EXata 5.1
Cellular 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 Cellular Model Library are listed in Table 1-1.

TABLE 1-1. Cellular Library Models

Model Name	Model Type	Reference
Abstract Cellular	Multilayer	Chapter 2
GSM	Multilayer	Chapter 3
User Behavior	Miscellaneous	Section 4.1

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          802.11
```

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          802.11
```

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 EXata N syntax.

Example:

```
[N8-1.0 N2-1.0] MAC-PROTOCOL      802.11
```

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
802.11
```

`<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>	*<Type>*	*<Description>*
<Designation>	[*<Range>*]	
<Scope>	[*<Default Value>*]	
[*<Instances>*]	[*<Unit>*]	

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`
String	String value Examples: `TEST`, `SWITCH1`
Time	Time value expressed in EXata time syntax (refer to *EXata User's Guide*) Examples: `1.5S`, `200MS`, `10US`
Filename	Name of a file in EXata filename syntax (refer to *EXata User's Guide*) Examples: `../../data/terrain/los-angeles-w` (For Windows and UNIX) `C:\scalable\exata\5.1\scenarios\WF\WF.nodes` (For Windows) `/root/scalable/exata/5.1/scenarios/WF/WF.nodes` (For UNIX)
Path	Path to a directory in EXata path syntax (refer to *EXata User's Guide*) Examples: `../../data/terrain` (For Windows and UNIX) `C:\scalable\exata\5.1\scenarios\default` (For Windows) `/root/scalable/exata/5.1/scenarios/default` (For UNIX)
IP Address	IPv4 or IPv6 address Examples: `192.168.2.1`, `2000:0:0:0::1`

TABLE 1-3. Parameter Types (Continued)

Type	Description
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 EXata 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.

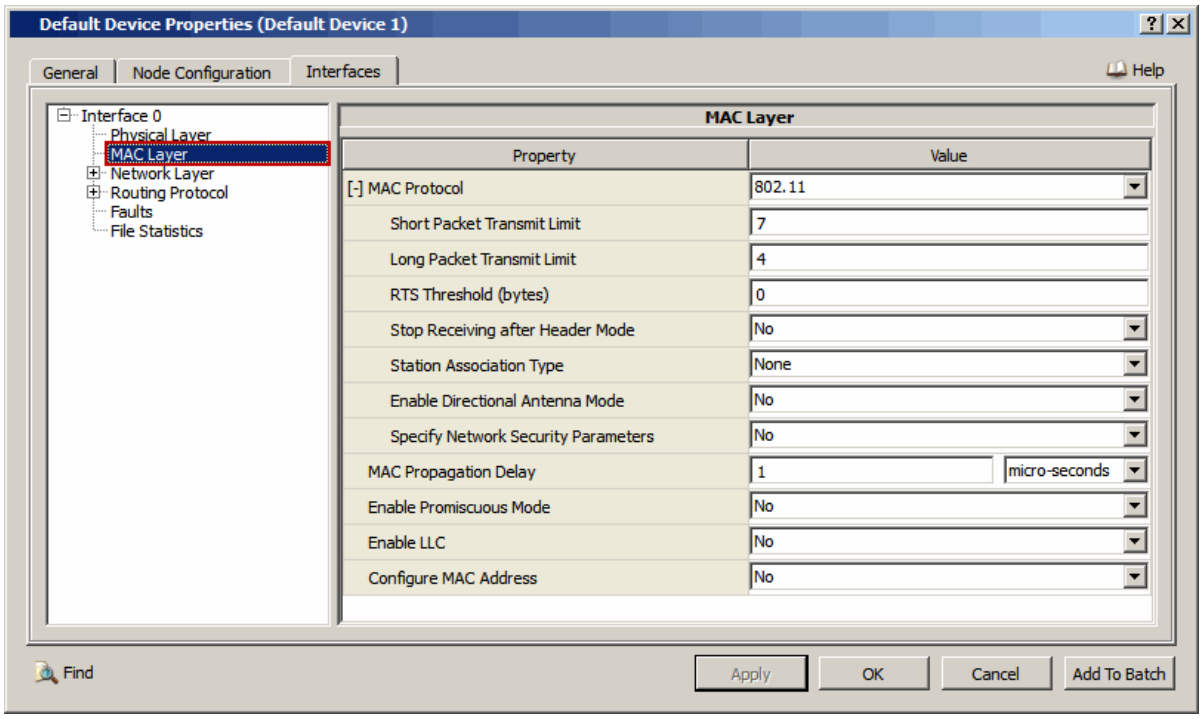

FIGURE 1-1. Path to a Parameter Group

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.

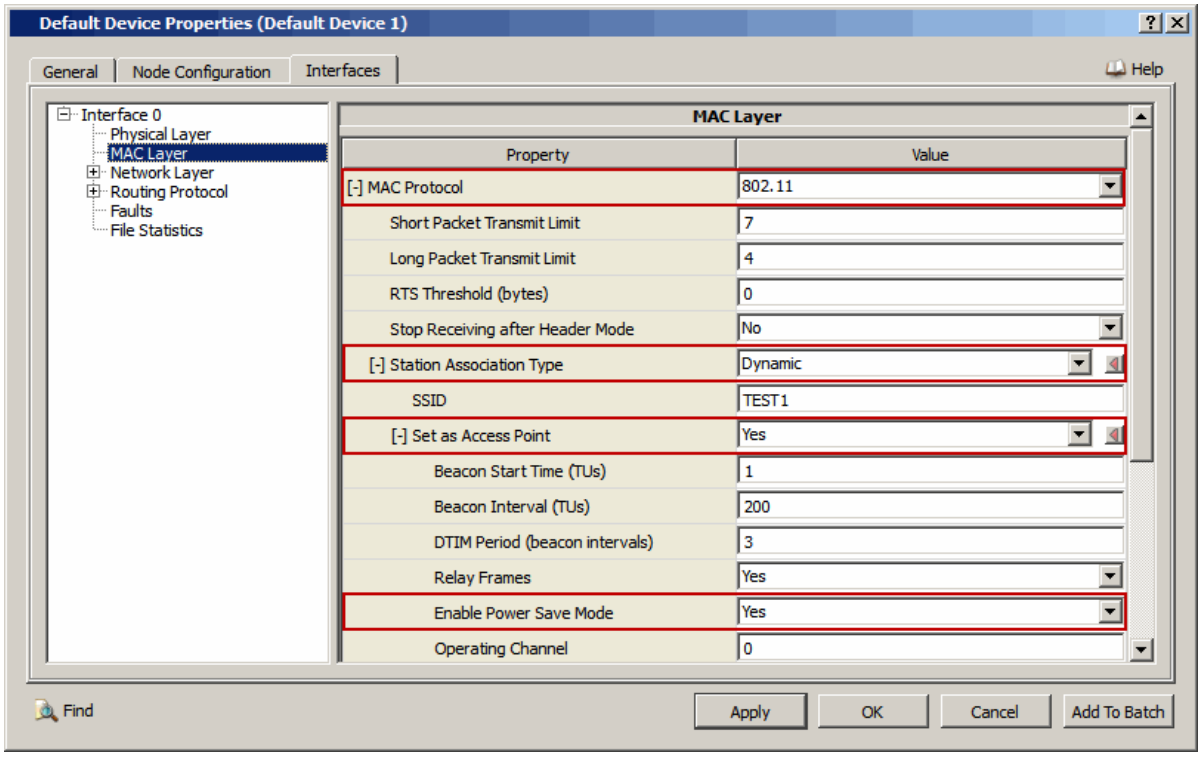

FIGURE 1-2. Path to a Specific Parameter

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 Abstract Cellular

2.1 Description

In the Abstract Cellular Model, a single base station serves a circular service area that is divided into multiple sectors, each of which is allocated with a certain amount of bandwidth. For each base station, several control channels are defined. A large number of base stations cover the simulated area and they are connected to a hub, the switch center, with wired links. The hub routes the control and data messages to/from the base stations. An aggregated node emulates the services originated or destined to nodes outside the simulated area. A gateway connects to all the BSs and the aggregated node. With help from HLR, the gateway routes the information flows between MSs or between MS and the aggregated node. See Figure 2-1.

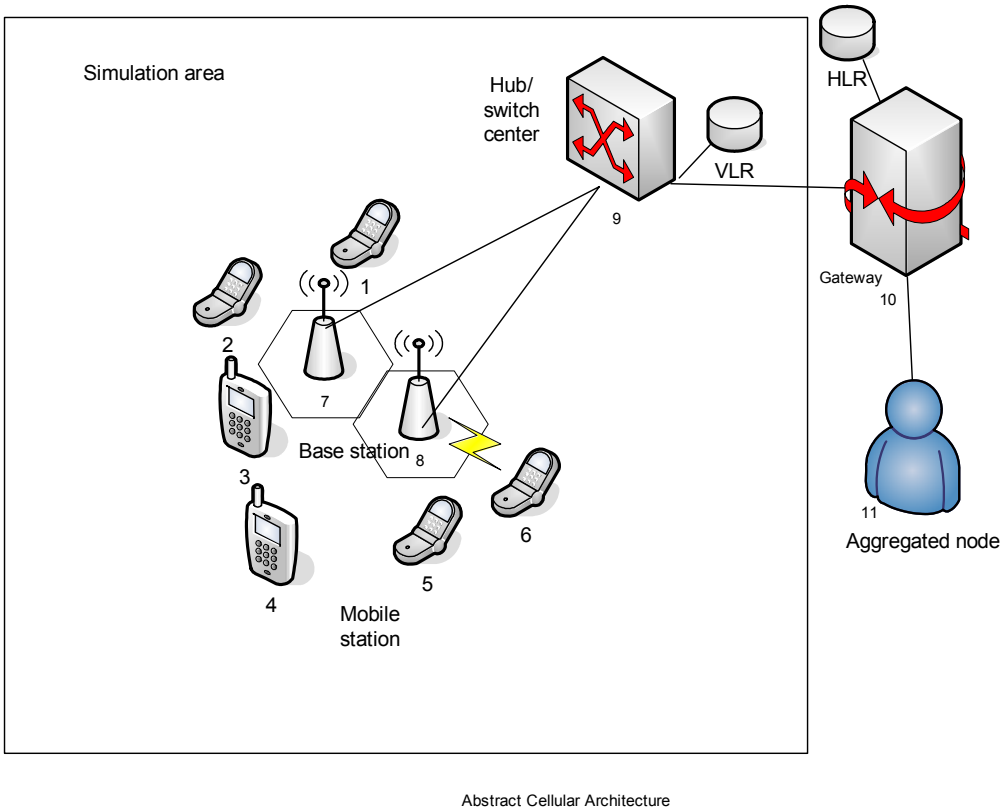

FIGURE 2-1. Abstract Cellular Architecture

A mobile station, supporting various types of services, selects and associates the optimal base station and updates its location to the VLR at the hub to facilitate the call setup process. At a user's request, a mobile station sends channel requests to the associated base station with other necessary information. The base station(s) and the switch center build up the connection with the called party either in or outside the simulation area by allocating channel resources to both communication parties, if needed. The resources are released when communication is over. A mobile station also initiates handover when signal strength from the associated base station diminishes. Communication between mobile stations and base stations is over the air via radio transmission. Base stations can carry out call admission control, and congestion control by monitoring the run-time resource usage and accepting or rejecting the call.

2.2 Features and Assumptions

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

2.2.1 Implemented Features

- Support 900 MHz or 1800 MHz band at MSs and BSs
- Support various types of traffic
- Different fidelity for control and traffic channel

- Dynamic channel assignment and release
  - Channel Request on demand
  - Channel allocation/release
- Call admission control
- Handover
  - Intra-cell HO
  - Inter-cell intra SC HO
  - Inter-cell Inter SC HO
  - Attach/cell selection and reselection
- Location update
  - Normal type
  - Periodic type
  - Attach type
- Location updating
- Call setup and tear down
  - Voice call setup
  - Voice call tear down
  - PDP context activation
- PDP context deactivation
- Threshold based Call admission control
- VLR/HLR operations
  - Insert, delete, update Records
  - Look up records
  - VLR and HLR interaction
- Update/Cancel Location

2.2.2 Omitted Features

- Security
- Authentication
- Billing
- Transmissions on traffic channels

2.2.3 Assumptions and Limitations

- Completely time synchronized
- BSs are sectorized regularly
- MS never power off/detach
- MS knows all the BSs downlink control channel frequency
- VLR is located at the switch center
- HLR is located at gateway
- No power control
- When performance optimization is enabled in the model, signal strength measurement is based on the location of MSs and BSs.

- A generic PHY layer is used
- The only application that can be used is the Cellular Abstract Application (see Section 2.4.4)

2.3 Supplemental Information

None.

2.4 Command Line Configuration

2.4.1 Network Layer Configuration

To configure the network layer of the Abstract Cellular model, include the following parameters in the scenario configuration (.config) file:

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

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

Abstract Cellular Layer 3 Parameters

Table 2-1 describes the Abstract Cellular Layer 3 parameters specified in the scenario configuration (.config) file.

Table 2-2 describes the base station configuration parameters.

Table 2-3 describes the switch center configuration parameters.

Table 2-4 describes the gateway configuration parameters.

Table 2-5 describes the aggregated node configuration parameters.

See Section 1.2.1.3 for a description of the format used for the parameter tables.

TABLE 2-1. Abstract Cellular Layer 3 Parameters

Parameter	Value	Description
CELLULAR-ABSTRACT-OPTIMIZATION-LEVEL *Optional* *Scope:* Global	List: • MEDIUM • LOW *Default:* LOW	Specifies the optimization level of the model.
CELLULAR-NODE-TYPE *Optional* *Scope:* Global, Node	List: • CELLULAR-MS • CELLULAR-BS • CELLULAR-SC • CELLULAR-GATEWAY • CELLULAR-AGGREGATED-NODE *Default:* CELLULAR-MS	Specifies the cellular node type. The possible node types are: • CELLULAR-MS: Node is a mobile station. There are no additional configuration parameters for a mobile station. • CELLULAR-BS: Node is a base station, a combination of BTS and BSC. The configuration parameters for a base station are listed in Table 2-2. • CELLULAR-SC: Node is a switch center or hub. The configuration parameters for a switch center are listed in Table 2-3. • CELLULAR-GATEWAY: Node is a gateway that connects switch centers with Public Data networks and Public Switched Telephone Networks (represented by aggregated nodes in the Abstract cellular model). The configuration parameters for a gateway are listed in Table 2-4. • CELLULAR-AGGREGATED-NODE: Node is an aggregated node which emulates the services originated or destined to nodes outside the simulated area. The configuration parameters for an aggregated node are listed in Table 2-5.
CELLULAR-ABSTRACT-MOVEMENT-THRESHOLD *Optional* *Scope:* Global	Real *Range:* ≥ 0.0 *Default:* 0.0 *Unit:* meters	Distance that a MS moves before the signal measurement is updated. This parameter is used only if CELLULAR-ABSTRACT-OPTIMIZATION-LEVEL is set to MEDIUM.
CELLULAR-STATISTICS *Optional* *Scope:* Global, Node	List: • YES • NO *Default:* YES	Enables abstract cellular statistics.

Table 2-2 describes the base station configuration parameters. These parameters are applicable only if CELLULAR-NODE-TYPE is set to CELLULAR-BS.

TABLE 2-2. Base Station Parameters

Parameter	Value	Description
CELLULAR-BS-CELL-ID *Optional* *Scope:* Global, Node	Integer *Range:* ≥ 0 *Default:* see description	Cell ID. This is the identifier for the cell cover by the BS and it is unique in each location area. **Note:** The default value is the node ID.
CELLULAR-BS-LAC *Optional* *Scope:* Global, Node	Integer *Range:* ≥ 0 *Default:* see description	Location area code in which the BS is located. Each location area in a cellular system has its unique location area code. An MS could be covered by multiple BSs. These BSs may belong to different location areas at the same time. The LAC and cell ID information can be used to determine which MSC and BS the MS attaches to. **Note:** The default value is the node ID.
CELLULAR-ABSTRACT-BS-CONTROL-CHANNEL-UPLINK *Optional* *Scope:* Global, Node	Integer or string *Range:* ≥ 0 (if channel index is used) *Default:* 0	Name or index of the uplink control channel.
CELLULAR-ABSTRACT-BS-CONTROL-CHANNEL-DOWNLINK *Optional* *Scope:* Global, Node	Integer or string *Range:* ≥ 0 (if channel index is used) *Default:* 0	Name or index of the downlink control channel.
CELLULAR-ABSTRACT-BS-NUMBER-SECTOR *Optional* *Scope:* Global, Node	Integer *Range:* > 0 *Default:* 6	Number of sectors in the cell.
ABSTRACT-CELLULAR-BS-SECTOR-BANDWIDTH *Optional* *Scope:* Global, Node *Instances:* sector index	Integer *Range:* > 0 *Default:* 1000 *Unit:* kbps	Bandwidth allocated to the sector. There should be one instance of this parameter for each sector of the cell.

TABLE 2-2. Base Station Parameters (Continued)

Parameter	Value	Description
CELLULAR-ABSTRACT-BS-SERVICE *Optional* *Scope:* Global, Node	List: • {DATA} • {DATA,VOICE} • {VOICE} *Default:* {DATA,VOICE}	Services available at the BS.
CELLULAR-ABSTRACT-BS-CONTROL-INFORMATION-INTERVAL *Optional* *Scope:* Global, Node	Time *Range:* > 0S *Default:* 20MS	Control information broadcast interval. This is the interval at which the control channel periodically broadcasts the location and other system information of the BS.
CELLULAR-BS-ASSOCIATE-SC *Required* *Scope:* Global, Node	Integer *Range:* ≥ 0	Node ID of the associated switch center.

Table 2-3 describes the switch center configuration parameters. These parameters are applicable only if CELLULAR-NODE-TYPE is set to CELLULAR-SC.

TABLE 2-3. Switch Center Parameters

Parameter	Values	Description
CELLULAR-SC-LAC-LIST *Required* *Scope:* Global, Node	Node-list	List of LACs belonging to the switch center. The LAC list helps the gateway and HLR to route calls. An SC can contain multiple LACs and in one LAC there could be multiple BSs. But a LAC can belong to only one SC.
CELLULAR-SC-CONTROL-BS *Required* *Scope:* Global, Node	Node-list	List of BSs controlled by the switch center.
CELLULAR-SC-CONNECT-GATEWAY *Required* *Scope:* Global, Node	Integer *Range:* ≥ 0	Node ID of the gateway connected to the switch center.

Table 2-4 describes the gateway configuration parameters. These parameters are applicable only if CELLULAR-NODE-TYPE is set to CELLULAR-GATWAY.

TABLE 2-4. Gateway Parameters

Parameter	Value	Description
CELLULAR-GATEWAY-CONNECT-SC *Required* *Scope:* Global, Node	Node-list	List of SCs connected to the gateway.
CELLULAR-GATEWAY-CONNECT-AGGREGATED-NODE *Required* *Scope:* Global, Node	Integer *Range:* ≥ 0	Node ID of the aggregated node connected to the gateway.

Table 2-5 describes the aggregated node configuration parameters. These parameters are applicable only if CELLULAR-NODE-TYPE is set to CELLULAR-AGGREGATED-NODE.

TABLE 2-5. Aggregated Node

Parameter	Value	Description
CELLULAR-AGGREGATED-NODE-CONNECT-GATEWAY *Required* *Scope:* Global, Node	Integer *Range:* ≥ 0	Node ID of the gateway connected to the aggregated node.

2.4.2 MAC Layer Configuration

To configure the MAC layer of the Abstract Cellular model, include the following parameters in the scenario configuration (.config) file:

```
[<Qualifier>] MAC-PROTOCOL CELLULAR-MAC
[<Qualifier>] CELLULAR-MAC-PROTOCOL ABSTRACT-MAC
```

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

There are no additional parameters for configuring the MAC layer of the Abstract Cellular model.

2.4.3 Physical Layer Configuration

The Abstract Cellular model uses Abstract PHY as the physical layer model. To configure the Abstract PHY model, include the following parameters in the scenario configuration (.config) file:

```
[<Qualifier>] PHY-MODEL PHY-ABSTRACT
```

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

See *Wireless Model Library* for details of configuring the Abstract PHY model.

2.4.4 Abstract Cellular Application Configuration

Application Configuration File Parameters

To configure the Abstract Cellular application, include the following statement in the application configuration (.app) file:

```
CELLULAR-ABSTRACT-APP <Source> <Destination> <Start Time> <Duration>
                      <Service Type> <Required Bandwidth>
```

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

The Abstract Cellular application parameters are described in Table 2-6. See Section 1.2.1.3 for a description of the format used for the parameter table.

TABLE 2-6. Abstract Cellular Application Parameters

Parameter	Value	Description
`<Source>` *Required*	Integer *Range:* ≥ `0`	Node ID of the calling node. This should be a MS or Aggregate node.
`<Destination>` *Required*	Integer *Range:* ≥ `0`	Node ID of the called node. This should be a MS or Aggregate node.
`<Start Time>` *Required*	Time *Range:* > `0S`	Start time of the call.
`<Duration>` *Required*	Time *Range:* > `0S`	Duration of the call.

TABLE 2-6. Abstract Cellular Application Parameters (Continued)

Parameter	Value	Description
<Service Type> *Optional*	List: • VOICE • VIDEOPHONE • TEXT-MAIL • PICTURE-MAIL • ANIMATION-MAIL • WEB *Default:* VOICE	Service type.
<Required Bandwidth> *Required*	Real *Range:* > 0.0 *Unit:* kbps	Bandwidth required for service.

Scenario Configuration File Parameters

Table 2-7 describes the Abstract Cellular application parameters that can be specified in the scenario configuration (.config) file.

TABLE 2-7. Abstract Cellular Application Scenario Configuration File Parameters

Parameter	Value	Description
APPLICATION-STATISTICS *Optional* *Scope:* Global, Node	List: • YES • NO *Default:* NO	Indicates whether statistics collection is enabled for applications (including the Abstract Cellular application). **Note:** To collect statistics for the Abstract Cellular application set either APPLICATION-STATISTICS or CELLULAR-STATISTICS or both to YES.
CELLULAR-STATISTICS *Optional* *Scope:* Global, Node	List: • YES • NO *Default:* YES	Indicates whether statistics collection is enabled for abstract cellular models including the Abstract Cellular application). **Note:** To collect statistics for the Abstract Cellular application set either APPLICATION-STATISTICS or CELLULAR-STATISTICS or both to YES.

Examples of Parameter Usage

In the following example of Abstract Cellular application configuration, node 36 calls node 99 390 seconds after the simulation starts. The call is a voice call of duration 196 seconds and 13 kbps is reserved for the call.

