QualNet 6.1
Standard Interfaces Model Library

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1 Introduction

Multiple simulators can be used to simulate different aspects of the same scenario. The results of such a co-operative simulation can be more realistic and meaningful than those obtained by using any single simulator. The simulators interoperate with each other via data sharing to achieve a consistent representation of the simulation environment. Several standards, such as Distributed Interactive Simulation (DIS) and High Level Architecture (HLA), have been developed to facilitate data sharing among simulators.

High Level Architecture

High Level Architecture (HLA) is a specification that enables two or more software programs (usually simulation software) to interoperate. The software programs communicate with each other through a Run-Time Infrastructure (RTI) module, which implements the HLA interface specification.

In HLA terminology, the collection of communicating simulations is called a *federation* and each simulation is called a *federate*. The object and interaction classes used in the federation are defined in a module called Federation Object Model (FOM). Information is exchanged between simulations using this FOM.

See Chapter 2 for details of the QualNet HLA interface.

Distributed Interactive Simulation

Distributed Interactive Simulation (DIS) is an IEEE standard for interfacing multiple simulation tools into a single, real-time simulation. The transport of information between simulators is performed using UDP and broadcast and/or multicast IP. Although superseded by HLA and IEEE 1516, DIS still remains popular for its simplicity of operation and the ease of creating a DIS interface.

See Chapter 3 for details of the QualNet DIS interface.

Socket Interface

The Socket Interface provides inter-process communication between QualNet and an external program over a TCP socket, with QualNet acting as the server and the external program as the client. Several types of messages can be sent between the two processes.

See Chapter 4 for details of the QualNet Spcket Interface.

1.1 Conventions Used

1.1.1 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.

1.1.1.1 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 1.1.1.2) determine the parameter value for a node or interface.

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

Example:

```
MAC-PROTOCOL            MACDOT11
```

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

Example:

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

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

Example:

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

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

Example:

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

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

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

Examples of parameter declarations in input files are:

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

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

1.1.1.2 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.

1.1.1.3 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 1-1 shows the format of parameter tables. Table 1-3 shows examples of parameter descriptions in this format.

TABLE 1-1. Parameter Table Format

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

Parameter Column

The first column contains the following entries:

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

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

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

  Examples of scope specification are:

  Scope: All

  Scope: Subnet, Interface

  Scope: Global, Node

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

Examples of instance specification are:

Instances: channel number

Instances: interface index

Instances: queue index

Values Column

The second column contains the following information:

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

  Table 1-2 shows the values a parameter can take for each type.

TABLE 1-2. Parameter Types

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

Filename	Name of a file in QualNet filename syntax (refer to *QualNet User's Guide*)
	Examples:
	`../../data/terrain/los-angeles-w`
	(For Windows and UNIX)
	`C:\snt\qualnet\6.1\scenarios\WF\WF.nodes`
	(For Windows)
	`/root/snt/qualnet/6.1/scenarios/WF/WF.nodes`
	(For UNIX)

Path	Path to a directory in QualNet path syntax (refer to *QualNet User's Guide*)
	Examples:
	`../../data/terrain` (For Windows and UNIX)
	`C:\snt\qualnet\6.1\scenarios\default`
	(For Windows)
	`/root/snt/qualnet/6.1/scenarios/default`
	(For UNIX)

IP Address	IPv4 or IPv6 address Examples: `192.168.2.1`, `2000:0:0:0::1`

TABLE 1-2. 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 1-3.

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

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

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

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

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

Examples of range specification are:

Range: ≥ `0`

Range: `(0.0, 1.0]`

Range: `[1, MAX-COUNT]`

Range: `[1S, 200S]`

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

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

Description Column

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

Table 1-3 shows examples of parameter descriptions using the format described above.

TABLE 1-3. 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.

1.1.2 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

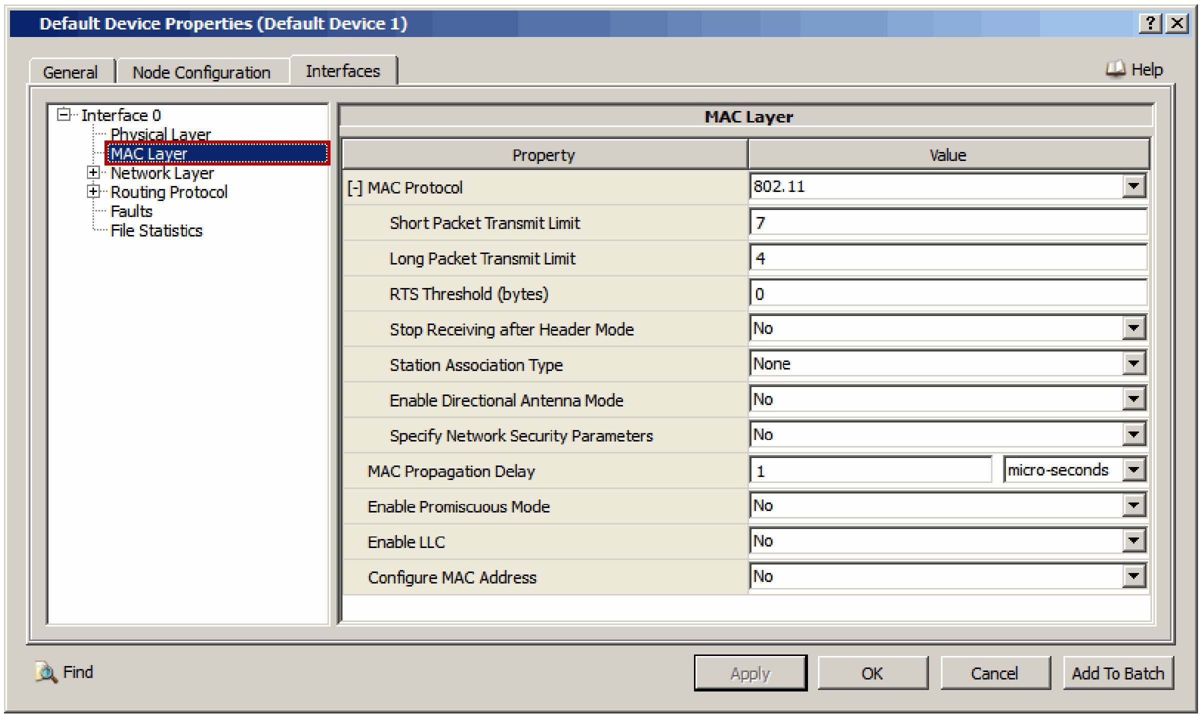
The following statement:

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.



Property	Value
[-] MAC Protocol	802.11
Short Packet Transmit Limit	7
Long Packet Transmit Limit	4
RTS Threshold (bytes)	0
Stop Receiving after Header Mode	No
Station Association Type	None
Enable Directional Antenna Mode	No
Specify Network Security Parameters	No
MAC Propagation Delay	1 micro-seconds
Enable Promiscuous Mode	No
Enable LLC	No
Configure MAC Address	No

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

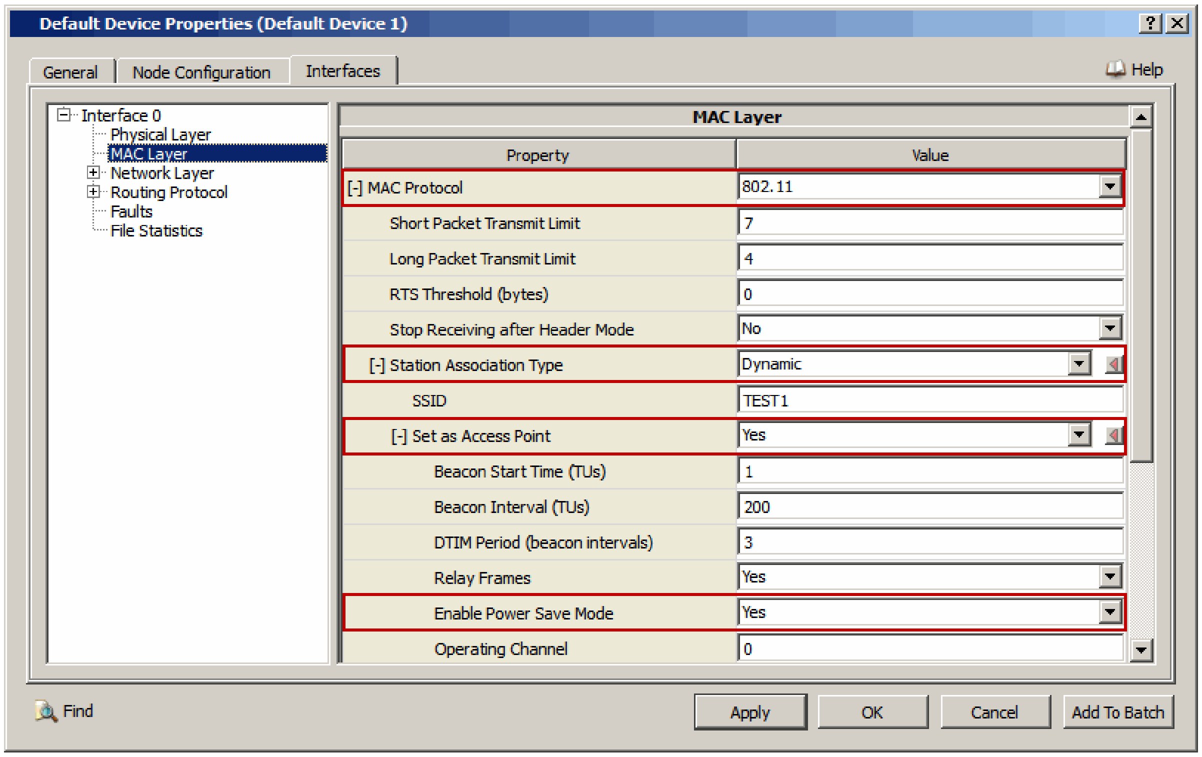
The following statement:

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.



Property	Value
[-] MAC Protocol	802.11
Short Packet Transmit Limit	7
Long Packet Transmit Limit	4
RTS Threshold (bytes)	0
Stop Receiving after Header Mode	No
[-] Station Association Type	Dynamic
SSID	TEST1
[-] Set as Access Point	Yes
Beacon Start Time (TUs)	1
Beacon Interval (TUs)	200
DTIM Period (beacon intervals)	3
Relay Frames	Yes
Enable Power Save Mode	Yes
Operating Channel	0

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 1-4.

TABLE 1-4. 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 1-5 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 1-5.

TABLE 1-5. 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 1-6 is an example of a parameter mapping table.

TABLE 1-6. 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 High Level Architecture (HLA) Interface

High Level Architecture (HLA) is a specification that enables two or more software programs (usually simulation software) to interoperate. The software programs communicate with each other through a Run-Time Infrastructure (RTI) module, which implements the HLA interface specification. The RTI software typically comprises a RTI Executive process and a RTI library. Some RTIs have an additional process called the Federation Executive process. Typically, RTI library functions are added to each simulation and each simulation is linked with RTI libraries at compile time. The RTI Executive process is a globally known process that initializes RTI components and provides services to the distributed simulations. This enables the simulations to communicate with each other.

In HLA terminology, the collection of communicating simulations is called a *federation* and each simulation is called a *federate*. The object and interaction classes used in the federation are defined in a module called Federation Object Model (FOM). Information is exchanged between simulations using this FOM.

For example, a FOM could define an object class representing a plane, with latitude, longitude, and altitude values as object attributes. A federate creates an instance of a plane and periodically updates its position (the latitude, longitude, and altitude attributes). Through the RTI, another federate can access this plane and receive its position updates.

Interaction classes are defined to implement interactions between federates. Whereas objects and object attributes are more permanent in nature, interactions are transitory. For example, when simulating the blinking of a light on a plane, each blink can be sent as an interaction.

Federates announce their ability to create objects, update object attributes, and send interactions by publishing them. Federates subscribe to object classes, object attributes, and interaction classes of interest created by other federates.

Section 2.1 lists the system requirements and describes how to install and compile the HLA interface.

Section 2.2 describes how to use the HLA interface to run QualNet with an external program.

Appendix B describes the Real-time Platform Reference Federation Object Model (RPR FOM) used by the QualNet HLA interface, the RPR FOM 1.0 Extensions Interface Communications Document, and the Dynamic Statistics Interface Communications Document.

QualNet and HLA Time Management

The HLA standard defines a number of optional time management services. However, RPR FOM federate support for these services is optional and they are not supported in QualNet. Instead, QualNet operates with time stepped, clock driven, independent time advance. This clock driven simulation is considered "real-time" because each second of wall clock time is equivalent to one second in the virtual world.

Limitations of the QualNet HLA Interface

- The QualNet HLA interface supports the HLA 1.3 standard. It does not support the HLA 1594 standard.
- The QualNet HLA interface is supported on distributed architectures but is not thread-safe and can not be run shared-memory parallel systems.

2.1 System Requirements, Installation, and Compilation

2.1.1 System Requirements

In addition to the systems requirements to run and compile QualNet, the QualNet HLA interface requires RTI software to run.

Refer to *QualNet Installation Guide* for systems requirements for running QualNet and to *QualNet Programmer's Guide* for requirements for compiling QualNet on shared memory systems. Refer to *QualNet Distributed Reference Guide* for requirements for running and compiling QualNet on distributed architectures.

Supported RTIs

Before trying to build the Standard Interfaces Library you must install a RTI that provides the RTI C++ header files and libraries for development. You cannot build the Standard Interfaces Library with a Java only RTI or if you have only installed the RTI runtime libraries. Any RTI implementation that follows the HLA 1.3 standard should work but may require some custom settings. In particular, MAK RTI (2.1 or higher) is supported by the QualNet HLA Interface.

Note: Some 64 bit installations of the MAK RTI are missing the iconv_64.dll. You should contact VT MAK support ((http://www.mak.com) to get this file.

2.1.2 Installation

The QualNet HLA interface is part of the QualNet distribution and does not need to be installed separately. However, QualNet needs to be recompiled in order to activate the HLA interface (see Section 2.1.4).

Before trying to build the Standard Interfaces Library you must install a RTI that provides the RTI C++ header files and libraries for development. You cannot build the Standard Interfaces Library with a Java-only RTI or if you have only installed the RTI runtime libraries.

To instal the RTI, follow the instructions that come with the RTI software package.

2.1.3 Environment Variables

This section lists the RTI environment variables that need to be set before the HLA interface can be built. Some RTI installations may set these variables automatically. Consult your RTI documentation for details on the options and libraries required for compiling and linking.

Section 2.1.3.1 describes the environment variables for all RTIs. Section 2.1.3.2 describes the environment variables for MAK RTI and Section 2.1.3.3 describes the environment variables for PoRTIco.

2.1.3.1 Environment Variables for All RTIs

This sections describes the environment variables for all RTIs.

- `RTI_HOME`: Specifies the RTI installation directory.
- `RTI_INCLUDE_DIR`: Specifies the directory containing the RTI C++ header files. The default value of this variable is `$(RTI_HOME)/include`.
- `RTI_DEFINES`: Specifies the HLA-specific compiler options. The default value of this variable is `DRTI_USES_STD_FSTREAM`.
- `RTI_LIB_DIR`: Specifies the directory containing the RTI development libraries. This may not be the same as the directory containing the RTI runtime libraries. The default value of this variable is `$(RTI_HOME)/lib`.
- `RTI_LIBRARY`: Specifies the options for linking with the RTI library. The default value depends on the type of build.

  For 32-bit Windows platforms the default value is `libRTI-NG.lib libFedTime.lib`.

  For 64-bit Windows platforms, the default value is `libRTI-NG_64.lib libFedTime_64.lib`.

  For Linux platforms, the default value is `–lRTI-NG -lfedtime`.
- `RTI_ADDITIONAL_LIBRARIES`: Specifies additional link options. The default is no additional link options.

Note: **1.** When setting environment variables that contain spaces, place quotes outside the entire expression. For example:

```
set "RTI_HOME=C:\Program Files\Portico\portico-0.8"
export "RTI_LIBRARY=-lRTI-NG -lFedTime"
```

2. On some Linux systems, depending on the version of the linker used, you must add the path to the RTI library directory to the `LD_LIBRARY_PATH` environment variable for the linker to find all of the dependencies for the RTI libraries.

2.1.3.2 Environment Variables for MAK RTI

On Windows platforms, to use the MAK RTI debug libraries, set `RTI-LIBRARY` to `libRTI-NGd.lib libfedtimed.lib`.

2.1.3.3 Environment Variables for PoRTIco

PoRTIco (http://porticoproject.org) is an open source, Java based RTI with a C++ wrapper. It requires Java to be installed. The PoRTIco libraries need to be able to find the Java Virtual Machine library (libjvm). On most platforms, the HLA Interface can be built without explicitly telling the linker to include libjvm. If you have a special development environment, you may need to explicitly tell the linker where to find libjvm.

The default PoRTIco installation is 32 bit only. If you wish to use 64 bit you will need to get the PoRTIco sources and rebuild it. PoRTIco places the RTI header files in $(RTI_HOME)\include\ng6.

Windows

If PoRTIco version 1.0.1 installed in C:\Program Files\Portico, set the environment variables as follows:

- Set `RTI_HOME` to `C:\Program Files\Portico\portico-1.0.1`.
- Set `RTI_INCLUDE_DIR` to `C:\Program Files\Portico\portico-1.0.1\include\ng6`.

Linux

If PoRTIco version 1.0.1 and JDK are installed in /usr/local, set the environment variables as follows:

- Set `LD_LIBRARY_PATH` to `/usr/local/jdk1.6.0_16/jre/lib/i386/client/:/usr/local/portico-1.0.1/lib`.
- set `RTI_HOME` to `/usr/local/portico-1.0.1`.
- Set `RTI_INCLUDE_DIR` to `/usr/local/portico-1.0.1/include/ng6`.
- Set `RTI_LIBRARY` to `-lRTI-NG -lFedTime`.

2.1.4 Compilation

This section describes how to compile QualNet to enable HLA support.

2.1.4.1 Compilation on Windows

To compile QualNet with HLA support on Windows, perform the following steps:

1. Open a command window and change the directory to QUALNET_HOME/main.
2. Open the file QUALNET_HOME/main/Makefile-addons-windows with a text editor.
   Change the line
   ```
   #include ../interfaces/hla/Makefile-windows
   ```
   to
   ```
   include ../interfaces/hla/Makefile-windows
   ```
3. Copy the makefile for your compiler to Makefile. For example, if you are using VC9 on a 32-bit platform, use the following command to make a copy of the makefile:
   ```
   copy Makefile-windows-vc9 Makefile
   ```
   Refer to *QualNet Programmer's Guide* for the list of makefiles for different compilers.
4. Use the following commands to remove all object files and recompile:
   ```
   nmake clean
   nmake
   ```

2.1.4.2 Compilation on Linux

To compile QualNet with HLA support on Linux, perform the following steps:

1. Open a command window and change the directory to QUALNET_HOME/main.
2. To automatically select the makefile for your system, type the following command:

   ```
   ./configure.sh
   ```

   The script will prompt you for the model libraries that should be compiled with QualNet. Type "Yes" when the script prompts you for including the HLA interface. The script will create a file called Makefile in the folder QUALNET_HOME/main.

   Note: Once you have created the makefile using this script, you do not need to run the script again unless you want to change the list of libraries to be compiled with QualNet.

3. Alternatively, manually select and edit the makefiles as follows:
   a. Open the file QUALNET_HOME/main/Makefile-addons-unix with a text editor.
   Change the line

   ```
   #include ../interfaces/hla/Makefile-unix
   ```

   to

   ```
   include ../interfaces/hla/Makefile-unix
   ```

   b. Copy the makefile for your compiler to Makefile. For example, for Red Hat Enterprise Linux 5.3 and other Linux distributions with glibc 2.5 and gcc 4.1 on a 32-bit platform, use the following command to make a copy of the makefile:

   ```
   cp Makefile-linux-glibc-2.5-gcc-4.1 Makefile
   ```

   Refer to *QualNet Programmer's Guide* for the list of makefiles for different compilers.

4. Use the following commands to remove all object files and recompile:

   ```
   make clean
   make
   ```

2.2 Using the HLA Interface

This section describes the procedure to use the HLA interface to simulate a scenario in a federation comprising QualNet and an external simulator.

Section 2.2.1 describes the general procedure for using the HLA interface.

Section 2.2.2 describes how to create QualNet scenarios for use with the HLA interface.

Section 2.2.3 describes the sequence of events when a scenario is simulated in a federation comprising QualNet and an external simulator.

Section 2.2.4 describes how to use the HLA interface to run a simulation in testfed and QualNet. testfed (test federate) program is a command-line based program included in the QualNet distribution which federates directly with QualNet. testfed is primarily used to test the QualNet HLA interface without the overhead of running a full constructive simulation tool.

Section 2.2.5 describes how to use the HLA interface to run a simulation in VR Forces and QualNet.

2.2.1 General Procedure for Using HLA Interface

In general, simulating a scenario using the HLA interface comprises the steps listed below. These steps are explained in the following sections.

1. Create a simulation scenario for the external simulator.
2. Create a QualNet scenario that is compatible with the external simulation scenario.
3. Start the RTI.
4. Start the external simulator and load the scenario.
5. Start QualNet and run the QualNet scenario equivalent to the external simulator scenario.
6. Run the simulation in the external simulator.

2.2.2 Creating Scenarios

For QualNet to provide communication effects to the external simulator, it should simulate the same communicating entities as the external simulator scenario. The QualNet scenario should define the protocol stack and communication capabilities of all communicating entities in the scenario to be simulated.

You can create a QualNet scenario manually or use Synchronizer to generate the equivalent compatible QualNet scenario. Refer to *QualNet User's Guide* for details of creating QualNet scenarios. See Section A.1 for details of using Synchronizer.

Tips for Configuring Scenarios

The following are some tips for creating scenarios for the HLA interface:

- If terrain is used, specify a proper propagation model that will take terrain features into account, for example, the Irregular Terrain Model (ITM). See *Wireless Model Library* for details of ITM and other propagation models.
- The default parameter values for the 802.11 MAC protocol may prevent communication to take place over large distances. If the 802.11 MAC protocol is used in a scenario in which nodes are separated by large distances, make sure that the 802.11 MAC parameters are properly set. Alternatively, use another MAC protocol, such as Generic MAC. See *Wireless Model Library* for details of the 802.11 MAC and Generic MAC models.

2.2.2.1 Command Line Configuration

To enable the HLA interface, include the following parameter in the scenario configuration (.config) file:

```
HLA         YES
```

Note: The default value of the parameter `HLA` is `NO`.

HLA Interface Parameters

In addition to the other parameters required to configure a simulation scenario (refer to *QualNet User's Guide*), the parameters described in Table 2-1 must be configured in order to use the HLA interface.

TABLE 2-1. HLA Interface Parameters

Parameter	Value	Description
`HLA-DEBUG` *Optional* *Scope:* Global	List: • `YES` • `NO` *Default:* `NO`	Enables debug output from HLA communications effects requests.
`HLA-DEBUG-2` *Optional* *Scope:* Global	List: • `YES` • `NO` *Default:* `NO`	Enables verbose debug output from HLA communications effects requests.
`HLA-FEDERATION-NAME` *Required* *Scope:* Global	String	Name of the HLA federation to join. All simulators in the joint simulation must use the same federation name.
`HLA-FED-FILE-PATH` *Required* *Scope:* Global	Filename	Name of the Federation Execution DEtails (FED) file to use for the joint simulation.
`HLA-FEDERATE-NAME` *Required* *Scope:* Global	String	Name used by QualNet to identify itself to the HLA federation.
`HLA-RPR-FOM-VERSION` *Required* *Scope:* Global	List: • `0.5` • `1.0` *Default:* `1.0`	Version of RPR-FOM to use.
`HLA-NAWC-GATEWAY-COMPATIBILITY` *Optional* *Scope:* Global	List: • `YES` • `NO` *Default:* `NO`	Specifies whether QualNet should operate in NAWC Gateway compatibility mode. The NAWC Gateway translates between DIS and HLA and requires special processing.
`HLA-XYZ-EPSILON` *Optional* *Scope:* Global	Real *Range:* ≥ `0` *Default:* `0.5` *Unit:* meters	Minimum change in any of the X-, Y-, or Z-coordinates of an entity's position before the position is updated in QualNet.

TABLE 2-1. HLA Interface Parameters

Parameter	Value	Description
`HLA-TICK-INTERVAL` *Optional* *Scope:* Global	Time *Range:* ≥ `0S` *Default:* `200MS`	Minimum time between checks to see if the RTI has any Attribute Updates or Interactions for QualNet to process.
`HLA-MOBILITY-INTERVAL` *Optional* *Scope:* Global	Time *Range:* ≥ `0S` *Default:* `500MS`	Minimum time between processing Entity position updates.
`HLA-ENTITIES-FILE-PATH` *Required* *Scope:* Global	Filename	Name of the Entities file. This file corresponds to the RPR FOM Physical Entity objects in HLA. The format of the Entities file is described in Section 2.2.2.1.1.
`HLA-RADIOS-FILE-PATH` *Required* *Scope:* Global	Filename	Name of the Radios file. This file corresponds to the RPR FOM Radio Transmitter objects in HLA. The format of the Radios file is described in Section 2.2.2.1.2.
`HLA-NETWORKS-FILE-PATH` *Required* *Scope:* Global	Filename	Name of the Networks file. This file defines groups of radios that can communicate with each other. The format of the Networks file is described in Section 2.2.2.1.2.
`HLA-DYNAMIC-STATISTICS` *Optional* *Scope:* Global	List: • `YES` • `NO` *Default:* `YES`	Indicates whether HLA dynamic statistics are enabled (see Section B.3 for details). HLA statistics will only be sent when using the GUI. Only the metrics selected using the Dynamics Statistics feature (refer to *QualNet User's Guide*) will be sent.
`HLA-DYNAMIC-STATISTICS-METRIC-UPDATE-MODE` *Optional* *Scope:* Global	List: • `VERBOSE` • `BRIEF` *Default:* `VERBOSE`	Level of detail in the Metric Update notifications (see Section B.3 for details). `VERBOSE`: Include nodeId and Metric Definition descriptions with the metric update. `BRIEF`: Include only the metric data. **Note:** This parameter is applicable only if `HLA-DYNAMIC-STATISTIS` is set to `YES`.

TABLE 2-1. HLA Interface Parameters

Parameter	Value	Description
`HLA-DYNAMIC-STATISTICS-SEND-NODEID-DESCRIPTIONS` *Optional* *Scope:* Global	List: • `YES` • `NO` *Default:* `NO`	Indicates whether nodeId Description notifications are sent (see Section B.3 for details). **Note:** This parameter is applicable only if `HLA-DYNAMIC-STATISTIS` is set to `YES`.
`HLA-DYNAMIC-STATISTICS-SEND-METRIC-DEFINITIONS` *Optional* *Scope:* Global	List: • `YES` • `NO` *Default:* `NO`	Indicates whether Metric Definition notifications are sent (see Section B.3 for details). **Note:** This parameter is applicable only if `HLA-DYNAMIC-STATISTIS` is set to `YES`.

2.2.2.1.1 Format of the Entities File

The Entities file is used by both HLA and DIS (see Chapter 3). This file corresponds to the RPR FOM Physical Entity objects in HLA and to Entities in DIS.

Each line in the Entities file has the following format (all entries are on the same line):

```
<Marking>, <Force ID>, <Nationality>, <Lat>, <Long>, <Alt>, <Entity
Type Attributes>
```

where

`<Marking>`	Marking for the entity. This is a string value. QualNet uses this string to identify the entity. Each entity in the federation should have a unique marking.
`<Force ID>`	Force ID of the entity. This can be `F` (for friendly), `O` (for opposing), or `N` (for neutral).
`<Nationality>`	Nationality of the entity. This is a string value. This is the same as the `Country` field of the `EntityType` attribute. See RPR FOM for HLA (see Section B.1) and the description of the Entity State PDU for DIS (see Section B.4).
`<Lat>`	Initial latitude of the entity.
`<Long>`	Initial longitude of the entity.
`<Alt>`	Initial altitude of the entity (in meters). This is the height above the WGS84 ellipsoid.
`<Entity Type Attributes>`	The seven fields `EntityType` attribute (which define the type of the unit): `<EA1>, <EA2>, <EA3>, <EA4>, <EA5>, <EA6>, <EA7>` where `<EA1>` through `<EA7>` are the seven fields of the `EntityType` attribute.

Example

The following is an example of an Entities file:

```
Tank11, F, USA, 43.533208,  6.680064,  0.5, 1, 1, 225, 1, 1, 1, 0
Tank12, F, USA, 43.533081,  6.676147,  0.5, 1, 1, 225, 1, 1, 1, 0
Tank13, F, USA, 43.533072,  6.671681,  0.5, 1, 1, 225, 1, 1, 1, 0
```

2.2.2.1.2 Format of the Radios File

The Radios file is used by both HLA and DIS (see Chapter 3). This file corresponds to the RPR FOM Radio Transmitter objects in HLA and to Transmitters in DIS.

