Node Bs, nodes 10 and 11 as RNCs, node 12 as SGSN, node 13 as GGSN, and node 14 as HLR.

```
[ 1 thru 6] UMTS-NODE-TYPE    UE
[ 7 thru 9] UMTS-NODE-TYPE    NodeB
[ 10 thru 11] UMTS-NODE-TYPE  RNC
[ 12] UMTS-NODE-TYPE  SGSN
[ 13] UMTS-NODE-TYPE  GGSN
[ 14] UMTS-NODE-TYPE  HLR
```

4. Configure the HLR server for the SGSN and GGSN and the primary GGSN for the SGSN.

```
[12 13] UMTS-HLR-SERVER   14 // HLR server of this PLMN is node 14
[12]    UMTS-PRIMARY-GGSN  13 // SGSN node 12's primary GGSN is node 13
```

5. Create two channels to be used for UMTS FDD.

```
PROPAGATION-CHANNEL-FREQUENCY[0] 2.15e9
PROPAGATION-CHANNEL-NAME[0] downlink
PROPAGATION-CHANNEL-FREQUENCY[1] 1.95e9
PROPAGATION-CHANNEL-NAME[1] uplink
```

6. Configure the UMTS PHY for all UEs and Node Bs. (We configure the PHY at the subnet level.)

```
[N8-192.0.0.0] PHY-MODEL            PHY-CELLULAR
[N8-192.0.0.0] CELLULAR-PHY-MODEL   PHY-UMTS
[N8-192.0.0.0] PHY-RX-MODEL         PHY-UMTS
```

7. Configure UMTS layer 2 for all UEs and Node Bs. (We configure layer 2 at the subnet level.)

```
[N8-192.0.0.0] MAC-PROTOCOL           CELLULAR-MAC
[N8-192.0.0.0] CELLULAR-MAC-PROTOCOL  UMTS-LAYER2
```

8. Assign the downlink and uplink frequencies to Node Bs wireless radios. Here, we assign same frequencies to both Node Bs due to the nature of WCDMA. We assign channel 0 for downlink and assign channel 1 for uplink.

```
[7 thru 9] UMTS-NodeB-DOWNLINK-CHANNEL 0
[7 thru 9] UMTS-NodeB-UPLINK-CHANNEL   1
```

9. Configure the listenable channels such that Node Bs and UEs can listen to all the channels assigned to this PLMN.

```
[N8-192.0.0.0] PHY-LISTENABLE-CHANNELS downlink,uplink
```

10. Configure the routing protocol for the UMTS core network consisting of SGSNs, HLRs and GGSNs. In this example, we configure Bellman-Ford as the routing protocol for the backbone network.

```
[12 13 14] ROUTING-PROTOCOL BELLMANFORD
```

11. Configure the IP network. Connect IP node 15 to GGSN node 13. Connect nodes 15 and 16 and nodes 15 and 17.

```
LINK N8-192.0.9.0 {13, 15}   // connect GGSN node 13 to IP node 15
LINK N8-192.0.10.0 {15, 16}  // connect node 15 to node 16
LINK N8-192.0.11.0 {15, 17}  // connect node 15 to node 17
```

12. Configure the default gateway for IP nodes to allow traffic between the IP network and the UEs. Node 15 is the default gateway for all IP nodes. (See Appendix A for details.)

```
# Node 15 is the default gateway for the IP subnet
[15 16 17 ] DEFAULT-GATEWAY 192.0.9.1
```

13. Configure the routing protocol for the IP subnet. In this example, we configure RIP as the routing protocol for the IP subnet.

```
[15 16 17] ROUTING-PROTOCOL RIP
```

2.1.7.3 GUI Configuration

To configure the sample scenario in the GUI, perform the steps described below:

Note: Only the configuration steps specific to UMTS are described here. To configure a complete scenario, additional scenario components need to be configured, as described in *QualNet User's Guide*.