```
CELLULAR-ABSTRACT-APP 36 99 390S 196S VOICE 13.000000
```

2.5 GUI Configuration

This section describes how to configure the Abstract Cellular model in the GUI.

2.5.1 Network Layer Configuration

To configure the Network layer of the Abstract Cellular Model, perform the following steps:

1. Go to **Default Device Properties Editor > Node Configuration > Network Layer**.
2. Set **Network Protocol** to *Cellular Layer3.*
3. Set **Cellular Layer3 Protocol** to *Abstract Cellular Layer3* and set the dependent parameters listed in Table 2-8.

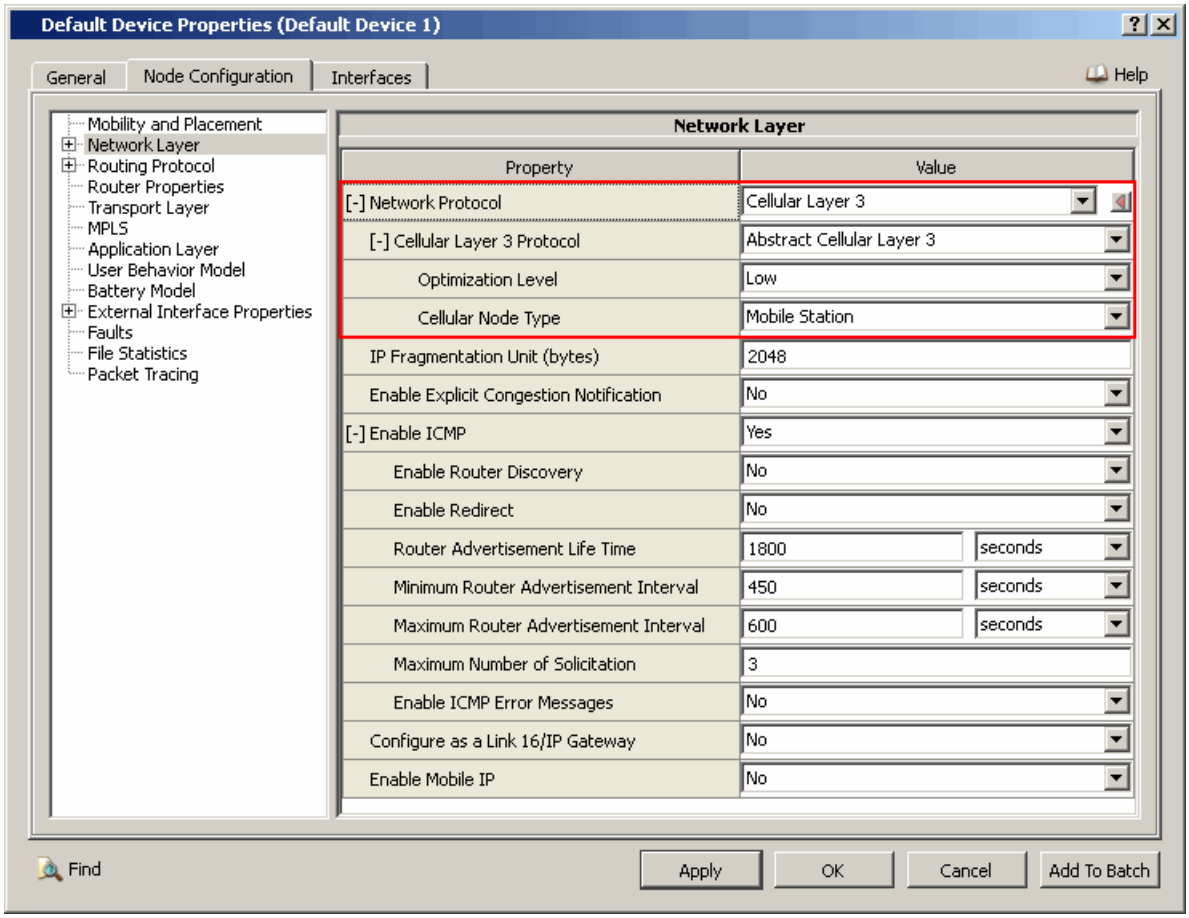

FIGURE 2-2. Setting Abstract Cellular Layer 3 Parameters

TABLE 2-8. Command Line Equivalent of Abstract Cellular Layer 3 Parameters

GUI Parameter	Scope of GUI Parameter	Command Line Parameter
Cellular Layer 3 Protocol	Node	CELLULAR-LAYER3-PROTOCOL
Optimization Level	Node	CELLULAR-ABSTRACT-OPTIMIZATION-LEVEL
Cellular Node Type	Node	CELLULAR-NODE-TYPE

4. If **Optimization Level** is set to *Medium*, then set the dependent parameters listed in Table 2-9.

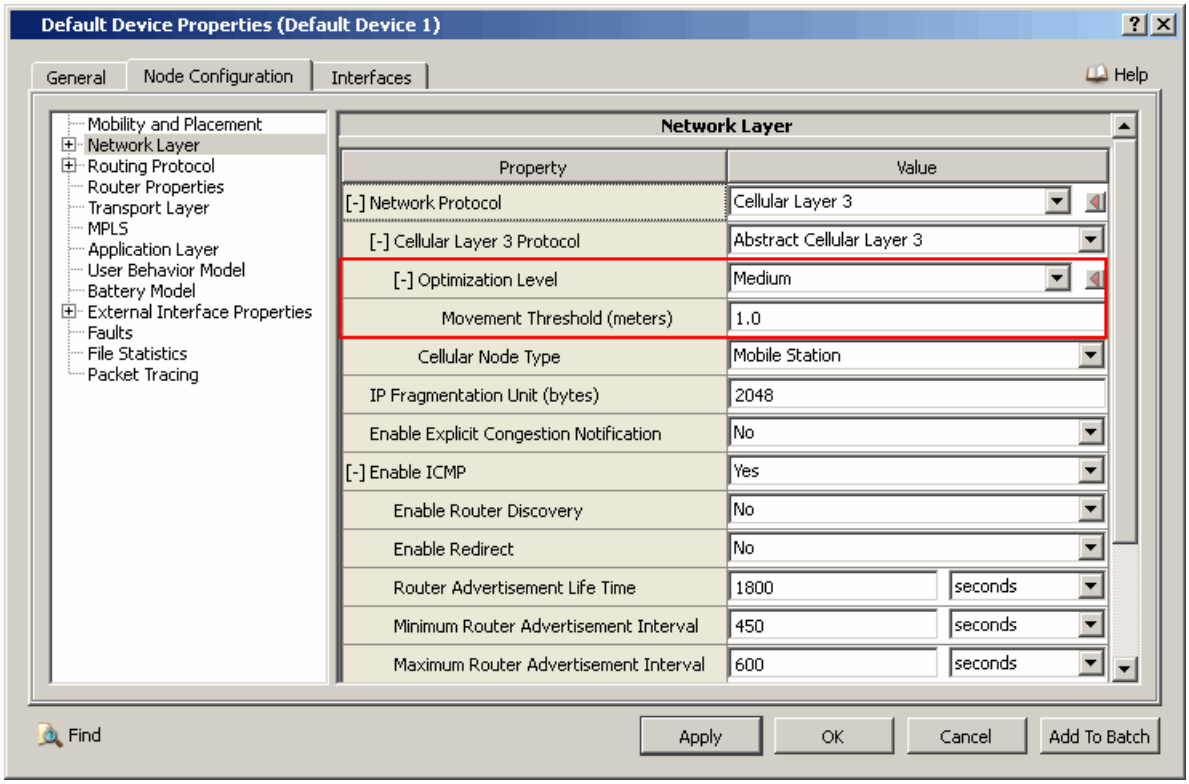

FIGURE 2-3. Setting Optimization Level

TABLE 2-9. Command Line Equivalent of Optimization Level Parameters

GUI Parameter	Scope of GUI Parameter	Command Line Parameter
Movement Threshold	Node	CELLULAR-ABSTRACT-MOVEMENT-THRESHOLD

5. If **Cellular Node Type** is set to *Base Station*, then set the parameters listed in Table 2-10.

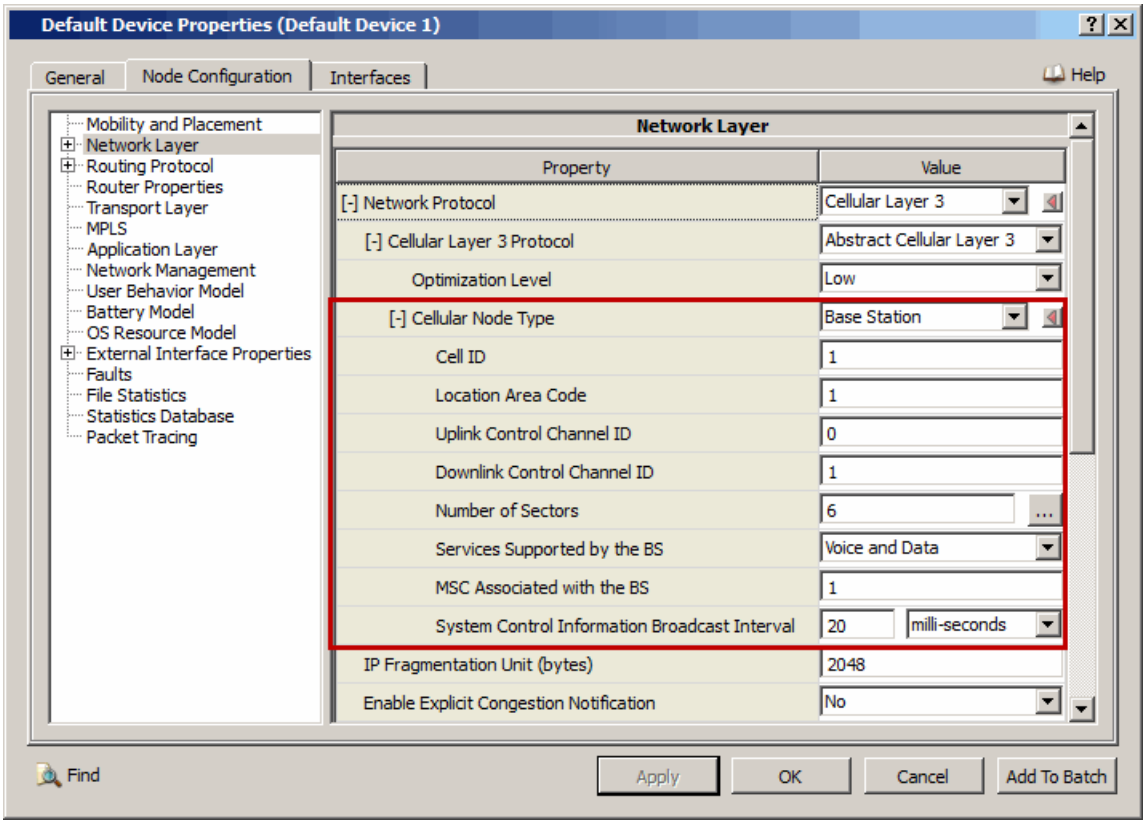

FIGURE 2-4. Setting Base Station Parameters

TABLE 2-10. Command Line Equivalent of Base Station Parameters

GUI Parameter	Scope of GUI Parameter	Command Line Parameter
Cell ID	Node	CELLULAR-BS-CELL-ID
Location Area Code	Node	CELLULAR-BS-LAC
Uplink Control Channel ID	Node	CELLULAR-ABSTRACT-BS-CONTROL-CHANNEL-UPLINK
Downlink Control Channel ID	Node	CELLULAR-ABSTRACT-BS-CONTROL-CHANNEL-DOWNLINK
Number of Sectors	Node	CELLULAR-ABSTRACT-BS-NUMBER-SECTOR
Services Supported by the BS	Node	CELLULAR-ABSTRACT-BS-SERVICE
MSC Associated with the BS	Node	CELLULAR-BS-ASSOCIATE-SC
System Control Information Broadcast Interval	Node	CELLULAR-ABSTRACT-BS-CONTROL-INFORMATION-INTERVAL

6. To configure the sector properties, do the following:

   a. Click the **Open Array Editor** ... button in the **Value** column for **Number of Sectors**. This opens the Array Editor (Figure 2-5).

   b. In the left panel of the Array Editor, select the index of the sector to be configured. In the right panel, set the parameters listed in Table 2-11 for the selected index.

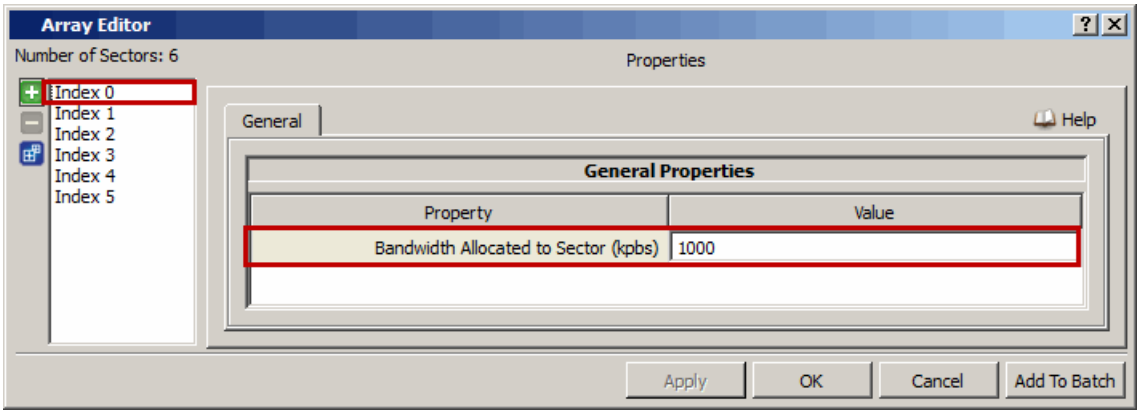

FIGURE 2-5. Setting Sector Parameters

TABLE 2-11. Command Line Equivalent of Sector Parameters

GUI Parameter	Scope of GUI Parameter	Command Line Parameter
Bandwidth Allocated to Sector	Node	ABSTRACT-CELLULAR-BS-SECTOR-BANDWIDTH

7. If **Cellular Node Type** is set to *Mobile Switch Center*, then set the parameters listed in Table 2-12.

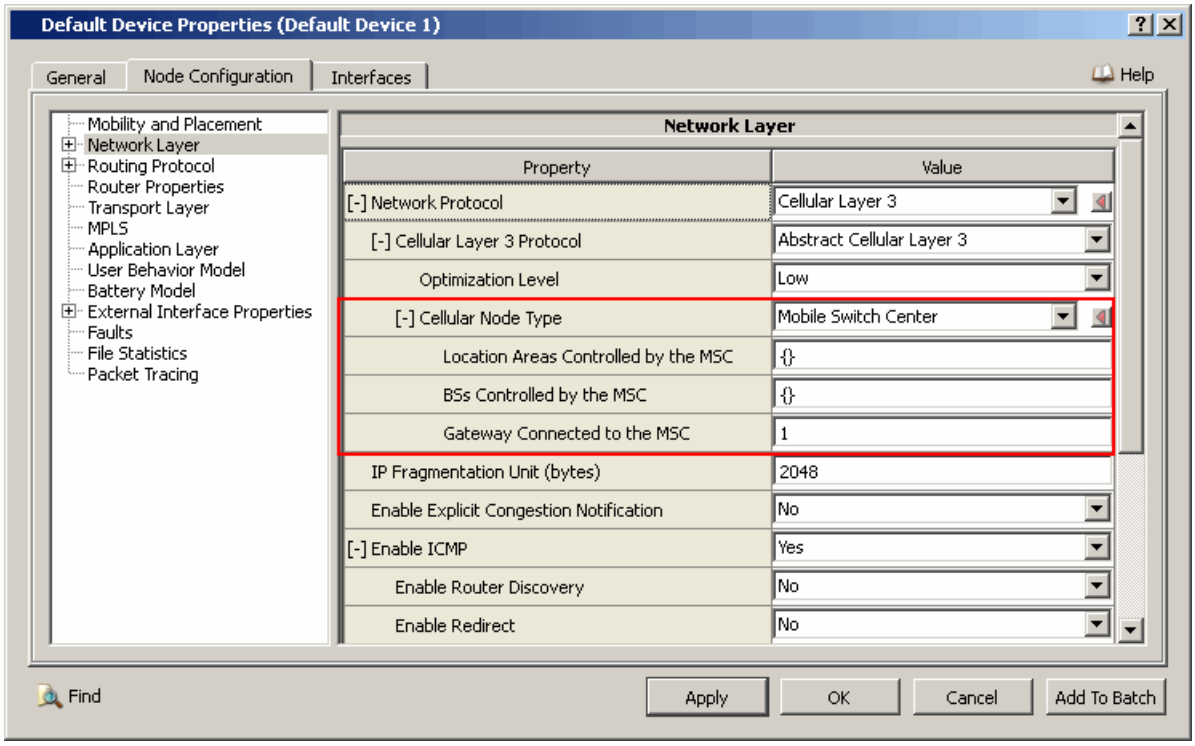

FIGURE 2-6. Setting MSC Parameters

TABLE 2-12. Command Line Equivalent of MSC Parameters

GUI Parameter	Scope of GUI Parameter	Command Line Parameter
Location Areas Controlled by the MSC	Node	CELLULAR-SC-LAC-LIST
BSs Controlled by the MSC	Node	CELLULAR-SC-CONTROL-BS
Gateway Connected to the MSC	Node	CELLULAR-SC-CONNECT-GATEWAY

8. If **Cellular Node Type** is set to *Gateway*, then set the parameters listed in Table 2-13.

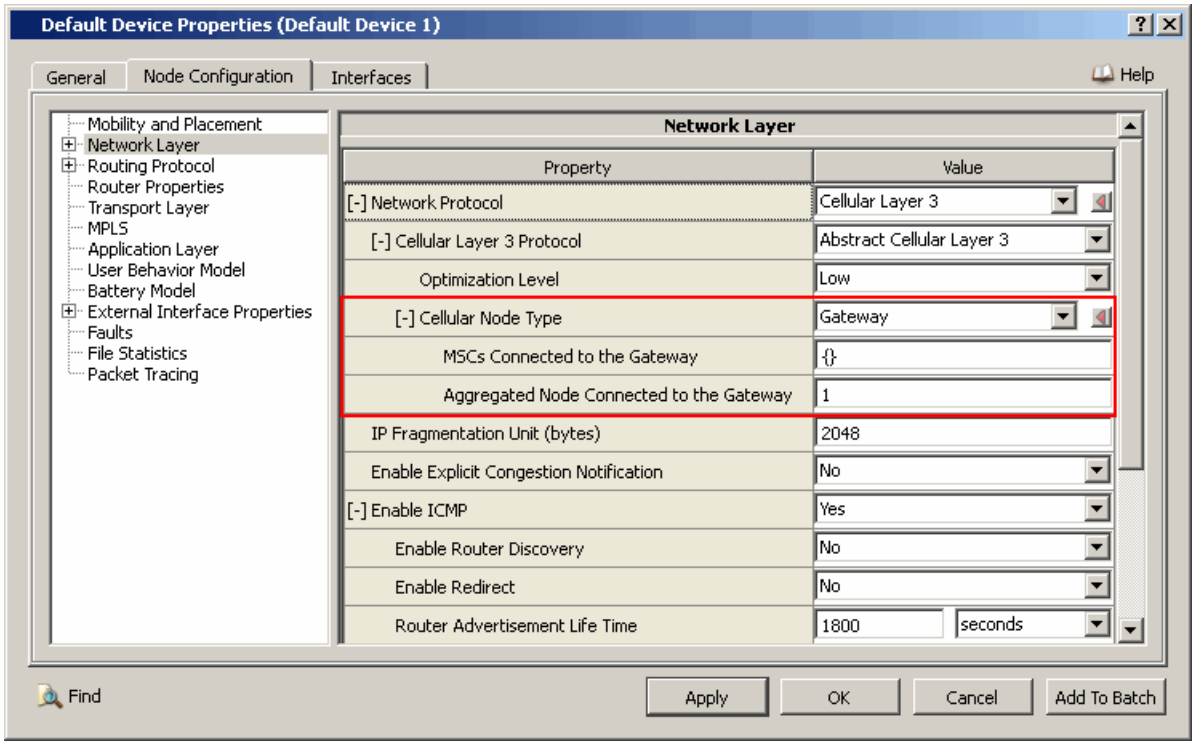

FIGURE 2-7. Setting Gateway Parameters

TABLE 2-13. Command Line Equivalent of Gateway Parameters

GUI Parameter	Scope of GUI Parameter	Command Line Parameter
MSCs Connected to the Gateway	Node	`CELLULAR-GATEWAY-CONNECT-SC`
Aggregated Node Connected to the Gateway	Node	`CELLULAR-GATEWAY-CONNECT-AGGREGATED-NODE`

9. If **Cellular Node Type** is set to *Aggregated Node*, then set the parameters listed in Table 2-14.

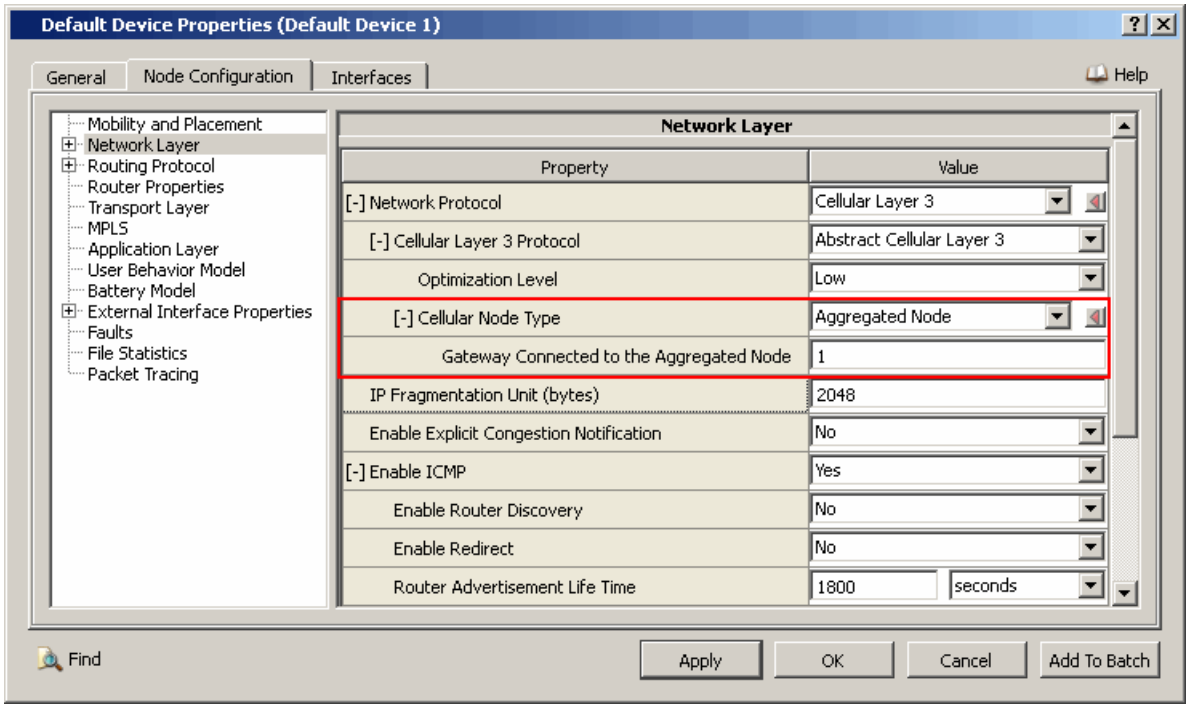

FIGURE 2-8. Setting Aggregated Node Parameters

TABLE 2-14. Command Line Equivalent of Aggregated Node Parameters

GUI Parameter	Scope of GUI Parameter	Command Line Parameter
Gateway Connected to the Aggregated Node	Node	CELLULAR-AGGREGATED-NODE-CONNECT-GATEWAY

2.5.2 MAC Layer Configuration

To configure the Abstract Cellular MAC parameters, perform the following steps:

1. Go to one of the following locations:

- To set properties for a specific subnet, go to **Wireless Subnet Properties Editor > MAC Layer**.
- To set properties a specific interface of a node, go to one of the following locations:
  - **Interface Properties Editor > Interfaces > Interface # > MAC Layer**.
  - **Default Device Properties Editor > Interfaces > Interface # > MAC Layer**.

In this section, we show how to configure the Abstract Cellular MAC parameters in the Wireless Subnet Properties Editor. Parameters can be set in the other properties editors in a similar way.

2. Set **MAC Protocol** to *Cellular MAC* and set the dependent parameters listed in Table 2-15.

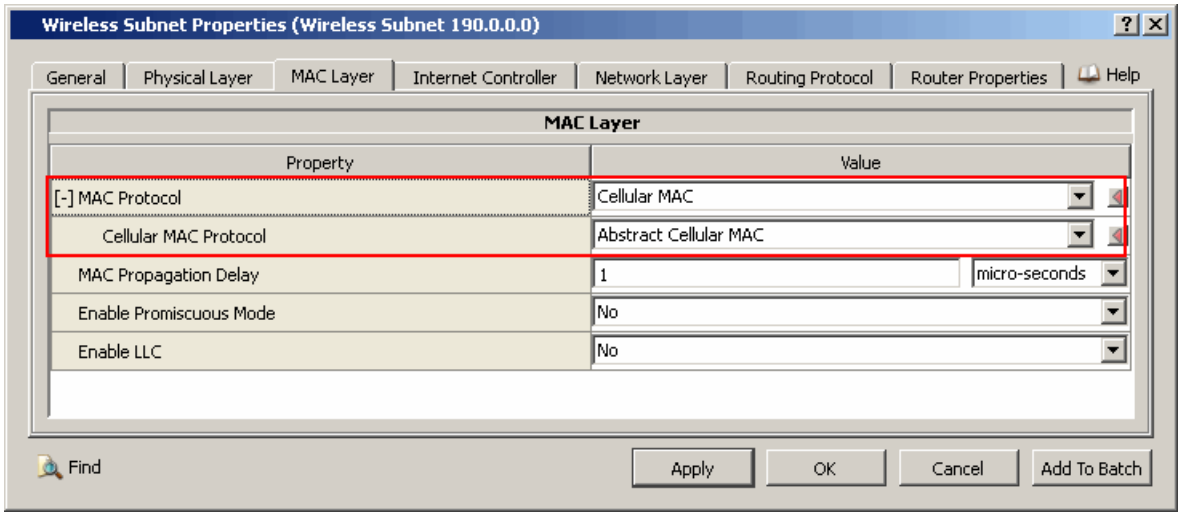

FIGURE 2-9. Configuring Abstract Cellular MAC Parameters

TABLE 2-15. Command Line Equivalent of Abstract Cellular MAC Parameters

GUI Parameter	Scope of GUI Parameter	Command Line Parameter
Cellular MAC Protocol	Subnet, Interface	CELLULAR-MAC-PROTOCOL

Setting Parameters

- Set **Cellular MAC Protocol** to *Abstract Cellular MAC*.

2.5.3 Physical Layer Configuration

The Abstract Cellular model uses Abstract PHY as the physical layer model. To configure the Abstract PHY model, perform the following steps:

1. Go to one of the following locations:
   - To set properties for a specific subnet, go to **Wireless Subnet Properties Editor > Physical Layer**.
   - To set properties a specific interface of a node, go to one of the following locations:
     - **Interface Properties Editor > Interfaces > Interface # > Physical Layer**.
     - **Default Device Properties Editor > Interfaces > Interface # > Physical Layer**.

   In this section, we show how to configure the Abstract PHY parameters in the Wireless Subnet Properties Editor. Parameters can be set in the other properties editors in a similar way.

2. Set **Radio Type** to *Abstract.* Refer to *Wireless Model Library* for setting the dependent parameters.

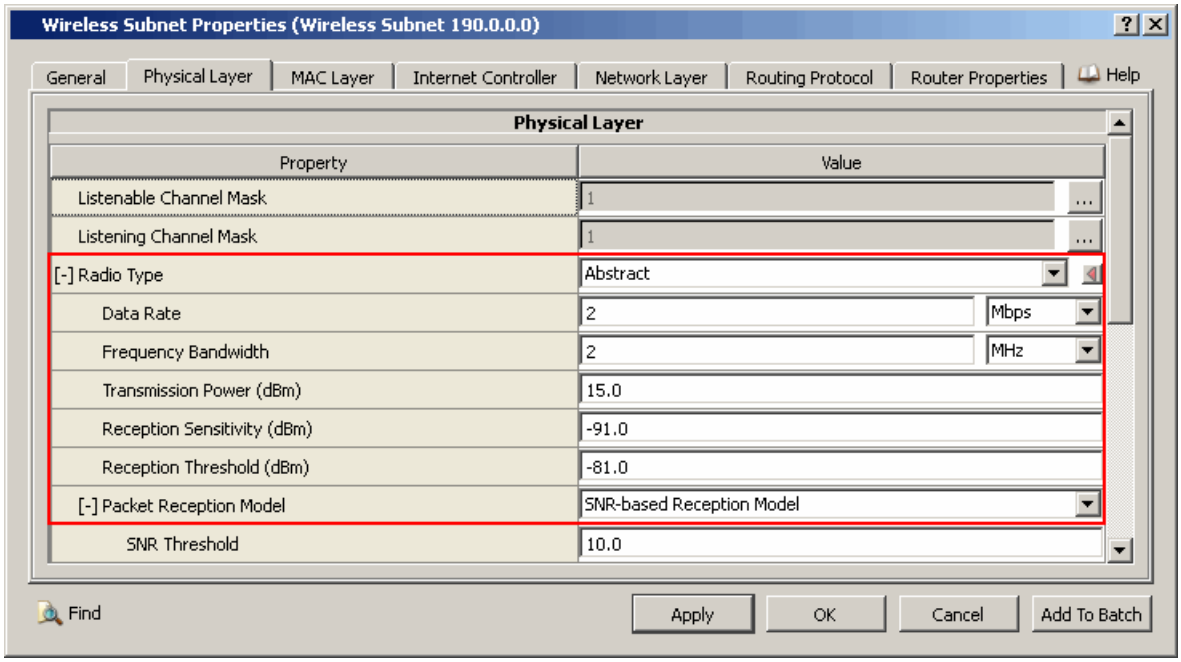

FIGURE 2-10. Configuring Abstract PHY Parameters

2.5.4 Abstract Cellular Application Configuration

To configure an Abstract Cellular application session, perform the following steps:

1. Click the **CELLULAR** button in the **Applications** tab of the Standard Toolset.
   - To set up an Abstract Cellular application 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 Abstract Cellular application session, on the canvas, double-click on the node. A symbol is displayed next to the node.
2. Open the Abstract Cellular Application 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 2-16.

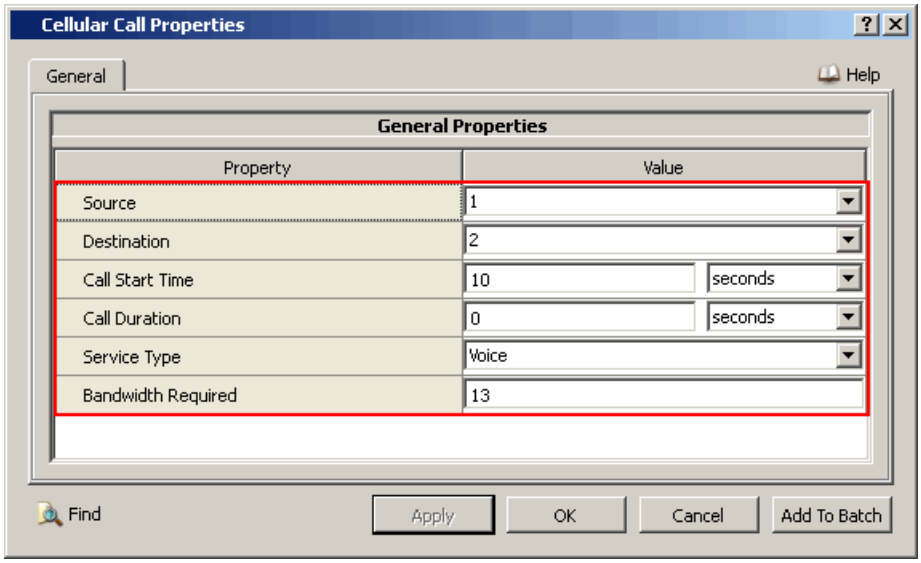

FIGURE 2-11. Setting Abstract Cellular Application Parameters

TABLE 2-16. Command Line Equivalent of Abstract Cellular Application Parameters

GUI Parameter	Command Line Parameter
Source	`<Source>`
Destination	`<Destination>`
Call Start Time	`<Start Time>`
Call Duration	`<Duration>`
Service Type	`<Service Type>`
Bandwidth Required	`<Required Bandwidth>`

Configuring Statistics Parameters

Statistics for applications (including Abstract Cellular Application) can be collected at the global and node levels. See Section 4.2.9 of *EXata User's Guide* for details of configuring statistics parameters.

To enable statistics collection for Abstract Cellular Application, check either the box labeled **Application** or the box labeled **Cellular** in the appropriate properties editor.

TABLE 2-17. Command Line Equivalent of Statistics Parameters

GUI Parameter	Scope of GUI Parameter	Command Line Parameter
Application	Global, Node	`APPLICATION-STATISTICS`
Cellular	Global, Node	`CELLULAR-STATISTICS`

2.6 Statistics

Table 2-18, Table 2-19, Table 2-20, Table 2-21, Table 2-22 and Table 2-23 lists the statistics collected for the Abstract Cellular model that are output to the statistics (.stat) file at the end of simulation. Table 2-24 lists the statistics collected for the Abstract Cellular Application.

Cellular Layer 3 Statistics

Tables 10 through 14 show the Cellular Layer 3 Statistics.

TABLE 2-18. Cellular Layer 3 Statistics - Mobile Station

Statistic	Description
General	
Number of system information received from BSs	Total number of system information messages received from BSs.
Number of measurement report received from MAC	Total number of measurement reports received from MAC.
Cell Selection/Reselection Attach/Detach	
Number of cell selection (attach) performed	Total number of cell selections (attached) performed.
Number of cell reselection performed	Total number of cell reselections performed.
Location Update	
Number of location update attempts made	Total number of location update attempts made.
Number of location update request sent to SC	Total number of location update requests sent to SC.
Average number of location update request Sent Per Attempt	Average number of location update requests sent per location update attempt.
Number of location update succeeded	Total number of location updates succeeded.
Number of location update request rejected	Total number of location update requests failed.
Number of location update failed	Total number of location updates failed.
Channel Request	
Number of channel request attempt made	Total number of channel request attempts made.
Number of channel requests sent	Total number of channel requests sent.
Number of immediate assignments received	Total number of immediate assignments received.
Number of immediate assignment rejection received	Total number of immediate assignment rejections received.
Number of channel requests succeeded	Total number of successful channel requests.
Number of channel requests failed	Total number of unsuccessful channel requests.
Average number of channel requests sent per attempt	Average number of channel requests sent per channel request attempt.
Average channel access delay	Average delay in accessing the channel.
CM Service	
Number of CM service requests sent	Total number of CM service requests sent.
Number of CM service requests accepted	Total number of CM service requests accepted.
Number of CM service requests rejected	Total number of CM service requests rejected.
Paging	
Number of page requests received	Total number of page requests received.

TABLE 2-18. Cellular Layer 3 Statistics - Mobile Station (Continued)

Statistic	Description
Number of page response sent	Total number of page responses sent.
Handover	
Number of handover required sent to BS	Total number of handovers required sent to BS.
Number of radio interface handover received from BS	Total number of radio interface handovers received from BS.
Number of radio interface handover complete sent to BS	Total number of radio interface handover complete messages sent to BS.
Number of handover required rejects received from BS	Total number of handover failures received from BS.
Call Management	
Number of voice call originated at MS	Total number of voice calls originated at MS.
Number of voice call terminated at MS	Total number of voice calls terminated at MS.
Number of data call originated at MS	Total number of data calls originated at MS.
Number of data call terminated at MS	Total number of data calls terminated at MS.
Network - Application	
Number of start call request received from application	Total number of start call request messages received from application.