Each line in the Radios file has the following format (all entries are on the same line):

```
<Node ID>, <Marking>, <Radio Index>, <Delta-X>, <Delta-Y>, <Delta-Z>,
<Radio Type Attributes>
```

where

`<Node ID>`	ID of the node corresponding to the Radio Transmitter object.
`<Marking>`	Marking for the host entity. This is a string value. This marking should be the same as the marking for the entity specified in the Entities file (see Section 2.2.2.1.1).
`<Radio Index>`	Radio index, which uniquely identifies the Radio Transmitter object on the host entity.
`<Delta-X>`, `<Delta-Y>`, `<Delta-Z>`	Relative position of the radio as mounted on the entity (in meters) using a world coordinate system that has the Y and Z axes swapped compared to the RPR-FOM geocentric Coordinate System.
`<Entity Type Attributes>`	The six fields `RadioType` attribute (which define the type of the radio): `<RA1>, <RA2>, <RA3>, <RA4>, <RA5>, <RA6>` where `<RA1>` through `<RA6>` are the six fields of the `RadioType` attribute.

Example

The following is an example of a Radios file:

```
1, Tank11, 0, 0.0, 0.0, 0.0, 7, 1, 225, 3, 1, 1
2, Tank12, 1, 0.0, 0.0, 0.0, 7, 1, 225, 3, 1, 1
3, Tank13, 2, 0.0, 0.0, 0.0, 7, 1, 225, 3, 1, 1
```

2.2.2.1.3 Format of the Networks File

The Networks file is used by both HLA and DIS (see Chapter 3). This file defines groups of radios that can communicate with each other.

Each line in the Networks file has the following format (all entries are on the same line):

```
<Network Name>; <Frequency>; <Node IDs>; <Destination Address>
```

where

`<Network Name>`	Name of the network. This field is not used by QualNet.
`<Frequency>`	Frequency of the network (in Hz). This field is not used by QualNet.
`<Node IDs>`	List of IDs of nodes that belong to the network. The node IDs are separated by commas. **Note:** A node can belong to only one network.
`<Destination Address>`	IP address of the default destination used for transmissions on the network. The default destination is used when the receiver is not specified in the communications request. The local broadcast IP address (`255.255.255.255`) is the default, although other IP addresses can be substituted (e.g., multicast IP addresses). A value of `0.0.0.0` indicates that all transmissions on the network should be modeled as unicast (in which case the default destination is dynamically assigned at run time). **Note:** The default address, `255.255.255.255`, is used for single-hop broadcasts. `0.0.0.0` should generally be used for multi-hop (or otherwise relayed) communications, when a network spans network infrastructure present in QualNet but not represented in HLA.

Example

The following is an example of a Networks file:

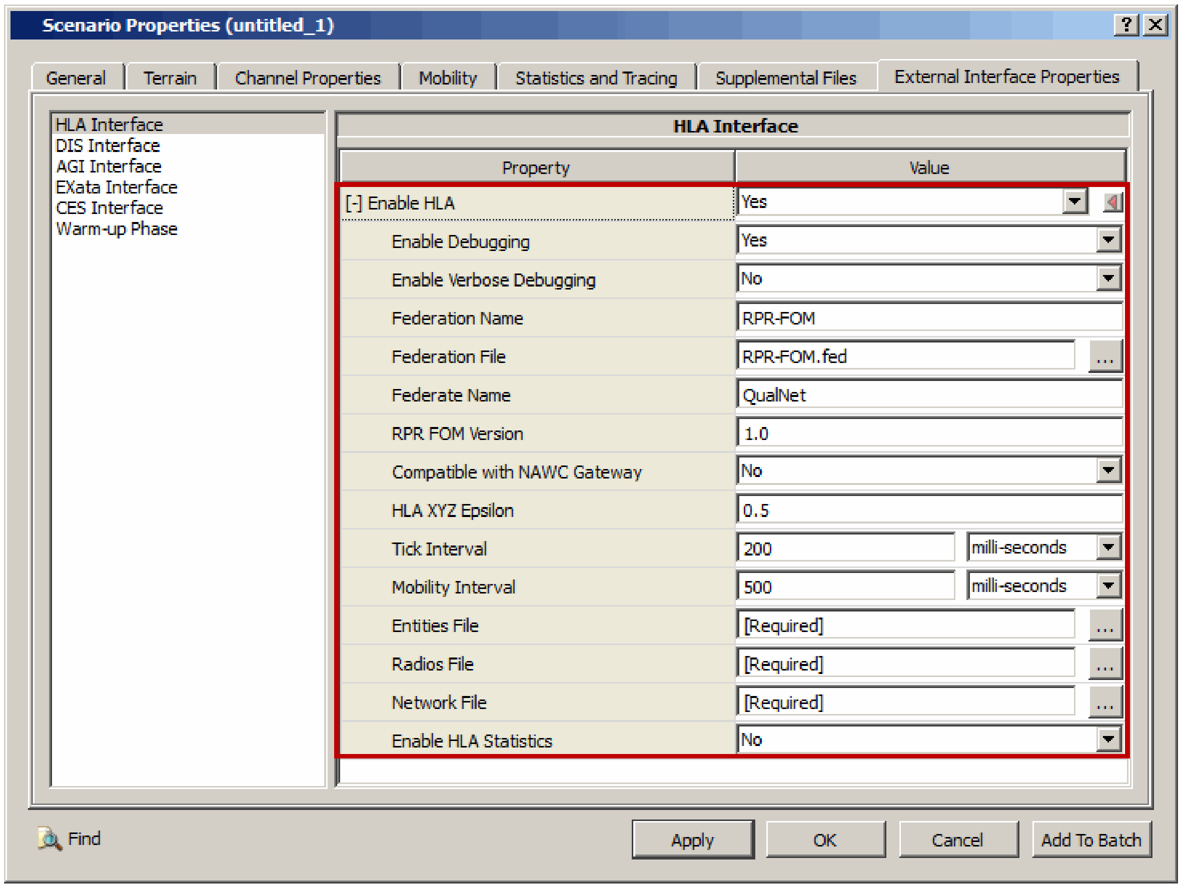
```
N1;30000000;1,2,3,4;255.255.255.255
N2;35000000;5,6,7,8;255.255.255.255
N3;40000000;9,10,11,12;255.255.255.255
N4;45000000;13,14,15,16;255.255.255.255
N5;50000000;17,18,19,20;255.255.255.255
N6;225000000;21,23;255.255.255.255
N7;230000000;24,27;0.0.0.0
```

2.2.2.2 GUI Configuration

In addition to the other parameters required to configure a simulation scenario (refer to *QualNet User's Guide*), the HLA interface parameters must be configured as described below.

To configure the HLA interface parameters, perform the following steps:

1. Go to **Scenario Properties Editor > External Interfaces > HLA Interface**.
2. Set **Enable HLA** to *Yes* and set the dependent parameters listed in Table 2-2.



HLA Interface

Property	Value
[-] Enable HLA	Yes
Enable Debugging	Yes
Enable Verbose Debugging	No
Federation Name	RPR-FOM
Federation File	RPR-FOM.fed
Federate Name	QualNet
RPR FOM Version	1.0
Compatible with NAWC Gateway	No
HLA XYZ Epsilon	0.5
Tick Interval	200 milli-seconds
Mobility Interval	500 milli-seconds
Entities File	[Required]
Radios File	[Required]
Network File	[Required]
Enable HLA Statistics	No

FIGURE 2-1. Configuring HLA Interface Parameters

TABLE 2-2. Command Line Equivalent of HLA Interface Parameters

GUI Parameter	Scope of GUI Parameter	Command Line Parameter
Enable Debugging	Global	`HLA-DEBUG`
Enable Verbose Debugging	Global	`HLA-DEBUG-2`
Federation Name	Global	`HLA-FEDERATION-NAME`
Federation File	Global	`HLA-FED-FILE-PATH`
Federate Name	Global	`HLA-FEDERATE-NAME`
RPR FOM Version	Global	`HLA-RPR-FOM-VERSION`
Compatible with NAWC Gateway	Global	`HLA-NAWC-GATEWAY-COMPATIBILITY`

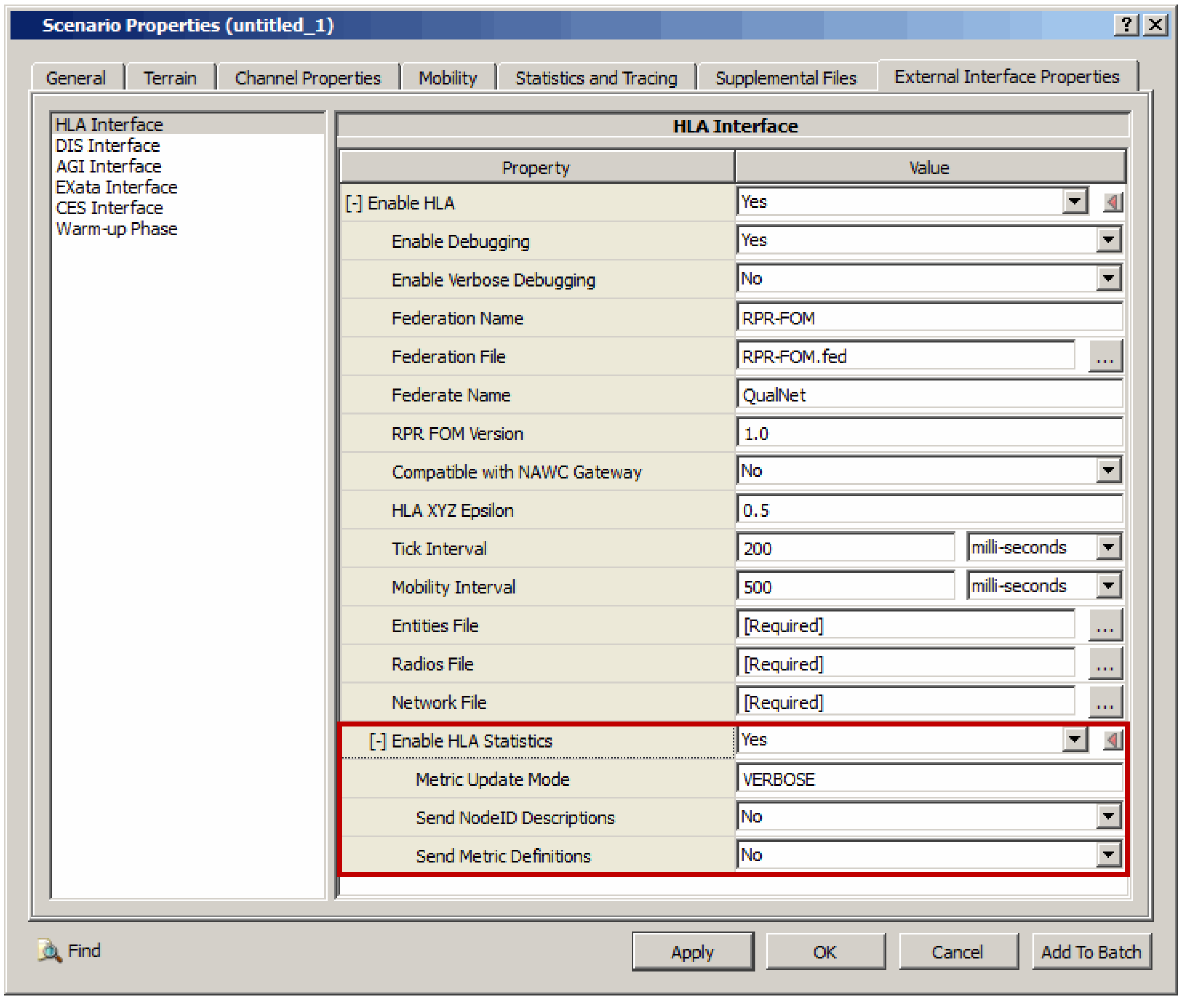
TABLE 2-2. Command Line Equivalent of HLA Interface Parameters (Continued)

GUI Parameter	Scope of GUI Parameter	Command Line Parameter
HLA XYZ Epsilon	Global	`HLA-XYZ-EPSILON`
Tick Interval	Global	`HLA-TICK-INTERVAL`
Mobility Interval	Global	`HLA-MOBILITY-INTERVAL`
Entities File	Global	`HLA-ENTITIES-FILE-PATH`
Radios File	Global	`HLA-RADIOS-FILE-PATH`
Networks File	Global	`HLA-NETWORKS-FILE-PATH`
Enable HLA Statistics	Global	`HLA-DYNAMIC-STATISTICS`

Setting Parameters

- Set **Federation File** to the name of the Federation file.
- Set **Entities File** to the name of the Entities file. See Section 2.2.2.1.1 for the format of the Entities file.
- Set **Radios File** to the name of the Radios file. See Section 2.2.2.1.2 for the format of the Radios file.
- Set **Networks File** to the name of the Networks file. See Section 2.2.2.1.3 for the format of the Networks file.

3. If **HLA Statistics** is set to *Yes*, then set the dependent parameters listed in Table 2-2.



Property	Value
[-] Enable HLA	Yes
Enable Debugging	Yes
Enable Verbose Debugging	No
Federation Name	RPR-FOM
Federation File	RPR-FOM.fed
Federate Name	QualNet
RPR FOM Version	1.0
Compatible with NAWC Gateway	No
HLA XYZ Epsilon	0.5
Tick Interval	200 milli-seconds
Mobility Interval	500 milli-seconds
Entities File	[Required]
Radios File	[Required]
Network File	[Required]
[-] Enable HLA Statistics	Yes
Metric Update Mode	VERBOSE
Send NodeID Descriptions	No
Send Metric Definitions	No

FIGURE 2-2. Configuring HLA Statistics Parameters

TABLE 2-3. Command Line Equivalent of HLA Statistics Parameters

GUI Parameter	Scope of GUI Parameter	Command Line Parameter
Metric Update Mode	Global	`HLA-DYNAMIC-STATISTICS-METRIC-UPDATE-MODE`
Send NodeID Descriptions	Global	`HLA-DYNAMIC-STATISTICS-SEND-NODEID-DESCRIPTIONS`
Send Metric Definitions	Global	`HLA-DYNAMIC-STATISTICS-SEND-METRIC-DEFINITIONS`

2.2.3 Sequence of Events

The sequence of events in a typical HLA federation consisting of QualNet and a client federate is as follows:

1. Client loads the scenario and joins federation.
2. QualNet loads the equivalent scenario and joins federation.
3. QualNet waits for the first entity update sent by the client federate. The update can be for any entity, whether or not it has a representation in the QualNet scenario. (Only communicating entities in the client scenario need to be represented in QualNet.)
4. The QualNet simulation starts initializing when the first entity update is received. The initialization time depends on the complexity of the scenario. The simulation starts after the initialization is complete. The warm-up phase of QualNet starts when the simulation starts. In the warm-up phase, depending on the configuration, all communication effects requests are treated as being either unsuccessful or successful with zero delay.
5. During the simulation, when the client federate moves an entity, it updates the Entities position and the RTI sends an Entity Attribute Update (see Section B.1). When QualNet receives the Entity Attribute Update, it consults the Entities and Radios files (see Section 2.2.2) to move the appropriate QualNet nodes.
6. During the simulation, the client federate sends ApplicationSpecificRadioSignal (ASRS) interactions to request communication effects modeling (see Section B.1). When QualNet receives an ASRS interaction, it models the traffic and can respond as follows:
   - If the communication is successful, QualNet sends a Process Message interaction indicating that the message was delivered to the destination. This interaction is sent to the client as soon as the modeled message is delivered to the destination node in QualNet.
   - Whether or not the communication is successful, QualNet sends a Timeout interaction summarizing the delivery status to all potential recipients. This occurs when the processing of the message is complete: either after the timeout value indicated in the original ApplicationSpecificRadioSignal interaction, or after all potential recipients have processed the signal, whichever occurs first.
7. The client federate can also indicate if entities are damaged or destroyed, or hosted radios are turned on or off. QualNet will model such effects appropriately (for example, a destroyed entity will deactivate all associated QualNet nodes).
8. The QualNet simulation runs for the time specified by the QualNet `SIMUALTION-TIME` parameter, irrespective of when the client simulation ends. The statistics file is generated when the QualNet simulation ends.

2.2.4 Using HLA Interface with testfed

This section describes how to use the QualNet HLA interface with testfed. testfed (test federate) is a command-line based program included in the QualNet distribution which is primarily used to test the QualNet HLA interface without the overhead of running a full constructive simulation tool. See Section A.2 for the details of compiling and using testfed.

2.2.4.1 Creating Scenarios for testfed and QualNet

testfed uses the same scenario files as QualNet. Refer to *QualNet User's Guide* for details of configuring scenarios in QualNet. In addition, the parameters described in Section 2.2.2 also need to be configured.

2.2.4.2 testfed-QualNet Demonstration

This section describes how to run testfed with QualNet using a sample scenario, iitsec, located in QUALNET_HOME\scenarios\hla\iitsec.

To run this demo, the RTI must already be installed, and QualNet must already have been recompiled with HLA support.

Please note that running **rtiexec** is not necessary if using MAK RTI in its default "lightweight" mode, or if the DMSO RTI is configured to run in this mode as well.

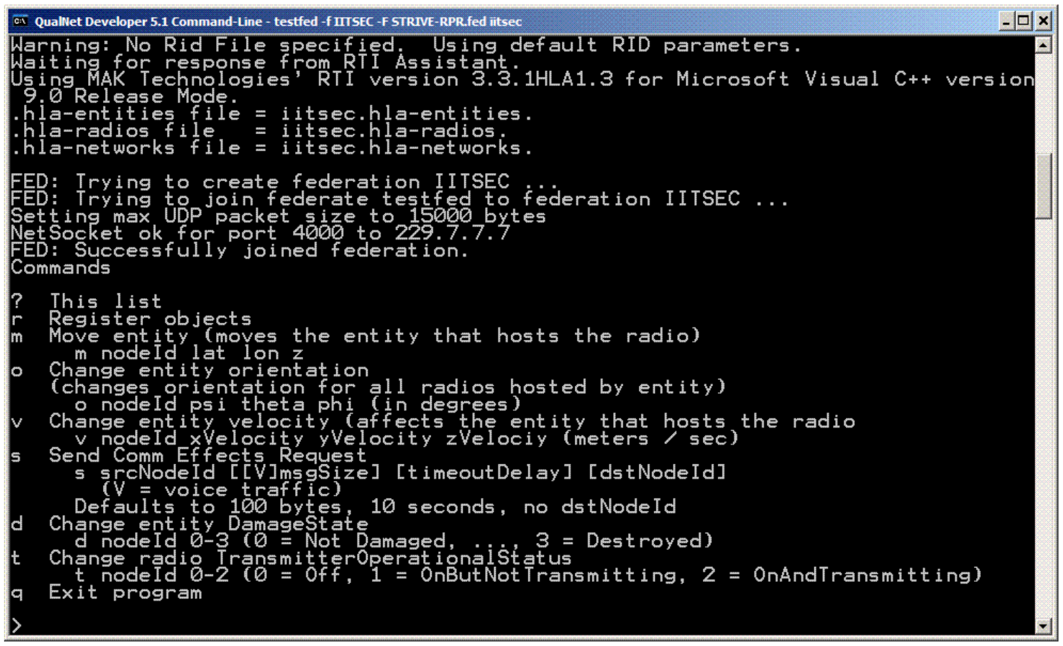
1. Start the RTI, if necessary.

   a. Start rtiexec if necessary.

   b. Wait for rtiexec to finish initializing.

2. Open a command window and change the directory to QUALNET_HOME\scenarios\hla\iitsec. Start testfed by typing the following command:

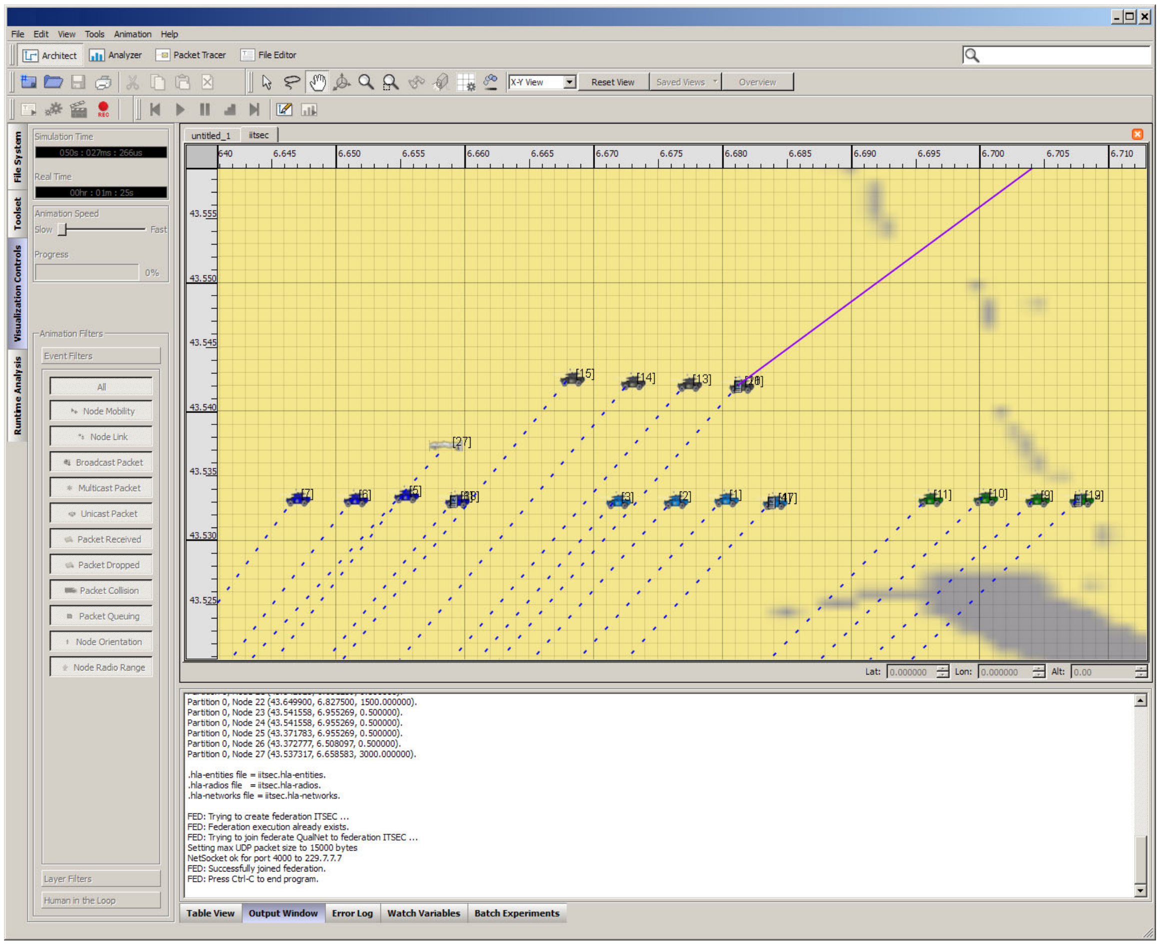
```
testfed -f ITSEC -F STRIVE-RPR.fed iitsec
```



```
QualNet Developer 5.1 Command-Line - testfed -f IITSEC -F STRIVE-RPR.fed iitsec
Warning: No Rid File specified.  Using default RID parameters.
Waiting for response from RTI Assistant.
Using MAK Technologies' RTI version 3.3.1HLA1.3 for Microsoft Visual C++ version
 9.0 Release Mode.
.hla-entities file = iitsec.hla-entities.
.hla-radios file   = iitsec.hla-radios.
.hla-networks file = iitsec.hla-networks.

FED: Trying to create federation IITSEC ...
FED: Trying to join federate testfed to federation IITSEC ...
Setting max UDP packet size to 15000 bytes
NetSocket ok for port 4000 to 229.7.7.7
FED: Successfully joined federation.
Commands

?  This list
r  Register objects
m  Move entity (moves the entity that hosts the radio)
     m nodeId lat lon z
o  Change entity orientation
   (changes orientation for all radios hosted by entity)
     o nodeId psi theta phi (in degrees)
v  Change entity velocity (affects the entity that hosts the radio
     v nodeId xVelocity yVelocity zVelociy (meters / sec)
s  Send Comm Effects Request
     s srcNodeId [[V]msgSize] [timeoutDelay] [dstNodeId]
       (V = voice traffic)
     Defaults to 100 bytes, 10 seconds, no dstNodeId
d  Change entity DamageState
     d nodeId 0-3 (0 = Not Damaged, ..., 3 = Destroyed)
t  Change radio TransmitterOperationalStatus
     t nodeId 0-2 (0 = Off, 1 = OnButNotTransmitting, 2 = OnAndTransmitting)
q  Exit program

>
```

FIGURE 2-3. Starting testfed

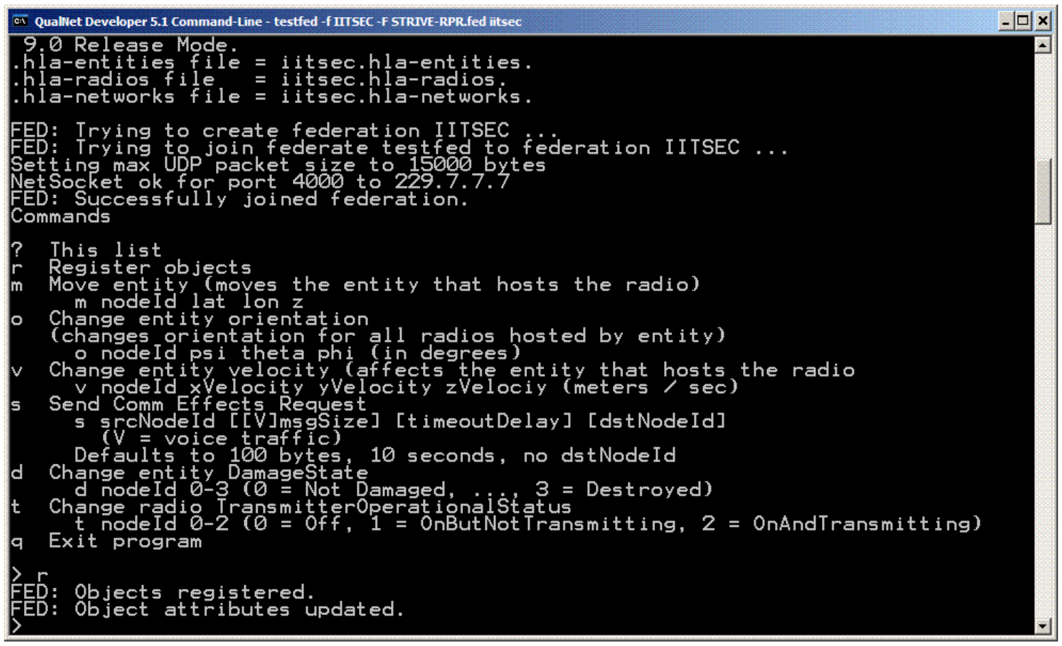
3. Start the QualNet GUI and open the scenario QUALNET_HOME\scenarios\hla\iitsec in the GUI. Open the **Output Window** panel to display the HLA debug messages. On the canvas, zoom in on the vehicles. Click on the Run Simulation button to begin simulation initialization.



```
Partition 0, Node 22 (43.649900, 6.827500, 1500.000000).
Partition 0, Node 23 (43.541558, 6.955269, 0.500000).
Partition 0, Node 24 (43.541558, 6.955269, 0.500000).
Partition 0, Node 25 (43.371783, 6.955269, 0.500000).
Partition 0, Node 26 (43.372777, 6.508097, 0.500000).
Partition 0, Node 27 (43.537317, 6.658583, 3000.000000).

.hla-entities file = iitsec.hla-entities.
.hla-radios file   = iitsec.hla-radios.
.hla-networks file = iitsec.hla-networks.

FED: Trying to create federation ITSEC ...
FED: Federation execution already exists.
FED: Trying to join federate QualNet to federation ITSEC ...
Setting max UDP packet size to 15000 bytes
NetSocket ok for port 4000 to 229.7.7.7
FED: Successfully joined federation.
FED: Press Ctrl-C to end program.
```