1. Select the UMTS nodes from the Devices tab and on the canvas, place six UMTS-UE nodes, three UMTS-NodeB nodes, two UMTS-RNC nodes, and one UMTS -GGSN node, one UMTS-SGSN node, and one UMTS-HLR node.
2. Place a wireless subnet icon on the canvas. Connect the six UMTS-UE nodes and the three UMTS-NodeB nodes to the wireless subnet.
3. Using point-to-point links connect two of the UMTS-NodeB nodes to one UMTS-RNC node and connect the third UMTS-NodeB node to the other UMTS-RNC node. Connect the two UMTS-RNC nodes to the UMTS-SGSN node.
4. Create the backbone network. Connect the UMTS-SGSN node to the UMTS-GGSN node and the UMTS-HLR node. Connect the UMTS-HLR node to the UMTS-GGSN node. (The UMTS-SGSN, UMTS-GGSN, and UMTS-HLR nodes can also be connected via a network.)

5. Enable UMTS layer 3 for all point-to-point links (see Figure 2-10).

   Figure 2-21 shows the canvas after completing the above steps.

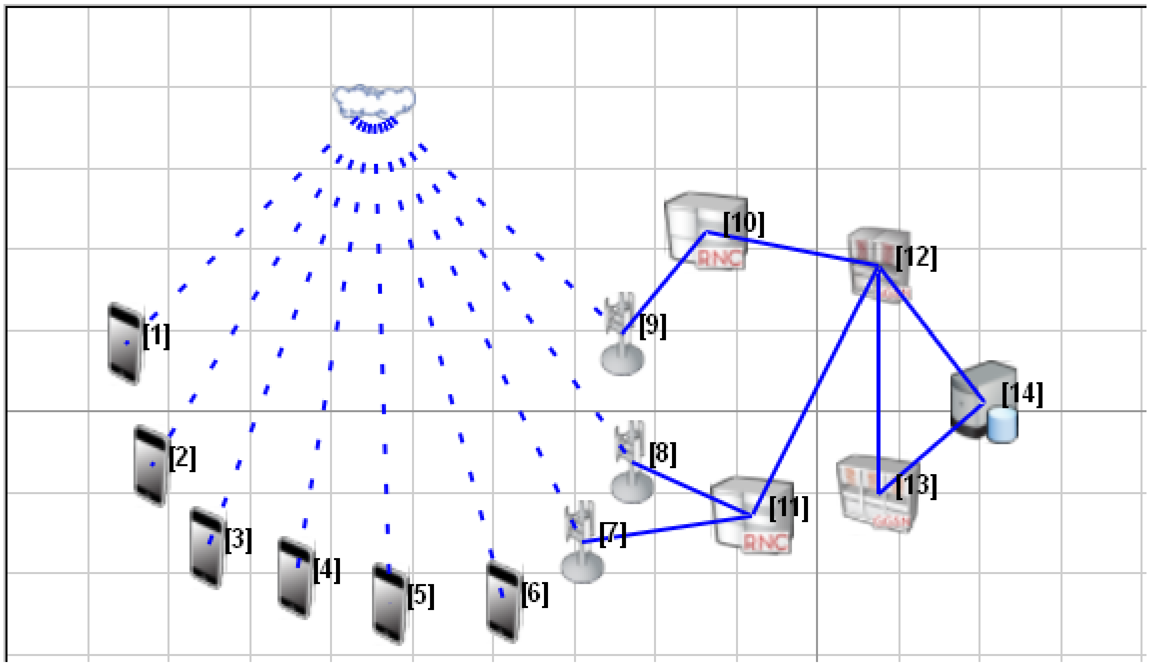

FIGURE 2-21. Sample Scenario: UMTS Configuration

6. Create two wireless channels.
7. Set **Listenable Channels** for the wireless subnet to *downlink* (see Figure 2-7). This will set the listenable channels for all UEs.
8. Set **Listenable Channels** to *uplink* for the NodeBs (see Figure 2-14).