Number of end call request received from application	Total number of end call request messages received from application.
Number of call reject messages sent to application	Total number of call reject messages sent to application.
Number of call dropped messages sent to application	Total number of call dropped messages sent to application.

TABLE 2-19. Cellular Layer 3 Statistics - Base Station

Statistic	Description
System Information	
Number of system information broadcasted	Total number system information messages broadcast.
Channel Request	
Number of channel request received from MS	Total number of channel requests received from MS.
Number of immediate assignment sent to MS	Total number of immediate assignments sent to MS.
Number of immediate assignment reject sent to MS	Total number immediate assignment rejects sent to MS.
CM Service	
Number of CM service reject by BS sent to MS (cause: unsupported service)	Total number of CM service rejects by BS sent to MS (cause: unsupported service).
Page	
Number of paging messages received from SC	Total number of paging messages received from SC.
Number of page request sent to MS	Total number of page requests sent to MS.
Number of page response received from MS	Total number of page responses received from MS.
Handover	
Number of MS initiated handover required messages received from MS	Total number of MS initiated handover required messages received from MS.

TABLE 2-19. Cellular Layer 3 Statistics - Base Station (Continued)

Statistic	Description
Number of MS initiated handover required forward to SC	Total number of MS initiated handover required messages forwarded to SC.
Number of handover request received from SC	Total number of handover requests received from SC.
Number of handover request acknowledgement sent to SC	Total number of handover request acknowledgements sent to SC.
Number of handover failure sent to SC	Total number handover commands received from SC.
Number of MS initiated handover required reject received from SC	Total number of MS initiated handover required rejects received from SC.
Number of MS initiated handover required reject forward to MS	Total number of MS initiated handover required rejects forwarded to MS.
Number of handover command received from SC	Total number handover commands received from SC.
Number of radio interface handover command sent to MS	Total number of radio interface handover commands sent to MS.
Number of radio interface handover complete received from MS	Total number of radio interface handover complete messages received from MS.
Number of handover complete sent to SC	Total number of handover complete messages received sent to SC.

TABLE 2-20. Cellular Layer 3 Statistics - Switch Center

Statistic	Description
Location Update	
Number of location update requests received	Total number of location update requests received.
Number of location update accept sent	Total number of location update acceptances sent.
Number of location update rejects sent	Total number of location update rejections sent.
Number of MAPD update location sent to HLR	Total number of MAPD update locations sent to HLR.
Number of MAPD cancel location received from HLR	Total number of MAPD cancel locations received from HLR.
CM Service	
Number of CM service requests received	Total number of CM service requests received.
Number of CM service accept sent	Total number of CM service acceptances sent.
Page	
Number of paging sent to BS	Total number of paging messages sent to BS.
Number of page response received	Total number of paging responses received.
Handovers	
Number of handover required received	Total number of handover requireds' received.
Number of intraCell (InterSector) handover required received	Total number of intraCell (InterSector) handover requireds received.
Number of interCell-intraSC handover required received	Total number of interCell-intraSC handover requireds received.
Number of interSC handover required received	Total number of interSC handover requireds received.
Number of handover request sent to BS	Total number of handover requests sent to BS.
Number of handover request acknowledgement received from BS	Total number of handover request acknowledgements received from BS.

TABLE 2-20. Cellular Layer 3 Statistics - Switch Center (Continued)

Statistic	Description
Number of handover request failure received from BS	Total number of handover request failures received from BS.
Number of handover required reject sent to BS.	Total number of handover required rejects sent to BS.
Number of handover command sent to BS	Total number of handover commands sent to BS.
Number of handover complete received from BS	Total number of handover complete messages received from BS.

TABLE 2-21. Cellular Layer 3 Statistics - Gateway

Statistic	Description
Location Update	
Number of MAPD update location received from VLR	Total number of MAPD update location received from VLR.
Number of MAPD cancel location sent to VLR	Total number of MAPD cancel location sent to VLR.
Call Management	
Number of interSc MO-MT voice calls handled	Total number of interSC MO-MT voice calls handled.
Number of interSc MO-MT data calls handled	Total number of interSC MO-MT data calls handled.
Number of MS to aggregated node voice calls handled	Total number of MS to aggregated node voice calls handled.
Number of MS to aggregated node data calls handled	Total number of MS to aggregated node data calls handled.
Number of aggregated node to MS voice calls handled	Total number of aggregated node to MS voice calls handled.
Number of aggregated node to MS data calls handled	Total number of aggregated node to MS data calls handled.

TABLE 2-22. Cellular Layer 3 Statistics - Aggregated Node

Statistic	Description
Call Management	
Number of aggregated node to MS voice call initiated	Total number of aggregated node to MS voice calls initiated.
Number of MS to aggregated node voice call received	Total number of MS to aggregated node voice calls received.
Number of aggregated node to MS data call initiated	Total number of aggregated node to MS data calls initiated.
Number of MS to aggregated node data call received	Total number of MS to aggregated node data calls received.
Network-Application	
Number of start call request received from application	Total number of start call requests received from application.

TABLE 2-22. Cellular Layer 3 Statistics - Aggregated Node (Continued)

Statistic	Description
Number of end call request received from application	Total number of end call requests received from application.
Number of call reject messages sent to application	Total number of call reject messages sent to application.
Number of call dropped messages sent to application	Total number of call dropped messages sent to application.

MAC Layer Statistics

Table 2-23 shows the MAC Layer Statistics.

TABLE 2-23. MAC Layer Statistics

Statistic	Description
Number of packets sent on downlink control channel	Total number of packets sent on downlink control channel, only meaningful at base stations.
Number of packets received on downlink control channel	Total number of packets received on downlink control channel, only meaningful at mobile stations.
Number of packets sent on uplink control channel	Total number of packets transmitted on uplink control channel, only meaningful at mobile stations.
Number of packets received on uplink control channel	Total number of packets received on uplink control channel, only meaningful at base stations.
Number of packets sent on TCH	Total number of packets transmitted on traffic channel.
Number of packets received on TCH	Total number of packets received on traffic channel.

Abstract Cellular Application Statistics

Table 2-24 lists the Abstract Cellular Application statistics.

TABLE 2-24. Abstract Cellular Application Statistics

Statistic	Description
Number of application requests sent to layer 3	Total number originating application requests sent to layer 3.
Number of application requests received	Total number of terminating application requests received from layer 3.
Number of application requests accepted	Total number of application requests accepted by the node.
Number of application requests rejected	Total number of application requests rejected.
Number of application requests rejected (cause: System Busy)	Total number of application requests rejected (cause: System Busy).
Number of application requests rejected (cause: Network not Found)	Total number of application requests rejected (cause: Network Not Found).
Number of application requests rejected (cause: Too Many Active App)	Total number of application requests rejected (cause: Too Many Active Applications).
Number of application requests rejected (cause: Unknown User)	Total number of application requests rejected (cause: Unknown User).
Number of application requests rejected (cause: User Power Off)	Total number of application requests rejected (cause: User Power Off).

TABLE 2-24. Abstract Cellular Application Statistics (Continued)

Statistic	Description
Number of application requests rejected (cause: User Busy)	Total number of application requests rejected (cause: User Busy).
Number of application requests rejected (cause: Unsupported Service)	Total number of application requests rejected (cause: Unsupported Service).
Number of application requests rejected (cause: User Unreachable)	Total number of application requests rejected (cause: User Unreachable)
Number of applications successfully end	Total number of applications successfully ended.
Number of origin applications successfully end	Total number of origin applications successfully ended.
Number of terminating applications successfully end	Total number of terminating applications successfully ended.
Total number of applications dropped	Total number of applications dropped.
Number of origin application dropped	Total number of originating applications dropped.
Number of origin applications dropped (cause: Handover Failure)	Total number of applications dropped (cause: Handover Failure).
Number of origin applications dropped (cause: Self PowerOff)	Total number of originating applications dropped (Cause: Self PowerOff).
Number of origin applications dropped (cause: Remote PowerOff)	Total number of originating applications dropped (Cause: Remote PowerOff).
Number of terminating applications dropped	Total number of terminating applications dropped.
Number of terminating applications dropped (cause: Handover Failure)	Total number of terminating applications dropped (Cause: Handover Failure).
Number of terminating applications dropped (cause: Self PowerOff)	Total number of terminating applications dropped (Cause: Self PowerOff).
Number of terminating applications dropped (cause: Remote PowerOff)	Total number of terminating applications dropped (Cause: Remote PowerOff).

2.7 Sample Scenario

2.7.1 Scenario Description

The sample scenario consists of 10 MSs, 1 BS, 1 SC, 1 Gateway and 1 Aggregated Node deployed in an area of 1500m *1500m.

In this scenario, 10 MSs communicate with 1 BS via a radio interface, and BS connects to the SC, the SC connects to the gateway, and the gateway connects to the aggregated node, all via wired links.

2.7.2 Command Line Configuration

The network deployment or planning also includes the allocation of physical radio channels. Here we assume each BS needs a pair radio channels with different frequency to function as downlink and uplink control channel, respectively. Thus, 2 radio channels need to be defined as follows.