FIGURE 2-4. Debug Messages in QualNet GUI

4. In the testfed window, type the `r` (register) command to create entity and radio objects in the federation.

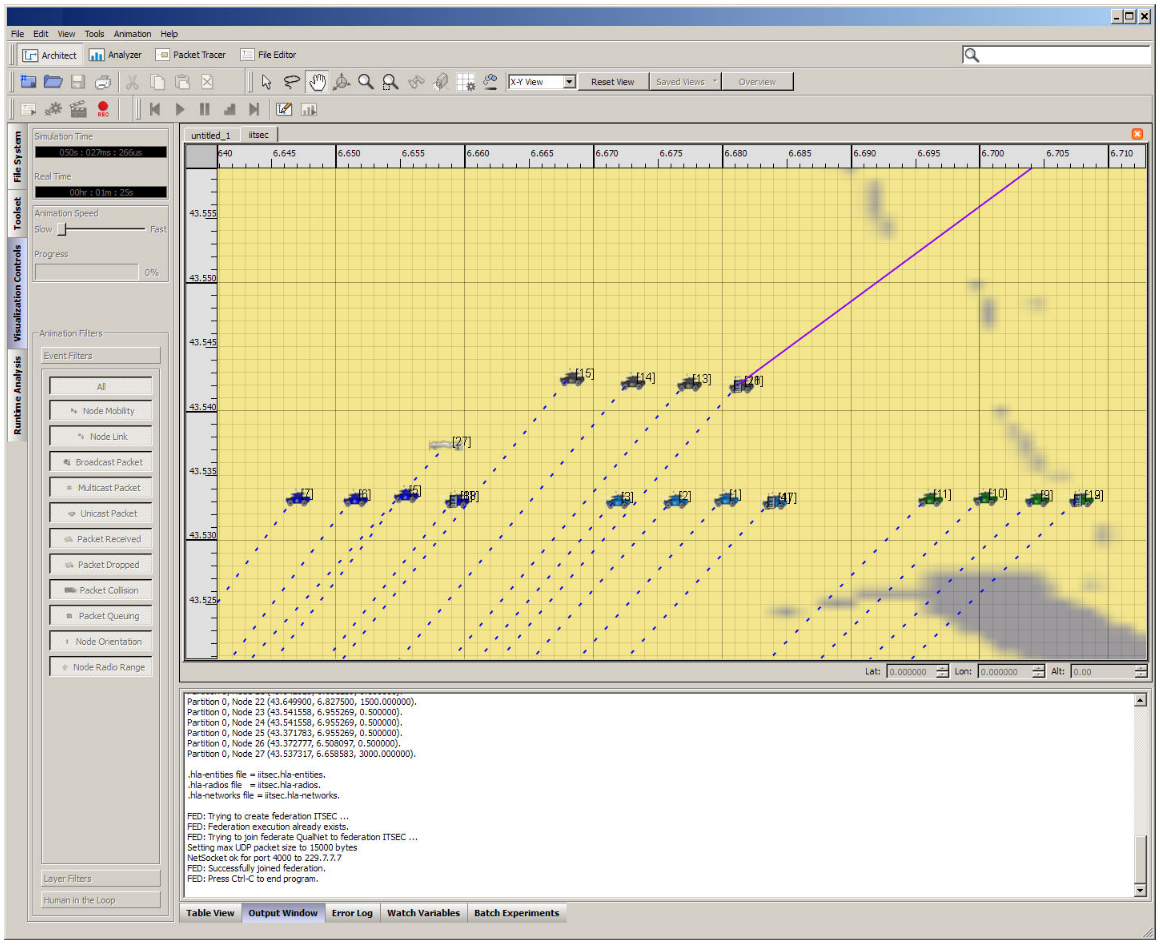


QualNet Developer 5.1 Command-Line - testfed -f IITSEC -F STRIVE-RPR.fed iitsec

```
 9.0 Release Mode.
.hla-entities file = iitsec.hla-entities.
.hla-radios file   = iitsec.hla-radios.
.hla-networks file = iitsec.hla-networks.

FED: Trying to create federation IITSEC ...
FED: Trying to join federate testfed to federation IITSEC ...
Setting max UDP packet size to 15000 bytes
NetSocket ok for port 4000 to 229.7.7.7
FED: Successfully joined federation.
Commands

?  This list
r  Register objects
m  Move entity (moves the entity that hosts the radio)
     m nodeId lat lon z
o  Change entity orientation
   (changes orientation for all radios hosted by entity)
     o nodeId psi theta phi (in degrees)
v  Change entity velocity (affects the entity that hosts the radio
     v nodeId xVelocity yVelocity zVelociy (meters / sec)
s  Send Comm Effects Request
     s srcNodeId [[V]msgSize] [timeoutDelay] [dstNodeId]
       (V = voice traffic)
     Defaults to 100 bytes, 10 seconds, no dstNodeId
d  Change entity DamageState
     d nodeId 0-3 (0 = Not Damaged, ..., 3 = Destroyed)
t  Change radio TransmitterOperationalStatus
     t nodeId 0-2 (0 = Off, 1 = OnButNotTransmitting, 2 = OnAndTransmitting)
q  Exit program

> r
FED: Objects registered.
FED: Object attributes updated.
>
```

FIGURE 2-5. Output of testfed Register Command

5. In the QualNet GUI, Click the **Play** button in the toolbar at the top of the window.



```
Partition 0, Node 22 (43.649900, 6.827500, 1500.000000).
Partition 0, Node 23 (43.541558, 6.955269, 0.500000).
Partition 0, Node 24 (43.541558, 6.955269, 0.500000).
Partition 0, Node 25 (43.371783, 6.955269, 0.500000).
Partition 0, Node 26 (43.372777, 6.508097, 0.500000).
Partition 0, Node 27 (43.537317, 6.658583, 3000.000000).

.hla-entities file = iitsec.hla-entities.
.hla-radios file   = iitsec.hla-radios.
.hla-networks file = iitsec.hla-networks.

FED: Trying to create federation ITSEC ...
FED: Federation execution already exists.
FED: Trying to join federate QualNet to federation ITSEC ...
Setting max UDP packet size to 15000 bytes
NetSocket ok for port 4000 to 229.7.7.7
FED: Successfully joined federation.
FED: Press Ctrl-C to end program.
```

FIGURE 2-6. Running QualNet Simulation

6. In the testfed window:

- Use the **m** (move) command to move entities. All radios hosted by the entity are moved in QualNet.

  A sample move command is:

  `m 1 40 10 0` (Node 1 moves to 40 degrees latitude, 10 degrees longitude, and 0 meters altitude)

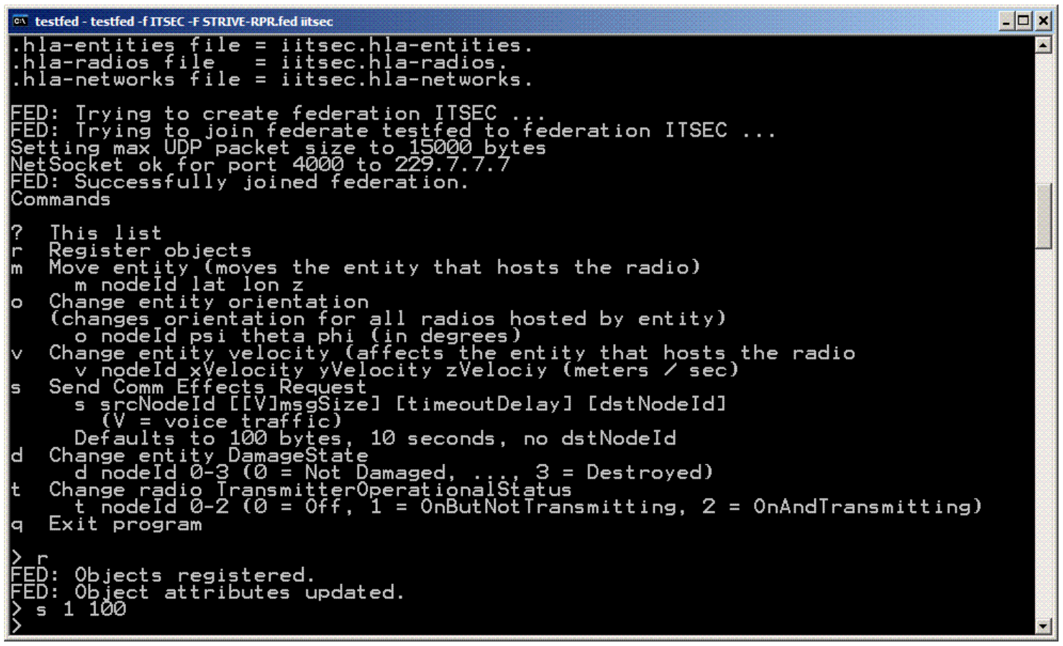
- Use the `s` (send communication) command to direct QualNet to simulate a communication.

  Press **Enter** several times to see the results as they come in.

  Some sample send commands are:

`s 1 100`	(Node 1 broadcasts 100 bytes data)
`s 1 V5 30 3`	(Node 1 broadcasts 5 seconds of voice with a timeout of 30 seconds to node 3)

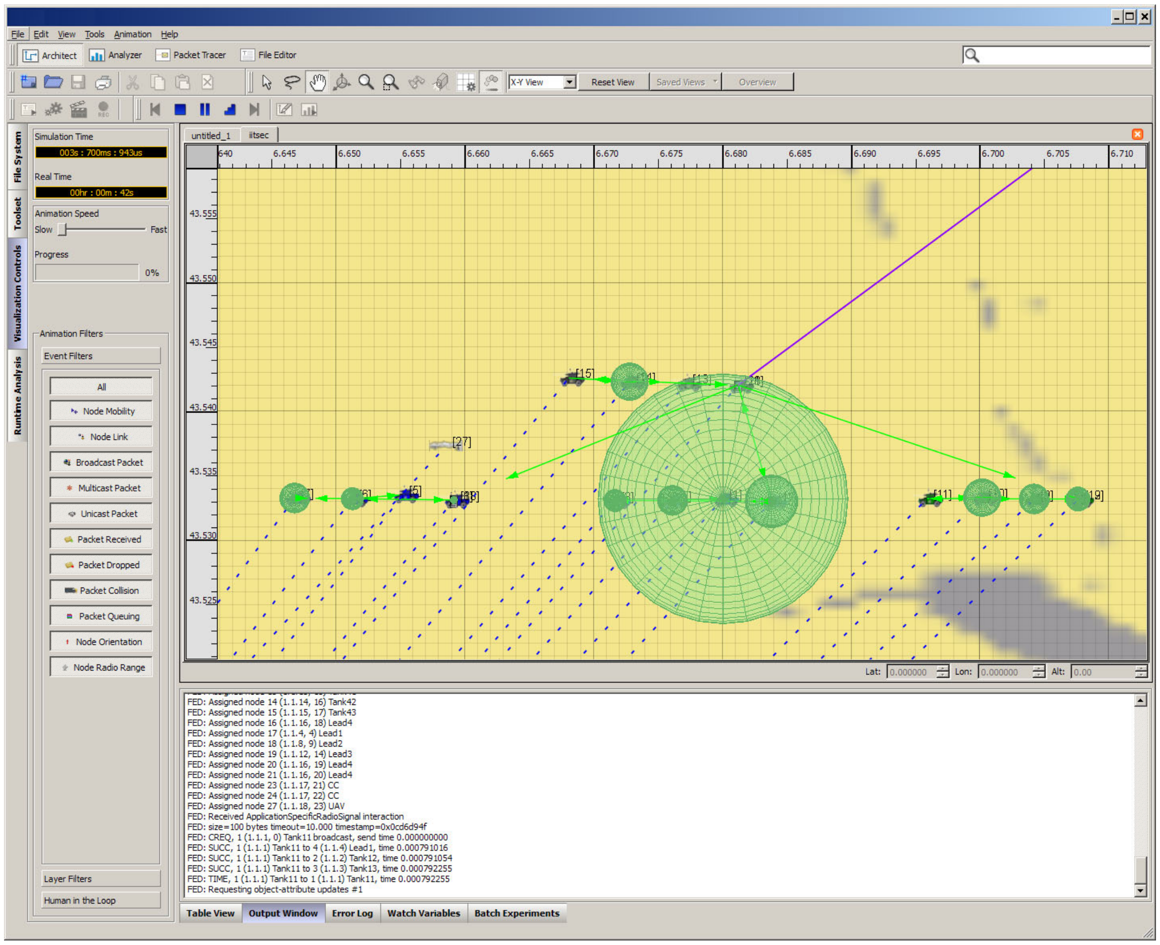
  Observe the translated request and result messages in the QualNet window.



testfed - testfed -f ITSEC -F STRIVE-RPR.fed iitsec

```
.hla-entities file = iitsec.hla-entities.
.hla-radios file   = iitsec.hla-radios.
.hla-networks file = iitsec.hla-networks.

FED: Trying to create federation ITSEC ...
FED: Trying to join federate testfed to federation ITSEC ...
Setting max UDP packet size to 15000 bytes
NetSocket ok for port 4000 to 229.7.7.7
FED: Successfully joined federation.
Commands

?  This list
r  Register objects
m  Move entity (moves the entity that hosts the radio)
     m nodeId lat lon z
o  Change entity orientation
   (changes orientation for all radios hosted by entity)
     o nodeId psi theta phi (in degrees)
v  Change entity velocity (affects the entity that hosts the radio
     v nodeId xVelocity yVelocity zVelociy (meters / sec)
s  Send Comm Effects Request
     s srcNodeId [[V]msgSize] [timeoutDelay] [dstNodeId]
       (V = voice traffic)
     Defaults to 100 bytes, 10 seconds, no dstNodeId
d  Change entity DamageState
     d nodeId 0-3 (0 = Not Damaged, ..., 3 = Destroyed)
t  Change radio TransmitterOperationalStatus
     t nodeId 0-2 (0 = Off, 1 = OnButNotTransmitting, 2 = OnAndTransmitting)
q  Exit program

> r
FED: Objects registered.
FED: Object attributes updated.
> s 1 100
>
```

FIGURE 2-7. Entering Send Communication Command in testfed



```
FED: Assigned node 14 (1.1.14, 16) Tank42
FED: Assigned node 15 (1.1.15, 17) Tank43
FED: Assigned node 16 (1.1.16, 18) Lead4
FED: Assigned node 17 (1.1.4, 4) Lead1
FED: Assigned node 18 (1.1.8, 9) Lead2
FED: Assigned node 19 (1.1.12, 14) Lead3
FED: Assigned node 20 (1.1.16, 19) Lead4
FED: Assigned node 21 (1.1.16, 20) Lead4
FED: Assigned node 23 (1.1.17, 21) CC
FED: Assigned node 24 (1.1.17, 22) CC
FED: Assigned node 27 (1.1.18, 23) UAV
FED: Received ApplicationSpecificRadioSignal interaction
FED: size=100 bytes timeout=10.000 timestamp=0x0cd6d94f
FED: CREQ, 1 (1.1.1, 0) Tank11 broadcast, send time 0.000000000
FED: SUCC, 1 (1.1.1) Tank11 to 4 (1.1.4) Lead1, time 0.000791016
FED: SUCC, 1 (1.1.1) Tank11 to 2 (1.1.2) Tank12, time 0.000791054
FED: SUCC, 1 (1.1.1) Tank11 to 3 (1.1.3) Tank13, time 0.000792255
FED: TIME, 1 (1.1.1) Tank11 to 1 (1.1.1) Tank11, time 0.000792255
FED: Requesting object-attribute updates #1
```

FIGURE 2-8. Effect of testfed Command on QualNet Simulation

7. In the QualNet GUI, not all transmission circles may appear to be drawn when an `s` command is issued. To see them, reduce the animation speed in the GUI by dragging the **Animation Speed** slider in the Status Display panel on the left.
8. In the testfed window, type the `q` (quit) command to exit from testfed.
9. Run the QualNet scenario to completion in order to generate the statistics file.

2.2.5 Using HLA Interface with VR Forces

This section describes how to use the QualNet HLA interface with VT MAK 's' VR-Forces (http://www.mak.com).

VR-Forces is a Computer-Generated Forces (CGF) toolkit. It provides an intuitive GUI that allows non-programmers to build scenarios by positioning forces, creating routes and waypoints, and assigning tasks or plans with simple point and click. During scenario execution, VR-Forces vehicles interact with the terrain, follow roads, avoid obstacles, detect and engage enemy forces, and calculate damage. Vehicle dynamics, sensor capabilities, and damage models are fully configurable with no programming necessary. Entities in VR-Forces also communicate with each other, such as sending and receiving commands, providing sensor updates, and other network centric operations. VR-Forces assumes perfect communications, i.e., all messages are delivered, regardless of the communications environment.

2.2.5.1 Creating Scenarios

Create scenarios for VR-Forces and QualNet, as described in Section 2.2.2.

2.2.5.2 Starting RTI

In order to run the HLA interface, the RTI software should be installed and properly configured.

This section describes how to start the MAK RTI. For other RTIs, refer to the documentation for the RTI.

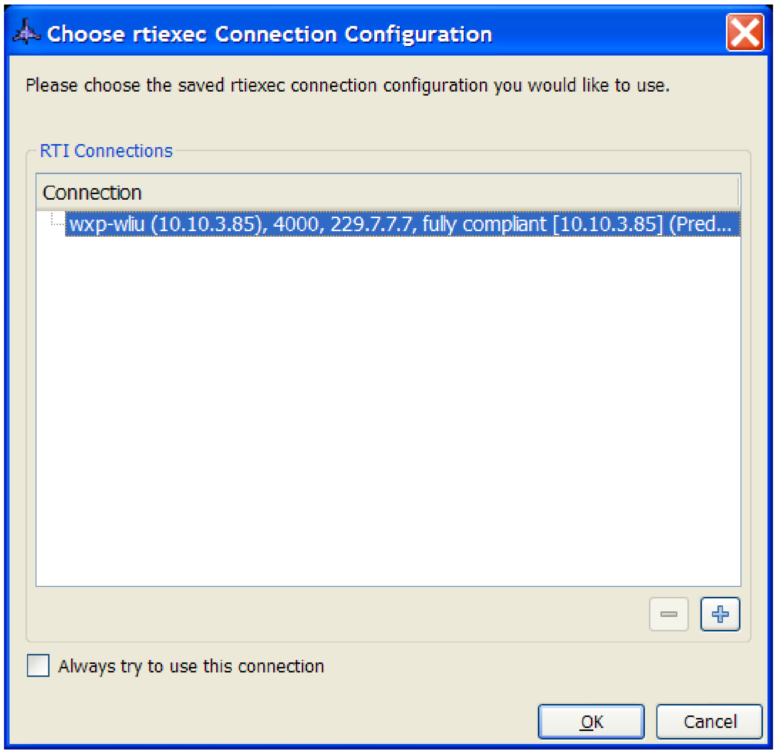
Starting MAK RTI

For details, refer to *MAK RTI Reference Manual* and *VR-Forces User's Guide*.

To use the RTI, the RTI Executive process should be started. The RTI Executive process for MAK RTI is called RtiExec. RtiExec is a centralized application that supports the RTI services needing centralized synchronization and control. There should only be one RtiExec process running.

To start RtiExec, perform the following steps (the following steps assume that MAK RTI is installed at the default location):

1. Select **Start > All Programs > MAK Technologies > MAK RTI 3.3.1 > rtiexec**.
2. In the connection configuration window that is displayed, one or more configurations corresponding to the available network interfaces will be listed. Select a connection with a network address that allows for communication with QualNet and click **OK**.


Choose rtiexec Connection Configuration

Please choose the saved rtiexec connection configuration you would like to use.

RTI Connections

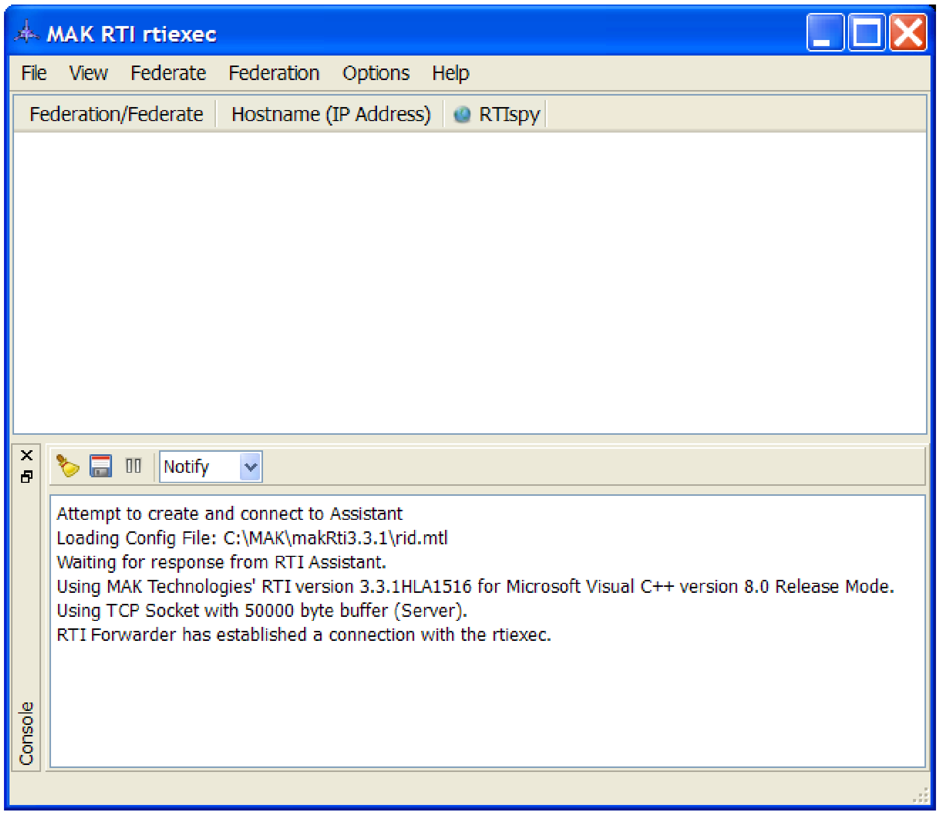
Connection

wxp-wliu (10.10.3.85), 4000, 229.7.7.7, fully compliant [10.10.3.85] (Pred...

Always try to use this connection

FIGURE 2-9. RtiExec Connection Configuration

The RtiExec status window is displayed when RtiExec has successfully launched.


MAK RTI rtiexec
File View Federate Federation Options Help
Federation/Federate Hostname (IP Address) RTIspy
Notify
Console

```
Attempt to create and connect to Assistant
Loading Config File: C:\MAK\makRti3.3.1\rid.mtl
Waiting for response from RTI Assistant.
Using MAK Technologies' RTI version 3.3.1HLA1516 for Microsoft Visual C++ version 8.0 Release Mode.
Using TCP Socket with 50000 byte buffer (Server).
RTI Forwarder has established a connection with the rtiexec.
```

FIGURE 2-10. RtiExec Started

Notes: 1. Depending on the RTI configuration, it may not be necessary to explicitly start RtiExec before starting QualNet. If an HLA-enabled scenario is loaded in QualNet before starting RtiExec, then the user will be prompted to start RtiExec during the launching of QualNet.

2. Running an HLA federation over a VPN or through a firewall usually requires special configuration of the RTI and may require customization of the VPN or firewall. Refer to *MAK RTI Reference Manual* for details.

2.2.5.3 Starting VR-Forces

This section outlines the procedure to start VR-Forces and load a scenario. For more details, refer to *VR-Forces User's Guide*.

Starting VR-Forces with RtiExec Already Running

If the RtiExec has already been started (see Section 2.2.5.2), then perform the following steps to start VR-Forces:

1. Select **Start > All Programs > MAK Technologies > VR-Forces 3.11.0.1 > VR-Forces HLA 1.3 RPR FOM 1.0**.

Note: Depending on your VR-Forces license configuration, it may be necessary to start a local license manager before starting VR-Forces.

2. In the RTI connection window that is displayed, select an RTI connection and click **Connect**.

Note: All simulators in the federation must use the same RTI. Select an RTI connection that will also be available to the computer running QualNet.

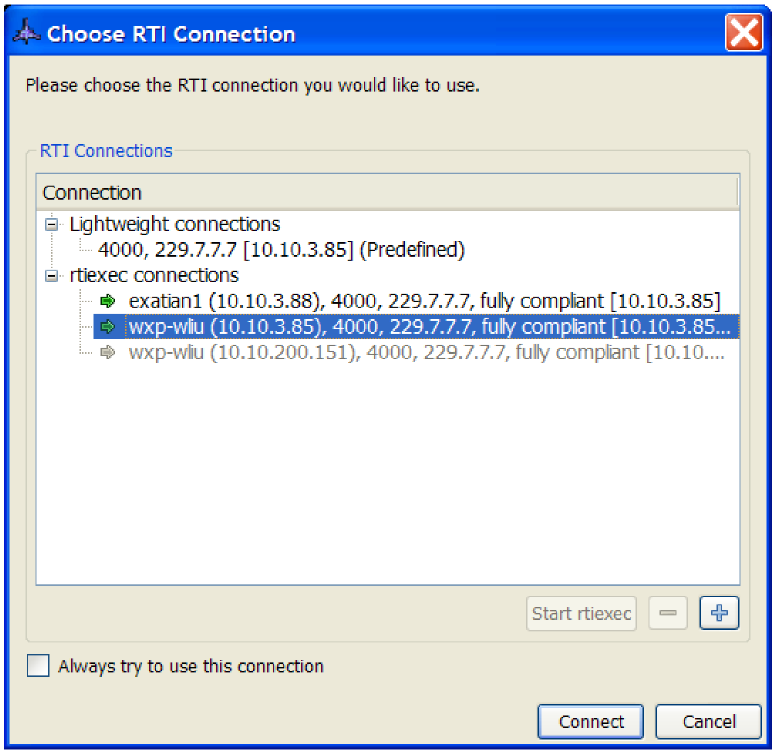
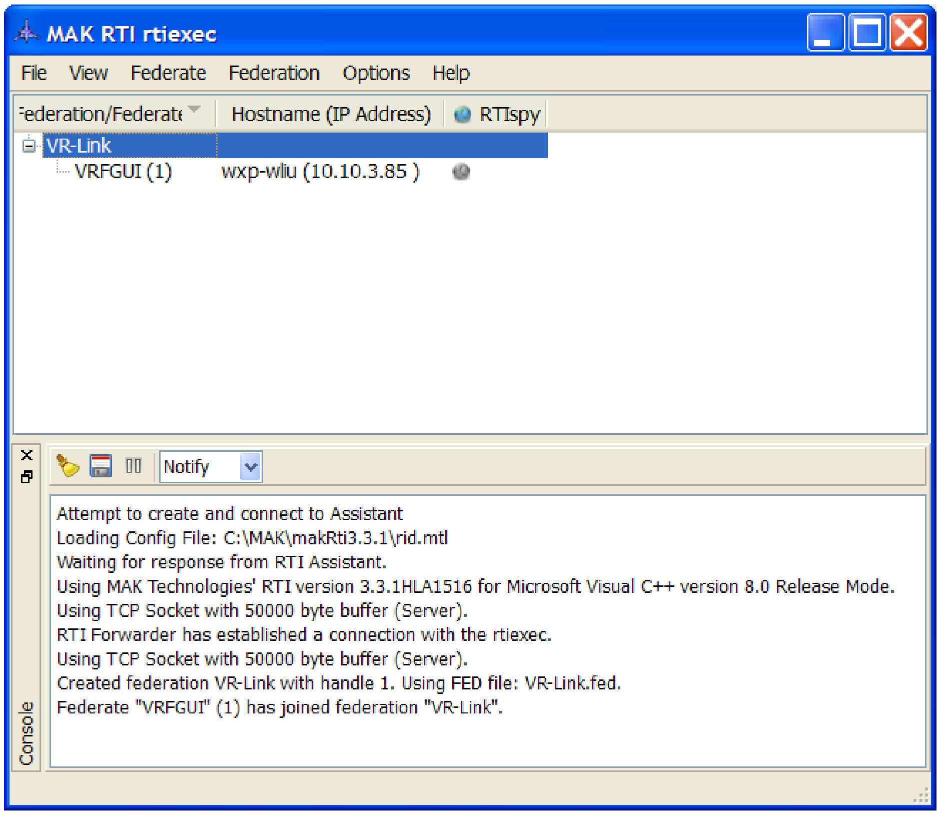

Choose RTI Connection
Please choose the RTI connection you would like to use.
RTI Connections
Connection
Lightweight connections
4000, 229.7.7.7 [10.10.3.85] (Predefined)
rtiexec connections
exatian1 (10.10.3.88), 4000, 229.7.7.7, fully compliant [10.10.3.85]
wxp-wliu (10.10.3.85), 4000, 229.7.7.7, fully compliant [10.10.3.85...
wxp-wliu (10.10.200.151), 4000, 229.7.7.7, fully compliant [10.10....
Start rtiexec
Always try to use this connection
Connect
Cancel

FIGURE 2-11. Connecting VR-Forces to RTI

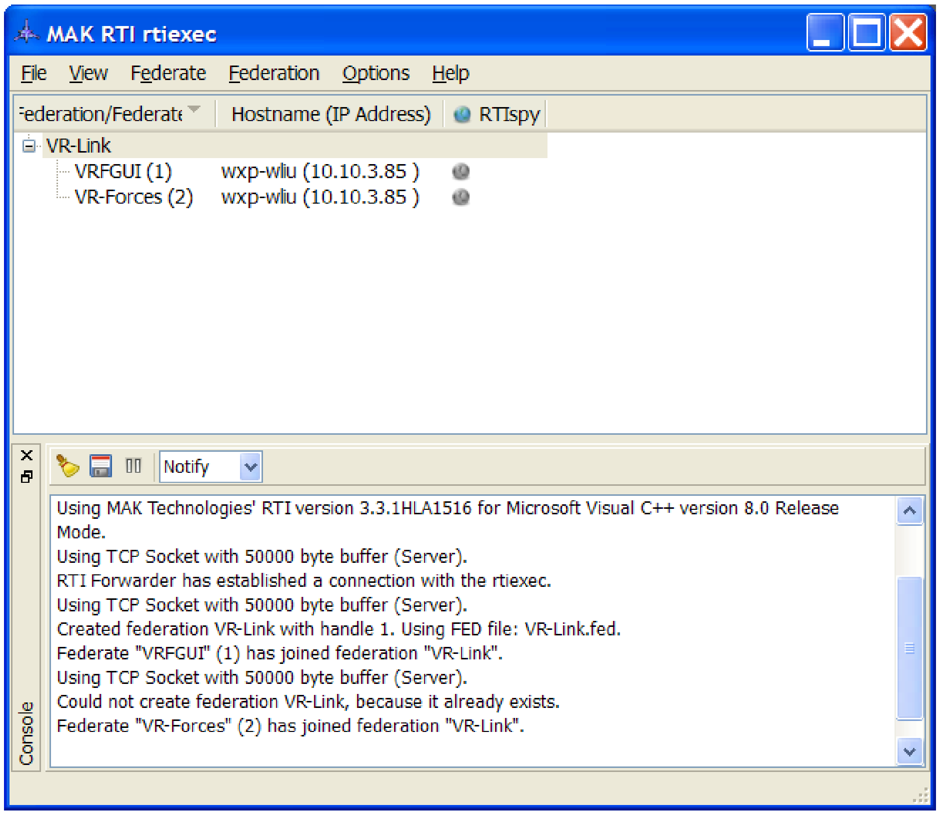
When the connection is established, the RtiExec status window is updated and shows that the VR-Forces GUI has joined the federation.



```
Attempt to create and connect to Assistant
Loading Config File: C:\MAK\makRti3.3.1\rid.mtl
Waiting for response from RTI Assistant.
Using MAK Technologies' RTI version 3.3.1HLA1516 for Microsoft Visual C++ version 8.0 Release Mode.
Using TCP Socket with 50000 byte buffer (Server).
RTI Forwarder has established a connection with the rtiexec.
Using TCP Socket with 50000 byte buffer (Server).
Created federation VR-Link with handle 1. Using FED file: VR-Link.fed.
Federate "VRFGUI" (1) has joined federation "VR-Link".
```

FIGURE 2-12. VR-Forces GUI Joins the Federation

3. The RTI connection window is displayed again. Select the same RTI connection and click **Connect**. The VR-Forces simulator join the federation and the RtiExec status window will be updated.



```
Using MAK Technologies' RTI version 3.3.1HLA1516 for Microsoft Visual C++ version 8.0 Release
Mode.
Using TCP Socket with 50000 byte buffer (Server).
RTI Forwarder has established a connection with the rtiexec.
Using TCP Socket with 50000 byte buffer (Server).
Created federation VR-Link with handle 1. Using FED file: VR-Link.fed.
Federate "VRFGUI" (1) has joined federation "VR-Link".
Using TCP Socket with 50000 byte buffer (Server).
Could not create federation VR-Link, because it already exists.
Federate "VR-Forces" (2) has joined federation "VR-Link".
```

FIGURE 2-13. VR-Forces Simulator Joins the Federation

4. Load the scenario to be simulated.

Note: Do not press the **Play** button. The simulation should be started after the QualNet scenario has also been loaded, as described in Section 2.2.5.5.