9. Configure **MAC Protocol** for the wireless subnet as *Cellular MAC* and set **Cellular MAC Protocol** to *UMTS Layer 2* (see Figure 2-8).
10. Configure **Radio Type** for the wireless subnet as *Cellular PHY* and set **Cellular PHY Model** to *UMTS PHY Model* (see Figure 2-9).
11. For UMTS-NodeB7, UMTS-NodeB8, and UMTS-NodeB9, set **Downlink Channel** to *0* and **Uplink Channel** to *1* (see Figure 2-12).
12. For UMTS-SGSN12, set **My Home Location Register Server** to *14* and **My Primary GGSN Node** to *13* (see Figure 2-16).
13. For UMTS-GGSN13, set **My Home Location Register Server** to *14* (see Figure 2-17).
14. Configure the routing protocol for UMTS-SGSN12, UMTS-SGSN13, and UMTS-HLR14 to be Bellman-Ford.
15. Create an IP data network. Place three nodes of the Default device type on the canvas. Connect one of the default devices (node15) to the other two default devices (nodes 16 and 17) and to UMTS-GGSN13 node by point-to-point links (see Figure 2-22).

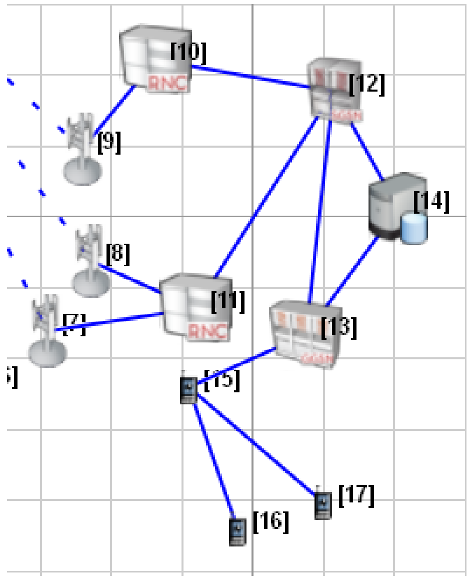

FIGURE 2-22. Sample Scenario: IP Network

16. Configure the default gateway for nodes 15, 16, and 17 to be UMTS-GGSN13.

a. Go to **Default Device Properties Editor > Node Configuration > Routing Protocol**.

b. Set **Configure Default Gateway** *[= Yes]* **> Default Gateway** to *13* as shown in Figure 2-23.