```
PROPAGATION-CHANNEL-FREQUENCY[0] 890.0e6
PROPAGATION-CHANNEL-FREQUENCY[1] 935.0e6
```

Here, only the channel frequency and the channel index are defined, and other channel-related parameters are omitted. See *EXata User's Guide* to choose the appropriate options for other parameters such propagation limit, propagation loss mode, fading mode, and listenable and listening channels.

Basic Cellular Node Properties

- Node type

```
[1 thru 10] CELLULAR-NODE-TYPE    CELLULAR-MS
[11] CELLULAR-NODE-TYPE           CELLULAR-BS
[12] CELLULAR-NODE-TYPE           CELLULAR-SC
[13] CELLULAR-NODE-TYPE           CELLULAR-GATEWAY
[14] CELLULAR-NODE-TYPE           CELLULAR-AGGREGATED-NODE
```

- Protocols

  For the Network layer, choose CELLULAR-LAYER3 as the network protocol and ABSTRACT-LAYER3 as the underlying cellular layer3 protocol.

```
NETWORK-PROTOCOL CELLULAR-LAYER3
CELLULAR-LAYER3-PROTOCOL ABSTRACT-LAYER3
```

  For the MAC layer, choose CELLULAR-MAC as MAC protocol and ABSTRACT-MAC as the underlying cellular MAC protocol.

```
MAC-PROTOCOL CELLULAR-MAC
CELLULAR-MAC-PROTOCOL ABSTRACT-MAC
```

  For the PHY layer, only PHY-ABSTRACT is supported. Refer to the *EXata User's Guide* for more detail on the usage of PHY-ABSTRACT model.

- Optimization level: When the optimization level is medium, some of the control messages such as system information, are abstracted out. To enable this optimization, configure the following parameters:

```
CELLULAR-ABSTRACT-OPTIMIZATION-LEVEL MEDIUM
```

  Only LOW and MEDIUM are supported at this time. The LOW option disables the optimization, while the MEDIUM option enables optimization.

```
CELLULAR-ABSTRACT-MOVEMENT-THRESHOLD 1.0
```

  These parameters specify how long a distance MS moves to report a signal measurement when optimization is used.

- Statistics: You can specify whether to collect the simulation statistics related to the Abstract Cellular model.

```
CELLULAR-STATISTICS YES
```

Node Properties for Base Station

- Cell ID: Each BS has a cell ID, which is unique in a location area.

```
[11] CELLULAR-BS-CELL-ID 1
```

- Location Area Code: Each BS belongs to a certain area which is indexed by the location's area code. In one location area, there may be multiple BSs.

```
[11] CELLULAR-BS-LAC 1
```

  In this example, only one BS is in each location area.
- Control channels

```
[11] CELLULAR-ABSTRACT-BS-CONTROL-CHANNEL-UPLINK 0
[11] CELLULAR-ABSTRACT-BS-CONTROL-CHANNEL-DOWNLINK 1
```

- Number of sectors: In this example, each BS is divided into 6 sectors.

```
[11] CELLULAR-ABSTRACT-BS-NUMBER-SECTOR 6
```

- Bandwidth allocation

```
[1] ABSTRACT-CELLULAR-BS-SECTOR-BANDWIDTH[1] 1000
```

- Services supported at each BS

```
[1] CELLULAR-ABSTRACT-BS-SERVICE VOICE
```

- Control information broadcast interval

```
[1] CELLULAR-ABSTRACT-BS-CONTROL-INFORMATION-INTERVAL 30
```

- BS control policy

```
[11] CELLULAR-ABSTRACT-BS-ADMISSION-CONTROL-POLICY THRESHOLD-BASED
[11] CELLULAR-ABSTRACT-BS-CONGESTION-CONTROL-POLICY PROBABILISTIC
```

Node Properties for Switch Center

- Location Area Code list: Each SC may control over multiple location area, and this information is kept in the location area list to help SC route information flow between BSs possibly belonging to different location area.

```
[512] CELLULAR-SC-LAC-LIST {1}
```

Interconnection Between Cellular Nodes

Information about the interconnection relationship between cellular nodes is used to facilitate routing.

- Interconnection between BS and SC

```
[12] CELLULAR-SC-CONTROL-BS {11}
[11] CELLULAR-BS-ASSOCIATE-SC 12
```

- Interconnection between SC and Gateway Node

```
[12] CELLULAR-SC-CONNECT-GATEWAY 13
[13] CELLULAR-GATEWAY-CONNECT-SC {12}
```

- Interconnection between Gateway and Aggregated Node.

```
[13] CELLULAR-GATEWAY-CONNECT-AGGREGATED-NODE 14
[14] CELLULAR-AGGREGATED-NODE-CONNECT-GATEWAY 13
```

Configure the Cellular Applications

The Application Configuration file is specified as follows:

```
APP-CONFIG-FILE ./app1.app
```

Include the following lines in the Application Configuration file:

```
CELLULAR-ABSTRACT-APP 1 8 51S 176S VIDEO-PHONE 160.000000
CELLULAR-ABSTRACT-APP 3 9 390S 196S VOICE 13.000000
CELLULAR-ABSTRACT-APP 5 3 270S 30S ANIMATION-MAIL 112.000000
```

2.7.3 GUI Configuration

1. Place 14 nodes and a wireless subnet on the canvas.
2. Select all nodes, go to **Default Device Properties Editor > Node Configuration > Network Layer**.
   a. Set **Network Protocol** as *Cellular Layer3*.
   b. Set the cellular node types as follows:
      i. For nodes 1-10, set **Cellular Node Type** to *MS* and set all the dependent parameters as shown in Figure 2-2.
      ii. For node 11, set **Cellular Node Type** to *BS* and set all the dependent parameters as shown in Figure 2-4.
      iii. For node 12, set **Cellular Node Type** to *MSC* and set all the dependent parameters as shown in Figure 2-6.
      iv. For node 13, set **Cellular Node Type** to *Gateway* and set all the dependent parameters as shown in Figure 2-7.
      v. For node 14, set **Cellular Node Type** to *Aggregated Node* and set all the dependent parameters as shown in Figure 2-8.
3. Connect all mobile stations and the base station to the wireless subnet.
4. Connect the BS to SC, SC to Gateway and Gateway to Aggregated node through wired links.
5. Go to **Wireless Subnet Properties > Physical Layer** and set **Radio Type** to *Abstract* as shown in Figure 2-10.
6. Go to **Wireless Subnet Properties > MAC Layer a**nd set **MAC Protocol** *[=Cellular MAC]* **> Cellular MAC Protocol** to *Abstract Cellular MAC* as shown Figure 2-11.
7. Select the Cellular Abstract Application from the Applications tab. Configure the application between node 1 and node 8, node3 and node 9, node 5 and node 3 and set the application properties as shown in Figure 2-12. Set the properties for Cellular Abstract application as follows:

   Between 1 and 8: Call Start time - 51S
   Call Duration - 176S
   Service Type - VIDEO-PHONE
   Bandwidth - 160.000000

Between 3 and 9: Call Start time - 390S
Call Duration - 196S
Service Type - VOICE
Bandwidth - 13.000000

Between 5 and 3: Call Start time - 270S
Call Duration - 30S
Service Type – ANIMATION-MAIL
Bandwidth - 112.000000

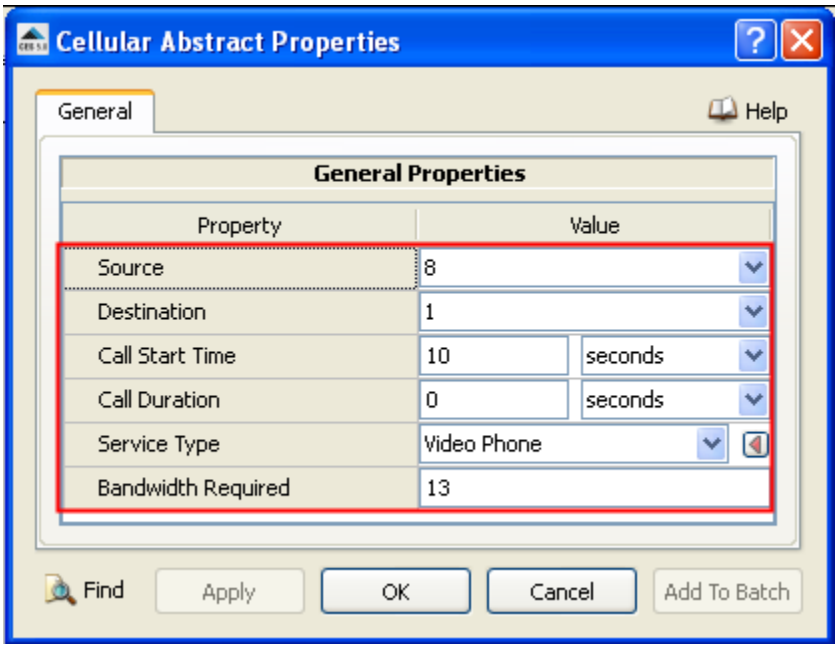

FIGURE 2-12. Setting Cellular Abstract Application Properties

2.8 Scenarios Included in EXata

The EXata distribution includes several sample scenarios for the Abstract Cellular model. All scenarios are located in the directory EXATA_HOME/scenarios/cellular/AbstractCellular. Table 2-25 lists the sub-directory where each scenario is located.

TABLE 2-25. Abstract Cellular Model Scenarios Included in EXata

Scenario	Description
CACThreshold	Shows the example of successful Threshold based Call Admission Control Policy, i.e. for every M channel requests, N channels should be rejected.
CallSetUp	Shows the example of successful Call Set Up and Call Tear down in the Abstract Cellular Model.
CellSelection	Shows the example of Power Off when a MS is in the middle of Call Set Up or Call Termination and/or is also undergoing Handover.

TABLE 2-25. Abstract Cellular Model Scenarios Included in EXata (Continued)

Scenario	Description
ChannelAllocationc	Shows the example of allocation and release procedures of channels in the Abstract Cellular Model.
Congestion	Shows the example of successful Round Robin Congestion Control in the Abstract Cellular Model.
InterCellHO	Shows the example of how a successful Inter Cell Hand Over in the Abstract Cellular Model is done.
IntraCellHO	Shows the example of successful Intra Cell Hand Over in the Abstract Cellular Model and to test if VLR/ HLR operation are done in case of intra cell HO.
LocationUpdate	Shows how Normal Location Update and Periodic Location Update take place in the Abstract Cellular Model, and to test the VLR/ HLR operations in case of mobility to a different location area.
PDP	Shows the example of a scenario running multiple applications simultaneously originating and terminating from different MS and of various types of supported services (VIDEO-PHONE, ANIMATION-MAIL, VOICE, WEB, PICTURE-MAIL, TEXT-MAIL) and thus check PDP activation and deactivation.

2.9 References

1. "The GSM System for Mobile Communications", Michel Mouly and Marie-Bernadette Pautet, Telecom Publishing, June 1, 1992.
2. GSM 05.08, “Radio subsystem link control.”
3. GSM 05.02, “Multiplexing and multiple access on the radio path.”
4. GSM 04.08, “Mobile radio interface Layer 3 specification; Core network protocols.”
5. GSM 04.07, “Mobile radio interface signaling layer 3.”
6. GSM 03.03, “Numbering, Addressing and Identification.”

3 Global System for Mobile Communications (GSM) Model

3.1 Description

The GSM model in EXata models the behavior of Mobile Stations (MSs), Base Stations (BSs), and Mobile Switching Centers (MSCs), and the “Um” (BS-to-MS) and “A” (BS-to-MSC) interfaces. The MSs can be located anywhere and can be mobile. The BSs and MSC are stationary. The GSM model allows multiple MSs, multiple BSs, and a single MSC in any scenario. Each BS is connected to the MSC by a wired point-to-point link.

3.2 Features and Assumptions

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

3.2.1 Implemented Features

- Configuration of MSC, multiple Base Stations, and multiple Mobile Stations
- Standard band is supported (900 MHz Mobile Stations and Base Stations)
- Cell selection and re-selection
- Dynamic channel assignment and release
- Location update
- Call setup and tear-down
- Handover (intra-MSC and inter-cell/Base Station).

3.2.2 Omitted Features

- Roaming

3.2.3 Assumptions and Limitations

- There can be only one MSC in a scenario.
- The paging broadcast packet is transmitted only in the BS in which the terminating MS is currently present.
- Value of C2 Cell Reselection parameter is assumed to be 2.0 dB.
- After every call completion, the cell selection and location update procedures are initiated for the originating as well as terminating MS.
- A call request destined to a MS that is busy is dropped.
- Only the GSM Call (see Section 3.4.2) application is supported for the GSM model.

3.3 Supplemental Information

None.

3.4 Command Line Configuration

This section describes how to configure a GSM scenario in command line. Section 3.4.1 describes how to configure a GSM network. Section 3.4.2 describes how to configure the GSM Call application.

3.4.1 Configuring GSM Network

Configuring the Um Interface (MS-BS)

To configure the Um Interface, define the radio channels and channel allocation used in the simulation and specify the GSM-related Physical layer properties.

- Channel Frequencies: As per the GSM standards, uplink channels (MS transmitting, BS receiving) should be in the frequency range 890 - 915 MHz and downlink channels (BS transmitting, MS receiving) should be in the frequency range 935 - 960 MHz. Each uplink/downlink channel pair is assigned frequencies as follows:

  Downlink Frequency = (890 + 0.2 n) MHz, 0 < n < 124

  Uplink Frequency = Downlink Frequency + 45 MHz

  Refer to *EXata User's Guide* for details of configuring channel frequencies.
- Control Channels: Each BS is assigned a set of channels (in pairs). One pair is for downlink and uplink control channels. The remaining channels are assigned as traffic channels to MSs. See Table 3-1.
- Listenable Channels: The list of listenable channels for each BS and MS should include all the channels so that all BSs and MSs can potentially listen to all channels.

  Refer to *EXata User's Guide* for details of configuring listenable and listening channels.
- PHY and MAC Properties: The Physical and MAC layer parameters are described in Table 3-1.

Configuring the A Interface (BS-MSC)

Each BS is connected to the MSC by a wired point-to-point link. In a GSM scenario, routing should be configured to allow packets to be transferred between a BS and MSC over the point-to-point link

connecting them. This can be done by means of static routes or any suitable wired routing protocol (such as Bellman Ford).

Topology Configuration

The details of the scenario topology need to be specified. This is done in the GSM Configuration file (see Section 3.4.1.1). For each BS, the GSM Configuration file specifies its Location Area Code (LAC), the channels assigned to it, the ID of the MSC, and information about the neighbor BSs. For each MSC, the GSM Configuration file specifies the BSs connected to it.

Enabling GSM Model

To enable the GSM model at a node, include the following parameter in the scenario configuration (.config) file:

```
[<Qualifier>] NETWORK-PROTOCOL     GSM-LAYER3
```

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

GSM Parameters

Table 3-1 lists the GSM parameters specified in the scenario configuration (.config) file. See Section 1.2.1.3 for a description of the format used for the parameter table.

TABLE 3-1. GSM Parameters

Parameter	Value	Description
`GSM-NODE-TYPE` *Required* *Scope:* All	List: • `GSM-MS` • `GSM-BS` • `GSM-MSC`	GSM node type. `GSM-MS`: Mobile Station (MS) `GSM-BS`: Base Station (BS) `GSM-MSC`: Mobile Switching Center (MSC)
`GSM-HANDOVER-MARGIN` *Optional* *Scope:* All	Real *Unit:* dBm *Default:* `0.0`	Handover margin. This handover margin is used for selecting the target BS to perform handover. When selecting the neighbor BS to perform handover, a BS considers only those neighbor BSs with RSS larger than both the handover margin and the RSS of the current serving BS. **Note:** This parameter is used only if `GSM-NODE-TYPE` is set to `GSM-BS`.
`GSM-CONTROL-CHANNEL` *Optional* *Scope:* All	String (see note)	Downlink control channel (broadcast channel;) assigned to a BS. This parameter is specified as a channel index or channel name enclosed in `[` and `]`. *Example*: `[2] GSM-CONTROL-CHANNEL [0]` **Note:** This parameter is required if `GSM-NODE-TYPE` is set to `GSM-BS`.

TABLE 3-1. GSM Parameters (Continued)

Parameter	Value	Description
GSM-CONTROL-CHANNEL-LIST *Optional* *Scope:* All	String (see note)	Control channels used by MSs. This parameter is specified as a space-separated list of channel indices or channel names enclosed in [and]. *Example*: [3] GSM-CONTROL-CHANNEL-LIST [0 4] This list consists of all broadcast channels (because each MS can potentially listen to all broadcast channels). **Note:** This parameter is required if GSM-NODE-TYPE is set to GSM-MS.
MAC-PROTOCOL *Optional* *Scope:* All	List: • GSM	MAC protocol used at the interface. **Note:** This parameter must be specified for each Um interface.
PHY-MODEL *Optional* *Scope:* All	List: • PHY-GSM	Radio model used at the interface. **Note:** This parameter must be specified for each Um interface.
PHY-GSM-DATA-RATE *Optional* *Scope:* All	Integer *Unit:* bps *Default:* 270833	Data transmission rate. **Note:** This parameter is applicable only to each Um interface.
PHY-GSM-TX-POWER *Optional* *Scope:* All	Real *Unit:* dBm *Default:* 15.0	Radio's transmission power. **Note:** This parameter is applicable only to each Um interface.
PHY-GSM-RX-SENSITIVITY *Optional* *Scope:* All	Real *Unit:* dBm *Default:* -91.0	Reception sensitivity for the radio. **Note:** This parameter is applicable only to each Um interface.
PHY-GSM-RX-THRESHOLD *Optional* *Scope:* All	Real *Unit:* dBm *Default:* -92.0	Minimum reception threshold to accept a packet. **Note:** This parameter is applicable only to each Um interface.
PHY-RX-MODEL *Required* *Scope:* All	List: • BER-BASED	Packet reception model. Refer to *Wireless Model Library* for details of the BER-based reception model. **Note:** This parameter must be specified for each BS and MS.

TABLE 3-1. GSM Parameters (Continued)

Parameter	Value	Description
GSM-NODE-CONFIG-FILE *Required* *Scope:* Global	Filename	Name of the GSM Configuration file. The GSM Configuration file describes the GSM configuration parameters for each node. The format of the GSM Configuration file is described in Section 3.4.1.1.
GSM-STATISTICS *Optional* *Scope:* Global, Node	List: • YES • NO *Default:* NO	Enables GSM statistics.

3.4.1.1 Format of the GSM Node Configuration File

The GSM node configuration file defines the GSM layer 3 properties of mobile stations, base stations, and mobile switching centers.

The GSM node configuration file can have three types of entries:

- GSM Mobile Station Specification
- GSM Base Station Specification
- GSM Mobile Switching Center Specification

The GSM Mobile Station Specification has the following format:

```
GSM-MS <NodeId>
```

where

`<Node ID>` Node ID of the mobile station.

Examples of Mobile Station Specification are:

```
GSM-MS 1
GSM-MS 25
```

The GSM Base Station Specification has the following format (all parameters are entered on the same line):

```
GSM-BS <Node ID> <LAC> <Cell ID> <Channel Range> <MSC Node ID>
       <Neighbor BS Info>
```

where

`<Node ID>` Node ID of the base station.

`<LAC>` Location area code in which the BS is located.

Each location area in a cellular system has its unique location area code.

`<Cell ID>` Identifier for the cell cover by the BS. It is unique within each location area.

`<Channel Range>` Range of channels allocated to the base station.

The range is specified in the following format:

```
<lowest index>-<highest index>
```

where

`<lowest index>`: Lowest channel index allocated to the base station

`<highest index>`: Highest channel index allocated to the base station

Channels are allocated in (downlink, uplink) pairs. The first pair is used for control channels. The remaining pairs are used as traffic channels.

`<MSC Node ID>` Node ID of the mobile switching center to which the base station is connected.

`<Neighbor BS Info>` Information about the neighboring base stations.

This is specified as a space-separated list of one to six triads in the following format:

```
<Control Channel>-<LAC>-<Cell ID>
```

where

`<Control Channel>`: Index of the downlink control channel used by the neighbor base station

`<LAC>`: Location area code of the neighbor base station

`<Cell ID>`: Cell ID of the neighbor base station

Note: Triads are separated by spaces. There are no spaces within a triad.

Examples of Base Station Specification are:

```
GSM-BS 7 1 1 0-3 9 4-1-2
GSM-BS 8 1 2 4-7 9 0-1-1
```

The GSM Mobile Switching Center Specification has the following format:

```
GSM-MSC <Node ID> <Linked BS Info>
```

where

`<Node ID>` Node ID of the mobile switching center.

`<Linked BS Info>` Information about the base stations connected to the MSC.

This is specified as a space-separated list of one or more triads in the following format:

```
<BS Node ID>-<LAC>-<Cell ID>
```

where

`<BS Node ID>`: Node ID of the base station

`<LAC>`: Location area code of the base station

`<Cell ID>`: Cell ID of the base station

Note: Triads are separated by spaces. There are no spaces within a triad.

Examples of Mobile Switching Center Specification are:

```
GSM-MSC 9  7-1-1 8-1-2
GSM-MSC 10 9-1-1 10-1-2
```

3.4.2 GSM Call Application Configuration

Application Configuration File Parameters

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

```
GSM <Source> <Destination> <Start Time> <Duration>
```

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

The GSM Call application parameters are described in Table 3-2. See Section 1.2.1.3 for a description of the format used for the parameter table.

TABLE 3-2. GSM Call Parameters

Parameter	Value	Description
`<Source>` *Required*	Integer *Range:* ≥ 0	Node ID of the calling node. The calling node should be a mobile station.
`<Destination>` *Required*	Integer *Range:* ≥ 0	Node ID of the called node. The called node should be a mobile station.

TABLE 3-2. GSM Call Parameters (Continued)

Parameter	Value	Description
<Start Time> *Required*	Time *Range:* > 0S	Start time of the call.
<Duration> *Required*	Time *Range:* > 0S	Duration of the call.

Scenario Configuration File Parameters

Table 3-3 describes the Abstract Cellular application parameters that can be specified in the scenario configuration (.config) file.

TABLE 3-3. GSM Call Scenario Configuration File Parameters

Parameter	Value	Description
APPLICATION-STATISTICS *Optional* *Scope:* Global, Node	List: • YES • NO *Default:* NO	Indicates whether statistics collection is enabled for applications (including the GSM Call application). **Note:** To collect statistics for the GSM Call application set either APPLICATION-STATISTICS or CELLULAR-STATISTICS or both to YES.
CELLULAR-STATISTICS *Optional* *Scope:* Global, Node	List: • YES • NO *Default:* YES	Indicates whether statistics collection is enabled for abstract cellular models including the GSM Call application). **Note:** To collect statistics for the GSM Call application set either APPLICATION-STATISTICS or CELLULAR-STATISTICS or both to YES.

Examples of Parameter Usage

In the following example of GSM Call application configuration, node 20 calls node 25 400 seconds after the simulation starts. The call duration is 200 seconds.