Starting VR-Forces without RtiExec Already Running

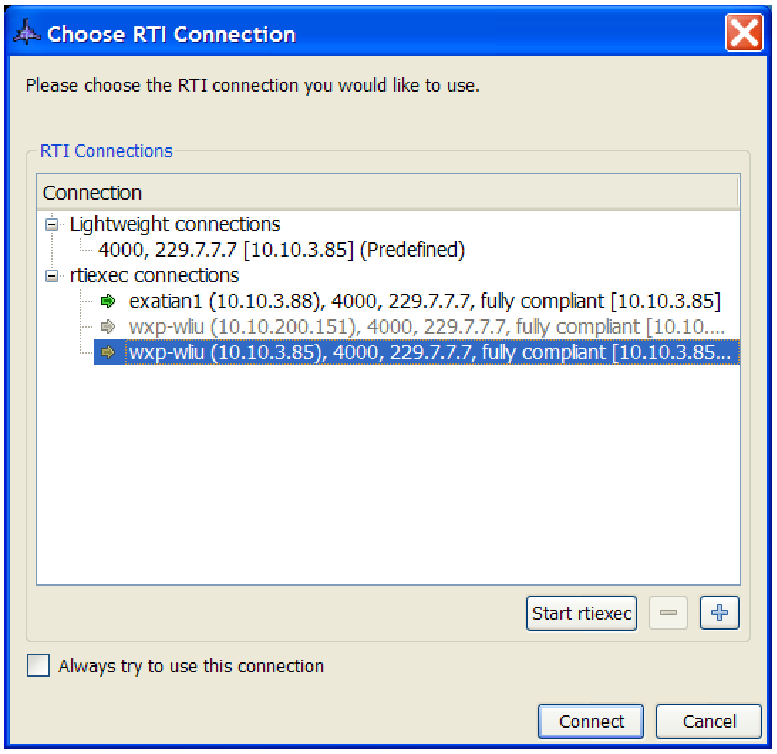
If the RtiExec has not already been started (see Section 2.2.5.2), then perform the following steps to start VR-Forces:

1. Select **Start > All Programs > MAK Technologies > VR-Forces 3.11.0.1 > VR-Forces HLA 1.3 RPR FOM 1.0**.

Note: Depending on your VR-Forces license configuration, it may be necessary to start a local license manager before starting VR-Forces.

2. In the RTI connection window that is displayed, select an RTI connection and click **Start rtiexec**.

   Note: All simulators in the federation must use the same RTI. Select an RTI connection that will also be available to the computer running QualNet.


Choose RTI Connection

Please choose the RTI connection you would like to use.

RTI Connections

Connection
- Lightweight connections
  - 4000, 229.7.7.7 [10.10.3.85] (Predefined)
- rtiexec connections
  - exatian1 (10.10.3.88), 4000, 229.7.7.7, fully compliant [10.10.3.85]
  - wxp-wliu (10.10.200.151), 4000, 229.7.7.7, fully compliant [10.10....
  - wxp-wliu (10.10.3.85), 4000, 229.7.7.7, fully compliant [10.10.3.85...

FIGURE 2-14. Starting RtiExec from VR-Forces

RtiExec will start and the RtiExec status window will be displayed indicating that RtiExec has successfully started (see Figure 2-10).

3. In the RTI connection window that is displayed (see Figure 2-11), select an RTI connection and click **Connect**. When the connection is established, the RtiExec status window is updated and shows that the VR-Forces GUI has joined the federation (see Figure 2-12).

   Note: All simulators in the federation must use the same RTI. Select an RTI connection that will also be available to the computer running QualNet.

4. The RTI connection window is displayed again. Select the same RTI connection and click **Connect**. The VR-Forces simulator will join the federation and the RtiExec status window will be updated (see Figure 2-13).
5. Load the scenario to be simulated. Refer to *VR-Forces User's Guide* for details.
6. Enable external communications. To do this, go to **Options > Communication Model Settings** and check **Use External Communication Model** in the dialog that is displayed.

Note: Do not press the **Play** button. The simulation should be started after the QualNet scenario has also been loaded, as described in Section 2.2.5.5.

2.2.5.4 Starting QualNet Simulation

This section outlines the procedure of starting a simulation in QualNet. For details of using QualNet, refer to *QualNet User's Guide*.

Note: This section assumes that RtiExec has already been started, as described in Section 2.2.5.2 or Section 2.2.5.3. If RtiExec has not been started prior to starting the QualNet simulation, then the user will be prompted to start RtiExec. This procedure is similar to starting RtiExec from VR-Forces (see Section 2.2.5.3).

Starting Simulation from the Command Line

To start a QualNet simulation from the command line, perform the following steps.

1. Open a command window and change the directory to the folder where the QualNet scenario (which is equivalent to the VR-Forces scenario) is located.
2. Enter the following command to run the scenario:

   ```
   qualnet <config-file>
   ```

   where `<config-file>` is the name of the scenario configuration (.config) file.

   Status messages are displayed in the command window.
3. The RTI connection window is displayed. Select the RTI connection that is used by VR-Forces and click **Connect**. QualNet will join the federation and the RtiExec status window will be updated.

Starting Simulation from the GUI

To start a QualNet simulation from the GUI, perform the following steps.

1. Start the QualNet GUI.
2. In the **File System** panel, navigate to the QualNet configuration (.config) file for the scenario (which is equivalent to the VR-Forces scenario), right-click and select **Open**.

   Status messages are displayed in the **Output Window** panel.
3. After the scenario has finished initializing, click the **Play** button to start the simulation.
4. The RTI connection window is displayed. Select the RTI connection that is used by VR-Forces and click **Connect**. QualNet will join the federation and the RtiExec status window will be updated.

2.2.5.5 Running the Joint Simulation

To simulate the scenario jointly in VR-Forces and QualNet, do the following:

1. Press the **Play** button in VR-Forces. Visualization of the scenario should progress in both VR-Forces and QualNet.
2. When the simulation is complete, press the **Stop** button on QualNet and VR-Forces. Exit both QualNet and VR-Forces.

Re-running the Simulation

To run the simulation again, do the following:

1. Stop the QualNet simulation. If using the QualNet GUI, press the **Stop** button. If running QualNet from the command line, press **Ctrl+C**.
2. In VR-Forces, press the **Pause** button and then the **Rewind** button.
3. Restart the simulation in QualNet, as described in Section 2.2.5.4.
4. In VR-Forces, press the **Play** button.

3 Distributed Interactive Simulation (DIS) Interface

Distributed Interaction Simulation (DIS) is an IEEE standard for interfacing multiple simulation tools into a single, real-time exercise. The transport of information between simulators is performed using UDP and broadcast and/or multicast IP. Although formally superseded by HLA and IEEE 1516, DIS still remains popular today for its simplicity of operation and the ease in which a DIS interface can be created.

The QualNet DIS interface supports DIS protocol versions 2.0.3 through 2.0.6.

Major Features

Nearly all QualNet HLA functionality (see Chapter 2) is supported in DIS.

The following features are not supported:

- Dynamic statistics
- Dead-reckoning

Limitations of the QualNet DIS Interface

- The QualNet DIS interface is not supported on 64-bit platforms.
- QualNet DIS interface is not supported on parallel (shared memory and distributed architecture) platforms.

Section 3.1 lists the system requirements and describes how to install and compile the DIS interface.

Section 3.2 describes how to use the DIS interface to run QualNet with an external program.

Appendix B describes the DIS Protocol Data Units and the DIS Extensions Interface Communications Document.

3.1 System Requirements, Installation, and Compilation

3.1.1 System Requirements

Refer to *QualNet Installation Guide* for systems requirements for running QualNet and to *QualNet Programmer's Guide* for requirements for compiling QualNet on shared memory systems.

3.1.2 Installation

The QualNet DIS interface is part of the QualNet distribution and does not need to be installed separately. However, QualNet needs to be recompiled in order to activate the DIS interface (see Section 3.1.3).

3.1.3 Compilation

This section describes how to compile QualNet to enable DIS support.

3.1.3.1 Compilation on Windows

To compile QualNet with DIS support on Windows, perform the following steps:

1. Open a command window and change the directory to QUALNET_HOME/main.
2. Open the file QUALNET_HOME/main/Makefile-addons-windows with a text editor.

   Change the line

   ```
   #include ../interfaces/dis/Makefile-windows
   ```

   to

   ```
   include ../interfaces/dis/Makefile-windows
   ```

3. Copy the makefile for your compiler to Makefile. For example, if you are using VC9 on a 32-bit platform, use the following command to make a copy of the makefile:

   ```
   copy Makefile-windows-vc9 Makefile
   ```

   Refer to *QualNet Programmer's Guide* for the list of makefiles for different compilers.

4. Use the following commands to remove all object files and recompile:

   ```
   nmake clean
   nmake
   ```

3.1.3.2 Compilation on Linux

To compile QualNet with DIS support on Linux, perform the following steps:

1. Open a command window and change the directory to QUALNET_HOME/main.
2. To automatically select the makefile for your system, type the following command:

   ```
   ./configure.sh
   ```

   The script will prompt you for the model libraries that should be compiled with QualNet. Type "Yes" when the script prompts you for including the DIS interface. The script will create a file called Makefile in the folder QUALNET_HOME/main.

Note: Once you have created the makefile using this script, you do not need to run the script again unless you want to change the list of libraries to be compiled with QualNet.

3. Alternatively, manually select and edit the makefiles as follows:

   a. Copy the makefile for your compiler to Makefile. For example, for Red Hat Enterprise Linux 5.3 and other Linux distributions with glibc 2.5 and gcc 4.1 on a 32-bit platform, use the following command to make a copy of the makefile:

   ```
   cp Makefile-linux-glibc-2.5-gcc-4.1 Makefile
   ```

   Refer to *QualNet Programmer's Guide* for the list of makefiles for different compilers.

   b. Open the file QUALNET_HOME/main/Makefile-addons-unix with a text editor.
   Change the line

   ```
   #include ../interfaces/dis/Makefile-unix
   ```

   to

   ```
   include ../interfaces/dis/Makefile-unix
   ```

4. Use the following commands to remove all object files and recompile:

```
make clean
make
```

3.2 Using the DIS Interface

This section describes the procedure to use the DIS interface to run a simulation exercise consisting of QualNet acting as a communications server and other simulation applications acting as communications clients.

Section 3.2.1 describes the general procedure for using the DIS interface.

Section 3.2.2 describes how to create QualNet scenarios for use with the DIS interface.

Section 3.2.3 describes the sequence of events in an exercise consisting of QualNet acting as a communications server and another simulation application acting as a communications client.

Section 3.2.4 describes how to use the DIS interface to run a simulation in VR Forces and QualNet.

3.2.1 General Procedure for Using DIS Interface

In general, simulating a scenario using the DIS interface comprises the steps listed below. These steps are explained in the following sections.

1. Create a simulation scenario for the external simulator.
2. Create a QualNet scenario that is compatible with the external simulation scenario.
3. Start the external simulator and load the scenario.
4. Start QualNet and run the QualNet scenario equivalent to the external simulator scenario.

5. Run the simulation in the external simulator.

3.2.2 Creating Scenarios

For QualNet to provide communication effects to the external simulator, it should simulate the same communicating entities as the external simulator scenario. The QualNet scenario should define the protocol stack and communication capabilities of all communicating entities in the scenario to be simulated.

3.2.2.1 Command Line Configuration

To enable the DIS interface, include the following parameter in the scenario configuration (.config) file:

```
DIS          YES
```

Note: The default value of the parameter `DIS` is `NO`.

DIS Interface Parameters

In addition to the other parameters required to configure a simulation scenario (refer to *QualNet User's Guide*), the parameters described in Table 3-1 must be configured in order to use the DIS interface.

TABLE 3-1. DIS Interface Parameters

Parameter	Value	Description
`DIS-DEBUG-PRINT-COMMS` *Optional* *Scope:* Global	List: • `YES` • `NO` *Default:* `YES`	Enables debug output from DIS communications effects requests.
`DIS-DEBUG-PRINT-COMMS-2` *Optional* *Scope:* Global	List: • `YES` • `NO` *Default:* `YES`	Enables verbose debug output from DIS communications effects requests.
`DIS-DEBUG-PRINT-MAPPING` *Optional* *Scope:* Global	List: • `YES` • `NO` *Default:* `YES`	Enables printing of the mapping of Entity State PDUs to QualNet nodes, as it occurs.
`DIS-DEBUG-PRINT-DAMAGE` *Optional* *Scope:* Global	List: • `YES` • `NO` *Default:* `YES`	Enables printing of information to the screen when the Damage field for an entity changes. The Damage field appears in the Entity Appearance record of the Entity State PDU.
`DIS-DEBUG-PRINT-TX-STATE` *Optional* *Scope:* Global	List: • `YES` • `NO` *Default:* `YES`	Enables printing of transmitter state (on/off) to the screen.

TABLE 3-1. DIS Interface Parameters

Parameter	Value	Description
`DIS-DEBUG-PRINT-TX-POWER` *Optional* *Scope:* Global	List: • `YES` • `NO` *Default:* `YES`	Enables printing of details when QualNet probabilistically decreases the maximum transmit power of hosted radios when an entity suffers damage. **Note:** An entity with a Damage field equal to Destroyed will have all radios turned off.
`DIS-DEBUG-PRINT-MOBILITY` *Optional* *Scope:* Global	List: • `YES` • `NO` *Default:* `NO`	Enables printing of information to the screen when an entity is moved within QualNet.
`DIS-DEBUG-PRINT-TRANSMITTER-PDU` *Optional* *Scope:* Global	List: • `YES` • `NO` *Default:* `NO`	Enables printing of information about received Transmitter PDUs to the screen.
`DIS-DEBUG-PRINT-PDUS` *Optional* *Scope:* Global	List: • `YES` • `NO` *Default:* `NO`	Enables printing of a hex dump of most DIS PDUs.
`DIS-IP-ADDRESS` *Optional* *Scope:* Global	IP Address *Default:* `255.255.255.255`	IP address on which QualNet receives and sends DIS PDUs. This can be set to a local broadcast address (`255.255.255.255`) or a multicast address.
`DIS-PORT` *Optional* *Scope:* Global	Integer *Range:* `[0, 65535]` *Default:* `3000`	UDP port on which QualNet receives and sends DIS PDUs.
`DIS-RECEIVE-DELAY` *Optional* *Scope:* Global	Time *Range:* ≥ `0S` *Default:* `200MS`	Minimum amount of time that needs to pass since the last successful call to recv() to check for DIS PDUs on the socket, before recv() is called again.
`DIS-MAX-RECEIVE-DURATION` *Optional* *Scope:* Global	Time *Range:* ≥ `0S` *Default:* `5MS`	Maximum amount of time QualNet waits to empty the socket. Normally, QualNet calls recv() until there are no pending DIS PDUs on the socket (the DIS interface uses non-blocking sockets). Theoretically for very busy networks the socket will never empty, or it may take a long time to empty the socket. This parameter limits this duration, so as to give control back to the QualNet simulation kernel and also to allow time for other external interfaces.

TABLE 3-1. DIS Interface Parameters

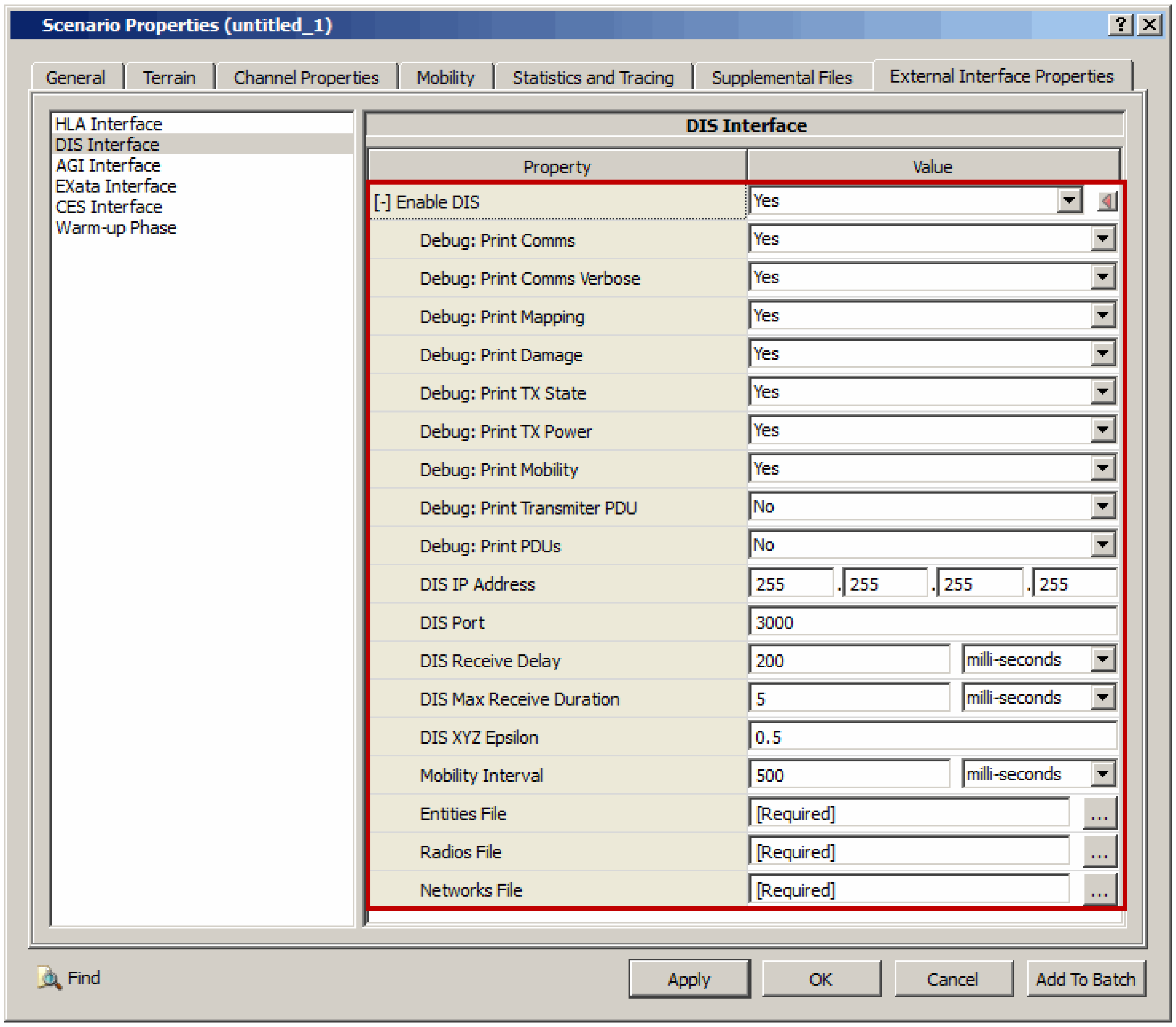
Parameter	Value	Description
`DIS-XYZ-EPSILON` *Optional* *Scope:* Global	Real *Range:* ≥ `0` *Default:* `0.5` *Unit:* meters	Minimum change in any of the x, y, or z coordinates of the GCC position before the change is reflected in QualNet.
`DIS-MOBILITY-INTERVAL` *Optional* *Scope:* Global	Time *Range:* ≥ `0S` *Default:* `500MS`	Minimum amount of time that needs to pass since the last scheduled mobility event for a given entity. Setting this value to `0S` will cause almost no mobility updates to be skipped. Setting it to a large value generally reduces simulation time, but skips more updates.
`DIS-ENTITIES-FILE-PATH` *Required* *Scope:* Global	Filename	Name of the Entities file. This file corresponds to Entities in DIS. The format of the Entities file is described in Section 2.2.2.1.1.
`DIS-RADIOS-FILE-PATH` *Required* *Scope:* Global	Filename	Name of the Radios file. This file corresponds to Transmitters in DIS. The format of the Radios file is described in Section 2.2.2.1.2.
`DIS-NETWORKS-FILE-PATH` *Required* *Scope:* Global	Filename	Name of the Networks file. This file defines groups of radios that can communicate with each other. The format of the Networks file is described in Section 2.2.2.1.3.

3.2.2.2 GUI Configuration

In addition to the other parameters required to configure a simulation scenario (refer to *QualNet User's Guide*), the DIS interface parameters must be configured as described below.

To configure the DIS interface parameters, perform the following steps:

1. Go to **Scenario Properties Editor > External Interfaces > DIS Interface**.
2. Set **Enable DIS** to *Yes* and set the dependent parameters listed in Table 3-2.



Property	Value
[-] Enable DIS	Yes
Debug: Print Comms	Yes
Debug: Print Comms Verbose	Yes
Debug: Print Mapping	Yes
Debug: Print Damage	Yes
Debug: Print TX State	Yes
Debug: Print TX Power	Yes
Debug: Print Mobility	Yes
Debug: Print Transmiter PDU	No
Debug: Print PDUs	No
DIS IP Address	255 . 255 . 255 . 255
DIS Port	3000
DIS Receive Delay	200 milli-seconds
DIS Max Receive Duration	5 milli-seconds
DIS XYZ Epsilon	0.5
Mobility Interval	500 milli-seconds
Entities File	[Required]
Radios File	[Required]
Networks File	[Required]

FIGURE 3-1. Configuring DIS Interface Parameters

TABLE 3-2. Command Line Equivalent of DIS Interface Parameters

GUI Parameter	Scope of GUI Parameter	Command Line Parameter
Debug: Print Comms	Global	`DIS-DEBUG-PRINT-COMMS`
Debug: Print Comms Verbose	Global	`DIS-DEBUG-PRINT-COMMS-2`
Debug: Print Mapping	Global	`DIS-DEBUG-PRINT-MAPPING`

TABLE 3-2. Command Line Equivalent of DIS Interface Parameters (Continued)

GUI Parameter	Scope of GUI Parameter	Command Line Parameter
Debug: Print Damage	Global	`DIS-DEBUG-PRINT-DAMAGE`
Debug: Print TX State	Global	`DIS-DEBUG-PRINT-TX-STATE`
Debug: Print TX Power	Global	`DIS-DEBUG-PRINT-TX-POWER`
Debug: Print Mobility	Global	`DIS-DEBUG-PRINT-MOBILITY`
Debug: Print Transmitter PDU	Global	`DIS-DEBUG-PRINT-TRANSMITTER-PDU`
Debug: Print PDUs	Global	`DIS-DEBUG-PRINT-PDUS`
DIS IP Address	Global	`DIS-IP-ADDRESS`
DIS Port	Global	`DIS-PORT`
DIS Receive Delay	Global	`DIS-RECEIVE-DELAY`
DIS Max Receive Duration	Global	`DIS-MAX-RECEIVE-DURATION`
DIS XYZ Epsilon	Global	`DIS-XYZ-EPSILON`
Mobility Interval	Global	`DIS-MOBILITY-INTERVAL`
Entities File	Global	`DIS-ENTITIES-FILE-PATH`
Radios File	Global	`DIS-RADIOS-FILE-PATH`
Networks File	Global	`DIS-NETWORKS-FILE-PATH`

Setting Parameters

- Set **Entities File Path** to the name of the Entities file. See Section 2.2.2.1.1 for the format of the Entities file.
- Set **Radios File Path** to the name of the Radios file. See Section 2.2.2.1.2 for the format of the Radios file.
- Set **Networks File Path** to the name of the Networks file. See Section 2.2.2.1.3 for the format of the Networks file.

3.2.3 Sequence of Events

The sequence of events in a typical DIS exercise consisting of QualNet acting as a communications server and another simulation application acting as a communications client is as follows:

1. The client loads the scenario and joins the exercise.
2. QualNet loads the equivalent scenario and joins the exercise.
3. QualNet waits for the first entity update sent by the client. The update can be for any entity, whether or not it has a representation in the QualNet scenario. (Only communicating entities in the external simulator scenario need to be represented in QualNet.)
4. The QualNet simulation starts initializing when the first entity update is received. The initialization time depends on the complexity of the scenario. The simulation starts after the initialization is complete. The warm-up phase of QualNet starts when the simulation starts. In the warm-up phase, depending on the configuration, all communication effects requests are treated as being either unsuccessful or successful with zero delay.
5. During the simulation, when the client simulation moves an entity, it sends an Entity State PDU (see Section B.4). When QualNet receives the Entity State PDU (see Section B.4), it consults the Entities and Radios files (see Section 2.2.2) to move the appropriate QualNet nodes.

6. During the simulation, the client sends Signal PDUs to request communication effects modeling (see Section B.4). When QualNet receives a Signal PDU, it models the traffic and can respond as follows:
    - If the communication is successful, QualNet sends a Data PDU containing a Process Message result indicating that the message was delivered to the destination. This PDU is sent to the client as soon as the modeled message is delivered to the destination node in QualNet.
    - Whether or not the communication is successful, QualNet sends a Data PDU containing a Timeout result summarizing the delivery status to all potential recipients. This occurs when the processing of the message is complete: either after the timeout value indicated in the original Signal PDU, or after all potential recipients have processed the signal, whichever occurs first.
7. The client can also indicate if entities are damaged or destroyed, or hosted radios are turned on or off. QualNet will model such effects appropriately (for example, a destroyed entity will deactivate all associated QualNet nodes).
8. The QualNet simulation runs for the time specified by the QualNet `SIMUALTION-TIME` parameter, irrespective of when the external simulation ends. The statistics file is generated when the QualNet simulation ends.

3.2.4 VR-Forces/QualNet Demonstration

This section describes how to use the QualNet DIS interface with VT MAK 's' VR-Forces (http://www.mak.com).

VR-Forces is a Computer-Generated Forces (CGF) toolkit. It provides an intuitive GUI that allows non-programmers to build scenarios by positioning forces, creating routes and waypoints, and assigning tasks or plans with simple point and click. During scenario execution, VR-Forces vehicles interact with the terrain, follow roads, avoid obstacles, detect and engage enemy forces, and calculate damage. Vehicle dynamics, sensor capabilities, and damage models are fully configurable with no programming necessary. Entities in VR-Forces also communicate with each other, such as sending and receiving commands, providing sensor updates, and other network centric operations. VR-Forces assumes perfect communications, i.e., all messages are delivered, regardless of the communications environment.

3.2.4.1 Creating Scenarios

Create scenarios for VR-Forces and QualNet, as described in Section 3.2.2.

3.2.4.2 Starting VR-Forces

Perform the following steps to start VR-Forces. For more details, refer to *VR-Forces User's Guide*.

1. Select **Start > All Programs > MAK Technologies > VR-Forces 3.11.0.1 > VR-Forces DIS**.

    Note: Depending on your VR-Forces license configuration, it may be necessary to start a local license manager before starting VR-Forces.