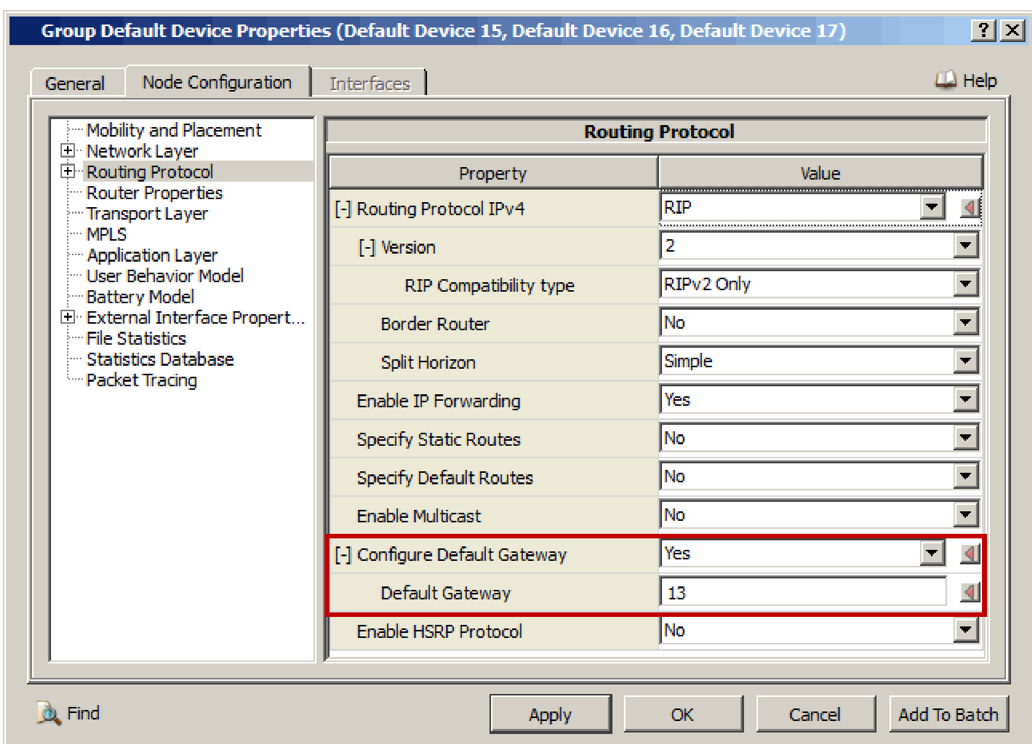

FIGURE 2-23. Setting Default Gateway for IP Nodes

17. Configure the routing protocol for the IP nodes (nodes 15, 16, and 17) to be *RIP*.
18. Click **File > Save**, to commit the changes. Click the **Run Simulation** button to execute the scenario and click the **Play** button to run the scenario.

2.1.8 Scenarios Included in QualNet

The QualNet distribution includes several sample scenarios for the UMTS protocol. All scenarios are located in the directory QUALNET_HOME/scenarios/umts. Table 2-30 lists the sub-directory where each scenario is located.

TABLE 2-30. UMTS Model Scenarios Included in QualNet

Scenario	Description
handover	Shows the example of handover of a mobile UE between 2 NodeBs.
handover_hsdpa	Shows the example of handover of a mobile UE between 2 NodeBs (HSDPA is enabled).
multi_ue_capacity	Shows the example for the capacity of a single cell with traffic flows among multiple UEs.
multi_ue_capacity_hsdpa	Shows the example for the capacity of a single cell with traffic flows among multiple UEs (HSDPA is enabled).
planning	Shows the example of planning of a small scale UMTS network.
planning_hsdpa	Shows the example of planning of a small scale UMTS network (HSDPA is enabled).
QoS	Shows the example of QoS support of a UMTS network.
QoS_hsdpa	Shows the example of QoS support of a UMTS network (HSDPA is enabled).
single_ue_capacity	Shows the example for the capacity of a UE in terms of throughput with multiple traffic flows between 2 UEs.
single_ue_capacity_hsdpa	Shows the example for the capacity of a UE in terms of throughput with multiple traffic flows between 2 UEs (HSDPA is enabled).

2.1.9 References

The UMTS model is based on the following 3GPP UMTS Technical Specifications Release 7 standards:

1. 3GPP TS 25.301: "Radio Interface Protocol Architecture"
2. 3GPP TS 25.201: "Physical layer - General description"
3. 3GPP TS 25.211: "Physical channel and mapping of transport channel onto physical channels (FDD)"
4. 3GPP TS 25.212: "Multiplexing and channel coding (FDD)”
5. 3GPP TS 25.213: "Spreading and modulation (FDD)"
6. 3GPP TS 25.214: "Physical layer procedures (FDD)"
7. 3GPP TS 25.215: "Physical layer - Measurements (FDD)"
8. 3GPP TS 25.321: "Medium access control (MAC) protocol specification"
9. 3GPP TS 25322: "RLC protocol Specification"
10. 3GPP TS 24.007: "Mobile radio interface signaling layer 3; General aspects"
11. 3GPP TS 24.008: "Mobile radio interface Layer 3 specification; Core network protocols; Stage 3"
12. 3GPP TS 23.009: "Handover procedures (Release 6)"

13. 3GPP TS 25.331: "Radio Resource Control (RRC) Protocol Specification"

14. 3GPP TS 25.308: "High Speed Downlink Packet Access (HSDPA) Overall Description"

15. 3GPP TS 29.060: "GPRS Tunnelling Protocol (GTP) across the Gn and Gp interface"

16. 3GPP TS 23.060: "General Packet Radio Service (GPRS); Service description; Stage 2"

3 Application Layer Models

This chapter describes features, configuration requirements and parameters, statistics, and scenarios for Application Layer Models in the UMTS Model Library, and consists of the following sections:

- Packet Service Applications
- UMTS Call Traffic Generator

3.1 Packet Service Applications

Packet Service (PS) applications in UMTS networks can be simulated by QualNet's traffic generator models. CBR and VBR models (refer to *Developer Model Library*) can be used to simulate conversational and streaming flows in UMTS networks.