```
GSM 20 25 400S 200S
```

3.5 GUI Configuration

This section describes how to configure a GSM scenario in command line. Section 3.5.1 describes how to configure a GSM network. Section 3.5.2 describes how to configure the GSM Call application.

3.5.1 Configuring GSM Network

Configuring the Um Interface (MS-BS)

To configure the Um Interface, define the radio channels and channel allocation used in the simulation and specify the GSM-related Physical layer properties. See Section 3.4.1 for details. Refer to *EXata User's Guide* for details of configuring channel frequencies and listenable and listening channels in the GUI.

Configuring the A Interface (BS-MSC)

Each BS is connected to the MSC by a wired point-to-point link. In a GSM scenario, routing should be configured to allow packets to be transferred between a BS and MSC over the point-to-point link connecting them. This can be done by means of static routes or any suitable wired routing protocol (such as Bellman Ford).

Refer to *EXata User's Guide* for details of configuring routing protocols in the GUI.

Topology Configuration

The details of the scenario topology need to be specified. For each BS, the GSM Configuration file specifies its Location Area Code (LAC), the channels assigned to it, the ID of the MSC, and information about the neighbor BSs. For each MSC, the GSM Configuration file specifies the BSs connected to it.

The topology can be specified by importing a GSM Configuration file (see Section 3.4.1.1) or specifying topology parameters in the properties editors, as described in the following steps.

Configuring Network Layer

To configure Network Layer parameters, perform the following steps:

1. Go to one of the following locations:
   - To set properties for a specific node, go to **Default Device Properties Editor > Node Configuration > Network Layer**.
   - To set properties for a subnet, go to **Wireless Subnet > Network Layer > General**.
   - To set properties for a specific interface of a node, go to one of the following locations:
     - **Interface Properties Editor > Interfaces > Interface # > Network Layer**.
     - **Default Device Properties Editor > Interfaces > Interface # > Network Layer**.

   In this section, we show how to configure the parameters for a specific node using the Default Device Properties Editor. Parameters can be set in the other properties editors in a similar way.

2. Set **Network Protocol** to *GSM Layer3* and set the dependent parameters listed in Table 3-4.

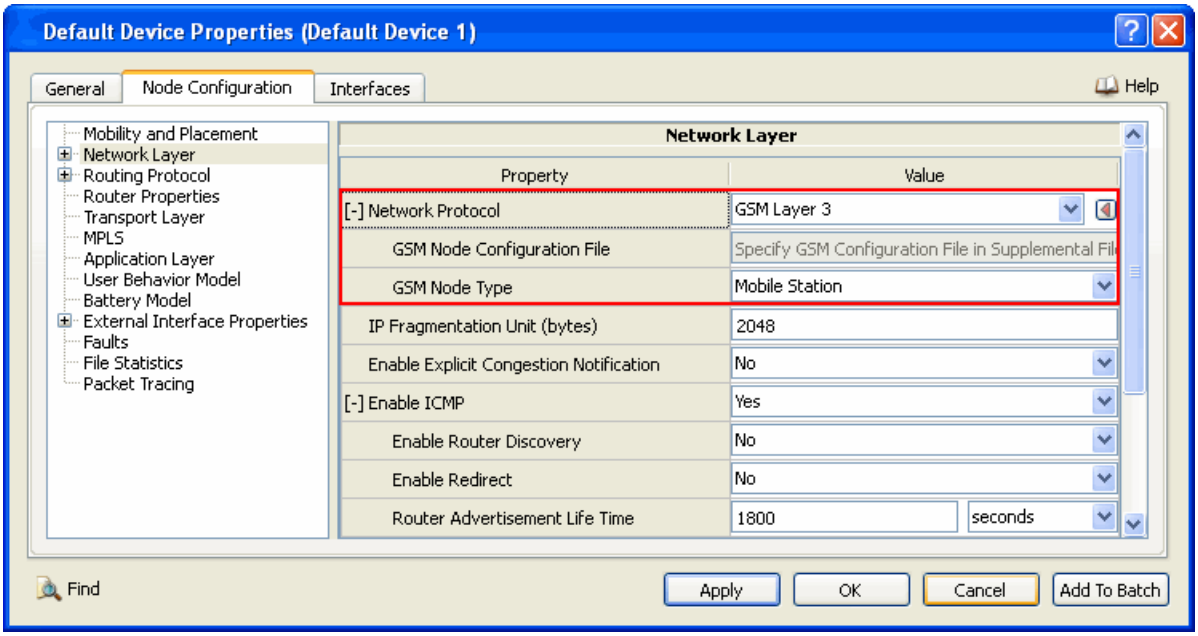

FIGURE 3-1. Setting GSM Node Type

TABLE 3-4. Command Line Equivalent of GSM Node Type Parameters

GUI Parameter	Scope of GUI Parameter	Command Line Parameter
GSM Node Type	Node, Subnet, Interface	`GSM-NODE-TYPE`

3. If **GSM Node Type** is set to *Base Station*, then set the dependent parameters listed in Table 3-5.

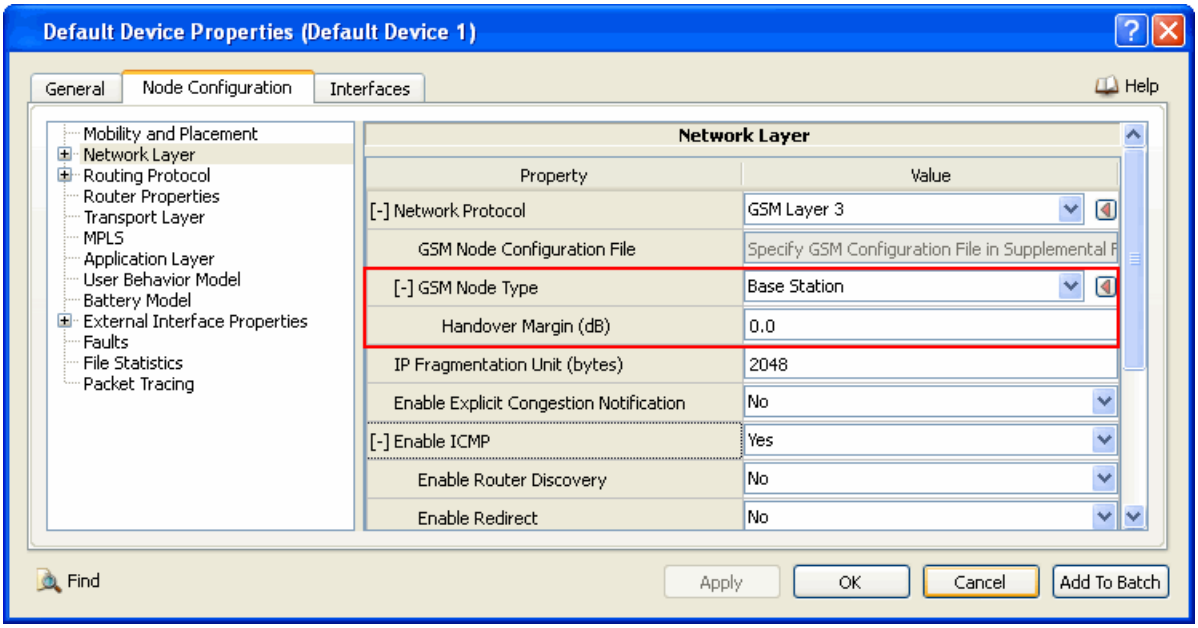

FIGURE 3-2. Setting GSM BS Parameters

TABLE 3-5. Command Line Equivalent of GSM BS Parameters

GUI Parameter	Scope of GUI Parameter	Command Line Parameter
Handover Margin	Node, Subnet, Interface	`GSM-HANDOVER-MARGIN`

Note: You may need to press **Apply** for the dependent parameters to be displayed.

Configuring MAC Layer

To configure the MAC Layer parameters, perform the following steps:

1. Go to one of the following locations:
   - To set properties for a subnet, go to **Wireless Subnet > MAC Layer**.
   - To set properties for a specific interface of a node, go to one of the following locations:
     - **Interface Properties Editor > Interfaces > Interface # > MAC Layer**.
     - **Default Device Properties Editor > Interfaces > Interface # > MAC Layer**.

   In this section, we show how to configure the parameters for a specific node using the Default Device Properties Editor. Parameters can be set in the other properties editors in a similar way.

2. Set **MAC Protocol** to *GSM* and set the dependent parameters for the node type.

Note: After setting the node type in the **Default Device Properties Editor > Node Configuration** tab, you may need to press **Apply** for the appropriate dependent parameters to be displayed in the **Default Device Properties Editor > Interfaces** tab

a. If **GSM Node Type** is set to *Mobile Station* in the **Default Device Properties Editor > Node Configuration** tab, then set the dependent parameters listed in Table 3-6.

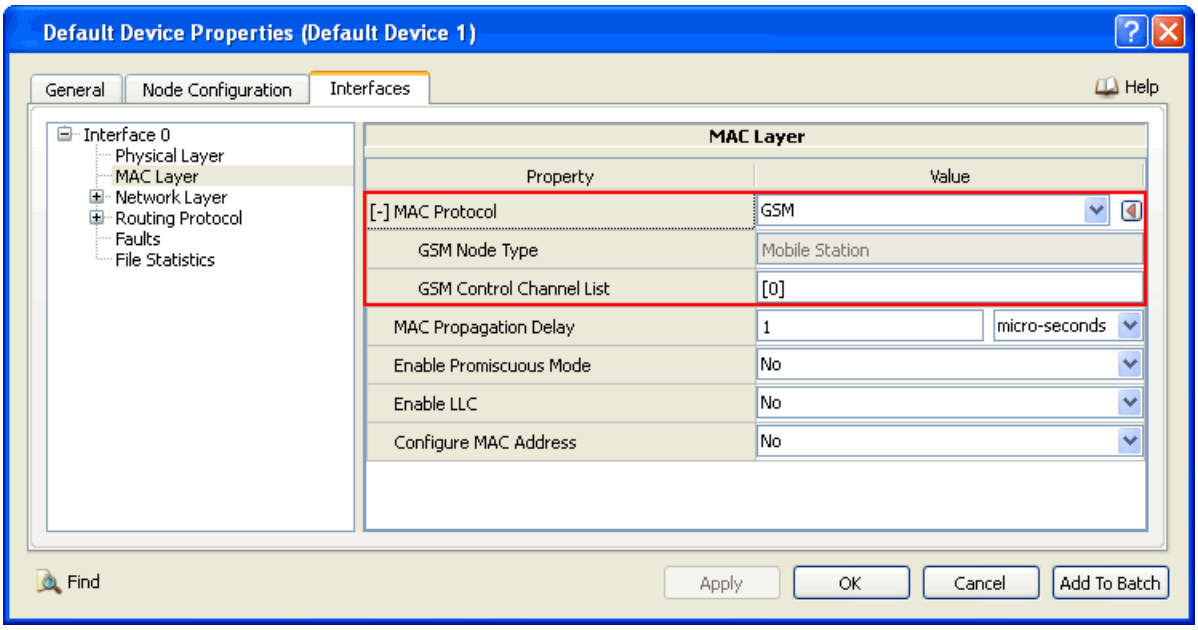

FIGURE 3-3. Setting GSM MS MAC Parameters

TABLE 3-6. Command Line Equivalent of GSM MS MAC Parameters

GUI Parameter	Scope of GUI Parameter	Command Line Parameter
GSM Control Channel List	Interface, Subnet	GSM-CONTROL-CHANNEL-LIST

b. If **GSM Node Type** is set to *Base Station* in the **Default Device Properties Editor > Node Configuration** tab, then set the dependent parameters listed in Table 3-7.

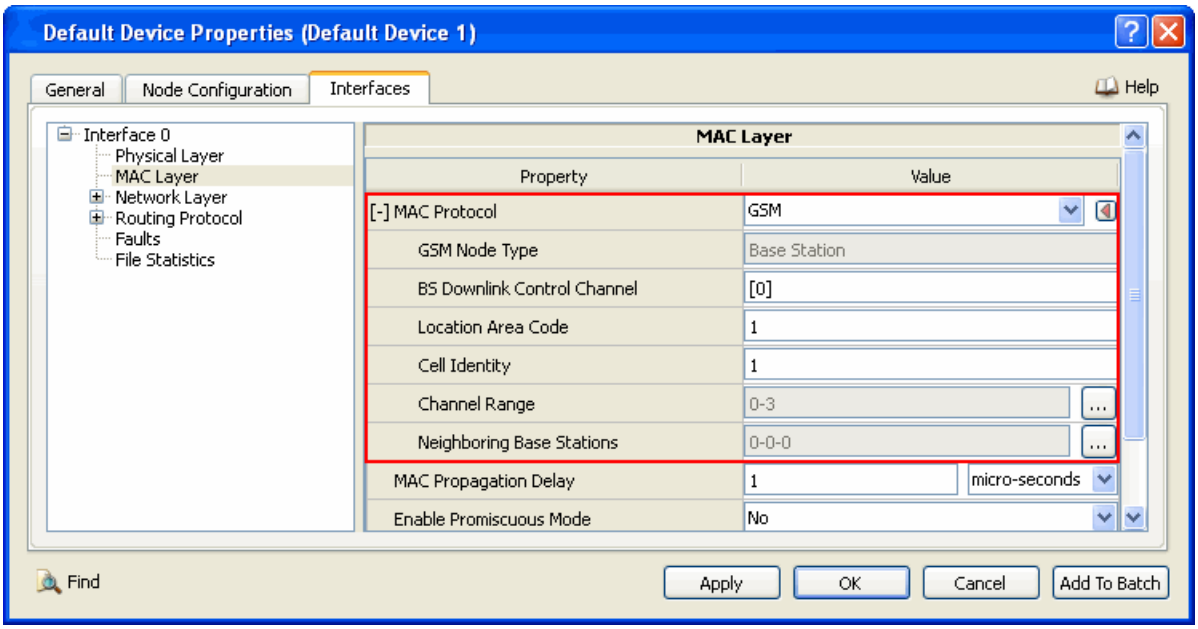

FIGURE 3-4. Setting GSM BS MAC Parameters

TABLE 3-7. Command Line Equivalent of GSM BS MAC Parameters

GUI Parameter	Scope of GUI Parameter	Command Line Parameter
BS Downlink Control Channel	Interface, Subnet	`GSM-CONTROL-CHANNEL`

Setting Parameters

- **Location Area Code**, **Cell Identity**, **Channel Range**, and **Neighboring Base Stations** correspond to entries in the GSM Configuration file (see Section 3.4.1.1).

TABLE 3-8. Command Line Equivalent of BS Topology Parameters

GUI Parameter	Command Line Parameter
Location Area Code	`<LAC>`
Cell Identity	`<Cell ID>`
Channel Range	`<Channel Range>`
Neighboring Base Stations	`<Neighbor BS Info>`

- To configure **Channel Range**, click on the **Open Editor** button in the **Value** column. This opens the Channel Range Editor.

FIGURE 3-5. Channel Range Editor

- To configure **Neighboring Base Stations**, click on the **Open Editor** button in the **Value** column. This opens the Neighboring Base Stations Editor.

FIGURE 3-6. Neighboring Base Stations Editor

Configuring Physical Layer

To configure the Physical Layer parameters, perform the following steps:

1. Go to one of the following locations:
   - To set properties for a subnet, go to **Wireless Subnet > Physical Layer**.
   - To set properties for a specific interface of a node, go to one of the following locations:
     - **Interface Properties Editor > Interfaces > Interface # > Physical Layer**.
     - **Default Device Properties Editor > Interfaces > Interface # > Physical Layer**.

   In this section, we show how to configure the parameters for a specific node using the Default Device Properties Editor. Parameters can be set in the other properties editors in a similar way.

2. Set **Radio Type** to *GSM* and set the dependent parameters listed in Table 3-9.

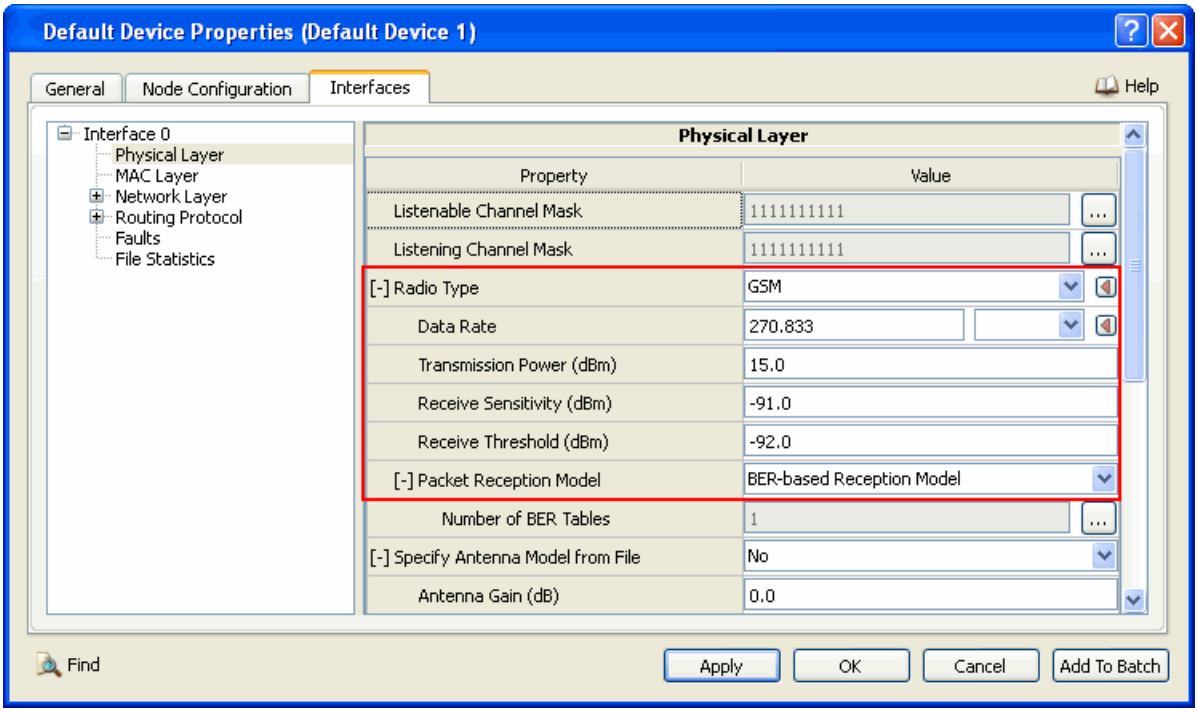

FIGURE 3-7. Setting GSM Physical Layer Parameters

TABLE 3-9. Command Line Equivalent of GSM Physical Layer Parameters

GUI Parameter	Scope of GUI Parameter	Command Line Parameter
Data Rate	Interface, Subnet	PHY-GSM-DATA-RATE
Transmission Power	Interface, Subnet	PHY-GSM-TX-POWER
Receive Sensitivity	Interface, Subnet	PHY-GSM-RX-SENSITIVITY
Receive Threshold	Interface, Subnet	PHY-GSM-RX-THRESHOLD
Packet Reception Model	Interface, Subnet	PHY-RX-MODEL

Setting Parameters

- Configure the parameters for the BER-based Reception Model. Refer to *Wireless Model Library* for details.

Importing the GSM Configuration File

To import a GSM Configuration file, perform the following steps:

1. Go to **Scenario Properties Editor > Supplemental Files**.
2. Set **GSM Node Configuration File** to the name of the GSM Configuration file. SeeSection 3.4.1.1 for the format of this file.

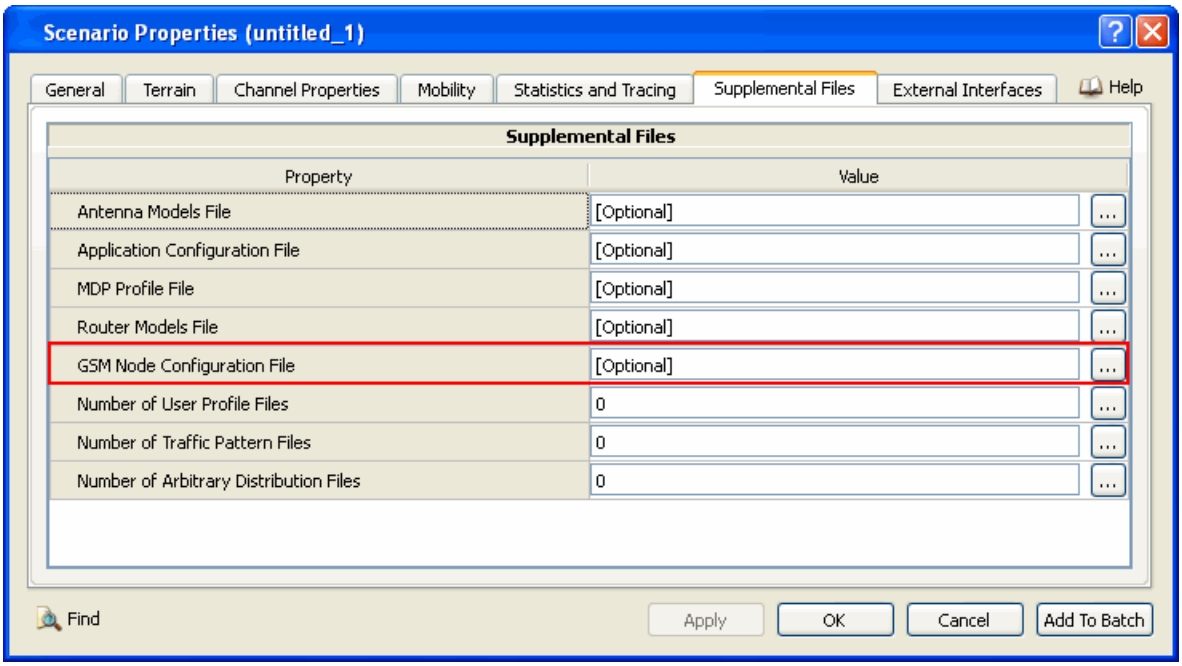

FIGURE 3-8. Importing the GSM Configuration File

TABLE 3-10. Command Line Equivalent of GSM Configuration File Parameters

GUI Parameter	Scope of GUI Parameter	Command Line Parameter
GSM Node Configuration File	Global	`GSM-NODE-CONFIG-FILE`

3.5.2 GSM Call Application Configuration

To configure a GSM Call application session, perform the following steps:

1. Click the **GSM** button in the **Applications** tab of the Standard Toolset.
   - To set up a GSM 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 GSM Call session, on the canvas, double-click on the node. A symbol is displayed next to the node.
2. Open the GSM 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 3-11.

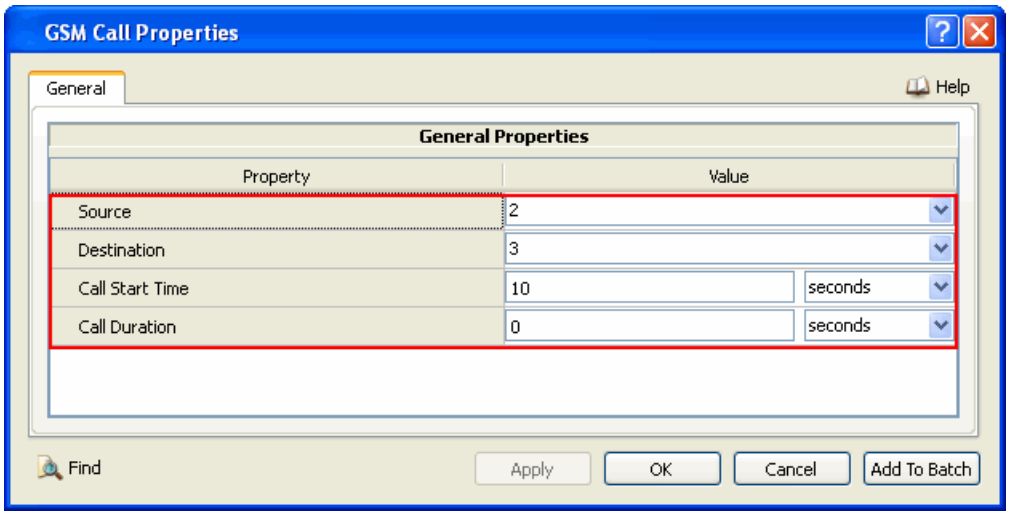

FIGURE 3-9. Setting GSM Call Parameters

TABLE 3-11. Command Line Equivalent of GSM Call Parameters

GUI Parameter	Command Line Parameter
Source	`<Source>`
Destination	`<Destination>`
Call Start Time	`<Start Time>`
Call Duration	`<Duration>`

Configuring Statistics Parameters

Statistics for applications (including GSM Call Application) can be collected at the global and node levels. See Section 4.2.9 of *EXata User's Guide* for details of configuring statistics parameters.

To enable statistics collection for GSM Call Application, check either the box labeled **Application** or the box labeled **GSM** in the appropriate properties editor.

TABLE 3-12. Command Line Equivalent of Statistics Parameters

GUI Parameter	Scope of GUI Parameter	Command Line Parameter
Application	Global, Node	`APPLICATION-STATISTICS`
GSM	Global, Node	`CELLULAR-STATISTICS`

3.6 Statistics

Table 3-13, Table 3-14, Table 3-15, Table 3-16 and Table 3-17 lists the statistics collected for the GSM model that are output to the statistics (.stat) file at the end of simulation.

GSM Layer 3 Statistics

Table 3-13 shows the GSM layer 3 MS Statistics.

TABLE 3-13. GSM Layer 3 Statistics - Mobile Station (MS)

Statistic	Description
Traffic Packets Sent	Total number of traffic packets sent to BS.
Traffic Packets Received	Total number of traffic packets received from BS.
Channel Request Sent	Total number of times channel requests sent to BS.
Channel Request Attempts Failed	Total number of times channel requests attempts failed.
Channel Assignments Received	Total number of times channel assignments received from BS.
Channel Release Received	Total number of times channel release packets received from BS.
Location Update Request Sent	Total number of times location updates request packets sent to BS.
Location Update Accept Received	Total number of times location updates accept packets received from BS.
Calls Initiated	Total number of calls initiated on MS.
Calls Received	Total number of calls received from other MS.
Calls Connected	Total number of calls connected on MS.
Calls Completed	Total number of calls completed on MS.
Handovers Performed	Total number of times handovers performed on MS.

Table 3-14 shows the GSM layer 3 BS statistics.

TABLE 3-14. GSM Layer 3 Statistics - Base Station (BS)

Statistic	Description
Traffic packets (On Air) Sent	Total number of traffic packets sent to air interference.
Traffic packets (On Air) Received	Total number of traffic packets received from air interference
Channel Requests Received	Total number of times channel requests received form MSs.
Channel Assignment Attempts Failed	Total number of times channel assignment attempts failed.
Channels Assigned	Total number of times channel assigned to MSs.
Channels Released	Total number of times channel released on BS.
Channels Not Seized (T3101 Expirations)	Total number of times channel seized due to timer T3101 expiration.
Paging Request Sent	Total number of paging requests sent on air interference.
Location Update Received	Total number of times location updated packets received from MSs.
Measurement Report Received	Total number of times channel measurement reports received from MSs.
Handovers Completed (Incoming MS).	Total number of times handover completed on incoming MSs.
Handovers Attempted (Outgoing MS)	Total number of times handover attempts packets received from MSs.
Handovers Completed (Outgoing MS)	Total number of handover completed on MSs.
Handovers Failed (Outgoing MS)	Total number of times handover requests failed.

Table 3-15 shows the GSM Layer 3 MSC statistics.

TABLE 3-15. GSM Layer 3 Statistics - Mobile Switching Center (MSC)

Statistic	Description
Location Update Request Received	Total number of times location update requests received from BSs.
Calls Requested	Total number of times calls initiation requests received.
Calls Connected	Total number of calls connected.
Calls Completed	Total number of calls completed successfully.
Handover Required Received	Total number of handover required messages received from BSs.
Handovers Completed	Total number of handover completed successfully.
Handovers Failed	Total number of times handover requests failed
Traffic Packets Transferred	Total number of traffic packets transferred.

MAC Layer Statistics

Table 3-16 shows the MAC layer MS statistics.

TABLE 3-16. MAC Layer Statistics - Mobile Station (MS)

Statistic	Description
Cell Selections	Total number of times MS selected cell.
Cell Selection Failures	Total number of times MS failed to select any cell.
Cell Reselection Attempts	Total number of times MS tried to reselect another cell.

Physical Layer Statistics

Table 3-17 shows the PHY layer statistics.

TABLE 3-17. Physical Layer Statistics

Statistic	Description
Signals transmitted	Total number of signals transmitted on physical layer.
Signals received and forwarded to MAC	Total number of signals received from the physical layer and forwarded to the MAC layer.

3.7 Scenarios Included in EXata

The EXata distribution includes several sample scenarios for the GSM model. All scenarios are located in the directory EXATA_HOME/scenarios/cellular/gsm. Table 3-18 lists the sub-directory where each scenario is located.

TABLE 3-18. GSM Model Scenarios Included in EXata

Scenario	Description
call-establishment	Show the example of Call Establishment between two MS.
cell-selection-reselection	Show the example of Cell Selection and Re-Selection procedure.

TABLE 3-18. GSM Model Scenarios Included in EXata (Continued)

Scenario	Description
handover	Show the example of Handover when MS moves from one BS to another BS in active state.
location-update	Show how to test Location Update Procedure.
two-links	Show the example of call request/GSM link between two MS at different time.

3.8 References

1. "The GSM System for Mobile communications," Michel Mouly and Marie-Bernadette Pautet.
2. GSM 05.02 "Multiplexing and multiple access on the radio path."
3. GSM 04.08 "Mobile radio interface Layer 3 specification; Core network protocols."
4. GSM 04.07 "Mobile radio interface signaling layer 3".
5. GSM 04.05 "Data Link (DL) Layer General Aspects".
6. GSM 04.06 "Mobile Station - Base Stations System (MS - BSS) Interface Data Link (DL) Layer Specification."
7. GSM 03.03 "Numbering, Addressing and Identification."
8. GSM 05.08 "Radio subsystem link control."

4 Miscellaneous Models

4.1 User Behavior Model

4.1.1 Description

In real network scenarios, the behaviors of network nodes may vary a lot based on their types and attributes. For example, some people may tend to use multimedia applications more often than others. Some may have longer phone calls than others. Such characteristics are referred to as user behaviors. In a network simulation, the traffic patterns and mobility patterns are affected significantly by user behaviors and environment factors. EXata mainly considers adding attributes to nodes and realizing traffic patterns based on related user attributes (i.e., traffic patterns specified for the user).

Currently in EXata, user attributes mainly include basic attributes such as age, sex, and traffic patterns. A user profile is used to describe the characteristics of a user using some distributions. It also refers to some traffic patterns to describe the characteristics of traffic flows generated by a user. The description of the traffic patterns are put in one or multiple traffic pattern definition files.

The traffic flows generated by user behavior model send feedbacks about its status (rejected, dropped, or successfully finished) to the user behavior model. The user behavior model then calculates a user dissatisfaction degree based on such feedbacks. This degree is intended to reflect users' perception of the service quality. In addition to this, for rejected or dropped flows, the user behavior model performs proper retries indicated by the traffic pattern.

Traffic patterns can be affected by many user attributes and environment factors. One of the requirements is to generate traffic, based on arbitrary distributions. EXata already provides APIs for both common random distribution functions, as well as user-defined random distributions.

4.1.2 Features and Assumptions

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

4.1.2.1 Implemented Features

- User attributes referenced by various models: sex, age, and position
- Configuring user attributes using profiles
- User attributes for specifying traffic patterns

- Random assignment of traffic destination
- User calling, re-call and termination patterns
- Distinction of area-of-interest and out-of-area users
- Calculation of network service perception

4.1.2.2 Omitted Features

None.

4.1.2.3 Assumptions and Limitations

None.

4.1.3 Supplemental Information

None.

4.1.4 Command Line Configuration

With each user, a user profile and a series of user status (along with the time when the status becomes applicable) are associated in the scenario configuration file. The user's status changes from one to the next at the specified times.

Each user profile specifies the age and sex of the user and the traffic pattern for each user status. User profiles are defined in one or more user profile files.

Each traffic pattern defines attributes such as the number of application sessions, time between sessions, and the traffic generator (and its parameters) to use for each session.Traffic patterns are defined in one or more traffic pattern files.

The User Behavior model is enabled for a node by associating a user profile with the node by means of the parameter `USER-PROFILE` (see Table 4-1).

User Profile Parameters

Table 4-1 shows the parameters available in the User Behavior model. See Section 1.2.1.3 for a description of the format used for the parameter table.

TABLE 4-1. User Behavior Model Parameters - User Profile

Parameter	Value	Description
USER-PROFILE *Optional* *Scope:* Global, Node	String	User profile assigned to a node. This should be name of a user profile defined in the user profile file by means of the USER-PROFILE parameter.
USER-STATUS *Optional* *Scope:* Global, Node *Instances:* status number	String	User status identifier. This should be one of the user status identifiers associated with the user profile assigned to this node. User profiles are defined in the user profile file. **Note:** For each instance of USER-STATUS, the scenario configuration should include an instance of USER-STATUS-START-TIME indicating when the status becomes applicable.
USER-STATUS-START-TIME *Optional* *Scope:* Global, Node *Instances:* status number	Time *Range:* ≥ 0S *Default:* 10S	Time when the user status with the same index becomes applicable, i.e., USER-STATUS-START-TIME[*i*] is the time when USER-STATUS[*i*] becomes applicable. **Note:** For each instance of USER-STATUS, the scenario configuration should include an instance of USER-STATUS-START-TIME indicating when the status becomes applicable.
USER-PROFILE-FILE *Optional* *Scope:* Global *Instances:* profile file number	Filename	Name of the user profile file(s). The format of the user profile file (.pf file) is described in Section 4.1.4.1
TRAFFIC-PATTERN-FILE *Optional* *Scope:* Global *Instances:* traffic file number	Filename	Name of the s traffic pattern file(s). The format of the traffic pattern file is described in Section 4.1.4.2

Example Usage of Parameters