2. Load the scenario to be simulated. Refer to *VR-Forces User's Guide* for details.
3. Enable external communications. To do this, go to **Options > Communication Model Settings** and check **Use External Communication Model** in the dialog that is displayed.

    Note: Do not press the **Play** button. The simulation should be started after the QualNet scenario has also been loaded, as described in Section 3.2.4.4.

3.2.4.3 Starting QualNet Simulation

This section outlines the procedure of starting a simulation in QualNet. For details of using QualNet, refer to *QualNet User's Guide*.

Starting Simulation from the Command Line

To start a QualNet simulation from the command line, perform the following steps.

1. Open a command window and change the directory to the folder where the QualNet scenario (which is equivalent to the VR-Forces scenario) is located.
2. Enter the following command to run the scenario:

   ```
   qualnet <config-file>
   ```

   where **`<config-file>`** is the name of the scenario configuration (.config) file.

   Status messages are displayed in the command window.

Starting Simulation from the GUI

To start a QualNet simulation from the GUI, perform the following steps.

1. Start the QualNet GUI.
2. In the **File System** panel, navigate to the QualNet configuration (.config) file for the scenario (which is equivalent to the VR-Forces scenario), right-click and select **Open**.

   Status messages are displayed in the **Output Window** panel.
3. After the scenario has finished initializing, click the **Play** button to start the simulation.

3.2.4.4 Running the Joint Simulation Exercise

To simulate the scenario jointly in VR-Forces and QualNet, do the following:

1. Press the **Play** button in VR-Forces. Visualization of the scenario should progress in both VR-Forces and QualNet.
2. When the simulation is complete, press the **Stop** button on QualNet and VR-Forces. Exit both QualNet and VR-Forces.

Re-running the Simulation

To run the simulation again, do the following:

1. Stop the QualNet simulation. If using the QualNet GUI, press the **Stop** button. If running QualNet from the command line, press **Ctrl+C**.
2. In VR-Forces, press the **Pause** button and then the **Rewind** button.
3. Restart the simulation in QualNet, as described in Section 3.2.4.3.
4. In VR-Forces, press the **Play** button.

4 Socket Interface

This chapter describes the details of the Socket Interface and is organized as follows:

- Section 4.1 describes the messages exchanged between QualNet and an external program using the Socket Interface.
- Section 4.2 describes some features of the Socket Interface.
- Section 4.3 describes the configuration parameters required for the Socket Interface.
- Section 4.4 describes the output files produced by running the Socket Interface.

4.1 Socket Interface Messages

This section describes the inter-process communication between QualNet and an external program using the Socket Interface.

Communication between QualNet and the external program is implemented over a TCP socket, with QualNet acting as the server and the external program as the client. Several types of messages can be sent between the two processes.

Figure 4-1 shows the different QualNet states and transitions that occur when interface messages are received.

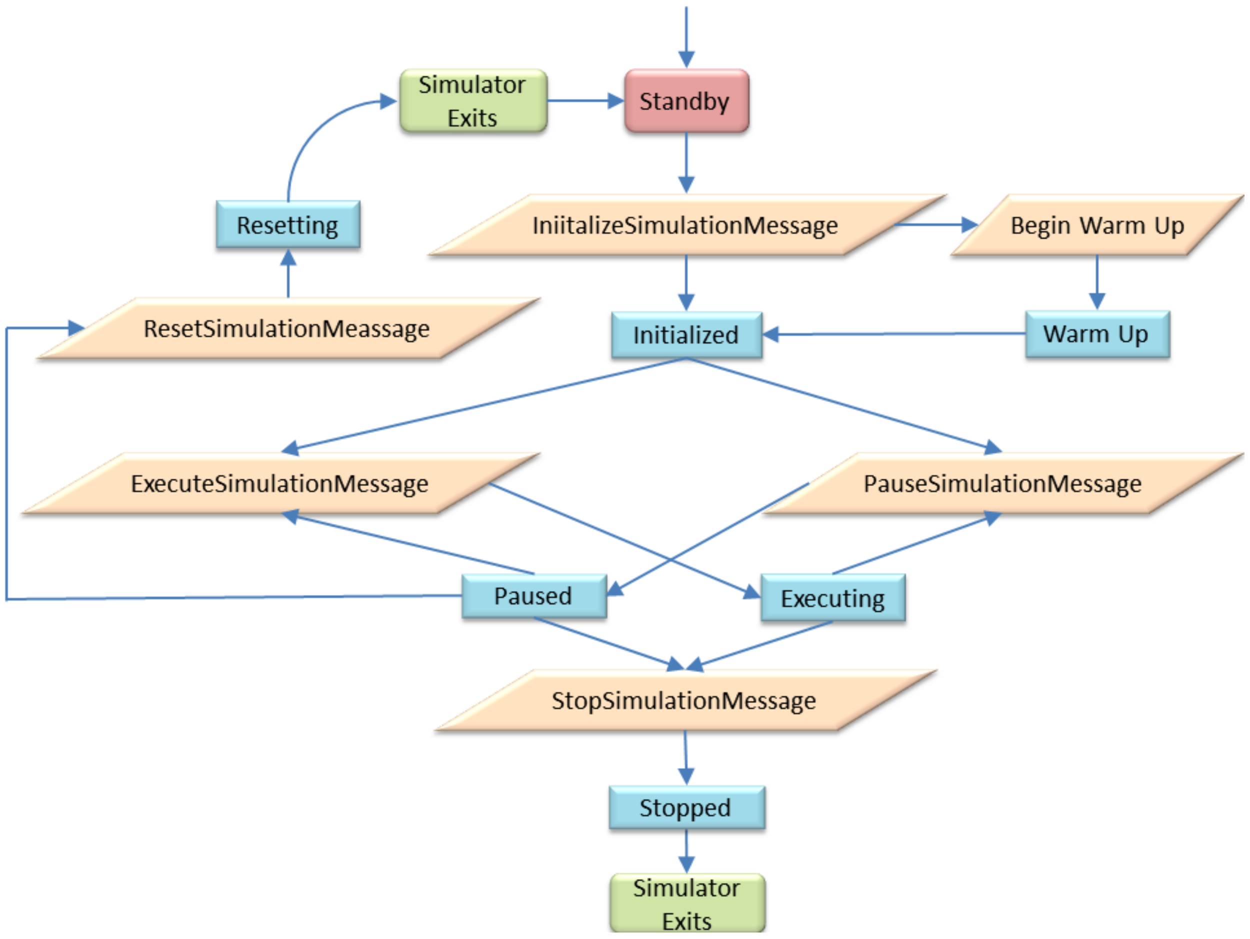


FIGURE 4-1. Socket State Transition Diagram

Section 4.1.1 describes the structure of interface messages. Section 4.1.2 describes the request messages, i.e., messages sent from the external program to QualNet. Section 4.1.3 describes the response messages, i.e., messages sent from QualNet to the external program.

4.1.1 Structure of Interface Messages

4.1.1.1 Data Types Used in Interface Messages

The size and data encoding for data types used in the interface messages are indicated in Table 4-1.

TABLE 4-1. Size of Data Types

Data Type	Size (in bytes)
Int8, UInt8	1
Int16, UInt16	2
Int32, UInt32	4
Int64, UInt64	8

TABLE 4-1. Size of Data Types (Continued)

Data Type	Size (in bytes)
Float64	8
Time	8
Coordinate	24
ListofUInt8	1 * length of the list
String	variable, encoded as 2 bytes containing the length of the string followed by the string with no terminating 0 value
LongString	variable, encoded as UInt32 (4 bytes) containing the length of the string followed by the string with no terminating 0 value
ListofString	variable, encoded as consecutive strings. The serialization and deserialization of this data type depends on the message context.
ListofGroups	variable, encoded as consecutive strings. This data type is used to encode a list of multicast groups. A multicast group is an IP address in the range 224.0.0.0 to 239.255.255.255. The serialization and deserialization of this data type is explained below.

Serialization of ListofGroups Data Type

The ListofGroups data type is serialized as consecutive strings. There is no explicit count for the number of strings in the field because the number of strings can be deduced from size of the message field. Each string in the ListofGroups is preceded by a 2-byte field that denotes the length of the string.

For example, the following ListofGroups (which is 44 bytes long) encodes three strings of lengths 13, 14, and 11 bytes:

```
<LEN-1><STRING-1><LEN-2><STRING-2><LEN-3><STRING-3>
```

where

`<LEN-1>`	Length of string 1 (13). This field is 2 bytes long.
`<STRING-1>`	String 1. This is 13 bytes long.
`<LEN-2>`	Length of string 2 (14). This field is 2 bytes long.
`<STRING-2>`	String 2. This is 14 bytes long.
`<LEN-3>`	Length of string 3 (11). This field is 2 bytes long.
`<STRING-3>`	String 3. This is 11 bytes long.

4.1.1.2 Format of Interface Messages

The messages exchanged between QualNet and the external program via the Socket Interface have the following format:

```
<Message Header> <Required Fields> <Option 1> ... <Option n>
```

The `Message Header` is made up of four fields, which are described in Table 4-2.

TABLE 4-2. Fields of a Message Header

Field	Data Type	Description
`MessageType`	UInt8	A unique integer identifying the message type. The `MessageType` of each message is listed with the description of the message in the following subsections.
`NumOptionFields`	UInt8	Number of optional fields in the message.
`Reserved`	UInt16	Reserved for future use. This field should be set to 0.
`MessageSize`	UInt32	Total message size, including the message header, in bytes.

The `Required Fields` of each message are described in the following subsections.

Each `Option` has the following format:

```
<Option Header> <Option Fields>
```

The `Option Header` is made up of four fields, which are described in Table 4-3.

TABLE 4-3. Fields of an Option Header

Field	Data Type	Description
`OptionType`	UInt8	A unique integer identifying the option type. The `OptionType` of each option is listed with the description of messages in the following subsections.
`Reserved`	UInt8	Reserved for future use. This field should be set to 0.
`Reserved`	UInt16	Reserved for future use. This field should be set to 0.
`OptionSize`	UInt32	Total option size, including the option header, in bytes.

The `Option Fields` for each message are described in the following subsections.

4.1.2 Request Messages

This section describes the messages sent from the external program to QualNet via the Socket Interface.

4.1.2.1 `InitializeSimulation` Message

This message is sent from the external program to QualNet to start a QualNet simulation. QualNet does not begin the simulation until an `InitializeSimulation` message is received. This message is required for both time managed and real time modes.

QualNet moves to the Initialized state after this message is processed.

Message Type: The `MessageType` field of the `InitializeSimulation` message is set to 1.

Required Fields: The required fields of the `InitializeSimulation` message are described in Table 4-4.

TABLE 4-4. Required Fields of `InitializeSimulation` Message

Field	Data Type	Description
`TimeManagementMode`	UInt8	Time management mode. 0: Time managed mode 1: Real time mode

Options: The optional fields of the `InitializeSimulation` message and the corresponding `OptionType` are described in Table 4-5.

TABLE 4-5. Optional Fields of `InitializeSimulation` Message

OptionType	Option Field	Data Type	Description
0	`CoordinateSystem`	UInt8	Coordinate system. 0: Cartesian (default) 1: Lat/Lon/Alt 2: GCC Cartesian
1	`Scenario`	LongString	Description of the simulation scenario.
2	`SourceResponseMulticast`	Bool	Indication whether responses to multicast messages should be sent to the message source. `YES`: Responses to multicast messages should be sent to the source of the message. `NO`: Responses to multicast messages should be sent to the multicast group owner (default).

4.1.2.2 `PauseSimulation` Message

This message is sent from the external program to QualNet to move QualNet to the Paused state from the Initialized state or Executing state.

Message Type: The `MessageType` field of the `PauseSimulation` message is set to 2.

Required Fields: This message has no required fields.

Options: The optional fields of the `PauseSimulation` message and the corresponding `OptionType` are described in Table 4-6.

TABLE 4-6. Optional Fields of PauseSimulation Message

OptionType	Option Field	Data Type	Description
`2`	`PauseTime`	Time	Time to pause the simulation. If this field is not included in the message or it timestamps are not enabled, QualNet will enter the pause state as soon as the message is received.

4.1.2.3 `ExecuteSimulation` Message

This message is sent from the external program to QualNet to move QualNet to the Execute state from the Pause or Initialized state.

Message Type: The `MessageType` field of the `ExecuteSimulation` message is set to 3.

Required Fields: This message has no required fields.

Options: This message has no optional fields.

4.1.2.4 `StopSimulation` Message

This message is sent from the external program to QualNet to gracefully end a QualNet simulation. When this message is received, QualNet statistics are printed to various files (see Section 4.4), socket connections are closed, and QualNet moves to the Stopping state.

Message Type: The `MessageType` field of the `StopSimulation` message is set to 4.

Required Fields: This message has no required fields.

Options: The optional fields of the `StopSimulation` message and the corresponding `OptionType` are described in Table 4-7.

TABLE 4-7. Optional Fields of `StopSimulation` Message

OptionType	Option Field	Data Type	Description
`2`	`StopTime`	Time	Time to stop the simulation. If this field is not included in the message or if timestamps are not enabled, QualNet ends as soon as the message is received.

4.1.2.5 `ResetSimulation` Message

This message is sent from the external program to QualNet to clean QualNet internal data structures and return QualNet to the Standby state. This gracefully ends the QualNet simulation like the `StopSimulation` message. QualNet socket connections are closed and statistics are output to various files (see Section 4.4). Following that, QualNet enters its original state and waits for socket connections to begin a new scenario.

QualNet moves to the Resetting state before it enters the Standby state.

Message Type: The `MessageType` field of the `ResetSimulation` message is set to 5.

Required Fields: This message has no required fields.

Options: The optional fields of the `ResetSimulation` message and the corresponding `OptionType` are described in Table 4-8.

TABLE 4-8. Optional Fields of `ResetSimulation` Message

OptionType	Option Field	Data Type	Description
`2`	`ResetTime`	Time	Time to reset the simulation. If this field is not included in the message or if timestamps are not enabled, QualNet resets as soon as the message is received. Parallel execution of the message is not supported.

4.1.2.6 `AdvanceTime` Message

This message is sent from the external program to QualNet to advances the simulation time when running in time managed mode.

Message Type: The `MessageType` field of the `AdvanceTime` message is set to 6.

Required Fields: The required fields of the `AdvanceTime` message are described in Table 4-9.

TABLE 4-9. Required Fields of `AdvanceTime` Message

Field	Data Type	Description
`TimeAllowance`	Time	Maximum allowable simulation time.

Options: This message has no optional fields.

4.1.2.7 `DynamicCommand` Message

This message is sent from the external program to QualNet to query or modify scenario parameters during the simulation.

Message Type: The `MessageType` field of the `DynamicCommand` message is set to 8.

Required Fields: The required fields of the `DynamicCommand` message are described in Table 4-10.

TABLE 4-10. Required Fields of `DynamicCommand` Message

Field	Data Type	Description
`Type`	UInt8	Type of operation to perform. 0: Read 1: Write 2: Execute

TABLE 4-10. Required Fields of `DynamicCommand` Message (Continued)

Field	Data Type	Description
`Path`	String	Path of dynamic object to perform operation on.
`Args`	String	Arguments to write or execute. This field is ignored for read operations.

Options: This message has no optional fields.

4.1.2.8 `CreatePlatform` Message

This message is sent from the external program to QualNet to create a new platform in the simulation.

Message Type: The `MessageType` field of the `CreatePlatform` message is set to 10.

Required Fields: The required fields of the `CreatePlatform` message are described in Table 4-11.

TABLE 4-11. Required Fields of `CreatePlatform` Message

Field	Data Type	Description
`EntityId`	String	Identification of the entity to create.
`Position`	Coordinate	Initial position of the entity.
`State`	UInt8	Initial damage state of the entity.

Options: The optional fields of the `CreatePlatform` message and the corresponding `OptionType` are described in Table 4-12.

TABLE 4-12. Optional Fields of `CreatePlatform` Message

OptionType	Option Field	Data Type	Description
`2`	`CreateTime`	Time	Time when the platform is created. If this field is not included in the message, the platform is created as soon as the message is received.
`4`	`Type`	UInt8,	Platform type. 0: Ground (default) 1: Air
`5`	`MulticastGroups`	ListofGroups	List of multicast groups that this platform is to join. A multicast group is represented by an IP address in the range 224.0.1.0 to 239.255.255.255.
`22`	`Velocity`	Coordinate	Vector with three elements. If coordinate system is Cartesian, velocity is (X/sec, Y/sec, Z/sec). If coordinate system is Lat-Lon-Alt, velocity is (Lat/sec, Lon/sec, Alt/sec). If coordinate system is GCC Cartesian, velocity is (X/sec, Y/sec, Z/sec).

4.1.2.9 `UpdatePlatform` Message

This message is sent from the external program to QualNet to update the position and/or the state of a platform.

Message Type: The `MessageType` field of the `UpdatePlatform` message is set to 11.

Required Fields: The required fields of the `UpdatePlatform` message are described in Table 4-13.

TABLE 4-13. Required Fields of `UpdatePlatform` Message

Field	Data Type	Description
`EntityId`	String	Identification of the entity to update or IP address for which only multicast groups will be modified.

Options: The optional fields of the `UpdatePlatform` message and the corresponding `OptionType` are described in Table 4-14.

TABLE 4-14. Optional Fields of `UpdatePlatform` Message

OptionType	Option Field	Data Type	Description
2	`UpdateTime`	Time	Time to update the platform. If this field is not included in the message, the platform is updated as soon as the message is received.
6	`Position`	Coordinate	New position. If this field is not included in the message, the platform's position is not changed.
7	`State`	UInt8	New state. 0: Communications are not damaged 1: Communications are damaged If this field is not included in the message, the platform's state is not changed.
9	`JoinMulticastGroups`	ListofGroups	List of multicast groups to join.
10	`LeaveMulticastGroups`	ListofGroups	List of multicast groups to leave.
22	`Velocity`	Coordinate	Vector with three elements. If coordinate system is Cartesian, velocity is (X/sec, Y/sec, Z/sec). If coordinate system is Lat-Lon-Alt, velocity is (Lat/sec, Lon/sec, Alt/sec). If coordinate system is GCC Cartesian, velocity is (X/sec, Y/sec, Z/sec).

4.1.2.10 `CommEffectsRequest` Message

This message is sent from the external program to QualNet and models communications between two nodes. A `CommEffectsResponse` is sent to the external program indicating whether the communication was successful or unsuccessful, along with the communication latency experienced. The fields `Id1` and `Id2` provide 16 bytes for message identification. `Id1` and `Id2` are returned to the external program in the `CommEffectsResponse` message. Failure messages are not sent for multicast or broadcast traffic.

Message Type: The `MessageType` field of the `CommEffectsRequest` message is set to 12.

Required Fields: The required fields of the `CommEffectsRequest` message are described in Table 4-15.

TABLE 4-15. Required Fields of `CommEffectsRequest` Message

Field	Data Type	Description
`Id1`	UInt64	First 8 bytes of message identification field.
`Id2`	UInt64	Second 8 bytes of message identification field.
`Protocol`	UInt8	Protocol for this message. 0: TCP 1: UDP 2: Network
`Size`	UInt32	Size of the simulated packet, in bytes.
`SenderId`	String	Entity ID of the message sender.
`ReceiverId`	String	Entity ID of the message receiver or multicast group. `255.255.255.255` is used for a broadcast message.

Options: The optional fields of the `CommEffectsRequest` message and the corresponding `OptionType` are described in Table 4-16.

TABLE 4-16. Optional Fields of `CommEffectsRequest` Message

OptionType	Option Field	Data Type	Description
`2`	`SendTime`	Time	Time to send the message. If this field is not included in the message, the request is sent as soon as the message is received.
`11`	`Precedence`	UInt8	Message priority. 0: Routine (default) 1: Priority 2: Immediate 3: Flash 4: Flash Override 5: Critical 6: Internet Control 7: Net Control **Note:** A message can not include more than one of the three options: `Precedence`, `DSCP`, and `TOS`. If none of `Precedence`, `DSCP`, and `TOS` is specified, then Routine priority is used.
`12`	`Description`	String	Description of this request. This is echoed back in the `CommEffectsResponse` message sent in response to this message.

TABLE 4-16. Optional Fields of `CommEffectsRequest` Message (Continued)

OptionType	Option Field	Data Type	Description
`13`	`FailureTimeout`	Time	Message failure timeout value (in seconds). If this field is not included in the message, then the timeout value specified in the configuration file (`SOCKET-INTERFACE-UDP-FAILURE-TIMEOUT` or `SOCKET-INTERFACE-TCP-FAILURE-TIMEOUT`) is used.
`18`	`DSCP`	UInt8	Request DSCP. The valid range for this field is 0-63. The bits indicate the following: 0-2: Precedence 3: Low Delay 4: High Throughput 5: High Reliability For example, if the `DSCP` field is set to 10 (001010 in binary), then the message is given a precedence value of 1 with High Throughput. **Note:** A message can not include more than one of the three options: `Precedence`, `DSCP`, and `TOS`.
`19`	`TOS`	UInt8	Request TOS. The valid range for this field is 0-255 (i.e., all 8 bits can be used). This value replaces the entire TOS byte in the IP header. **Note:** A message cannot include more than one of the three options: `Precedence`, `DSCP`, and `TOS`.
`24`	`TTL`	UInt8	Time-To-Live (TTL) field for communications. This is valid for TCP and UDP communications. For TCP communications, the first TCP packet sent from the source to the destination should specify the TTL that should be used for all subsequent packets from the source to the destination.

4.1.2.11 `GetRequest` Message

This message is sent from the external program to QualNet to query the Management Information Base (MIB) variable. This message allows the user to retrieve the value of a list of MIB variables.

Message Type: The `MessageType` field of the `GetRequest` message is set to 15.

Required Fields: The required fields of the `GetRequest` message are described in Table 4-17.

TABLE 4-17. Required Fields of `GetRequest` Message

Field	Data Type	Description
`EntityId`	String	Identification of the entity on which to perform the request operation.
`NumOIDs`	UInt16	Number of OIDs.
`OID`	ListofString	List of object identifiers on which to perform the operation. This list should have a number of strings equal to `NumOIDs`.

Options: This message has no optional fields.

4.1.2.12 `SetRequest` Message

This message is sent from the external program to QualNet to set the value of a MIBS variable.

Message Type: The `MessageType` field of the `SetRequest` message is set to 17.

Required Fields: The required fields of the `SetRequest` message are described in Table 4-18.

TABLE 4-18. Required Fields of `SetRequest` Message

Field	Data Type	Description
`EntityId`	String	Identification of the entity on which to perform the request operation.
`NumOIDs`	UInt16	Number of OIDs.
`OID`	ListofString	List of object identifiers on which to perform the operation. This list should have a number of strings equal to `NumOIDs`.
`Values`	ListofString	New values to set each OID to. The number of strings should be equal to `NumOIDs`. Each value corresponds to the OID field with the matching index.

Options: This message has no optional fields.

4.1.2.13 `GetNextRequest` Message

This message is sent from the external program to QualNet to query the Management Information Base (MIB) variable. For each specified OID, QualNet will return its lexicographical successor in a `GetResponse` message. For example, the lexicographical successor of 1.3.6.1.2.1.1.3 is 1.3.6.1.2.1.1.3.0, and the lexicographical successor of 1.3.6.1.2.1.1.3.0 is 1.3.6.1.2.1.1.5.0.

Message Type: The `MessageType` field of the `GetNextRequest` message is set to 18.

Required Fields: The required fields of the `GetNextRequest` message are described in Table 4-19.

TABLE 4-19. Required Fields of `GetNextRequest` Message

Field	Data Type	Description
`EntityId`	String	Identification of the entity on which to perform the request operation.
`NumOIDs`	UInt16	Number of OIDs.
`OID`	ListofString	List of object identifiers on which to perform the operation. The number of strings should be equal to `NumOIDs`.

Options: This message has no optional fields.

4.1.2.14 `GetBulkRequest` Message

This message is sent from the external program to QualNet to query the Management Information Base (MIB) variable. This message allows the user to retrieve a large section of the MIB. QualNet will perform one GetNext operation on each of the first `NumNonRepeat` OIDs specified, followed by a maximum of `MaxRepeat` GetNext operations on each of the remaining OIDs. This means that the maximum number of objects returned is `NumNonRepeat` + (`NumOIDs` - `MaxNumNonRepeat`) * `MaxRepeat`.

Message Type: The `MessageType` field of the `GetBulkRequest` message is set to 19.

Required Fields: The required fields of the `GetBulkRequest` message are described in Table 4-20.

TABLE 4-20. Required Fields of `GetBulkRequest` Message

Field	Data Type	Description
`EntityId`	String	Identification of the entity on which to perform the request operation.
`NumOIDs`	UInt16	Number of OIDs.
`NumNonRepeat`	UInt16	Number of scalar MIB objects.
`MaxRepeat`	UInt16	Maximum repetition of a non-scalar MIB object.
`MibsId`	ListofString	List of object identifiers on which to perform the operation. The number of strings should be equal to `NumOIDs`.

Options: This message has no optional fields.

4.1.2.15 `QuerySimulationState` Message

This message is sent from the external program to QualNet to query the simulation state of QualNet. A `SimulationState` message is sent to the external program with the current state of QualNet.

Message Type: The `MessageType` field of the `QuerySimulationState` message is set to 20.

Required Fields: This message has no required fields.

Options: This message has no optional fields.

4.1.2.16 `BeginWarmup` Message

This message is sent from the external program to QualNet to start the warm up phase (see Section 4.2.3). This message is sent after the `InitializeSimualtion` and `CreatePlatform` messages are sent to QualNet.

Message Type: The `MessageType` field of the `BeginWarmup` message is set to 21.

Required Fields: This message has no required fields.

Options: This message has no optional fields.

4.1.3 Response Messages

This section describes the messages sent from QualNet to the external program.

4.1.3.1 `SimulationState` Message

This message is sent from QualNet to the external program when QualNet changes state. Every new connection from an external program receives a `SimulationState` message containing the current QualNet state.

QualNet begins in the Standby state.

Message Type: The `MessageType` field of the `SimulationState` message is set to 0.

Required Fields: The required fields of the `SimulationState` message are described in Table 4-21.

TABLE 4-21. Required Fields of `SimulationState` Message

Field	Data Type	Description
`State`	UInt8	Current state. 1: Standby 2: Initialized 3: Paused 4: Executing 6: Resetting 8: Stopping 10: Warmup
`OldState`	UInt8	Previous state.

Options: This message has no optional fields.

4.1.3.2 `SimulationIdle` Message

This message is sent from QualNet to the external program when QualNet is idling, i.e., waiting for a time advance from the external program. This message is only used when QualNet is running in time managed mode. QualNet resumes the simulation when its time is advanced by an `AdvanceTime` message.

Message Type: The `MessageType` field of the `SimulationIdle` message is set to 7.

Required Fields: The required fields of the `SimulationIdle` message are described in Table 4-22.

TABLE 4-22. Required Fields of `SimulationIdle` Message

Field	Data Type	Description
`CurrentTime`	Time	Simulation time when QualNet starts idling, waiting for a time advance from the external program.

Options: This message has no optional fields.

4.1.3.3 `DynamicResponse` Message

This message is sent from QualNet to the external program to provide the result of the operation requested by a `DynamicCommand` message.

Message Type: The `MessageType` field of the `DynamicResponse` message is set to 9.

Required Fields: The required fields of the `DynamicResponse` message are described in Table 4-23.

TABLE 4-23. Required Fields of `DynamicResponse` Message

Field	Data Type	Description
`Type`	UInt8	Type of operation that was performed. 0: Read 1: Write 2: Execute
`Path`	String	Path of dynamic object that operation was performed on.
`Args`	String	Arguments passed in the originating DynamicCommand.
`Output`	String	Output of dynamic command.

Options: This message has no optional fields.

4.1.3.4 `CommEffectsResponse` Message

This message is sent from QualNet to the external program and provides a response to a `CommEffectsRequest` message indicating the result of the message delivery request.

Message Type: The `MessageType` field of the `CommEffectsResponse` message is set to 13.

Required Fields: The required fields of the `CommEffectsResponse` message are described in Table 4-24

TABLE 4-24. Required Fields of `CommEffectsResponse` Message

Field	Data Type	Description
`Id1`	UInt64	First 8 bytes of message identification field.
`Id2`	UInt64	Second 8 bytes of message identification field.
`SenderId`	String	Entity identification of the message sender.
`ReceiverId`	String	Entity identification of the message receiver.

TABLE 4-24. Required Fields of `CommEffectsResponse` Message (Continued)

Field	Data Type	Description
`Status`	Int8	Indication of success or failure. 0: Success 1: Failure due to expired FailureTimeout window. Any nonzero value indicates a failure.
`ReceiveTime`	Time	Time when the message was received. This will be the `SendTime` field of the `CommEffectsRequest` message plus the `Latency`. field of the `CommEffectsResponse` message. In real time mode, the simulation time at which the message was sent is used as `SendTime`.
`Latency`	Time	Time spent by the message in transit (`ReceiveTime` - `SendTime` field of the `CommEffectsRequest` message).

Options: The optional fields of the `CommEffectsResponse` message and the corresponding `OptionType` are described in Table 4-25.