Circuit Service (CS) voice calls in UMTS networks can be simulated by the UMTS Call traffic generator (see Section 3.2).

In QualNet, many of the traffic generator models, such as CBR, VBR, and FTP/Generic, support QoS configuration through the three QoS parameters: `PRECEDENCE`, `TOS`, and `DSCP`. In UMTS networks, only the `PRECEDENCE` parameter is supported.

Table 3-1 shows the mapping between the `PRECEDENCE` parameter and the UMTS QoS classes and handling priorities.

TABLE 3-1. UMTS QoS Classes and Handling Priorities

PRECEDENCE	UMTS QoS Class and Handling Priority
6-7	Conversational
4-5	Streaming
3	Interactive, handling priority = 1
2	Interactive, handling priority = 2
1	Interactive, handling priority = 3
0	Background

CBR and VBR models can be used to simulate conversational and streaming applications. However, for UMTS networks, each rate level imposes limits on the maximum data rate and maximum packet size. The CBR (or VBR) application should be configured such that the item size and effective data rate fall within these limits. Table 3-2 lists the data rate and packet size limits for conversational traffic. Table 3-3 lists the data rate and packet size limits for streaming traffic.

TABLE 3-2. Data Rate and Packet Size Limits for Conversational Traffic

Rate Level	Maximum Data Rate (bps)	Maximum Packet Size (Bytes)
1 (TTI 40ms)	28800	112
2 (TTI 20ms)	32000	48
3 (TTI 20ms)	64000	128
4 (TTI 20ms)	128000	288

TABLE 3-3. Data Rate and Packet Size Limits for Streaming Traffic

Rate Level	Maximum Data Rate (bps)	Maximum Packet Size (Bytes)
1 (TTI 40ms)	14400	40
2 (TTI 40ms)	28800	112
3 (TTI 40ms)	57600	256
4 (TTI 40ms)	115200	544

3.2 UMTS Call Traffic Generator

3.2.1 Description

The UMTS Call traffic generator is an application that simulates phone calls between two end users. The initiator places a call to the receiver and talks for a period of time during which the receiver is silent. After the initiator has finished talking, the receiver talks for a period of time during which the initiator is silent. The call continues with the initiator and receiver talking during alternate talk periods.

Note: In UMTS networks, a UMTS Call session can be configured only between two UE nodes.

3.2.2 Supplemental Information

None.

3.2.3 Command Line Configuration

To specify the UMTS Call application, include the following statement in the application configuration (.app) file:

```
UMTS-CALL <initiator> <receiver> <avg-talk-time> <start-time>
           <duration>
```

Note: All parameters should be entered on the same line.

The UMTS Call parameters are described in Table 3-4. See Section 1.2.1.3 for a description of the format used for the parameter table.

TABLE 3-4. UMTS Call Parameters

Parameter	Value	Description
`<initiator>` *Required*	Integer	Node ID or IP address of the initiator of the call.
`<receiver>` *Required*	Integer	Node ID or IP address of the receiver of the call.
`<avg-talk-time>` *Required*	Time	Average length of a talk period (the time during which one party talks and the other party listens). The length of the talk period is taken from an exponential distribution with <avg-talk-time> as the mean.
`<start-time>` *Required*	Time	Simulation time when the call starts.
`<duration>` *Required*	Time	Total length of the call. A typical value for this parameter is in the range 180S to 210S.

Examples of Command Line Configuration

In the following UMTS Call configuration, node 5 places a call to node 8 10 seconds after the start of simulation. The average length of a talk period is 15 seconds. The phone call ends after 100 seconds.

```
UMTS-CALL 5 8 10S 15S 100S
```

3.2.4 GUI Configuration

To configure a UMTS Call session, perform the following steps:

1. Click the **UMTS** button in the **Applications** tab.
   - To set up a UMTS Call session between two nodes, on the canvas, click on the source node, drag the mouse to the destination node, and release. An application link is displayed between the two nodes.
   - To set up a loopback UMTS Call session, on the canvas, double-click on the node. A symbol is displayed next to the node.
2. Open the UMTS Call Properties Editor by doing one of the following:
   - Right-click in the application link on the canvas and select **Properties** from the menu.
   - On the canvas, right-click on the symbol next to the node and select **Properties** from the menu.
   - In the **Applications** tab of Table View, either double-click on the application row or right-click on the application row and select Properties from the menu.
3. Set the parameters listed in Table 3-5.