```
USER-PROFILE-FILE          myprofile.pf
USER-PROFILE-FILE[1]       myprofile1.pf
USER-PROFILE-FILE[2]       myprofile2.pf
USER-STATUS                before-fireworks
USER-STATUS-START-TIME     0S
```

Configuring at the node level assigns a user status to one or more nodes. In this way, you can have different sets of nodes experiencing different status at the same time. For example, you can have a set of nodes watching a fireworks show while others watch a movie.

```
[1 thru 10]  USER-STATUS[0]              before-fireworks
[1 thru 10]  USER-STATUS-START-TIME[0]   0S
[1 thru 10]  USER-STATUS[1]              during-fireworks
[1 thru 10]  USER-STATUS-START-TIME[1]   600S
[11 thru 20] USER-STATUS[0]              start-movie
[11 thru 20] USER-STATUS-START-TIME[0]   300S
```

Note: All the user status for a node should be listed in chronological order with respect to the index

4.1.4.1 Format of the User Profile File

The user profile file contains one or more user profiles. Each user profile is defined using the following elements:

```
<Profile Name Specification>
<User Attributes Description>
<Traffic Description 1>
...
<Traffic Description n>
```

These elements are described in Table 4-2.

TABLE 4-2. User Profile Elements

Element	Description
<Profile Name Specification>	The profile name specification specifies the name of the user profile and has the following format: USER-PROFILE <name> where <name> Unique string that identifies the name of the profile
<User Attributes Description>	The user attributes description specify the age and gender of the user and has the following format: AGE <age> SEX <sex> where <age> User's age. This is specified as an integer distribution (see note). <sex> User's sex. This is specified as an integer distribution (see note).
<Traffic Description i>	The traffic description specifies the user's communication behavior in different states (e.g., different time periods) and has the following format: USER-STATUS <user-status-name> TRAFFIC-PATTERN <traffic-pattern-name> where <user-status-name> User status identifier. <traffic-pattern-name> Traffic pattern identifier. This should be the identifier of one of the traffic patterns defined in the traffic pattern file (see Section 4.1.4.2).

Note: **Integer Distributions:** Five random number distributions are supported: deterministic, uniform, exponential, truncated Pareto, and 4-parameter truncated Pareto.

- The deterministic distribution is specified as:

  ```
  DET  <value>
  ```

  It always returns `<value>` as the value.

- The uniform distribution is specified as:

  ```
  UNI <value-1> <value-2>
  ```

  It returns a value uniformly distributed between `<value-1>` and `<value-2>`.

- The exponential distribution is specified as:

  ```
  EXP <value>
  ```

  It returns a value from an exponential distribution with `<value>` as the mean.

- The truncated Pareto distribution is specified as:

  ```
  TPD <value-1> <value-2> <alpha>
  ```

  It returns a value from a truncated Pareto distribution with `<value-1>` as the lower end of the range, `<value-2>` as the upper limit of the truncation, and `<alpha>` as the shape parameter.

- The 4-parameter truncated Pareto distribution is specified as:

  ```
  TPD4 <value-1> <value-2> <value-3> <alpha>
  ```

  It returns a value from a truncated Pareto distribution with `<value-1>` as the lower end of the range, `<value-2>` as the lower limit of the truncation, `<value-3>` as the upper limit of the truncation, and `<alpha>` as the shape parameter.

For integer distributions, `<value>`, `<value-1>`, `<value-2>`, `<value-3>`, and `<alpha>` are integer values, e.g., `0`, `10`, `15`, etc.

4.1.4.2 Format of the Traffic Pattern File

This file can contain multiple traffic patterns. Each traffic pattern consists of the following elements:

```
<General Traffic Pattern Params>
<Traffic Session Description 1>
...
<Traffic Session Description n>
```

These elements are described in Table 4-3.

TABLE 4-3. Traffic Pattern Elements

Element	Description
<General Traffic Pattern Params>	The general traffic pattern parameters define the traffic pattern identifier and application sessions associated with it in the following format: TRAFFIC-PATTERN <pattern-name> NUM-APP-TYPES <num-app-types> MAX-NUM-APPS <max-num-apps> ARRIVAL-INTERVAL <max-num-apps> where: <pattern-name> Unique string that identifies the traffic pattern. This name is referred to by the user profile file to describe traffic generated by the user. <num-app-types> Number of application types used to generate traffic in the particular pattern. <max-num-apps> Maximum number of applications a node can have at any time. <max-num-apps> Interval for generating a new application.

TABLE 4-3. Traffic Pattern Elements (Continued)

Element	Description
<Traffic Session Description i>	Describes the characteristics of traffic session that will be generated by the application. There should be <num-app-types> traffic session descriptions. Each traffic session description has the following format: PROBABILITY <probability> RETRY-PROBABILITY <retry-probability> RETRY-INTERVAL <retry-interval> MAX-NUM-RETRIES <max-retries> <traffic-generator-description> where: <probability> Probability with which this particular traffic session will be selected to generate the application traffic. <retry-probability> Probability of retries if the application is rejected or dropped. <retry-interval> Delay before retry of the application. This is specified as a time distribution. <max-retries> Maximum number of retries. <traffic-generator-description> Specification of a traffic generator used to generate the real traffic. This is described below. The <traffic-generator-description> format is similar to the format of traffic generators in the application configuration (.app) file except that the source node ID and starting time parameters are omitted in the definition. If the application has an end time parameter, then the starting time plus durations used as the end time. The following is an example of a <traffic-generator-description>: CELLULAR-ABSTRACT-APP UNI 1 20 EXP 100S DET 0 DET 13 This example means the application CELLULAR-ABSTRACT-APP will be used to generate traffic. Its source node ID is the current node. Destination node ID is uniformly distributed between nodes 1 to 20. Its starting time is decided by previous parameter <ARRIVAL-INTERVAL> of the traffic pattern. Its duration is decided by exponential distribution with average time as 100S, service type is 0 (voice call), and bandwidth is 13kbps deterministically.

Example of Traffic Pattern File

A traffic pattern file is shown below:

```
TRAFFIC-PATTERN    active
NUM-APP-TYPES      2
MAX-NUM-APPS       DET 4
ARRIVAL-INTERVAL   EXP 5M
PROBABILITY        0.8
RETRY-PROBABILITY  0.5
RETRY-INTERVAL     EXP 20S
MAX-NUM-RETRIES    5
CELLULAR-ABSTRACT-APP UNI 1 20 EXP 100S DET 0 DET 13