TABLE 4-25. Optional Fields of `CommEffectsResponse` Message

OptionType	Option Field	Data Type	Description
12	`Description`	String	Description of the request. This is echoed back from the `CommEffectsRequest` message in response to which this message is sent.

4.1.3.5 `Error` Message

This message is sent from QualNet to the external program when an incorrect message is received. This message contains a numeric error code, a human-readable error string, and the entire original message that generated the error.

Message Type: The `MessageType` field of the `Error` message is set to 14.

Required Fields: The required fields of the `Error` message are described in Table 4-26.

TABLE 4-26. Required Fields of `Error` Message

Field	Data Type	Description
`Code`	UInt8	Error code. 0: No error 1: Configuration Error 2: Message Creation Error 3: Invalid Message 4: Invalid Transition 5: Invalid EntityId 6: Invalid State 7: Invalid Coordinates 8: Invalid ReceiverId 9: Empty Receiver List 10: Invalid Senderid 11: Invalid Send Time 12: Invalid Stop Time 13: Invalid SocketId 14: Simulator Warning 15: Simulator Error 16: Socket Error 17: Invalid Operation Type 18: Empty Scenario String 19: Invalid Dynamic Command 20: Invalid Protocol 21: Invalid Group 28: Invalid Simulation State 29: Invalid Node ID
`Error`	String	Human-readable error string.

Options: The optional fields of the `Error` message and the corresponding `OptionType` are described in Table 4-27.

TABLE 4-27. Optional Fields of `Error` Message

OptionType	Option Field	Data Type	Description
`16`	`OriginatingMessage`	QualNet Message	If a message caused the error, this field contains the complete error-causing message as it was received on the socket.

4.1.3.6 `GetResponse` Message

This message is sent from QualNet to the external program in response to a SNMP command (i.,e., `GetRequest`, `GetNextRequest`, `GetBulkRequest`, and `SetRequest` messages).

Message Type: The `MessageType` field of the `GetResponse` message is set to 16.

Required Fields: The required fields of the `GetResponse` message are described in Table 4-28

TABLE 4-28. Required Fields of `GetResponse` Message

Field	Data Type	Description
`EntityId`	String	Identification of the entity on which the request operation is performed.
`NumOIDs`	UInt16	Number of OIDs.
`OID`	ListofString	List of object identifiers on which the MIBS object operations were performed. The number of strings is equal to `NumOIDs`.
`Output`	ListofString	List of the outputs from the operation performed on the MIBS objects. The number of strings is equal to `NumOIDs`. Each output value corresponds to the `OID` field with the matching index.
`ErrorStatus`	ListofUInt8	List of SNMP errors. The following codes are used. 0: `noError`: No error. 1: `tooBig`: Message size is too big. 2: `noSuchName`: OID does not exist. 3: `badValue`: `Values` field of the `SetRequest` message is incorrect. 4: `readOnly`: Object was set by a `SetRequest` message but is read only. 5: `genErr`: Any other error. 6: `endOfMibView`: `GetNextRequest` or `GetBulkRequest` message has reached the last object in the database The number of errors is equal to `NumOIDs`. Each error value corresponds to the OID field with the matching index. Currently `tooBig`, `badValue`, and `genErr` are not returned.

Options: This message has no optional fields.

4.2 Features of Socket Interface

This section describes some features of the Socket Interface.

4.2.1 Multicast and Broadcast Support

Platforms are added to multicast groups by the `MulticastGroups` field in the `CreatePlatform` message and the `JoinMulticastGroups` field in the `UpdatePlatform` message. Platforms are removed from multicast groups by the `LeaveMulticastGroups` field in the `UpdatePlatform` message. Multicast routing must be configured in the QualNet scenario configuration file.

Multicast and broadcast responses are handled differently from unicast responses. Unicast `CommEffectsResponse` messages are always sent back to the external program that initiated the `CommEffectsRequest` message. For multicast and broadcast `CommEffectsRequest` messages, the external program that receives the `CommEffectsResponse` may be different from the external program that initiated the `CommEffectsRequest`. QualNet handles `CommEffectsResponse` messages for multicast and broadcast as follows:

1. QualNet checks if an external program has added the platform to the multicast group or broadcast address. If so, QualNet sends a `CommEffectsResponse` with the `ReceiverId` set to the receiving platform's entity identifier to all external programs that have added the platform to the multicast group.

   The originator of the `CommEffectsRequest` message receives the response only if it has added the platform to the multicast group.
2. If no external program has added the platform to the multicast group or broadcast address, QualNet sends the `CommEffectsResponse` to the originator of the `CommEffectsRequest` message.

Multiple external programs may initiate a request to add the same platform to the same multicast group. QualNet adds the platform to the multicast group only once. However, each external program that initiates such a request receives a copy of the `CommEffectsResponse` for the given platform and multicast group. An external program may add a platform to a broadcast address in which case it will receive responses for the broadcast address.

When an external program sends a request to remove a platform from a multicast group, the platform is removed from the group even if other external programs have added that platform to the same multicast group.

4.2.2 Dynamic Commands

Dynamic commands are supported by the Socket Interface to allow an external program to view the QualNet scenario state and make modifications to the QualNet scenario while it is running. For example, using dynamic commands, a user can check if a platform is a subnet gateway and, if it not a gateway, the user can turn it into a subnet gateway.

The parts of the QualNet simulation that can be changed dynamically are organized in a directory structure called the Dynamic Hierarchy. The following is an example of a portion of a dynamic hierarchy:

```
/platform/A100/interface/192.0.0.2/PHY-ABSTRACT-DATA-RATE
/platform/A132/interface/192.0.0.3/PHY-ABSTRACT-DATA-RATE
/platform/A132/interface/192.0.3.101/PHY-ABSTRACT-DATA-RATE
/platform/B233/interface/192.0.3.122/PHY-ABSTRACT-DATA-RATE
```

This example shows three platforms: A100, A132 and B233. A100 and B233 belong to subnets 192.0.0.0 and 192.0.3.0 respectively. A132 belongs to both subnets because it has interfaces to both 192.0.0.0 and 192.0.3.0 subnets.

The variable `PHY-ABSTRACT-DATA-RATE` can be read and modified at any point in the simulation via a `DynamicCommand` message (see Section 4.1.2.7). For example, to read the value of the `PHY-`

ABSTRACT-DATA-RATE variable for platform A100, a DynamicCommand message with the following fields can be used:

Field	Value	Description
Type	0	Indication of a read operation.
Path	"/platform/A100/interface/192.0.0.2/PHY-ABSTRACT-DATA-RATE"	Path of dynamic object to perform the read operation on.
Args	""	Empty string.

The results of this operation are sent back in a DynamicResponse message (see Section 4.1.2.8), which may have the following fields:

Field	Value	Description
Type	0	Indication that a read operation was performed.
Path	"/platform/A100/interface/192.0.0.2/PHY-ABSTRACT-DATA-RATE"	Path of dynamic object on which the read operation was performed.
Args	""	Empty string.
Output	"2000000000"	Output of the dynamic command.

To change the value of the PHY-ABSTRACT-DATA-RATE variable for platform B233, a DynamicCommand message with the following fields can be used:

Field	Value	Description
Type	1	Indication of a write operation.
Path	"platform/B233/interface/192.0.0.2/PHY-ABSTRACT-DATA-RATE"	Path of dynamic object to perform the write operation on.
Args	"2500000000"	New value of the variable.

This will change the PHY Abstract data rate for platform B233. No DynamicResponse message is sent for write operations.

Table 4-29 summarizes the dynamic variables that are available for all platforms created through the Socket Interface. The interface address can be determined from the configuration file by tracing the platform mapping back to the node identifier using the entity mapping file (see Section 4.3.1.1). It can also be determined from the output file graph.log (see Section 4.4.3).

TABLE 4-29. Available Dynamic Variables and Results of Dynamic Commands

Path	Result of Read	Result of Write	Result of Execute
`/platform/<entityID>/interface/<ipAddress>/PHY-ABSTRACT-DATA-RATE`	Returns the current data rate (in bits per second).	Changes the data rate to the specified value (in bits per second).	Not applicable.
`/platform/<entityID>/interface/<ipAddress>/fault`	• Returns "yes" if the interface is faulted. • Returns "no" if the interface is not faulted. (Interface faults by dynamic commands are independent of a platform's damage state.)	Not applicable.	• Creates an interface fault if "yes" is specified • Interface is no longer faulted if "no" is specified.
`/platform/<entityID>/multicastGroups`	Returns list of multicast groups the platform is a member of, delimited by spaces.	Not applicable.	Not applicable.

4.2.3 Warm-up Phase

QualNet supports an optional phase that occurs between the Standby and Initialize phases called the Warm-up phase (see Figure 4-1). The warm-up phase provides additional time before the beginning of the simulation for the routing protocols to converge.

QualNet operation in warm-up phase works as follows:

1. QualNet loads the scenario configuration file.
2. QualNet enters the Standby state.

   Note: `CommEffectsRequest` messages received in the Standby state are treated as errors.
3. QualNet receives an `InitializeSimulation` message.
4. If a warm-up time is specified in the configuration file, then QualNet waits to receive the `BeginWarmup` message.

   a. Upon receiving the `BeginWarmup` message, QualNet enters the WarmUp state and begins the warm-up phase. In the warm-up phase, QualNet operates as follows:
      - QualNet processes `CreatePlatform`, `UpdatePlatform`, and `CommEffectsRequest` messages. `CommEffectsRequest` messages received in this phase are either processed as successes with 0 delay or dropped, depending on the warm-up parameters (see Section 4.2.3.1).
      - QualNet buffers unused messages until they are needed.

   b. QualNet begins running the scenario, forming routing tables, etc.

  c. QualNet processes statistics database queries during the warm-up phase. Database timestamps during the warm-up phase are negative. For example, if the warm-up phase duration is 10 minutes, then database timestamps will count from -10 minutes up to 0 minutes (warm-up time over).
  d. QualNet finishes warm-up phase and enters the Initialized state.

5. QualNet enters the Initialized state. If QualNet enters the Initialized state from the WarmUp state (i.e., if a warm-up time is specified in the configuration file), then QualNet responds to `CommEffectsRequest` messages received in the Initialized state with success and 0 delay.
6. QualNet receives a `PauseSimulation` message and enters the Paused state.
7. QualNet receives an `ExecuteSimulation` message and enters the Executing state. At this point, QualNet's internal simulation time is equal to the warm-up time. However, when communicating with external software QualNet will consider real time and simulation time to be zero.
8. QualNet runs as normal.

Note: The warm-up time is subtracted from all timestamps sent to the external program. The warm-up time is added to all timestamps received from the external program. This makes it appear that QualNet is at time 0 when transitioning to the execute phase.

4.2.3.1 Configuring Warm-up Phase Parameters

This section describes how to configure the warm-up phase parameters

4.2.3.1.1 Command Line Configuration

To configure the warm-up phase parameters for the command line interface, include the parameters listed in Table 4-30 in the scenario configuration (.config) file.

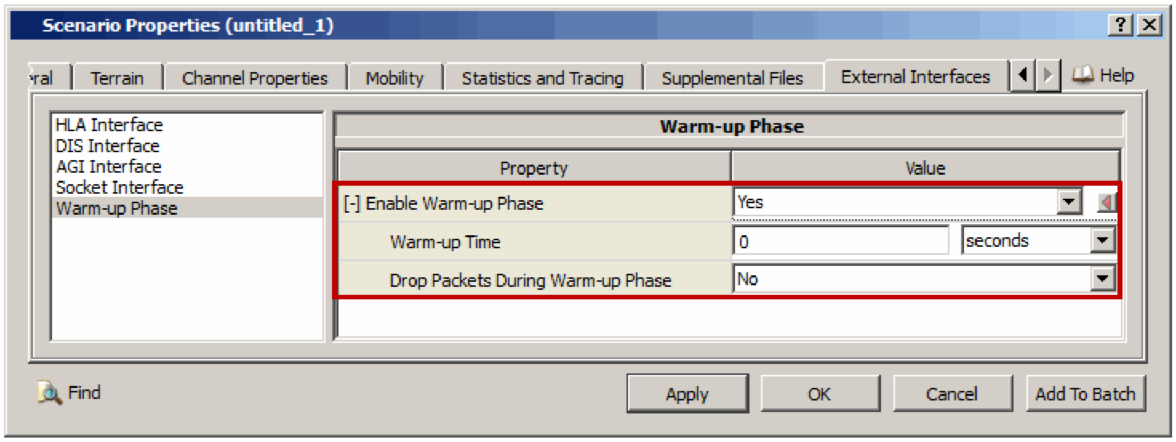
TABLE 4-30. Warm-up Phase Parameters

Parameter	Value	Description
`EXTERNAL-WARM-UP-TIME` *Optional* *Scope:* Global	Time *Range:* ≥ `0S` *Default:* `0S`	Length of the warm-up phase.
`EXTERNAL-WARM-UP-DROP` *Optional* *Scope:* Global	List: • `YES` • `NO` *Default:* `NO`	Indicates whether packets received from external sources in the warm-up phase are dropped or delivered to the destination with zero delay. By default external packets are delivered to the destination with zero delay.

4.2.3.1.2 GUI Configuration

To configure the warm-up phase parameters in the GUI, perform the following steps:

1. Go to **Scenario Properties Editor > External Interfaces > Warm-up Phase**.
2. To enable the warm-up phase, set **Enable Warm-up Phase** to *Yes* and set the dependent parameters listed in Table 4-31.



Warm-up Phase

Property	Value
[-] Enable Warm-up Phase	Yes
Warm-up Time	0 seconds
Drop Packets During Warm-up Phase	No

FIGURE 4-2. Setting Warm-up Phase Parameters

TABLE 4-31. Command Line Equivalent of Warm-up Phase Parameters

GUI Parameter	Scope of GUI Parameter	Command Line Parameter
Warm-up Time	Global	`EXTERNAL-WARM-UP-TIME`
Drop Packets During Warm-up Phase	Global	`EXTERNAL-WARM-UP-DROP`

4.3 Socket Interface Configuration

This section describes the parameters that need to be configured for the Socket Interface. These parameters configure QualNet to handle messages from the external program over the Socket Interface. The QualNet network scenario must be configured in addition to the Socket Interface.

Section 4.3.1 describes how to set up these parameters in the QualNet scenario configuration file.
Section 4.3.2 describes how to set up these parameters using the QualNet GUI.

4.3.1 Command Line Configuration

Table 4-32 lists the QualNet scenario configuration (.config) file parameters required for the Socket Interface. See Section 1.1.1 for a description of the format for specifying parameters in the QualNet configuration file and the format used for the parameter table.

TABLE 4-32. Socket Interface Configuration Parameters

Parameter	Value	Description
`SOCKET-INTERFACE` *Optional* *Scope:* Global	List: • `YES` • `NO` *Default:* `NO`	Indicates whether QualNet should use the Socket Interface. This parameter must be included and set to `YES` for the Socket Interface to be initialized.
`SOCKET-INTERFACE-NUM-PORTS` *Optional* *Scope:* Global	Integer *Range:* `> 0` *Default:* `1`	Number of ports socket interface is to open for incoming connections. Multiple connections may be created per port.
`SOCKET-INTERFACE-PORT` *Optional* if `SOCKET-INTERFACE-NUM-PORTS = 1` *Required* if `SOCKET-INTERFACE-NUM-PORTS > 1` *Scope:* Global *Instances:* index	Integer *Range:* `> 0` *Default:* See description.	Port numbers for socket interface. If `SOCKET-INTERFACE-NUM-PORTS` is 1, then this parameter can be omitted (in which case the default port number is 5033) or the port number can be specified as parameter `SOCKET-INTERFACE-PORT` or `SOCKET-INTERFACE-PORT[0]`. If `SOCKET-INTERFACE-NUM-PORTS` is greater than 1, then the configuration file should contain `SOCKET-INTERFACE-NUM-PORTS` instances of `SOCKET-INTERFACE-PORT[index]`.
`SOCKET-INTERFACE-UDP-FAILURE-TIMEOUT` *Optional* *Scope:* Global	Time *Range:* ≥ `0S` *Default:* `15S`	Time interval to wait before sending a `CommEffectsResponse` message indicating a failure in response to a UDP message.
`SOCKET-INTERFACE-TCP-FAILURE-TIMEOUT` *Optional* *Scope:* Global	Time *Range:* ≥ `0S` *Default:* 90S	Time interval to wait before sending a `CommEffectsResponse` message indicating a failure in response to a TCP message.
`SOCKET-INTERFACE-PRINT-PER-PACKET-STATS` *Optional* *Scope:* Global	Filename or List: • `STDOUT`	File to print per-packet statistics for each `CommEffectsRequest` message. If the value is a filename, statistics are printed to that file. If the value is `STDOUT`, statistics are printed on the terminal window. If this parameter is not specified, per-packet statistics are not printed.
`SOCKET-INTERFACE-LOG` *Optional* *Scope:* Global	List: • `FILE` • `STDOUT` • `NONE` *Default:* `FILE`	File to log data. If the value is `FILE`, all output is logged to files (see Section 4.4). If the value is `STDOUT`, all output is logged to the terminal window. If the value is `NONE`, output is not logged.

TABLE 4-32. Socket Interface Configuration Parameters (Continued)

Parameter	Value	Description
`SOCKET-INTERFACE-PRINT-REAL-TIME` *Optional* *Scope:* Global	List: • `0` • `1` *Default:* `0`	Indicates whether timestamps, if printed, indicate wall-clock time or simulation time. If the value is `0`, timestamps indicate simulation time. If the value is `1`, timestamps indicate simulation time as well as wall-clock time.
`SOCKET-INTERFACE-STATS-PRINT-REAL-TIME` *Optional* *Scope:* Global	List: • `0` • `1` *Default:* `0`	Indicates whether to output statistics based on real time or simulation time. If the value is `0`, statistics are based on simulation time. If the value is `1`, statistics are based on real time.
`SOCKET-INTERFACE-STATS-PRINT-INTERVAL` *Optional* *Scope:* Global	Time *Range:* ≥ `0S` *Default:* `60S`	Time interval used to output statistics.
`SOCKET-INTERFACE-GRAPH-PRINT-REAL-TIME` *Optional* *Scope:* Global	List: • `0` • `1` *Default:* `1`	Indicates whether the time interval specified by parameter `SOCKET-INTERFACE-GRAPH-PRINT-INTERVAL` is real time interval or simulation time interval. If the value is `0`, `SOCKET-INTERFACE-GRAPH-PRINT-INTERVAL` is a simulation time interval. If the value is `1`, `SOCKET-INTERFACE-GRAPH-PRINT-INTERVAL` is a real time interval.
`SOCKET-INTERFACE-GRAPH-PRINT-INTERVAL` *Optional* *Scope:* Global	Time *Range:* ≥ `0S` *Default:* `60S`	Time interval used to print data to the graph log file.
`SOCKET-INTERFACE-IDLE-WHEN-RESPONSE-SENT` *Optional* *Scope:* Global	List: • `YES` • `NO` *Default:* `NO`	Indicates whether QualNet should go into idle mode when a `CommEffectsResponse` message is sent. If the value is `YES`, QualNet goes into idle mode when a `CommEffectsResponse` message is sent. If the value is `NO`, sending a `CommEffectsResponse` message does not cause QualNet to go into idle mode.
`SOCKET-INTERFACE-ALWAYS-SUCCESS` *Optional* *Scope:* Global	List: • `YES` • `NO` *Default:* `NO`	Indicates whether all `CommEffectsResponse` messages sent by QualNet should indicate a success. If the value is `YES`, all `CommEffectsResponse` messages indicate a success. If the value is `NO`, `CommEffectsResponse` messages sent in response to unsuccessful requests indicate a failure. **Note:** Multicast traffic is not affected by this parameter.

TABLE 4-32. Socket Interface Configuration Parameters (Continued)

Parameter	Value	Description
`SOCKET-INTERFACE-CPU-HOG` *Optional* *Scope:* Global	List: • `YES` • `NO` *Default:* `NO`	Indicates whether QualNet should use up all available CPU time. If the value is `YES`, QualNet uses up all available CPU time. If the value is `NO`, QualNet does not use up all available CPU time, i.e., it uses the sleep system call.
`SOCKET-INTERFACE-ENTITY-MAPPING-FILE` *Optional* *Scope:* Global	Filename	Name of the entity mapping file. This file specifies the static mapping between the external entities and QualNet nodes. If this parameter is not specified, mapping between the external entities and QualNet nodes is done dynamically by assigning the next available QualNet node identifier to an external entity when that entity is created. The format of the entity mapping file is described in Section 4.3.1.1.
`SOCKET-INTERFACE-LOG-AUTOMATIC-FLUSH` *Optional* *Scope:* Global	List: • `YES` • `NO` *Default:* `YES`	Indicates whether QualNet should flush log files for each line of output. If the value is `YES`, QualNet will flush log files for each line of output. If the value is `NO`, QualNet allows the operating system to determine when log files should be flushed. This may result in a performance increase for large scenarios but individual lines of a log file will experience a delay before being committed to disk.
`SOCKET-INTERFACE-DISTRIBUTED-ENVIRONMENT` *Optional* *Scope:* Global	List: • `YES` • `NO` *Default:* `NO`	Indicates whether QualNet should support operation in a geographically distributed environment (where QualNet and its connected external programs are distributed physically and communication delays are larger than if they were in the same building). If the value is `YES`, QualNet will support operation in a geographically distributed environment. If the value is `NO`, QualNet will not provide special support for operation in a geographically distributed environment.
`SOCKET-INTERFACE-PAUSE-REPLY-ZERO-DELAY` *Optional* *Scope:* Global	List: • `YES` • `NO` *Default:* `NO`	Indicates whether QualNet should respond with 0 second delay after receiving a CommEffectsRequest message when it is in the “Pause” state. If the value is `YES`, QualNet will respond with 0 second delay for after receiving a CommEffectsRequest message when it is in the “Pause” state. If the value is `NO`, QualNet will not respond with 0 second delay for after receiving a CommEffectsRequest message when it is in the “Pause” state, and instead would buffer the messages to be processed when in “Execution” state.

TABLE 4-32. Socket Interface Configuration Parameters (Continued)

Parameter	Value	Description
`SOCKET-INTERFACE-PAUSE-ADVANCE-SIMULATION-TIME` *Optional* *Scope:* Global	List: • `YES` • `NO` *Default:* `NO`	Indicates whether QualNet should advance the simulation time in “Pause” state. If the value is `YES`, QualNet will advance the simulation time in “Pause” state. If the value is `NO`, QualNet will not advance the simulation time in “Pause” state.
`SOCKET-INTERFACE-ONLY-DEACTIVATE-MAPPED-NODES` *Optional* *Scope:* Global	List: • `YES` • `NO` *Default:* `NO`	Indicates whether QualNet should deactivate only nodes mapped in the entity mapping file during start-up. If the value is `YES`, QualNet will only deactivate mapped nodes during start-up If the value is `NO`, QualNet will deactivate all nodes in the scenario during start-up

4.3.1.1 Format of the Entity Mapping File

The entity mapping file specifies static mappings between the external entities and QualNet nodes. Several QualNet nodes can map to the same external entity. Each line in this file has the following format:

```
<External-Entity-ID> <QualNet-Node-List>
```

where

`<External-Entity-ID>`	Identifier (string) for the entity used by the external program.
`<QualNet-Node-List>`	List of `QualNet` nodes that map to the external entity. A node can be referenced by it node ID, hostname, or IP address. Node IDs, hostnames, and IP addresses in this list are separated by spaces. If the list contains a node ID, the node with that ID maps to the external entity. If the list contains a hostname, all `QualNet` nodes with that hostname map to the external entity. If the list contains an IP address, the node with that IP address (i.e., the node having that IP address as its interface address) maps to the external entity. **Note:** A hostname can be any string (including an integer or an IP address). When matching a node reference in the node list with hostnames, node IDs and IP addresses, a match with a hostname takes precedence over a match with a node ID or IP address.

Note: The entity identifier and node labels can optionally be enclosed within quotes (“).

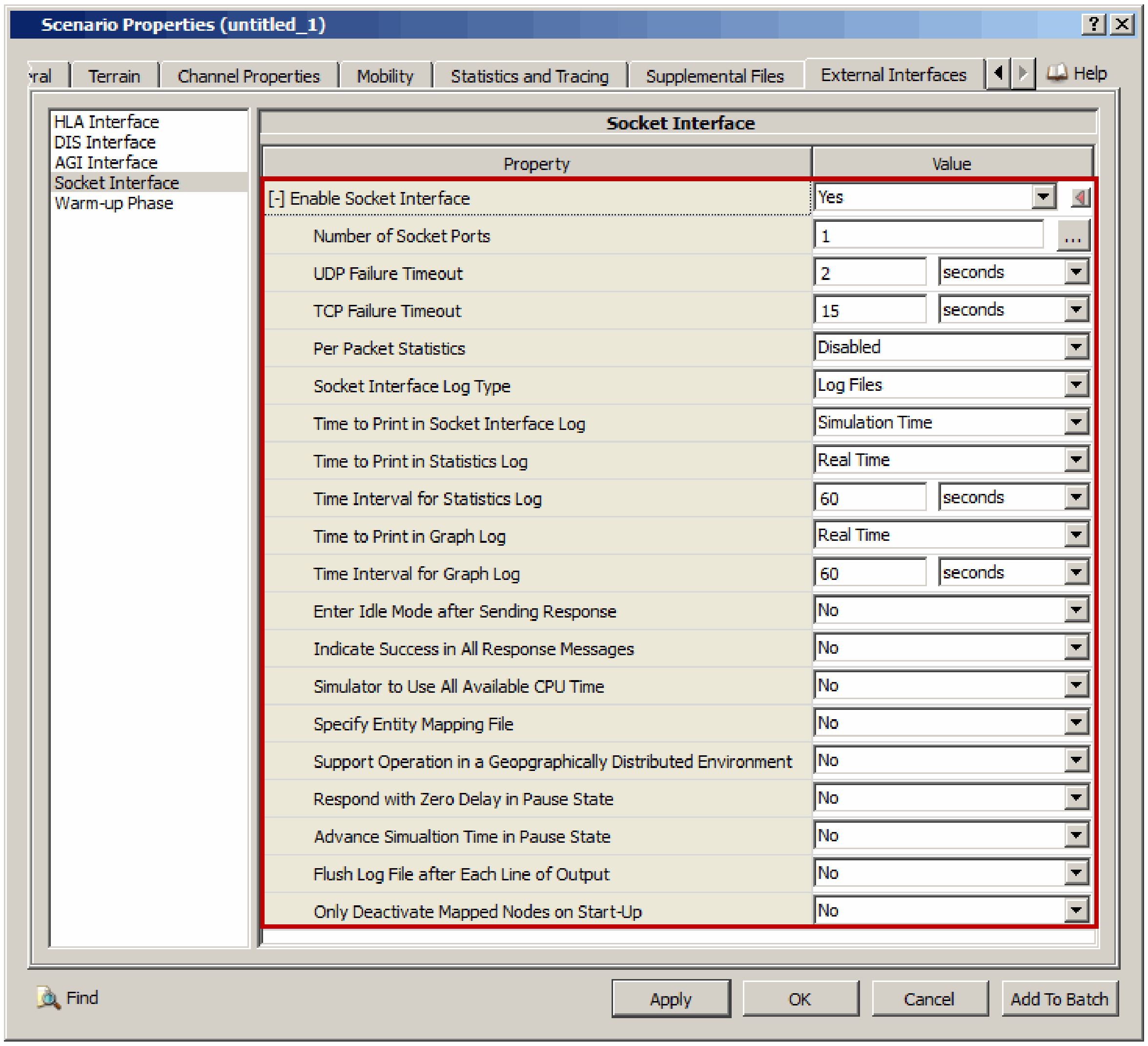
The following is an example of an entity mapping file:

```
# Entity ID        QualNet Node List

1                  10
2                  25 16 radio-101
"Entity 1"         501  192.168.1.1
3                  35 "Platform 1"
Station-10         15 20 35
```

4.3.2 GUI Configuration

To configure the QualNet Socket parameters using the QualNet GUI, do the following:

1. Go to **Scenario Properties Editor > External Interfaces > Socket Interface**.
2. Set the parameters listed in Table 4-33.