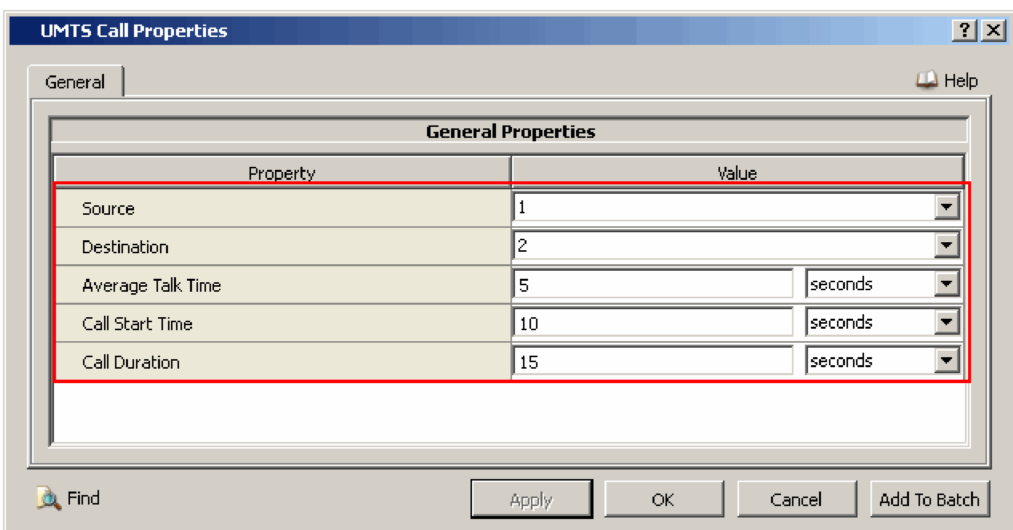

FIGURE 3-1. Configuring UMTS Call Parameters

TABLE 3-5. Command Line Equivalent of UMTS Call Parameters

GUI Parameter	Command Line Parameter
Source	`<initiator>`
Destination	`<receiver>`
Average Talk Time	`<avg-talk-time>`
Call Start Time	`<start-time>`
Call Duration	`<duration>`

Setting Parameters

- To specify an IP address as the initiator (receiver) ID, set **Source** (**Destination**) to one of the IP addresses listed in the drop-down list.

3.2.5 Statistics

Table 3-6 lists the statistics for the UMTS Call model that are printed to the statistics (.stat) file.

TABLE 3-6. UMTS Call Statistics

Statistic	Description
Number of phone call request sent to layer 3	Number of phone call requests sent to UMTS layer 3 Call Control entity by the application layer
Number of phone call request rcvd	Number of phone call requests from remote UEs received by this UE
Number of phone call request accepted	Number of phone call requests accepted by the UMTS layer 3 Call Control entity
Number of phone call request rejected	Number of phone call requests rejected by the UMTS layer 3 Call Control entity
Number of phone call request reject (cause: System Busy)	Number of phone call requests rejected due to the system being busy
Number of phone call request reject (cause: Network Not Found)	Number of phone call requests rejected due to the network being unavailable
Number of phone call request reject (cause: Too Many Active Phone Call)	Number of phone call requests rejected due to the maximum number of applications having being reached for this UE
Number of phone call request reject (cause: Unknown User)	Number of phone call requests rejected because the called party is not known to the network
Number of phone call request reject (cause: User Power Off)	Number of phone call requests rejected due to the called party having turned the power off
Number of phone call request reject (cause: User Busy)	Number of phone call requests rejected due to the called party being busy
Number of phone call request reject (cause: Unsupported Service)	Number of phone call requests rejected because the service is unsupported in the current network
Number of phone call request reject (cause: User Unreachable)	Number of phone call requests rejected because the remote UE is unreachable
Number of phone call successfully end	Number of phone call sessions (originating and terminating) that end successfully