TRAFFIC-PATTERN    medium
NUM-APP-TYPES      1
MAX-NUM-APPS       DET 1
ARRIVAL-INTERVAL   EXP 15M
PROBABILITY        0.5
RETRY-PROBABILITY  0.8
RETRY-INTERVAL     EXP 12M
MAX-NUM-RETRIES    2
CELLULAR-ABSTRACT-APP UNI 1 20 EXP 100S DET 3 DET 13
```

4.1.5 GUI Configuration

The User Behavior Model is configured using the Default Device Properties Editor.

1. To configure a User Behavior Model for a node, go to **Default Device Properties Editor > Node Configuration > User Behavior Model**.
2. Set **Enable User Behavior Modelling** to *Yes* as shown in Figure 4-1 and set dependent parameters listed in Table 4-4.

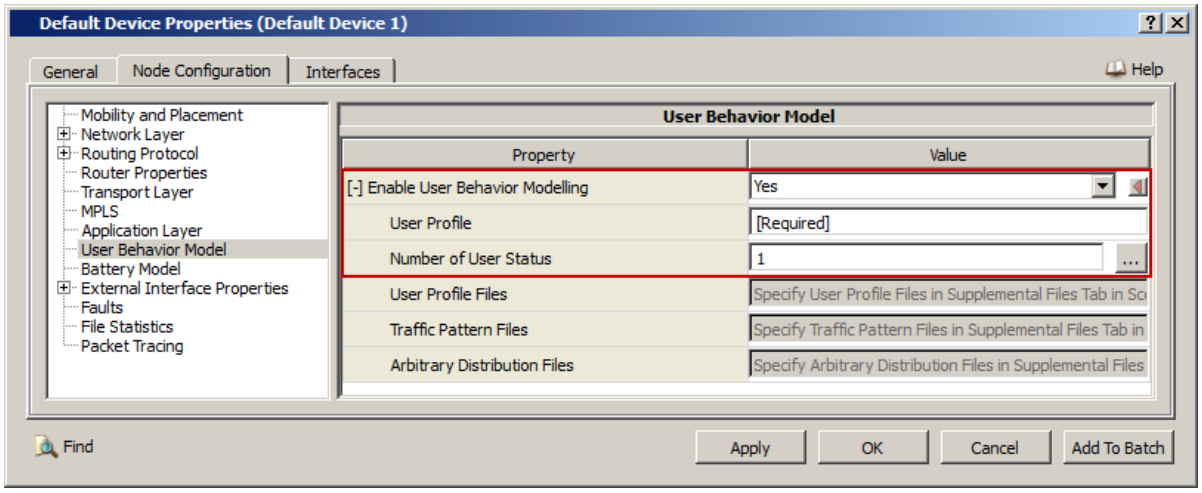

FIGURE 4-1. Enabling User Behavior Model

TABLE 4-4. Command Line Equivalent of User Behavior Model Parameters

GUI Parameter	Scope of GUI Parameter	Command Line Parameter
User Profile	Node	USER-PROFILE
Number of User Status	Node	N/A

Setting Parameters

- Set **Number of User Status** to a desired value as shown in Figure 4-1.

3. To configure the properties for the number of users, do the following:

   a. Click the **Open Array Editor** [...] button in the **Value** column. This opens the Array Editor (Figure 4-2).

   b. Set the parameters listed in Table 4-5 for each user status.

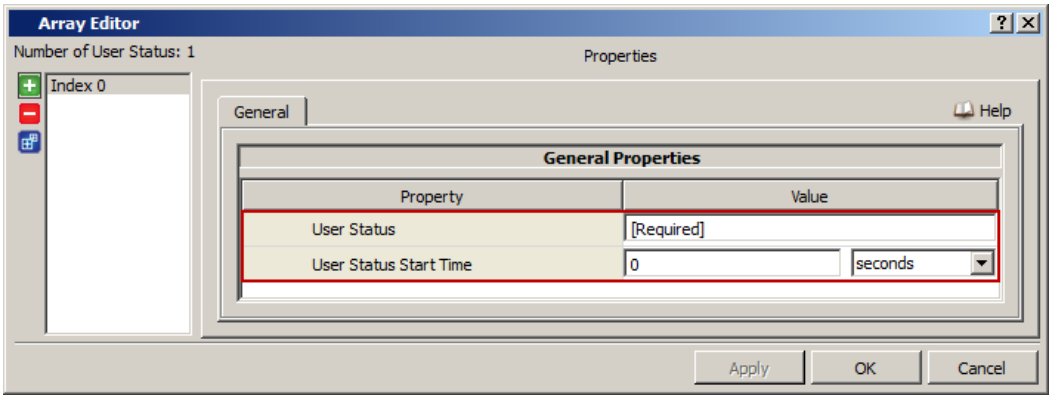

FIGURE 4-2. Setting Number of User Status Properties

TABLE 4-5. Command Line Equivalent of User-specific Parameters

GUI Parameter	Scope of GUI Parameter	Command Line Parameter
User Status	Node	USER-STATUS
User Status Start Time	Node	USER-STATUS-START-TIME

4. To configure User Profile Files, go to **Scenario Properties Editor > Supplemental Files**, set **Number of User Profile Files** *[=1]* and set the path of **User Profile File** *[0]* file to the desired file location as shown in the Figure 4-3.

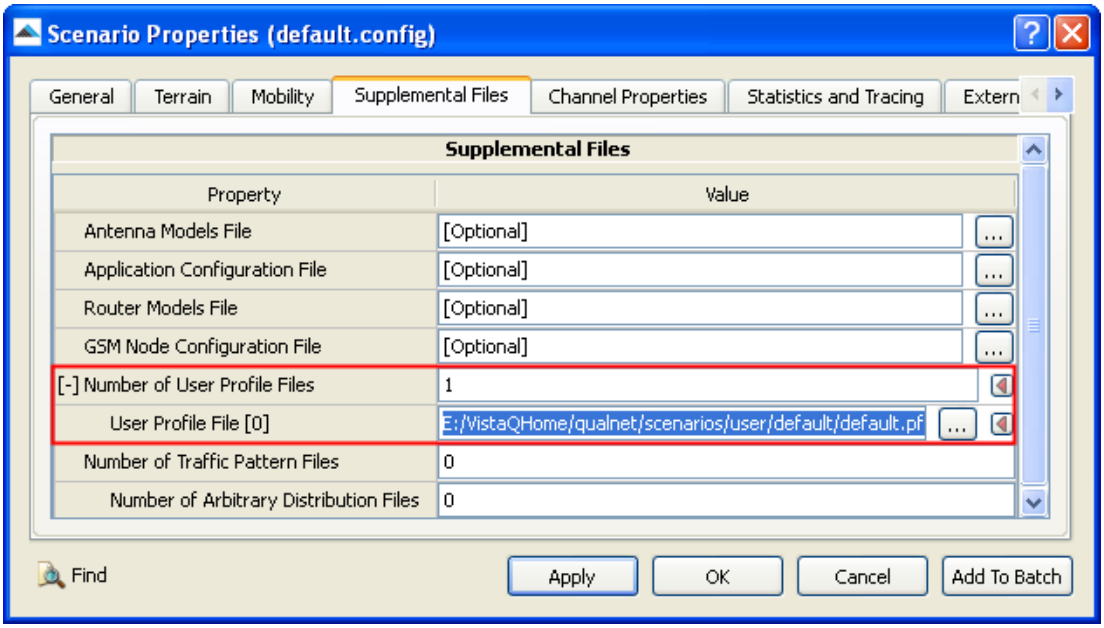

FIGURE 4-3. Setting User Profile File

5. To configure Traffic Pattern Files, go to **Scenario Properties Editor > Supplemental Files**, set **Number of Traffic Pattern Files** *[=1]* and set the path of **Traffic Pattern File** *[0]* to the desired file location as shown in the Figure 4-4.

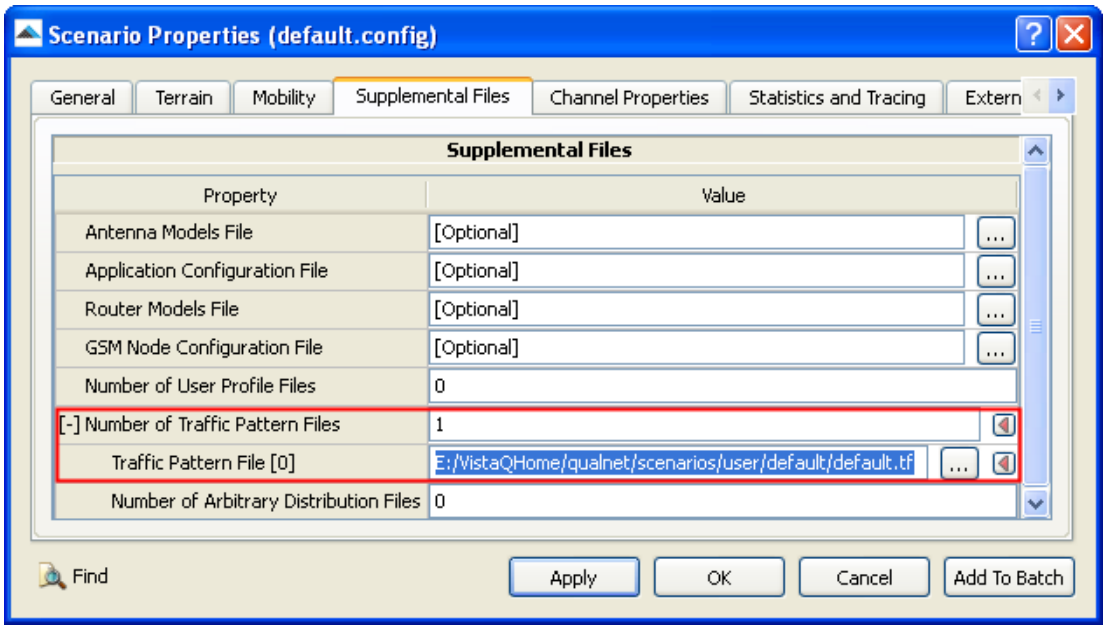

FIGURE 4-4. Setting the Traffic Pattern File

6. To configure Arbitrary Distribution Files, go to **Scenario Properties Editor > Supplemental Files**, set **Number of Arbitrary Distribution Files** *[=1]* and set the path of **Arbitrary Distribution File** *[0]* to the desired file location as shown in the Figure 4-5.

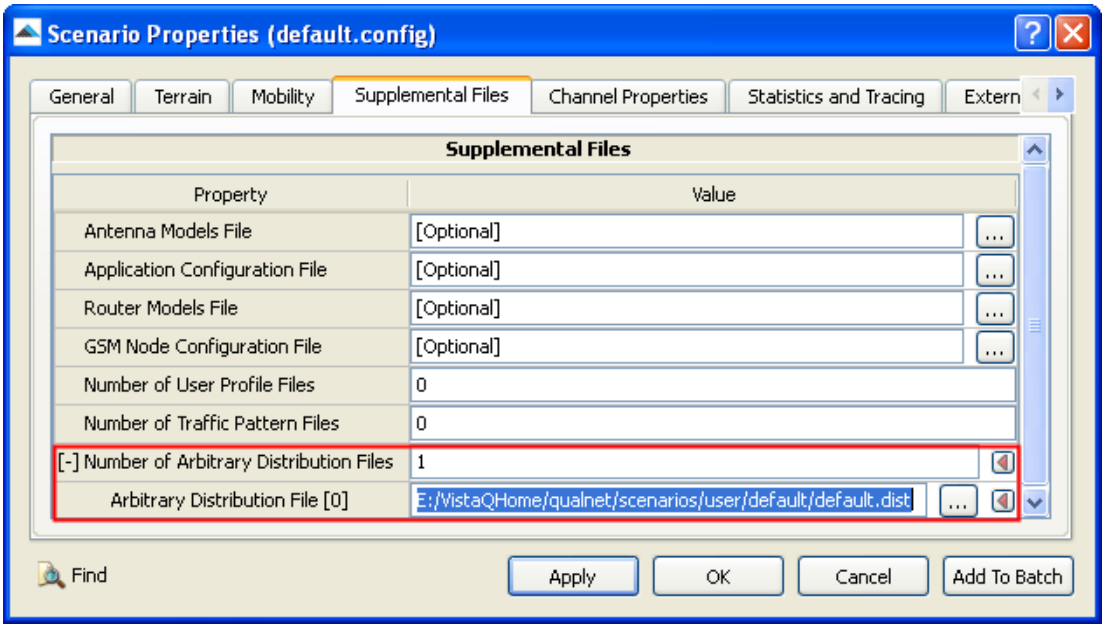

FIGURE 4-5. Setting the Arbitrary Distribution File

4.1.6 Statistics

Table 4-6 lists the statistics collected for the User Behavior model that are output to the statistics (.stat) file at the end of simulation.

TABLE 4-6. User Behavior Model Statistics

Statistic	Description
Average Dissatisfaction	The dissatisfaction degree is computed by finding the number of calls completed, rejected, and the number of calls made.
Applications Generated	Total number of applications the user tried to start.
Applications Successfully Finished	Total number of applications that finished successfully.
Applications Rejected	Total number of applications rejected.
Applications Dropped	Total number of application sessions dropped.
Retries	Total number of retry attempts made.
Average Retries per App	Average number of retry attempts made for an application.

Note: An application could be rejected, or dropped multiple times.

4.1.7 Sample Scenario

This section describes the way in which a user can easily create a simple scenario and run it using EXata.

4.1.7.1 Scenario Description

In order to depict the behavior of User Behavior Model, create a scenario that contains 30 nodes defined as Mobile Stations (MS), 2 Base Stations (BS), 1 Mobile Switching Center (MSC), 1 Gateway and 1 Aggregated Node. The User Behavior Model, and the Arbitrary Distribution Model are integrated in this sample scenario.

Topology - The topology is similar to any cellular scenario with 30 MS placed around 2 BS. The BS are controlled by a SC. A Gateway is placed between the Aggregated Node and Switching Center to establish connection.

4.1.7.2 Command Line Configuration

1. Comment out the APP-CONFIG-FILE (we recommend not using the application file if the traffic is only generated by the user-behavior model).
2. For each of the 30 nodes we now need to provide user profiles and traffic pattern files. In the sections below, default.pf is defined, which has three user-profiles: young, middle, and old. You must assign the nodes to one of these profiles. Assign the first 10 nodes to the young profile, the next 10 to the old, and the last 10 nodes to the middle.

```
[1 thru 10] USER-PROFILE young
[11 thru 20] USER-PROFILE old
[21 thru 30] USER-PROFILE middle
```

3. Add the default.pf file to the scenario.

```
USER-PROFILE-FILE./default.pf
```

Contents of sample USER-PROFILE FILE (default.pf)

```
USER-PROFILE        young
AGE                 UNI 10, 30
SEX                 UNI 0,1
USER-STATUS         before-fireworks
TRAFFIC-PATTERN     active
USER-STATUS         during-fireworks
TRAFFIC-PATTERN     inactive
USER-STATUS         after-fireworks
TRAFFIC-PATTERN     very-active
USER-STATUS         default
TRAFFIC-PATTERN     active

USER-PROFILE        middle
AGE                 UNI 31, 50
SEX                 UNI 0,1
USER-STATUS         before-fireworks
TRAFFIC-PATTERN     medium
USER-STATUS         during-fireworks
TRAFFIC-PATTERN     inactive
USER-STATUS         after-fireworks
TRAFFIC-PATTERN     active

USER-PROFILE        old
AGE                 UNI 51, 100
SEX                 UNI 0,1
USER-STATUS         after-fireworks
TRAFFIC-PATTERN     medium
```

4. Every user profile has a USER-STATUS keyword. This keyword is defined in the main configuration file. In the default.pf file, four statuses are defined: default, before-fireworks, after-fireworks, and during fireworks. You must set this parameter in the configuration file. This is an optional parameter, and if not specified, the default values are used.

```
USER-STATUS[0]              before-fireworks
USER-STATUS-START-TIME[0]   0S
USER-STATUS[1]              during-fireworks
USER-STATUS-START-TIME[1]   600S
USER-STATUS[2]              after-fireworks
USER-STATUS-START-TIME[2]   900S
```

5. Add the traffic pattern file to get the traffic for the above mentioned users. This is the same file that we have defined above. The file has three patterns: active, inactive, and medium.

```
TRAFFIC-PATTERN-FILE./default.tf
```

Contents of sample TRAFFIC-PATTERN FILE (default.tf)

```
TRAFFIC-PATTERN   active
NUM-APP-TYPES     2
MAX-NUM-APPS      DET 4
ARRIVAL-INTERVAL  EXP 5M
PROBABILITY       0.8
RETRY-PROBABILITY 0.5
RETRY-INTERVAL    mydist
MAX-NUM-RETRIES   5
CELLULAR-ABSTRACT-APP UNI 1 20 EXP 100S DET 23 DET 13
PROBABILITY       0.2
RETRY-PROBABILITY 0.1
RETRY-INTERVAL    EXP 5M
MAX-NUM-RETRIES   2
CELLULAR-ABSTRACT-APP UNI 11 15 EXP 50S DET 1 DET 13

TRAFFIC-PATTERN   medium
NUM-APP-TYPES     1
MAX-NUM-APPS      DET 1
ARRIVAL-INTERVAL  EXP 15M
PROBABILITY       0.5
RETRY-PROBABILITY 0.8
RETRY-INTERVAL    EXP 12M
MAX-NUM-RETRIES   2
CELLULAR-ABSTRACT-APP UNI 1 20 EXP 100S DET 3 DET 13

TRAFFIC-PATTERN   inactive
NUM-APP-TYPES     1
MAX-NUM-APPS      DET 4
ARRIVAL-INTERVAL  EXP 5M
PROBABILITY       0.1
RETRY-PROBABILITY 0.2
RETRY-INTERVAL    EXP 2M
MAX-NUM-RETRIES   1
```

6. Since the distributions in the traffic pattern files are custom user distributions, you must add the Arbitrary Distribution file in the scenario.

```
ARBITRARY-DISTRIBUTION-FILE ./default.dist
```

Contents of sample ARBITRARY DISTRIBUTION FILE (default.dst)