Property	Value
[-] Enable Socket Interface	Yes
Number of Socket Ports	1
UDP Failure Timeout	2 seconds
TCP Failure Timeout	15 seconds
Per Packet Statistics	Disabled
Socket Interface Log Type	Log Files
Time to Print in Socket Interface Log	Simulation Time
Time to Print in Statistics Log	Real Time
Time Interval for Statistics Log	60 seconds
Time to Print in Graph Log	Real Time
Time Interval for Graph Log	60 seconds
Enter Idle Mode after Sending Response	No
Indicate Success in All Response Messages	No
Simulator to Use All Available CPU Time	No
Specify Entity Mapping File	No
Support Operation in a Geopgraphically Distributed Environment	No
Respond with Zero Delay in Pause State	No
Advance Simualtion Time in Pause State	No
Flush Log File after Each Line of Output	No
Only Deactivate Mapped Nodes on Start-Up	No

FIGURE 4-3. Setting Socket Interface Parameters

TABLE 4-33. Command Line Equivalent of Socket Interface Parameters

GUI Parameter	Scope of GUI Parameter	Command Line Parameter
Enable Socket Interface	Global	`SOCKET-INTERFACE`
Number of Socket Ports	Global	`SOCKET-INTERFACE-NUM-PORTS`
UDP Failure Timeout	Global	`SOCKET-INTERFACE-UDP-FAILURE-TIMEOUT`
TCP Failure Timeout	Global	`SOCKET-INTERFACE-TCP-FAILURE-TIMEOUT`
Per Packet Statistics	Global	`SOCKET-INTERFACE-PRINT-PER-PACKET-STATS`
Socket Interface Log Type	Global	`SOCKET-INTERFACE-LOG`
Time to Print in Socket Interface Log	Global	`SOCKET-INTERFACE-PRINT-REAL-TIME`
Time to Print in Statistics Log	Global	`SOCKET-INTERFACE-STATS-PRINT-REAL-TIME`
Time Interval for Statistics Log	Global	`SOCKET-INTERFACE-STATS-PRINT-INTERVAL`
Time to Print in Graph Log	Global	`SOCKET-INTERFACE-GRAPH-PRINT-REAL-TIME`
Time Interval for Graph Log	Global	`SOCKET-INTERFACE-GRAPH-PRINT-INTERVAL`
Enter Idle Mode after Sending Response	Global	`SOCKET-INTERFACE-IDLE-WHEN-RESPONSE-SENT`
Indicate Success in All Response Messages	Global	`SOCKET-INTERFACE-ALWAYS-SUCCESS`
Simulator to Use All Available CPU Time	Global	`SOCKET-INTERFACE-CPU-HOG`
Specify Entity Mapping File	Global	N/A
Support Operation in a Geographically Distributed Environment	Global	`SOCKET-INTERFACE-DISTRIBUTED-ENVIRONMENT`
Respond with Zero Delay in Pause State	Global	`SOCKET-INTERFACE-PAUSE-REPLY-ZERO-DELAY`
Advance Simulation Time in Pause State	Global	`SOCKET-INTERFACE-PAUSE-ADVANCE-SIMULATION-TIME`
Flush Log File after Each Line of Output	Global	`SOCKET-INTERFACE-LOG-AUTOMATIC-FLUSH`
Only Deactivate Mapped Nodes on Start-Up	Global	`SOCKET-INTERFACE-ONLY-DEACTIVATE-MAPPED-NODES`

Setting Parameters

- To disable printing of per-packet statistics, set **Per Packet Statistics** to *Disabled*. To print per-packet statistics on the terminal window, set **Per Packet Statistics** to *Terminal WIndow*. To print per-packet statistics to a file, set **Per Packet Statistics** to *File.*
- To disable logging of data, set **CES Log Type** to *Disabled*. To log all output on the terminal window, set **CES Log Type** to *Terminal WIndow*. To log output to files, set **CES Log Type** to *Log Files.*

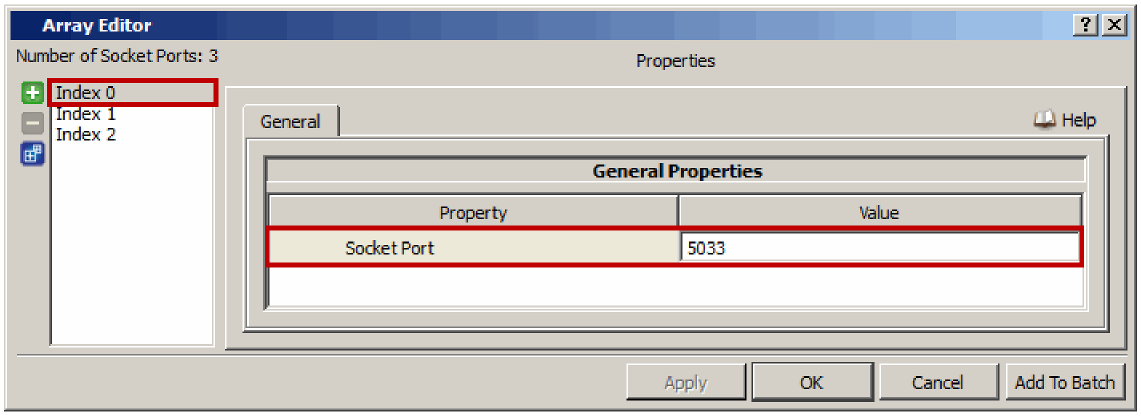
- To specify an entity mapping file, set **Specify Entity Mapping File** to *Yes*; otherwise, set **Specify Entity Mapping File** to *No*.

3. To configure Socket ports, do the following:

a. Set **Number of Socket Ports** as shown in Figure 4-3.

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

c. In the left panel of the Array Editor, select the index of the socket port to be configured. In the right panel, set the parameters listed in Table 4-34.



Array Editor

Number of Socket Ports: 3

Index 0
Index 1
Index 2

Properties

General

General Properties

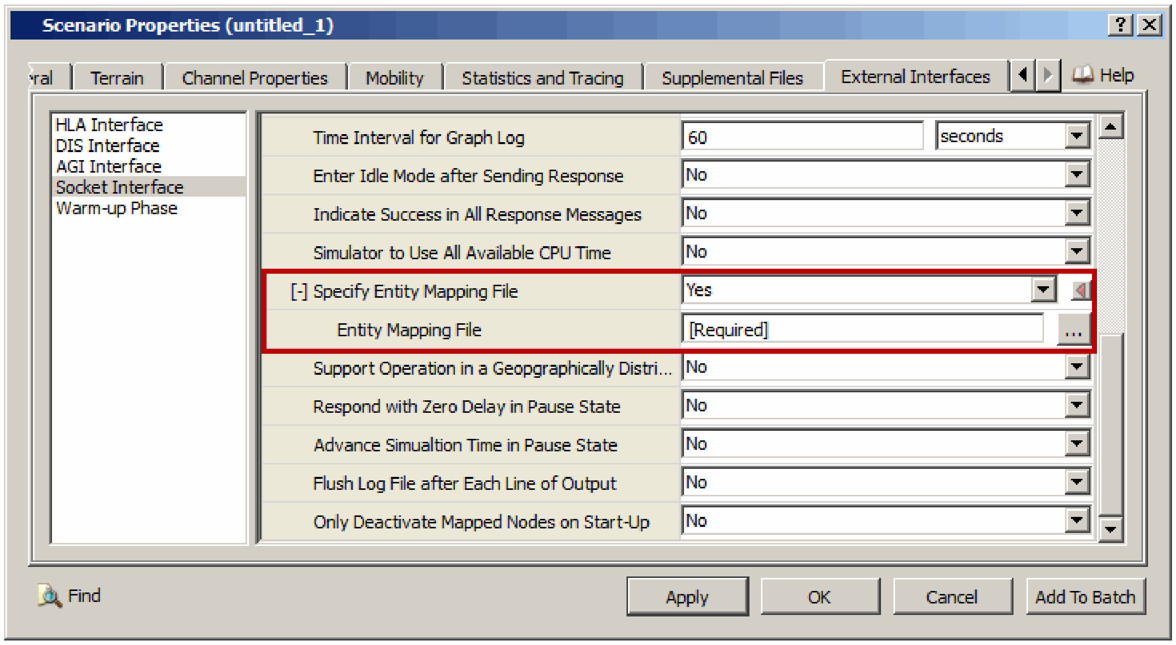
Property	Value
Socket Port	5033

FIGURE 4-4. Setting Socket Ports

TABLE 4-34. Command Line Equivalent of Socket Port Parameters

GUI Parameter	Scope of GUI Parameter	Command Line Parameter
Socket Port	Global	`SOCKET-INTERFACE-PORT`

4. If **Specify Entity Mapping File** is set to *Yes*, then set the dependent parameters listed in Table 4-33.



Time Interval for Graph Log	60 seconds
Enter Idle Mode after Sending Response	No
Indicate Success in All Response Messages	No
Simulator to Use All Available CPU Time	No
[-] Specify Entity Mapping File	Yes
Entity Mapping File	[Required]
Support Operation in a Geopgraphically Distri...	No
Respond with Zero Delay in Pause State	No
Advance Simualtion Time in Pause State	No
Flush Log File after Each Line of Output	No
Only Deactivate Mapped Nodes on Start-Up	No

FIGURE 4-5. Specifying Entity Mapping File

TABLE 4-35. Command Line Equivalent of Entity Mapping File Parameters

GUI Parameter	Scope of GUI Parameter	Command Line Parameter
Entity Mapping File	Global	`SOCKET-INTERFACE-ENTITY-MAPPING-FILE`

Setting Parameters

- Set **Entity Mapping File** to the name of the entity mapping file. See Section 4.3.1.1 for the format of the entity mapping file.

4.4 Output Files

This section describes the log files that are generated when QualNet Socket is run.

QualNet log files are generated in the directory from which QualNet is run. They are stored for each run in a directory that is named using the following convention:

```
CES_SOCKET_<date>_<time>
```

where

`<date>`	Date of the run (year, month, day) in the following format: YYYYMMDD
`<time>`	Time of the run (hour, minutes, seconds) in the following format: HHMMSS

Example

A directory with the name `CES_SOCKET_20040802_135822` stores log files for the run that began at 1:58:22 PM on August 2nd, 2004.

The log files generated by QualNet are listed in Table 4-36 and are explained in the following sections.

TABLE 4-36. QualNet Socket Log Files

Name	Description
driver.log	Messages received by QualNet from the external program.
errors.log	Errors encountered during the run.
graph.log	Network connectivity graph.
responses.log	Messages sent by QualNet to the external program.
stats.log	Performance statistics for QualNet.

4.4.1 File driver.log

The file driver.log records all messages sent by the external program to QualNet. The file contains one line for each message and has the following format:

```
<time> [<real-time>] <message_name> [<parameter_list>]
```

where

`<time>`	Simulation time when the command was sent, enclosed in square brackets.
`<real-time>`	Elapsed real time since the beginning of the simulation. This is only printed if `SOCKET-INTERFACE-PRINT-REAL-TIME` is set to `YES`.
`<message_name>`	Message name.
`<parameter_list>`	List of parameters included in the message. If the message does not include any parameters, this list is empty.

If the message has parameters, the parameter list is printed using the following format:

```
: <param-name> = <param-value> {,<param-name> = <param-value>}
```

where

`<param-name>`	Parameter name.
`<param-value>`	Parameter value.

See Section 4.1.2 for a description of interface messages that can be sent from the external program to QualNet and their associated parameters.

For an example of the file driver.log, see Section A.3.3.3.1.

4.4.2 File errors.log

The file errors.log records all errors that occur during a simulation run. Each error is printed on a line in the following format:

```
<time> ErrorMessage <error_type>, ERROR = <description>
       [originating message = <message>]
```

where

`<time>`	Simulation time when the error occurred, enclosed in square brackets.
`<error_type>`	Type of error.
`<description>`	Description of the error.
`<message>`	Message that caused the error. Some error entries may not include a message with them.

The possible error types that can be printed in the errors.log file are listed in Table 4-26.

For an example of file errors.log, see Section A.3.3.3.2.

4.4.3 File graph.log

The file graph.log records details of the routing status of scenario’s topology. Data are printed to the file graph.log at intervals defined by the parameter `SOCKET-INTERFACE-GRAPH-PRINT-INTERVAL`. After each interval, data are printed for each node in the scenario, followed by a region summary if regions have formed.

Information for each node as well as the region summary can span several lines in the log file. Each line in the file begins with a timestamp which indicates the simulation time when the information was printed.

The information for each entity is printed in the following format:

- The first line indicates the entity identifier (`EntityID`) and the node identifier (`NodeID`) that the entity maps to.
- The second line indicates the node location. If the QualNet scenario uses the Cartesian coordinate system, then the X-, Y-, and Z-coordinates of the node are printed. If the QualNet scenario uses the Lat/Lon/Alt coordinate system, then the latitude, longitude, and altitude of the node are printed.
- The third line indicates the platform type of the node (`Ground` or `Air`). See Section 4.1.2.8.
- Next, information is printed about the node’s interfaces. One line is printed for each subnet that the node belongs to and has the following format:
  - The node’s interface address and the subnet identifier of the subnet are printed.
  - If regions have formed in the subnet, and the node is a RAP, then the label `[RAP]` is printed on the same line after the subnet identifier, followed by a list of other nodes in the same region. Note that the entity identifiers corresponding to the nodes are printed.
- The next line indicates whether the node is a gateway, and if so, the subnets of which it is a gateway.

A region summary is printed only if regions have formed by that time in simulation. The region summary consists of the following information about each subnet which has formed regions:

- The first line indicates the subnet identifier followed by a list of entity identifiers of all gateways of the subnet.

- Each subsequent line corresponds to a region. All nodes belonging to a region are printed on a single line. The list of RAP nodes is printed first and is enclosed in parentheses.

For an example of file graph.log, see Section A.3.3.3.3.

4.4.4 File responses.log

The file responses.log records messages sent by QualNet to the external program. The file has the same format as the file driver.log.

See Section 4.1.3 for a description of interface messages sent from the external program to QualNet and their associated parameters.

For an example of the file responses.log, see Section A.3.3.3.4.

4.4.5 File stats.log

The file stats.log provides snapshots of the Socket Interface by recording performance statistics at fixed time intervals. The time interval is determined by the `SOCKET-INTERFACE-STATS-PRINT-INTERVAL` parameter in the QualNet configuration file (see Section 4.3).

Each line in the stats.log file prints one or more statistics and starts with a time-stamp (enclosed in square brackets).

For a description of the format and an example of the file stats.log, see Section A.3.3.3.5.

A Utility Programs

This appendix describes two utility programs that are part of the Standard Interfaces Model Library: Synchronizer and testfed.

A.1 Synchronizer

For QualNet to provide communication effects to another simulator in an HLA federation, it should simulate a scenario that has sufficient detail to simulate the protocol stack and communication capabilities of all communicating entities in the scenario simulated by the other simulator. Synchronizer is a simple, easy-to-use tool that takes a scenario created in another simulator in an HLA federation as input and creates an equivalent QualNet scenario.

Limitations

Synchronizer only supports HLA version 1.3. It does not support IEEE 1516.

A.1.1 Compiling Synchronizer

This section describes how to compile Synchronizer on Windows and Linux.

Note: Compiling Synchronizer requires the environment variables to be set as described in Section 2.1.3.

A.1.1.1 Compiling Synchronizer on Windows

To compile Synchronizer on Windows, perform the following steps:

1. Open a command window and change the directory to QUALNET_HOME\interfaces\hla\rprsynch.
2. Use the following commands to compile Synchronizer:

```
nmake -f Makefile-windows clean
nmake -f Makefile-windows
```

   This produces the executable file rprsynch.exe in the directory QUALNET_HOME\bin.

A.1.1.2 Compiling Synchronizer on Linux

To compile Synchronizer on Linux, perform the following steps:

1. Open a command window and change the directory to QUALNET_HOME\interfaces\hla\rprsynch.
2. Use the following commands to compile Synchronizer:

   ```
   make -f Makefile-unix clean
   make -f Makefile-unix
   ```

   This produces the executable file rprsynch in the directory QUALNET_HOME\bin.

A.1.2 Installing RTI

In order to extract HLA-based scenarios, an RTI must be installed. Synchronizer supports makRti3.3.1. Other RTIs that support the DLC standard and are link compatible with makRti should also work. Go to the following URL for information on makRti:

http://www.mak.com/products/rti.php

A.1.3 Settings Files and Extraction Rules

Synchronizer assists users in creating an QualNet scenario from a scenario in another federate. In this appendix, VR-Forces (http://www.mak.com/products/vrforces.php) is used as an example of the other federate in the HLA federation to show how Synchronizer creates an equivalent, compatible QualNet scenario from a third party simulator scenario. However, Synchronizer can work with any other simulator supporting HLA federation.

This sections describes the settings files and extraction rules used by Synchronizer.

A.1.3.1 Synchronizer Settings Files

Synchronizer uses two types of settings files to create an QualNet scenario from a VR-Forces scenario:

- **System Parameter Files:** These files (which have the extension ".hla") contain the general simulation configuration parameters.
- **Router Model Files:** These files (which have the extension ".router-models") contain definitions of pre-configured QualNet models for several types of network devices. Parameters specifying the hardware and software capabilities of the network device are associated with each router model.

Synchronizer uses settings files from the gui\devices subdirectory of the QualNet installation directory.

Note: Users can modify the settings files to customize the QualNet scenario generated by Synchronizer.

A.1.3.2 Extraction Rules

The QualNet scenario created by Synchronizer from a VR-Forces scenario has sufficient detail to simulate mobility and communication between entities in the VR-Forces scenario. For each entity in the VR-Forces scenario that has communication capabilities, Synchronizer creates a node in the QualNet scenario. Section A.1.3.2.1 describes how the properties of nodes in the QualNet scenario are configured and describes the rules for defining the topology in the QualNet scenario.

A.1.3.2.1 Configuring Nodes

HLA Entities are defined by an HLA Federation Object Model (FOM). Synchronizer requires an HLA (FOM that is based on or derived from version 1 of the Real-time Platform Reference (RPR-FOM.) The RPR FOM defines a number of classes. HLA objects of type BaseEntity.PhysicalEntity (Entities) get mapped to QualNet nodes while HLA objects of type EmbeddedSystem.RadioTransmitter (Radios) get mapped to QualNet interfaces. Synchronizer ignores Entities that do not have radios and radios that do not have Entities. Each radio has a type, which is defined using the six-field DIS/HLA Radio Entity Type Record. This type is used as an index to determine the network parameters QualNet will use to model the radio.

In a router model, the `HLA-RADIO-SYTEM-TYPE` parameter is used to determine which HLA radio types map to that router model. A value of -1 for the Radio Entity Type Record field acts as a wild card and matches any value.

For example, the HIGH-POWER-802.11b router model uses the default radio type for VR-Forces, 7.1.225.2.1.20, to assign 802.11b parameters to that radio type.

```
ROUTER-MODE                      HIGH-POWER-802.11b
HLA-RADIO-SYSTEM-TYPE            7.1.225.2.1.20
PHY-MODEL                        PHY802.11b
PHY-RX-MODEL                     PHY802.11b
PHY802.11-AUTO-RATE-FALLBACK     NO
```

A.1.3.2.2 Defining Topology

Synchronizer tries to create a reasonable network topology and assigns nodes to subnets based on the following rules:

- Entities with different Force IDs are placed in different subnets.
- Entities with incompatible MAC or network protocols are placed in different subnets.
- Aggregate Entities are mapped to QualNet hierarchies.
- Entities in different hierarchies are placed in different subnets.
- Entities that are not explicitly members of an Aggregate Entity are placed in the root hierarchy.
- If a VR-Forces Entity has multiple radios, the corresponding QualNet node has multiple interfaces and is used as a gateway.
  - If the radios are of different types, each interface of the QualNet node is assigned to a subnet in the node's hierarchy with matching Force ID, MAC, and network protocols.
  - If the radios are of the same type, one interface of the QualNet node is assigned to a subnet in its hierarchy with matching Force ID, MAC, and network protocols. All other interfaces are assigned to matching subnets in other hierarchies.

A.1.4 Using Synchronizer

This section describes how to use Synchronizer to create a QualNet scenario from a VR-Forces scenario from the command line interface and using the QualNet GUI.

A.1.4.1 Synchronizer Command Line Interface

The command line interface of Synchronizer can be used to create an QualNet scenario from a VR-Forces scenario. It can be particularly useful for batch file processing.

Note: The name, icon, and subnet assignments of nodes can not be changed directly when the command line interface is used. The users can edit the generated scenario configuration (.config) file to change these assignments.

To create an QualNet scenario from a VR-Forces scenario, do the following:

1. Load the VR-Forces scenario in VR Forces.
2. Open a command window, navigate to the QUALNET_HOME\bin subdirectory and type the following command:

```
rprsynch.exe  [-f <federation-name>] [-F <FED-file> [-d]
              [-N <node ID>] [-r] [-s <network-number>]
              [-t <timeout>] <scenario-name>
```

Note: All parameters must be entered on one line.

These parameters are explained in Table A-1.

TABLE A-1. Command Line Parameters

Parameter	Description
`-f <federation-name>` *Optional parameter*	Federation name specification. `<federation-name>` is the name of the federation name to join. The default value is RPR-FOM
`-F <FED-file>` *Optional parameter*	FED file specification. `<FED-file>` is the name of the FED file to use. The default value is RPR-FOM.fed.
`-d` *Optional parameter*	Option to run the program in debug mode.
`-N <node-ID>` *Optional parameter*	Initial node ID specification. `<node-ID>` is the initial node ID. The default value is 1.
`-r` *Optional parameter*	Indication to use RPR FOM 0.5. If this parameter is not used, RPR FOM 1.0 is used by default.
`-s <network-number>` *Optional parameter*	Specification of class A network number for new networks. `<network-number>` is the network number to use. The default value is 60.1.0.0.
`-t <timeout>` *Optional parameter*	Timeout specification. `<timeout>` is the number of seconds since the last entity is discovered before the program exits. The default value is 5.
`<scenario-name>` *Required parameter*	Scenario specification. `<scenario-name>` is the name of the scenario file.

Generated Files

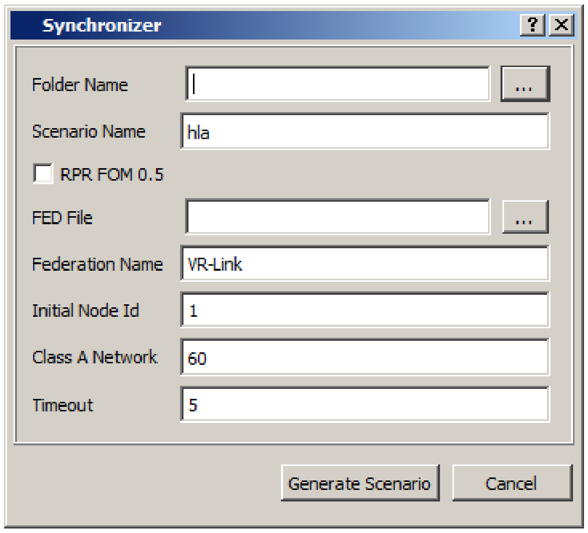
The following QualNet scenario files are created (any existing files are overwritten):

- HLA Entities File (<scenario-name>.hla-entities)
- HLA Radios File (<scenario-name>.hla-radios)
- HLA Networks File (<scenario-name>.hla-networks)
- Scenario Configuration File (<scenario-name>.config)
- Node Placement File (<scenario-name>.nodes)
- Applications File (<scenario-name>.app). This file is created only if it does not already exist.

A.1.4.2 Using Synchronizer from QualNet GUI

To create an QualNet scenario from a VR-Forces scenario using the QualNet GUI interface, do the following:

1. Load the VR-Forces scenario in VR Forces.
2. In QualNet GUI, go to **Tools > Synchronizer** to launch the Synchronizer GUI interface.



Folder Name	
Scenario Name	hla
RPR FOM 0.5	☐
FED File	
Federation Name	VR-Link
Initial Node Id	1
Class A Network	60
Timeout	5

FIGURE A-1. Synchronizer GUI Interface

3. In the **Folder Name** field, enter the name or browse to the folder where the generated scenario is to be created.
4. In the **Scenario Name** field, enter the name to be given to the generated scenario.
5. To use RPR FOM 0.5, check the **RPR FOM 0.5** box. (If this box is unchecked, RPR FOM 1.0 will be used.)
6. In the **FED File** field, enter the name or browse to the FED file to use.
7. Enter the name of the federation to join in the **Federation Name** field.
8. Enter the ID of the initial node in the **Initial Node Id** field.
9. Enter the class A network number for new networks in the **Class A Network** field.
10. In the Timeout field, enter the number of seconds since the last entity is discovered before the program exits.

11. Click the **Generate Scenario** button.

See Section A.1.4.1 for the files that are generated.

A.2 testfed

testfed (test federate) is a command-line based program included in the QualNet distribution which is primarily used to test the QualNet HLA interface without the overhead of running a full constructive simulation tool.

testfed federates directly with QualNet and takes the place of any RPR-FOM 0.5 or 1.0 compliant constructive simulation tool. testfed creates entities and radios based on input files, and can also request and receive results for communications effects from QualNet. testfed assigns attributes indicating locations, orientations, EntityType attributes, RadioSystemType attributes, and so on, based on the input files. Input files for testfed are the same as the files associated with a QualNet scenario (scenario configuration (.config) file, application configuration (.app) file, node position (.nodes) file, etc.)

A.2.1 Compiling testfed

This section describes how to compile testfed on Windows and Linux.

Note: Compiling testfed requires the environment variables to be set as described in Section 2.1.3.

A.2.1.1 Compiling testfed on Windows

To compile testfed on Windows, perform the following steps:

1. Open a command window and change the directory to QUALNET_HOME\interfaces\hla\testfed.
2. Use the following commands to compile testfed:

```
nmake -f Makefile-windows clean
nmake -f Makefile-windows
```

This produces the executable file testfed.exe in the directory QUALNET_HOME\bin.

A.2.1.2 Compiling testfed on Linux

To compile testfed on Linux, perform the following steps:

1. Open a command window and change the directory to QUALNET_HOME\interfaces\hla\testfed.
2. Use the following commands to compile testfed:

```
make -f Makefile-unix clean
make -f Makefile-unix
```

This produces the executable file testfed in the directory QUALNET_HOME\bin.

A.2.2 Creating Scenarios for testfed

testfed uses the same scenario files as QualNet. Refer to *QualNet User's Guide* for details of configuring scenarios in QualNet. In addition, the parameters described in Section 2.2.2 also need to be configured.

A.2.3 Running RTI

Depending on the RTI installed on your system, the RTI may not be explicitly started before running testfed. Some light-weight RTIs do not need to be started explicitly. Refer to the RTI documentation for details.

A.2.4 Running testfed

To run testfed with QualNet, perform the following steps:

1. Open a command window and change the directory to the location where the scenario is located.
2. Type the following command to run testfed:

```
testfed [-d] [-f <federation-name>] [-F <FED-file>] [-r] <input-file>
```

   These parameters are described in Table A-2.

TABLE A-2. testfed Parameters

Parameter	Description
`-d` *Optional parameter*	Turn on debugging mode.
`-f <federation-name>` *Optional parameter*	Set the federation name to `<federation-name>`. If this parameter is not specified, the default federation name is `RPR-FOM`.
`-F <FED-file>` *Optional parameter*	Set the FED file name to `<FED-file>`. If this parameter is not specified, the default federation name is `RPR-FOM.fed`.
`-r` *Optional parameter*	Use RPR FOM 0.5. If this parameter is not specified, RPR FOM 1.0 is used by default.
`<input-file>` *Required parameter*	Name of the scenario configuration file (without the extension `.config`).

3. Start the simulation in QualNet either from the command line or using the GUI. Use the same scenario files as for testfed. Refer to *QualNet User’s Guide* for details of running simulations.

   Note: If the QualNet simulation is run from the command line, then it must be run from a command window different from the one in which testfed is run.

4. You can use the testfed commands described in Section A.2.5 to interact with the QualNet simulation. These commands should be entered in the testfed window.

A.2.5 testfed Commands

This section describes the commands that can be used in testfed to interact with the QualNet simulation.

- List command

  The following command lists the available commands:

  `?` or **`h`**

- Register objects

  The following command registers all objects:

  ```
  r
  ```

- Move entity

  The following command moves the entity that hosts the radio:

  ```
  m <node-ID> <lat> <lon> <alt>
  ```

  where

`<node-ID>`	Node ID.
`<lat>`	Latitude (in degrees) of the new position.
`<lon>`	Longitude (in degrees) of the new position.
`<alt>`	Altitude (in meters) of the new position.

- Change entity orientation

  The following command changes the orientation of all radios hosted by the entity:

  ```
  o <node-ID> <psi> <theta> <phi>
  ```

  where

`<node-ID>`	Node ID.
`<psi>`, `<theta>`, `<phi>`	Euler angles (in degrees) of the new orientation in the world coordinate system.

- Change entity velocity

  The following command changes the velocity of the entity that hosts the radio:

```
v <node-ID> <x-velocity> <y-velocity> <z-velocity>
```

where

`<node-ID>`	Node ID.
`<x-velocity>`	New velocity (in meters/sec) along the X-axis of the world coordinate system.
`<y-velocity>`	New velocity (in meters/sec) along the Y-axis of the world coordinate system.
`<z-velocity>`	New velocity (in meters/sec) along the Z-axis of the world coordinate system.

- Send communication effects request

  The following command sends a communication effects request to QualNet:

```
s <source-ID> [[V]<message-size>] [<timeout-delay>] [<destination-ID>]
```

where

`<source-ID>`	Node ID of the source node.
`<message-size>`	Message size (in bytes). This parameter is optional. If it is not specified, the default message size is 100 bytes. If the message size is preceded by the flag `V`, it indicates voice traffic.
`<timeout-delay>`	Timeout delay (in seconds). The timeout delay is the maximum time QualNet will use to determine if the message was successfully delivered. If the communication is successful, QualNet sends a Process Message interaction indicating that the message was delivered to the destination. If there are multiple recipients, each successful delivery will generate a Process Message interaction. Whether or not the communication is successful, QualNet sends a Timeout interaction summarizing the delivery status. This occurs when the processing of a message is complete: either after the timeout value or after all potential recipients have processed the signal, whichever occurs first This parameter is optional. If it is not specified, the default timeout delay is 10 seconds.
`<destination-ID>`	Node ID of the destination node. This parameter is optional. If it is not specified, the packet is sent to the default address for the network, as defined in the Networks file (see Section 2.2.2.1.3).