TABLE 3-6. UMTS Call Statistics (Continued)

Statistic	Description
Number of originating phone call successfully end	Number of originating phone call sessions that end successfully
Number of terminating phone call successfully end	Number of terminating phone call sessions that end successfully
Number of phone call dropped	Number of phone call sessions (originating and terminating) that are dropped
Number of originating phone call dropped	Number of originating phone call sessions that are dropped
Number of originating phone call dropped (Cause: Handover Failure)	Number of originating call sessions that are dropped due to handover failure
Number of originating phone call dropped (Cause: Self PowerOff)	Number of originating call sessions that are dropped due to this UE powering off
Number of originating phone call dropped (Cause: Remote PowerOff)	Number of originating call sessions that are dropped due to the remote UE powering off
Number of terminating phone call dropped	Number of terminating call sessions that are dropped
Number of terminating phone call dropped (Cause: Handover Failure)	Number of terminating call sessions that are dropped due to handover failure
Number of terminating phone call dropped (Cause: Self PowerOff)	Number of terminating call sessions that are dropped due to this UE powering off
Number of terminating phone call dropped (Cause: Remote PowerOff)	Number of terminating call sessions that are dropped due to the remote UE powering off
Number of voice packets sent	Number of voice packets sent by this UE
Number of voice packets received	Number of voice packets received by this UE
Average end to end delay (seconds)	Average end to end delay for the received voice packets

A Routing between UMTS and IP Networks

This appendix describes how to configure scenarios with UMTS and IP networks to enable routing of packets between the two domains.

A.1 Routing in UMTS and IP Networks

Usually, a routing protocol is not needed within the access network. The nodes in the UTRAN, including UEs, Node Bs and RNCs, learn their connectivity through UMTS signaling. However, the scenario has to be configured to enable routing of packets beyond the UTRAN.

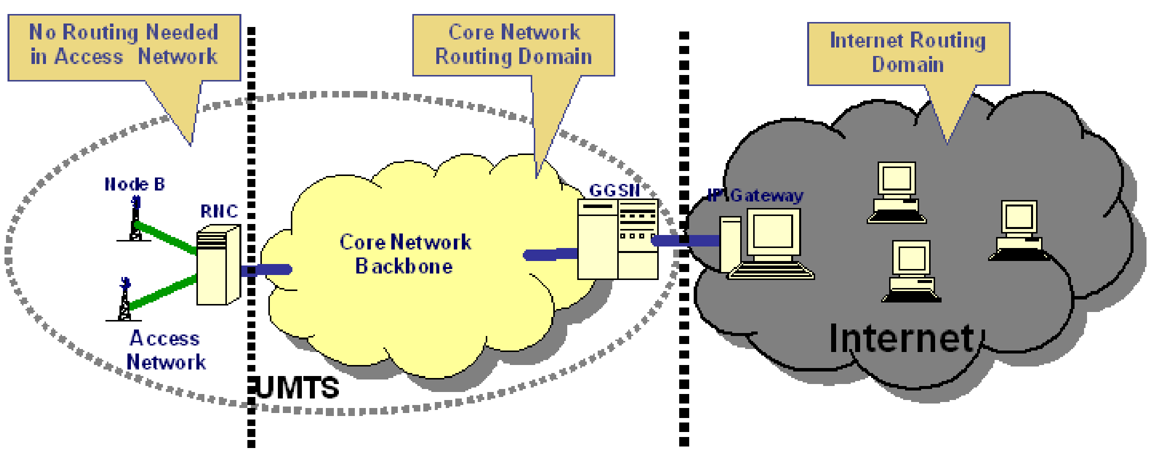

FIGURE A-1. Routing between UMTS and IP Networks

There are two aspects to routing in UMTS scenarios:

- A routing protocol is needed in the backbone core network of UMTS to enable routing between SGSNs, GGSNs, and HLRs, which may be several hops away from each other.

- IP Packet Data Networks (PDNs) have their own IP routing architecture. In order to route packets between the UMTS PLMN and IP networks, necessary routing information is needed, especially at the nodes on the boundary between the PLMN and PDN. These requirements for boundary nodes are described below.