```
ARBITRARY-DISTRIBUTION    mydist
NUM-POINTS    4
7   0.2
3   0.3
9   0.4
11  0.1
```

In the above example, probability distribution called "mydist" is defined. This distribution returns 7 with probability 0.2, or 3 with probability 0.3, or 9 with probability 0.4, or 11 with probability 0.10. It is always assumed that X and Y values are floating-point numbers. The X and Y values entered do not need to be normalized (the sum of them is equal to 1). While reading the distribution, EXata will normalize the data.

4.1.7.3 GUI Configuration

1. Place 35 nodes and a Wireless subnet on the canvas.
2. Select all Nodes, go to **Default Device Properties Editor > Node Configuration > Network Layer**:
   a. Set **Network Protocol** *[=Cellular Layer3]* **> Cellular Layer3 Protocol** to *Abstract Cellular Layer3*.
   b. Set the cellular node types as follows:
      i. For nodes 1-30, set **Cellular Node Type** to *MS* and set all the dependent parameters as shown in Figure 4-6.

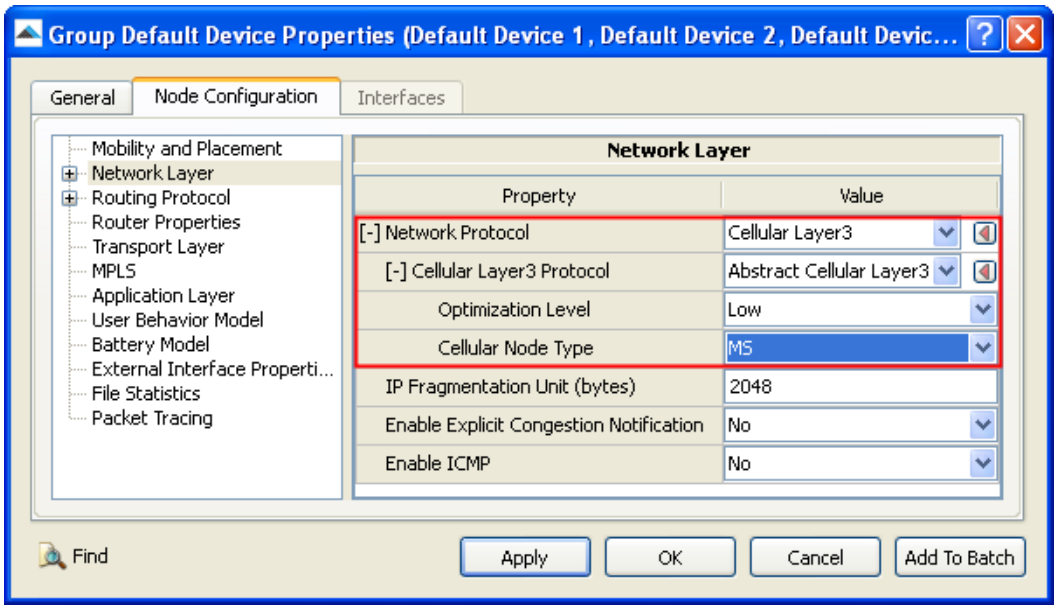

FIGURE 4-6. Setting the Node Type as MS

ii. For node 31 and 32, set **Cellular Node Type** to *BS* and set all the dependent parameters as shown in Figure 4.1.5. Also, set **BS Associate with SC** to *33*.

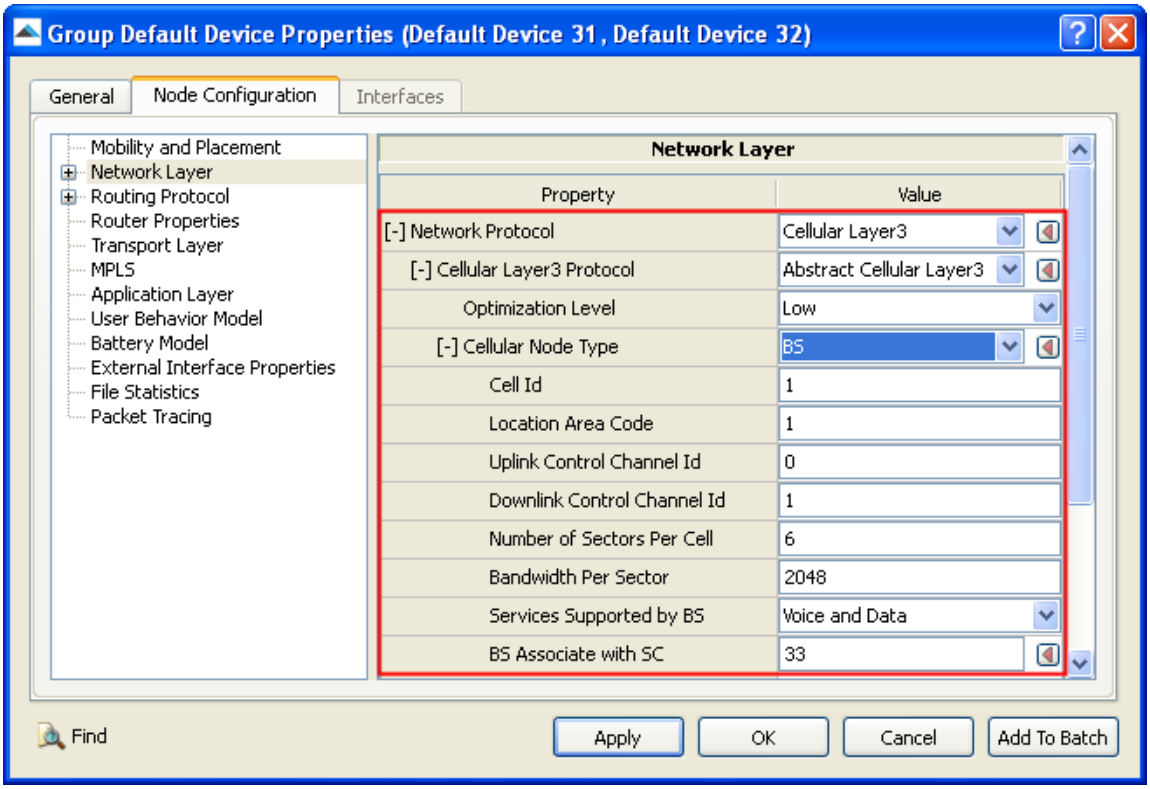

FIGURE 4-7. Setting Node Type to BS

iii. For node 33, set **Cellular Node Type** to *MSC* and set all the dependent parameters as shown in Figure 4-8. Also, set **SC Control Location Area** to *{1,2},* **SC Control BS** to *{31,32}* and **SC Connect to Gateway** to *34.*

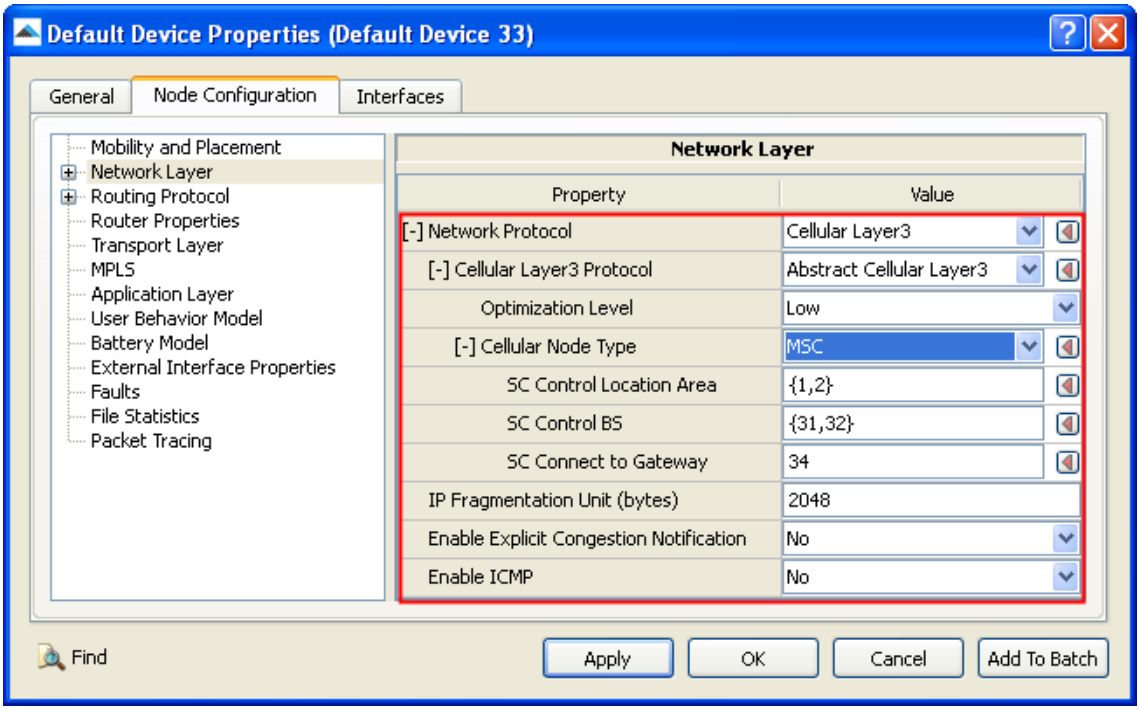

FIGURE 4-8. Setting Node Type to MSC

iv. For node 34, set **Cellular Node Type** to *Gateway* and set all the dependent parameters as shown in Figure 4-9. Also, set **Gateway Connect to Switch Centers** to *{33}* and set **Gateway Connect to Aggregated Node** to *35.*

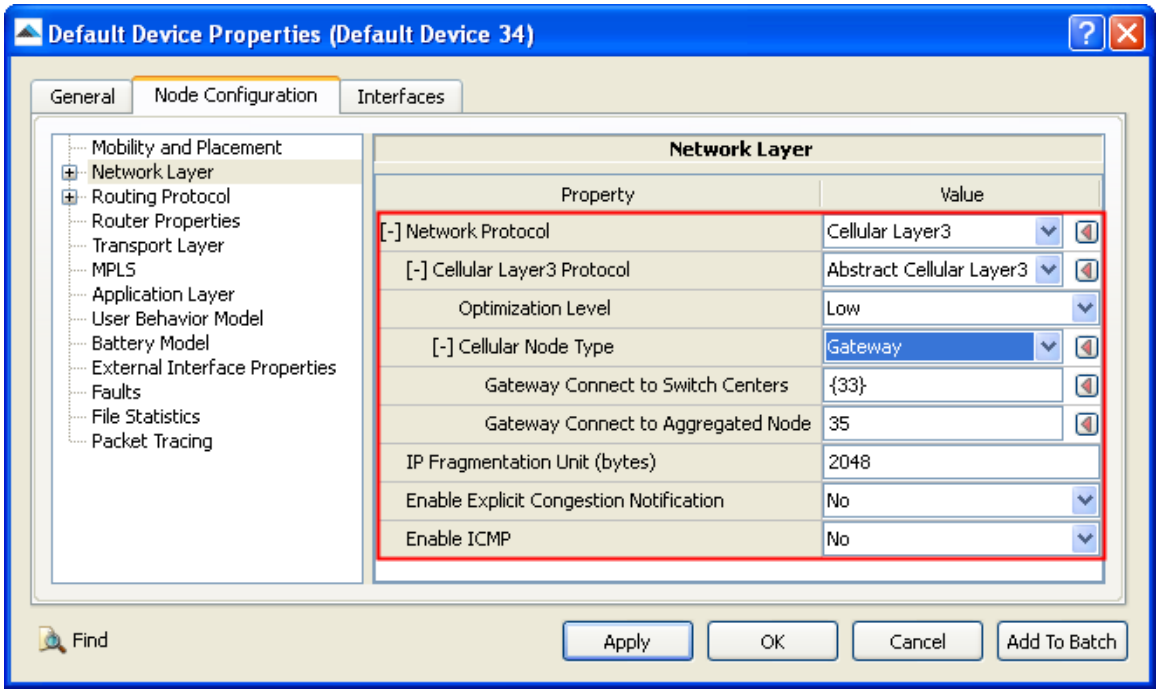

FIGURE 4-9. Setting Node Type to Gateway

v. For node 35, set **Cellular Node Type** to *Aggregated Node* and set all the dependent parameters as shown in Figure 4-10. Also set **Aggregated Node Connect to Gateway** to *34*.

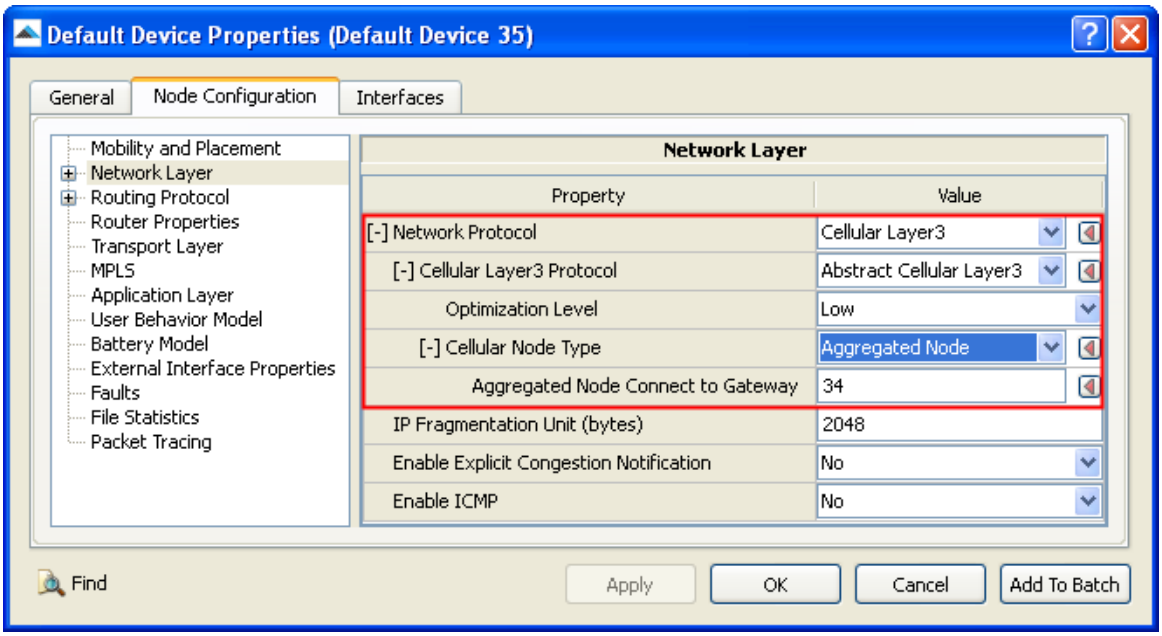

FIGURE 4-10. Setting Node Type to Aggregated Node

3. Go to **Wireless Subnet Properties Editor > Physical Layer**, set **Radio Type** to *Abstract* as shown in Figure 4-11.

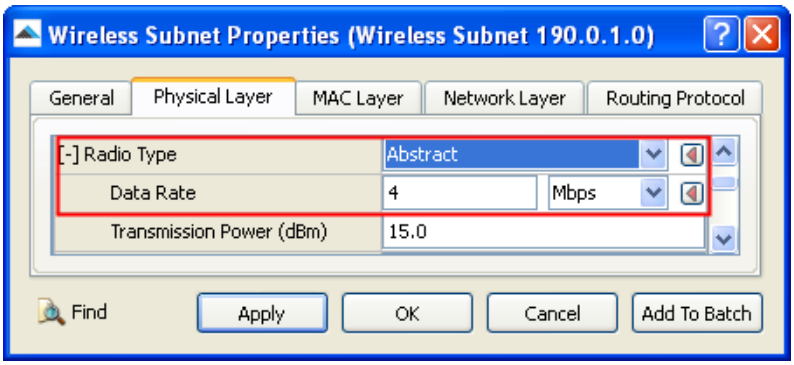

FIGURE 4-11. Setting the Wireless Subnet Properties

4. Go to **Wireless Subnet Properties Editor > MAC Layer**, set **MAC Protocol** *[= Cellular MAC]* **> Cellular MAC Protocol** to *Abstract Cellular MAC* as shown in Figure 4-12.

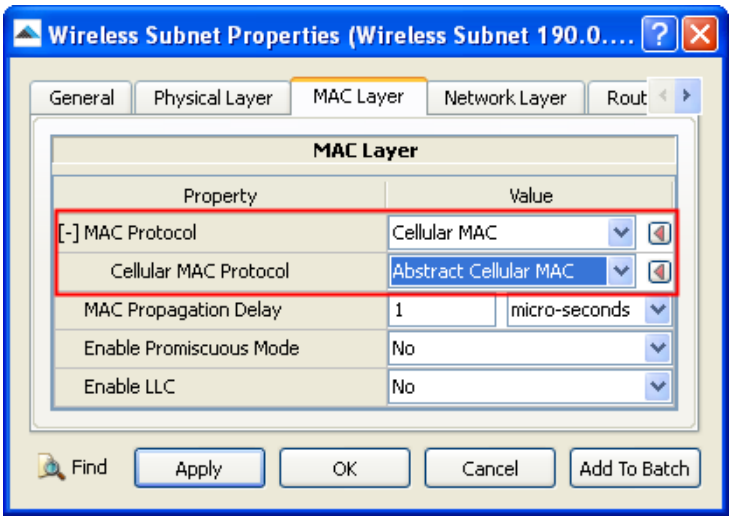

FIGURE 4-12. Setting the Mac Layer Protocol

5. Go to **Wireless Subnet Properties Editor > Network Layer > General**, set **Network Protocol** *[=Cellular Layer3]* **> Cellular Layer3 Protocol** to *Abstract Cellular Layer3* as shown in Figure 4-13.

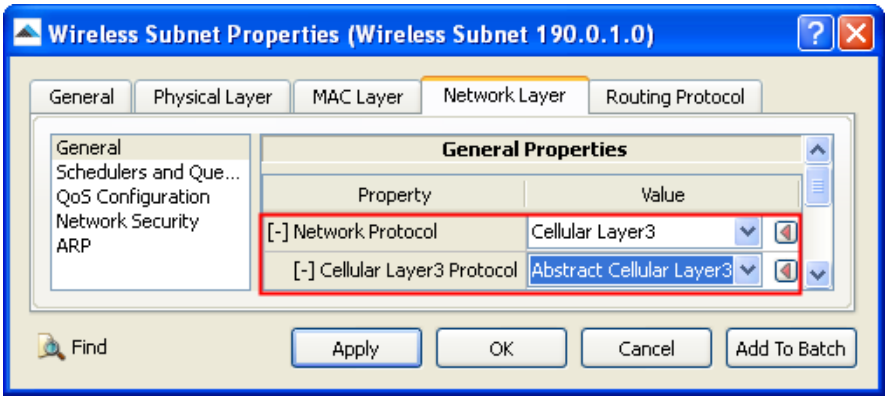

FIGURE 4-13. Setting the Network Layer Protocol

6. Connect nodes 1 to 32 to the wireless subnet.
7. Create wired links from nodes 31 to 33, 32 to 33, 33 to 34, and 34 to 35.
8. Go to wired links, **Point-to-point Link Properties Editor > Point-to-point Link Properties > General** and set **Link Type** *[= Wired]* **> MAC Protocol** to *Abstract Link MAC* as shown in Figure 4-14.

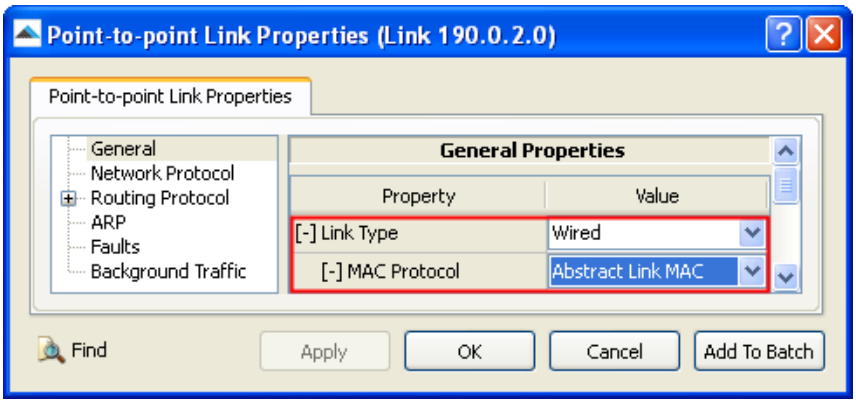

FIGURE 4-14. Setting the Mac Protocol for Point-to-Point Link

9. Go to wired links, **Point-to-point Link Properties Editor > Point-to-point Link Properties > Network Protocol** and set **Network Protocol** *[= Cellular Layer3]* **> Cellular Layer3 Protocol** to *Abstract Cellular Layer3* as shown in Figure 4-15.

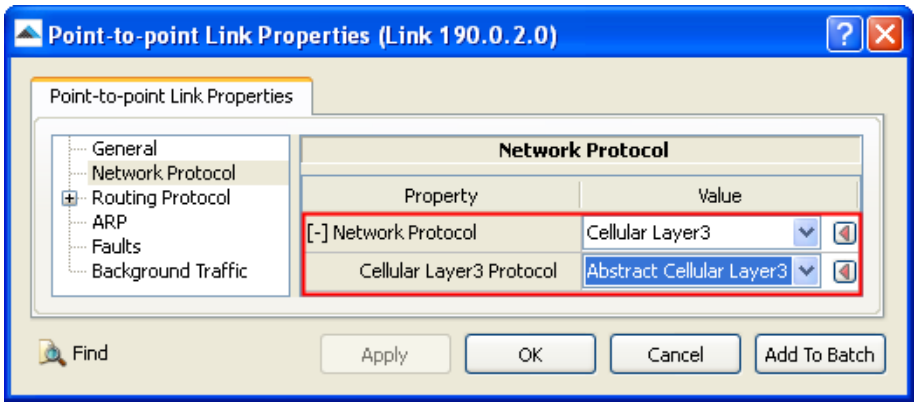

FIGURE 4-15. Setting the Network Layer Protocol for Point-to-Point Link

10. Create 4 wireless channels and set channel frequencies to *890 MHz, 935 MHz, 835.2 MHz* and *935.2 MHz*.
11. Go to **Scenario Properties Editor > Channel Properties** and set **Number of Channels** to *4*. Set **Channel Frequency** for the four channels as shown in the Figure 4-16.

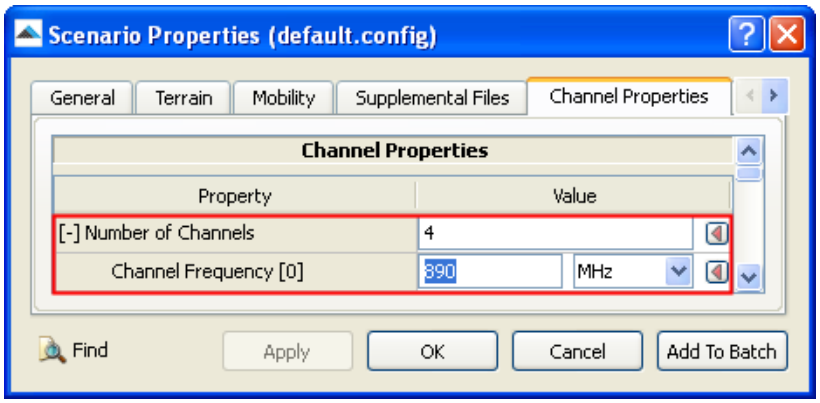

FIGURE 4-16. Setting the Number of Channels and Channel Frequency

12. Configure **User Profile** as *old* for nodes 1 to 10. Select nodes 1 to 10, go to **Default Device Properties Editor > Node Configuration > User Behavior Model** and set **Enable User Behavior Modelling** *[=Yes]* **> User Profile** to *young* as shown in Figure 4-17.

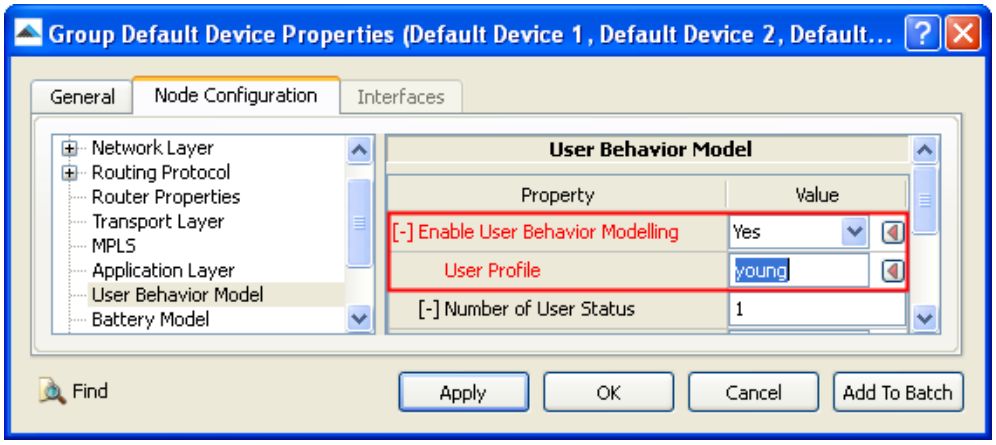

FIGURE 4-17. Setting User Profile to Young for Nodes 1-10

13. Configure **User Profile** as *old* for nodes 11 to 20. Select nodes 11 to 20, go to **Default Device Properties Editor > Node Configuration > User Behavior Model**, set **Enable User Behavior Modelling** *[=Yes]* **> User Profile** to *old* as shown in Figure 4-18.

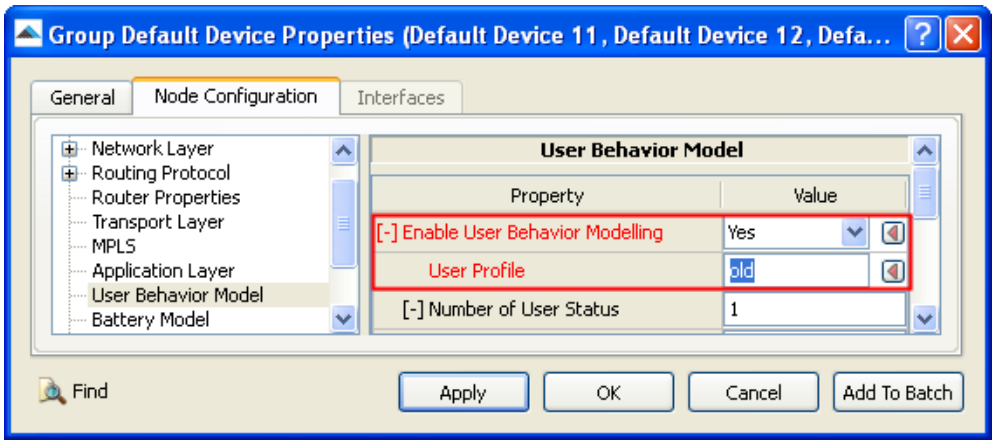

FIGURE 4-18. Setting User Profile as Old for Nodes 11-20

14. Configure **User Profile** as *middle* for nodes 21 to 30. Select nodes 21 to 30, go to **Default Device Properties Editor > Node Configuration > User Behavior Model** and set **Enable User Behavior Modelling** *[=Yes]* **> User Profile** to *middle* as shown in Figure 4-19.

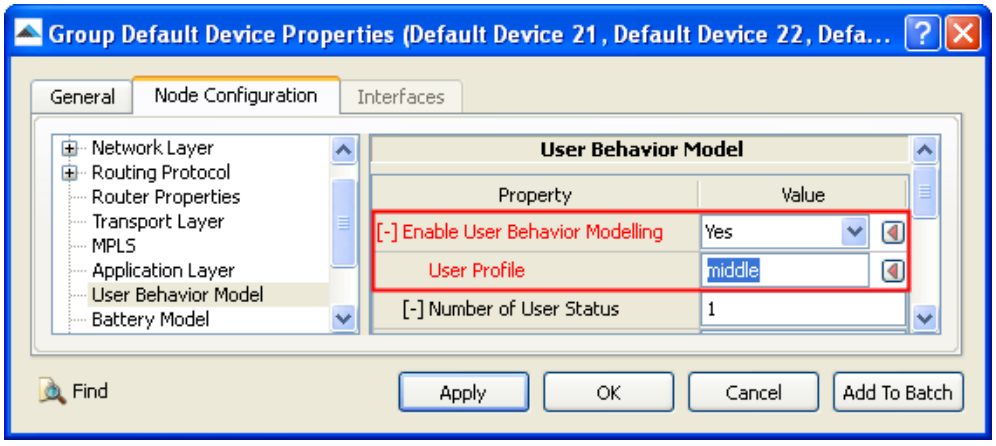

FIGURE 4-19. Setting User Profile as Middle for Nodes 21-30

15. Configure **User Status** and **User Status Start Time** for nodes 1 to 30 as shown in the Figure 4-20.

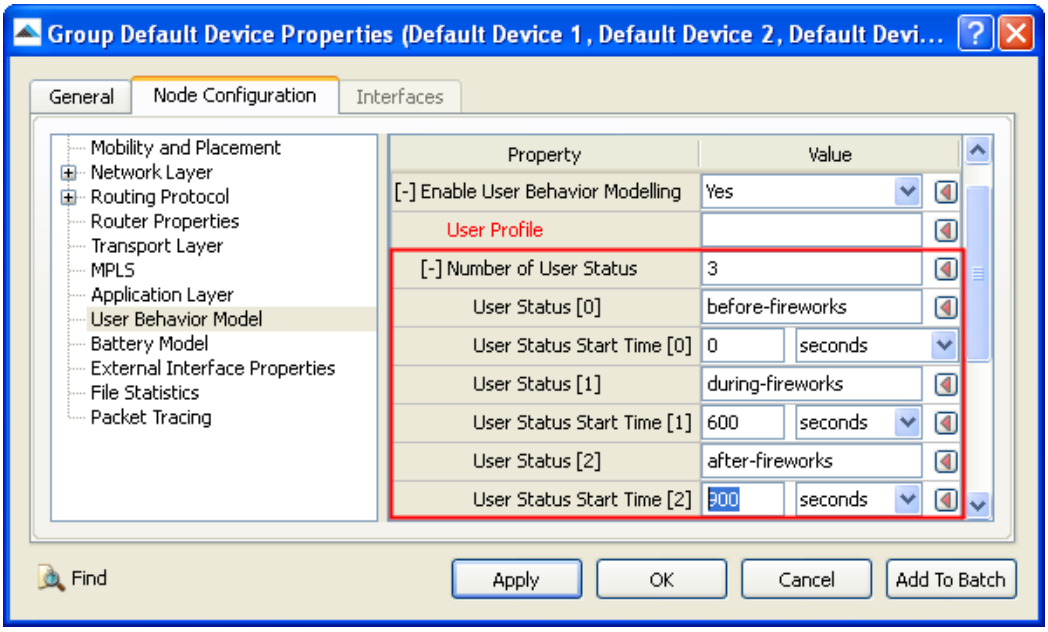

FIGURE 4-20. Setting the User Status Start Time

16. Add the User Profiles file “default.pf” to the scenario as shown in Figure 4-3.

17. Add the Traffic Pattern file “default.tf” to the scenario as shown in the Figure 4-4.

18. Add the Arbitrary Distribution file “default.dist” to the scenario as shown in Figure 4-5.

19. **Click File > Save**, to commit the changes. Click the **Run Live Simulation** button to execute the scenario and then click the **Play** button to run the scenario.

4.1.8 Scenarios Included in EXata

The EXata distribution includes several sample scenarios for the User Behavior model. All scenarios are located in the directory EXATA_HOME/scenarios/cellular/AbstractCellular/UBEE. Table 4-7 lists the sub-directory where each scenario is located.

TABLE 4-7. User Behavior Model Scenarios Included in EXata

Scenario	Description
ArrivalInterval	Shows the example of how UBEE works according to the Arrival Interval of traffic pattern File.
MultipleTrafficPatternFiles	Shows the example of how UBEE works in multiple traffic pattern files.

4.1.9 References

None.