Boundary Node Requirements

The boundary nodes should be configured to allow the following:

- **Routing from UMTS PLMN to IP networks**. The GGSN node needs to route packets to the proper IP gateway node.
- **Routing from IP networks to UMTS PLMN**. The following considerations apply for routing packets from IP networks to the UMTS PLMN:
  - The IP routers usually do not know the individual IP addresses assigned to UMTS UEs. However, they need to know how to reach the UMTS PLMN network as a whole.
  - The IP address segments allocated to a UMTS PLMN are usually statically configured.
  - The aggregate routing information for IP address segments of each UMTS PLMN needs to be advertised to IP networks.

A.2 Techniques for Inter-domain Routing

This section describes some techniques that can be used to enable routing of packets between UMTS PLMN and IP networks.

A.2.1 Routing Using BGP

The Border Gateway Protocol (BGP) can be used to connect the UMTS PLMN routing domain and the IP network routing domain. The following steps should be followed to correctly configure BGP routing:

1. Treat the UMTS PLMN routing domain as one autonomous system.
2. Set up autonomous systems in the IP network.
3. Configure BGP to advertise the aggregate routing information for the UMTS PLMN to IP networks.
4. Configure BGP to advertise the aggregate routing information for IP networks to the GGSN node of the UMTS PLMN.

Refer to *Multimedia and Enterprise Model Library* for BGP configuration details.

A.2.2 Routing by Making GGSN a Part of IP Network

In this configuration, the GGSN node of the UMTS PLMN is also included in the routing domain of the IP network. The GGSN node is also configured to be a gateway for the IP network. In order to configure the GGSN node as an IP gateway, it should have at least one interface in each of the routing domains (UMTS and IP network). The GGSN learns the routing information to IP nodes via the dynamic routing protocol configured for the IP network.

This method works for routing packets from the UMTS PLMN to the IP network. However, packets can not be routed from the IP network to the UMTS PLMN because the IP nodes do not know that the packets have to be routed to the GGSN node. In this case, static or default routes can be used to route packets from IP nodes to the UMTS PLMN (see Section A.2.3).

A.2.3 Routing Using Static Routes or Default Gateways

To route packets from an IP network to a UMTS PLMN, static routes or default gateways can be used.

Static routes can be configured to instruct IP nodes to route packets to the GGSN node of a UMTS PLMN. However, if the network topology is changing, static routes can become obsolete.

Alternatively, the GGSN node can be configured as the default gateway for IP nodes.

- If the IP node has no routing information for a destination address, it routes the packet to the default gateway.
- The default gateway can be multiple hops away.
- The GGSN node can be configured as the default gateway for all IP nodes.

Note: Since only one default gateway can be configured for each IP node, this approach works only if there is a single UMTS PLMN attached to the IP network.

A.2.4 Routing Using Special Protocols

To route packets between UMTS PLMN and IP networks, a routing protocol which advertises external networks inside its routing domain can be configured at the gateway node between the two domains.

Open Shortest Path First (OSPF) is a typical routing protocol that can be used to advertise routing information within a domain. Refer to *Multimedia and Enterprise Model* Library for a description of the OSPFv2 and OSPFv3 models.

A.3 Guidelines for Inter-domain Routing

The following are guidelines for configuring scenarios that require routing between UMTS PLMN and IP networks.

- For simple scenarios, it is convenient to use the GGSN node to connect the UMTS PLMN with the IP network.
  - Configure the GGSN node to have interfaces in both networks.
  - Configure a dynamic routing protocol for the UMTS backbone network.
  - Configure a routing protocol for the IP network.
  - Configure the GGSN node's interfaces to have the proper routing protocol. The GGSN node is part of both routing domains, which enables routing from the UMTS PLMN to the IP network.
  - For routing from the IP network to the UMTS PLMN, configure a default gateway for each IP node. The default gateway should be the IP address of the GGSN interface which connects to the IP network.
- For complex scenarios, it is convenient to use BGP to connect the UMTS PLMN network with the IP network and advertise the necessary routing information.