- Change entity damage state

  The following command changes the damage state of the entity:

```
d <node-ID> <damage-state>
```

where

`<node-ID>`	Node ID.
`<damage-state>`	Damage state (`0`, `1`, `2`, or `3`).

`0`	Not damaged
`1`	Slightly damaged: A 25% chance of up to 75% reduction in transmission power
`2`	Severely damaged: A 75% chance of up to 75% reduction in transmission power
`3`	Destroyed

- Change radio transmitter status

  The following command changes the transmitter status of the radio:

```
t <node-ID> <transmitter-state>
```

where

`<node-ID>`	Node ID.
`<transmitter-state>`	Transmitter state (`0`, `1`, or `2`).

`0`	Off
`1`	On but not transmitting
`2`	On and transmitting

- Exit program

  The following command ends the testfed session:

```
q
```

A.3 MTS Emulator

To test the functionality of the Socket Interface, a program called MTS was developed at Scalable Network Technologies. MTS is a fast and light-weight stand-alone program whose only purpose is to send messages to the QualNet and to receive responses over the Socket Interface. This section describes the details of the MTS program.

The QualNet Socket and MTS program interact through a TCP/IP socket. The default port is 5033, but the port can be changed in the QualNet configuration file by means of the `SOCKET-INTERFACE-PORT` parameter (see Section 4.3). The configuration files for QualNet and MTS determine their behavior and the messages exchanged between them.

This section is organized as follows:

- Section A.3.1 describes the commands that can be included in the MTS configuration file.
- Section A.3.2 describes the steps to run QualNet with MTS.
- Section A.3.3 describes a sample scenario and the input and output files for that scenario.

A.3.1 MTS Configuration File

The MTS configuration file determines the actions of MTS, such as times of node creation, mobility of nodes, when communications occur, and when to advance time. The MTS configuration file is similar in style to the QualNet scenario configuration file in that:

- Commands may be put in the file in any order.
- Each command is on one line.
- Lines may be commented with the '#' character.
- Each command consists of a command name followed by a list of required parameters and a list (possibly empty) of optional parameters. The required parameters must appear in the order specified. Optional parameters can appear in any order after the required parameters.

Note: Due to the limitation of the page width in this document, some commands are shown to span several lines. However, in the configuration files, there should not be any line breaks in the middle of a command.

The MTS commands and their associated parameters are listed below.

- **TimeManagementMode**: This command specifies the execution mode of MTS. The execution mode can be real time mode, time managed mode, or time managed fast mode.
  - In real time mode, MTS and QualNet run at wall-clock speed.
  - In time managed mode, MTS runs at a specified speed. The speed is specified as a multiple of wall-clock speed.
  - In time managed fast mode, MTS runs as fast as possible with the specified look-ahead interval.

  The syntax of the TimeManagementMode command is:

  ```
  TimeManagementMode <mode>
  ```

  The parameter is described in Table A-3.

Note: If more than one TimeManagementMode command is included in the MTS configuration file, the last TimeManagementMode command in the file determines the execution mode

TABLE A-3. Parameters of TimeManagementMode Command

Command Parameter	Options	Description
`<mode>` *Required*	 • `RealTime` • `TimeManaged [<speed>]` • `TimeMangedFast [<interval>]`	Execution mode of QualNet and MTS. If the value is `RealTime`, MTS runs in real time mode. If the value is `TimeManaged [<speed>]`, MTS runs in time managed mode at `<speed>` times wall-clock speed. `<speed>` is specified as a real number. If `<speed>` is not specified, the default speed-up factor is 2.0. If the value is `TimeManagedFast [<interval>]`, MTS runs in time managed fast mode with a look-ahead interval of `<interval>` seconds. `<interval>` is specified as a real number. If `<interval>` is not specified, the default look-ahead interval is 1.0 second.

Examples of the TimeManagementMode command are:

```
TimeManagementMode RealTime
TimeManagementMode TimeManaged 3.0
TimeManagementMode TimeManagedFast 2.0
```

- **Address**: This command specifies the IP address to which MTS is to connect.

  The syntax of the Address command is:

```
Address <address>
```

The parameter is described in Table A-4. If this command not included in the MTS configuration file, the default IP address to connect to is 127.0.0.1.

TABLE A-4. Parameters of Address Command

Command Parameter	Type/Options	Description
`<address>` *Required*	IP Address	The IP address to which MTS is to connect.

- **Port**: This command specifies the port number to which MTS is to connect.

  The syntax of the Port command is:

  ```
  Port <port>
  ```

  The parameter is described in Table A-5. If this command not included in the MTS configuration file, the default port to connect to is 5033.

TABLE A-5. Parameters of Port Command

Command Parameter	Type/Options	Description
`<port>` *Required*	Integer	The port number to which MTS is to connect.

- **PrintTimeAdvance**: This command causes MTS to print time advance information when running in time managed and time managed fast modes (see Table A-3).

  The syntax of the PrintTimeAdvance command is:

  ```
  PrintTimeAdvance
  ```

  This command does not have any parameters.

- **InitializeSimulation**: This command begins a QualNet simulation. QualNet does not begin the simulation until the InitializeSimulation command is received. This message is required for both time managed and real time modes.

  The syntax of the InitializeSimulation command is:

  ```
  InitializeSimulation [COORDINATESYSTEM <value>]
                       [SCENARIO <scenariostring>]
  ```

  The parameters are described in Table A-6.

TABLE A-6. Parameters of InitializeSimulation Command

Command Parameter	Type/Options	Description
`COORDINATESYSTEM <value>` *Optional*	• `Cartesian` • `LatLonAlt` • `GCCCartesian`	String indicating the coordinate system to be used. If this parameter is not specified, the Cartesian system is used by default.
`SCENARIO <scenariostring>` *Optional*	LongString	Description of the scenario.

Note: The value of the parameter `COORDINATE-SYSTEM` in the QualNet configuration file should be the same as the value of the parameter `COORDINATESYSTEM` of the InitializeSimulation command. If the values are different, an error message will be sent back to the external program and QualNet will not be initialized.

- **TestWarmup**: This command causes MTS to test the QualNet Warm-up phase (see Section 4.2.3). If TestWarmup is enabled, MTS will send all messages that are scheduled for 0 seconds to QualNet. `CreatePlatform` messages that will be active during the Warm-up phase should be scheduled for 0 seconds. Then it will send a `BeginWarmup` message and wait for QualNet to enter the Initialized state. Additionally, it will send several `CommEffectsRequest` messages.

  The syntax of the TestWarmup command is:

  ```
  TestWarmup
  ```

  This command does not have any parameters.

- **CreatePlatform**: This command causes a `CreatePlatform` message to be sent once, or repeatedly after a fixed interval. The `CreatePlatform` message creates an entity at the specified location.

  The syntax of the CreatePlatform command is:

  ```
  CreatePlatform <entityID> <time> [X <x-value>] [Y <y-value>]
                 [Z <z-value>] [VELX <x-value>] [VELY <y-value>]
                 [VELZ <z-value>] [DAMAGESTATE <state>]
                 [TYPE <platformtype>] [MULTICASTGROUPS <group>]
  ```

  or

  ```
  CreatePlatform <entityID> <time> [LAT <lat-value>] [LON <lon-value>]
                 [ALT <alt-value>] [VELLAT <lat-value>]
                 [VELLON <lon-value>] [VELALT <alt-value>]
                 [DAMAGESTATE <state>] [TYPE <platformtype>]
                 [MULTICASTGROUPS <group>]
  ```

  The parameters are described in Table A-7.

TABLE A-7. Parameters of CreatePlatform Command

Command Parameter	Type/Options	Description
`<entityID>` *Required*	String	Identifier of the entity to be created.
`<time>` Required	Real	Time (in seconds) when to send the first `CreatePlatform` message.
`X <x-value>` *Optional*	Real	x-coordinate (in meters) of the entity. If the Cartesian coordinate system is used and this parameter is not specified, the x-coordinate is 0.
`Y <y-value>` *Optional*	Real	y-coordinate (in meters) of the entity. If the Cartesian coordinate system is used and this parameter is not specified, the y-coordinate is 0.
`Z <z-value>` *Optional*	Real	z-coordinate (in meters) of the entity. If the Cartesian coordinate system is used and this parameter is not specified, the z-coordinate is 0.
`LAT <lat-value>` *Optional*	Real	Latitude (in degrees). If the Lat/Lon/Alt system is used and this parameter is not specified, the latitude is 0.

TABLE A-7. Parameters of CreatePlatform Command (Continued)

Command Parameter	Type/Options	Description
`LON <lon-value>` *Optional*	Real	Longitude (in degrees). If the Lat/Lon/Alt system is used and this parameter is not specified, the longitude is 0.
`ALT <alt-value>` *Optional*	Real	Altitude (in meters). If the Lat/Lon/Alt system is used and this parameter is not specified, the altitude is 0.
`VELX <x-value>` *Optional*	Real	Velocity (in meters/sec) of the entity in the X direction.
`VELY <y-value>` *Optional*	Real	Velocity (in meters/sec) of the entity in the Y direction.
`VELZ <z-value>` *Optional*	Real	Velocity (in meters/sec) of the entity in the Z direction.
`VELLAT <lat-value>` *Optional*	Real	Velocity (in degrees/sec) of the entity along the latitude.
`VELLON <lon-value>` *Optional*	Real	Velocity (in degrees/sec) of the entity along the longitude.
`VELALT <alt-value>` *Optional*	Real	Velocity (in meters/sec) of the entity along the altitude.
`DAMAGESTATE <state>` *Optional*	• `0` • `1`	Bitwise kill state. 0: Communications are not damaged 1: Communications are damaged
`TYPE <platformtype>` *Optional*	• `0` • `1`	Platform Type. 0: Ground node 1: Air node If this parameter is not specified, the node is a ground node.
MULTICASTGROUPS <group> *Optional*	ListofGroups	A list of multicast groups that this platform will join.

- **CommEffectsRequest**: This command causes a `CommEffectsRequest` message to be sent once or repeatedly after a fixed interval.

  The syntax of the CommEffectsRequest command is:

```
CommEffectsRequest <src> <dst> <time> [INTERVAL <interval>]
                   [ID1 <value>] [ID2 <value>] [<transport-protocol>]
                   [SIZE <size>] [DESCRIPTION <desc>]
                   [FAILURETIMEOUT <timeout>]
                   [PRECEDENCE <precedence>] [DSCP <value>] [TOS <tos>]
                             [TTL <ttl>] [END-TIME <end-time>]
```

Note: A CommEffectsRequest command can include at most one of the three parameters: `PRECEDENCE`, `DSCP`, and `TOS`.

The parameters are described in Table A-8.

TABLE A-8. Parameters of CommEffectsRequest Command

Command Parameter	Type/Options	Description
`<src>` *Required*	String	Identifier of the source entity.
`<dst>` *Required*	String	Identifier of the destination entity.
`<time>` *Required*	Real	Time (in seconds) when to send the first `CommEffectsRequest` message.
`INTERVAL <interval>` *Optional*	Real	Time to wait (in seconds) before resending the `CommEffectsRequest` message. If this parameter is not specified, the `CommEffectsRequest` message is sent only once.
`ID1 <value>` *Optional*	Integer	First 8 bits of the message identification field. If this parameter is not specified, the `ID1` is set to 0.
`ID2 <value>` *Optional*	Integer	Second 8 bits of the message identification field. If this parameter is not specified, the `ID2` is set to 0.
`<transport-protocol>` *Optional*	• `TCP` • `UDP`	Transport protocol to use (TCP or UDP). If this parameter is not specified, the UDP protocol is used.
`SIZE <size>` *Optional*	Integer	Message size (in bytes). If this parameter is not specified, the default size is 128 bytes.
`DESCRIPTION <desc>` *Optional*	String	Description of the `CommEffectsRequest` message. This is not used by QualNet but is included to let MTS provide a description for each `CommEffectsRequest` message.
`FAILURETIMEOUT <timeout>` *Optional*	Real	Message failure timeout value (in seconds). If this parameter is not specified, then the timeout value specified in the configuration file (`SOCKET-INTERFACE-UDP-FAILURE-TIMEOUT` or `SOCKET-INTERFACE-TCP-FAILURE-TIMEOUT`) is used.

TABLE A-8. Parameters of CommEffectsRequest Command (Continued)

Command Parameter	Type/Options	Description

`PRECEDENCE <precedence>`
 	
Optional
	String	Message precedence.
		The following values can be used to indicate the precedence level:
		`ROUTINE`
		`PRIORITY`
		`IMMEDIATE`
		`FLASH`
		`FLASHOVERRIDE`
		`CRITICAL`
		`INTERNETCONTROL`
		`NETCONTROL`

`DSCP <value>` *Optional*	Integer	Request DSCP. The valid range for this field is 0-63. The bits indicate the following: 0-2: Precedence 3: Low Delay 4: High Throughput 5: High Reliability For example, if the `DSCP` field is set to 10 (001010 in binary), then the message is given a precedence value of 1 with High Throughput.
`TOS <tos>` *Optional*	Integer	Request TOS. The valid range for this field is 0-255 (i.e., all 8 bits can be used). This value replaces the entire TOS byte in the IP header.
`TTL <ttl>` Optional	Real	Time-To-Live (TTL) field for communications (in seconds). This is valid for TCP and UDP communications. For TCP communications, the first TCP packet sent from the source to the destination should specify the TTL that should be used for all subsequent packets from the source to the destination.
`END-TIME <end-time>` Optional	Real	Time to stop sending the `CommEffectsRequest` message (in seconds). If this parameter is not specified, the `CommEffectsRequest` message is sent continually until the end of the simulation.

- **PrintSendMessage**: This command causes MTS to print information about `CommEfectsRequest` and `AdvanceSimulationTime` messages, in addition to the responses.

  The syntax of the PrintSendMessage command is:

  ```
  PrintSendMessage
  ```

  This command does not have any parameters.

- **UpdatePlatform**: This command causes an `UpdatePlatform` message to be sent once or repeatedly after a fixed interval. The `UpdatePlatform` message updates the position of an entity to the specified coordinates.

  The syntax of the UpdatePlatform command is:

  ```
  UpdatePlatform <entityID> <time> [X <x-value>] [Y <y-value>]
                 [Z <z-value>] [VELX <x-value>] [VELY <y-value>]
                 [VELZ <z-value>] [DAMAGESTATE <state>]
                 [JOINMULTICASTGROUPS <join-group>]
                 [LEAVEMULTICASTGROUP <leave-group>]
  ```

  or

  ```
  UpdatePlatform <entityID> <time> [LAT <lat-value>] [LON <lon-value>]
                 [ALT <alt-value>] [VELLAT <lat-value>]
                 [VELLON <lon-value>] [VELALT <alt-value>]
                 [DAMAGESTATE <state>]
                 [JOINMULTICASTGROUPS <join-group>]
                 [LEAVEMULTICASTGROUP <leave-group>]
  ```

Note: If the GCC-Cartesian coordinate system is used, then the `X`, `Y`, and `Z` values must be specified for position update. If these values are not specified, position update will not be sent to QualNet.

If the Cartesian coordinate system is used, then the `X` and `Y` values must be specified for position update. If these values are not specified, position update will not be sent to QualNet.

If the Lat/Lon/Alt coordinate system is used, then the `LAT` and `LON` values must be specified for position update. If these values are not specified, position update will not be sent to QualNet.

The parameters are described in Table A-9.

TABLE A-9. Parameters of UpdatePlatform Command

Command Parameter	Type/Options	Description
`<entityID>` *Required*	String	Identifier of the entity to be updated.
`<time>` *Required*	Real	Time (in seconds) when to send the first `UpdatePlatformState` message.
`X <x-value>` *Optional*	Real	New x-coordinate (in meters) of the entity. If the Cartesian coordinate system is used and this parameter is not specified, the x-coordinate is not updated.

TABLE A-9. Parameters of UpdatePlatform Command (Continued)

Command Parameter	Type/Options	Description
`Y <y-value>` *Optional*	Real	New y-coordinate (in meters) of the entity. If the Cartesian coordinate system is used and this parameter is not specified, the y-coordinate is not updated.
`Z <z-value>` *Optional*	Real	New z-coordinate (in meters) of the entity. If the Cartesian coordinate system is used and this parameter is not specified, the z-coordinate is not updated.
`LAT <lat-value>` Optional	Real	New latitude (in degrees). If the Lat/Lon/Alt system is used and this parameter is not specified, the latitude is not updated.
`LON <lon-value>` *Optional*	Real	New longitude (in degrees). If the Lat/Lon/Alt system is used and this parameter is not specified, the longitude is not updated.
`ALT <alt-value>` *Optional*	Real	New altitude (in meters). If the Lat/Lon/Alt system is used and this parameter is not specified, the altitude is not updated.
`VELX <x-value>` *Optional*	Real	Velocity (in meters/sec) of the entity in the X direction.
`VELY <y-value>` *Optional*	Real	Velocity (in meters/sec) of the entity in the Y direction.
`VELZ <z-value>` *Optional*	Real	Velocity (in meters/sec) of the entity in the Z direction.
`VELLAT <lat-value>` *Optional*	Real	Velocity (in degrees/sec) of the entity along the latitude.
`VELLON <lon-value>` *Optional*	Real	Velocity (in degrees/sec) of the entity along the longitude.
`VELALT <alt-value>` *Optional*	Real	Velocity (in meters/sec) of the entity along the altitude.
`DAMAGESTATE <state>` *Optional*	• `0` • `1`	Bitwise kill state. 0: Communications are not damaged 1: Communications are damaged
`JOINMULTICASTGROUPS <join-group>` *Optional*	ListofGroups	A list of multicast groups to join.
`LEAVEMULTICASTGROUPS <leave-group>` *Optional*	ListofGroups	A list of multicast groups to leave.

- **TimeStamp:** This command enables the use of timestamps in a scenario.

  The syntax of the command is:

  ```
  TimeStamp YES | NO
  ```

  If the argument is `YES`, then timestamps are enabled; otherwise, timestamps are not enabled. If this command is not included in the MTS configuration file, default values are used. By default, timestamps are enabled for time managed mode and are not enabled for real time mode.

- **PauseSimulation:** This command causes a `PauseSimulation` message to be sent at the specified time. This results in QualNet moving to the Paused state from the Initialized state or Executing state.

  The syntax of the PauseSimulation command is:

  ```
  PauseSimulation [<time>] [DURATION <duration>]
  ```

  The parameters are described in Table A-10.

TABLE A-10. Parameters of PauseSimulation Command

Command Parameter	Type/Options	Description
`<time>` *Optional*	Real	Time (in seconds) to send the `PauseSimulation` message. If this parameter is not specified, the default value is 0.0.
`DURATION <duration>` *Optional*	Real	Duration (in seconds) of the pause. If this parameter is not specified, the default value is 0.0.

- **StopSimulation:** This command causes a `StopSimulation` message to be sent at the specified time. This results in gracefully ending the QualNet simulation.

  The syntax of the StopSimulation command is:

  ```
  StopSimulation [<time>]
  ```

  The parameters are described in Table A-11.

TABLE A-11. Parameters of StopSimulation Command

Command Parameter	Type/Options	Description
`<time>` *Optional*	Real	Time (in seconds) to send the `StopSimulation` message. If this parameter is not specified, the default value is 0.0.

- **ResetSimulation:** This command causes a `ResetSimulation` message to be sent at the specified time. This results in QualNet internal data structures being cleaned and QualNet returning to the standby state.

  This gracefully ends the QualNet simulation like the StopSimulation command, however, in addition, the QualNet socket connections are closed and statistics are output to the statistics log file.

  The syntax of the ResetSimulation command is:

  ```
  ResetSimulation [<time>]
  ```

  The parameters are described in Table A-12.

TABLE A-12. Parameters of ResetSimulation Command

Command Parameter	Type/Options	Description
`<time>` *Optional*	Real	Time (in seconds) to send the `ResetSimulation` message. If this parameter is not specified, the default value is 0.0.

- **Read:** This dynamic command causes a `Read` message to be sent at the specified time. This allows scenario parameters to be queried during simulation.

  The syntax of the Read command is:

  ```
  Read [<time>] [PATH <path>]
  ```

  The parameters are described in Table A-13.

TABLE A-13. Parameters of Read Command

Command Parameter	Type/Options	Description
`<time>` *Optional*	Real	Time (in seconds) to send the `Read` message. If this parameter is not specified, the default value is 0.0.
`PATH <path>` *Optional*	String	Path of the dynamic object in the dynamic hierarchy to perform the operation on.

- **Write:** This dynamic command causes a `Write` message to be sent at the specified time. This allows scenario parameters to be modified during simulation.

  The syntax of the Write command is:

  ```
  Write [<time>] [PATH <path>] [ARGS <arguments>]
  ```

  The parameters are described in Table A-14.

TABLE A-14. Parameters of Write Command

Command Parameter	Type/Options	Description
`<time>` *Optional*	Real	Time (in seconds) to send the `Write` message. If this parameter is not specified, the default value is 0.0.
`PATH <path>` *Optional*	String	Path of the dynamic object in the dynamic hierarchy to perform the operation on.
`ARGS <arguments>` *Optional*	String	Arguments to write to the dynamic object.

- **Execute:** This dynamic command causes an `Execute` message to be sent at the specified time. This allows scenario parameters to be modified during simulation.

  The syntax of the Execute command is:

  ```
  Execute [<time>] [PATH <path>] [ARGS <arguments>]
  ```

  The parameters are described in Table A-15.

TABLE A-15. Parameters of Execute Command

Command Parameter	Type/Options	Description
`<time>` *Required*	Real	Time (in seconds) to send the `Execute` message. If this parameter is not specified, the default value is 0.0.
`PATH <path>` *Optional*	String	Path of the dynamic object in the dynamic hierarchy to perform the operation on.
`ARGS <arguments>` *Optional*	String	Arguments to write to the dynamic object.

- **GetRequest:** This SNMP command causes a `GetRequest` message to be sent at the specified time. This allows scenario parameters to be queried during simulation.

  The syntax of the GetRequest command is:

  ```
  GetRequest <entity-id> [<time>] [OID <oid>]
  ```

  The parameters are described in Table A-16.

TABLE A-16. Parameters of GetRequest Command

Command Parameter	Type/Options	Description
`<entity-id>` *Required*	String	Identification of the entity on which to perform the operation.
`<time>` *Optional*	Real	Time (in seconds) to send the `GetRequest` message. If this parameter is not specified, the default value is 0.0.
`OID <oid>` *Optional*	ListofString	List of object identifiers on which to perform the operation.

- **GetNextRequest:** This SNMP command causes a `GetNextRequest` message to be sent at the specified time. This allows scenario parameters to be queried during simulation.

  The syntax of the GetNextRequest command is:

  ```
  GetNextRequest <entity-id> [<time>] [OID <oid>]
  ```

  The parameters are described in Table A-17.

TABLE A-17. Parameters of GetNextRequest Command

Command Parameter	Type/Options	Description
`<entity-id>` *Required*	String	Identification of the entity on which to perform the operation.
`<time>` *Optional*	Real	Time (in seconds) to send the `GetRequest` message. If this parameter is not specified, the default value is 0.0.
`OID <oid>` *Optional*	ListofString	List of object identifiers on which to perform the operation.

- **SetRequest:** This SNMP command causes a `SetRequest` message to be sent at the specified time. This allows scenario parameters to be modified during simulation.

  The syntax of the SetRequest command is:

  ```
  SetRequest <entity-id> [<time>] [OID <oid>] [VALUE <value>]
  ```

  The parameters are described in Table A-18.

TABLE A-18. Parameters of SetRequest Command

Command Parameter	Type/Options	Description
`<entity-id>` *Required*	String	Identification of the entity on which to perform the operation.
`<time>` *Optional*	Real	Time (in seconds) to send the `SetRequest` message. If this parameter is not specified, the default value is 0.0.
`OID <oid>` *Optional*	ListofString	List of object identifiers on which to perform the operation.
`VALUE <value>` *Optional*	ListofString	List of new values for MIBS objects on which the operation is performed.

- **GetBulkRequest:** This SNMP command causes a `GetBulkRequest` message to be sent at the specified time. This allows scenario parameters to be queried during simulation.

  The syntax of the GetBulkRequest command is:

  ```
  GetBulkRequest <entity-id> [<time>] [NUMCSCALAR <num-scalar>]
                 [MAXREPEAT <max-repeat>] [OID <oid>]
  ```

  The parameters are described in Table A-19.

TABLE A-19. Parameters of GetBulkRequest Command

Command Parameter	Type/Options	Description
`<entity-id>` *Required*	String	Identification of the entity on which to perform the operation.
`<time>` *Optional*	Real	Time (in seconds) to send the `GetBulkRequest` message. If this parameter is not specified, the default value is 0.0.
`NUMSCALAR <num-scalar>` *Optional*	UInt16	Number of scalar MIBS objects.
`MAXREPEAT <max-repeat>` *Optional*	UInt16	Maximum repetitions of a non-scalar MIBS object.
`OID <oid>` *Optional*	ListofString	List of object identifiers on which to perform the operation.

- **QuerySimulationState:** This command causes a `QuerySimulationState` message to be sent at the specified time. This allows the simulation state to be queried during the simulation.

  The syntax of the QuerySimulationState command is:

  ```
  QuerySimulationState [<time>]
  ```

  The parameters are described in Table A-20.

TABLE A-20. Parameters of QuerySimulationState Command

Command Parameter	Type/Options	Description
`<time>` *Optional*	Real	Time (in seconds) to send the `QuerySimulationState` message. If this parameter is not specified, the default value is 0.0.

A.3.2 Running QualNet and MTS

To run QualNet with MTS using the Socket Interface, perform the following steps:

1. Set up a scenario by editing the QualNet configuration file (see Section 4.3.1) and the MTS configuration file (see Section A.3.1).
2. Open two command windows. In one window, change the directory to the one where the QualNet configuration file is stored. In the other window, change the directory to the one where the MTS configuration file is stored.
3. In the QualNet command window, type the following command:

   For Windows:

   ```
   %QUALNET_HOME%\bin\qualnet <QualNet-config-file>
   ```

   For Linux:

   ```
   $QUALNET_HOME/bin/qualnet <QualNet-config-file>
   ```

   where

`<QualNet-config-file>`	Name of the QualNet configuration file (see Section 4.3.1).

4. In the MTS window, type the following command:

   For Windows:

   ```
   %QUALNET_HOME%\bin\mts-socket <MTS-configuration-file>
   ```

   For Linux:

   ```
   $QUALNET_HOME/bin/mts-socket <MTS-configuration-file>
   ```

   where

`<MTS-configuration-file>`	Name of the MTS configuration file (see Section A.3.1).

A.3.3 Sample Scenario for Running QualNet and MTS

This section describes a sample scenario for running QualNet with MTS using the Socket Interface. Section A.3.3.1 gives a description of the scenario to be simulated. Section A.3.3.2 describes the input files (MTS configuration file, QualNet configuration file, and the entity mapping file) for the scenario. Section A.3.3.3 describes the output (log) files produced for the scenario.

A.3.3.1 Scenario Description

The following is a description of the sample scenario.

1. QualNet can simulate 5.0 seconds ahead of MTS.
2. Three nodes, node A100, node A200, and node A300, are created at time 10. Nodes A100 and A200 are ground nodes with initial position (41.000005, 46.000005). Node A300 is an air node with initial position (41.000005, 46.000005, 5.0).
3. Starting at 150 seconds, node 1 sends 512-byte TCP messages to node 2 every 2 seconds.
4. Starting at 150 seconds, node 2 sends 512-byte TCP messages to node 1 every 2 seconds.
5. Node A200 is damaged at 250 seconds.

A.3.3.2 Input Files

In this section, we describe how to set up the input files to run the scenario described in Section A.3.3.1.

A.3.3.2.1 MTS Configuration File

The MTS configuration file for the sample scenario of Section A.3.3.1 is called mts-config.txt and is shown in Figure A-2. Comments in the file explain how each command corresponds to the scenario.

Notice that two extra commands, which are extraneous to the scenario Section A.3.3.1, are included in the configuration file. These commands are included to illustrate the type of error and response messages generated. The first of these is a command to change a node's position beyond the range and results in ana error message (see Section A.3.3.3.2). The other is a communications request to a damaged node and results in a communications response indicating a failure (see Section A.3.3.3.4).

Note: Commands can be entered in the file in any order.

```
# File name: mts-config.txt

# Tell MTS which IP address to connect to.
Address 127.0.0.1

# Tell MTS which port to connect to.
Port 5032

# Initializes simulation and set the coordinate system.
InitializeSimulation COORDINATESYSTEM LatLonAlt

# Tell QualNet which execution mode to use, and how far ahead
# it can simulate.
TimeManagementMode TimeManagedFast 5.0

# Create A100 (ground node) at location (41.000005, 46.000005, 0.0) at time 10.
CreatePlatform A100 10.0 X 41.00005 Y 46.000005 Z 0.0  TYPE 0

# Create A200 (ground node by default) at location (41.000005, 46.000005, 0.0)
# at time 10.
CreatePlatform A200 10.0 X 41.00005 Y 46.000005 Z 0.0

# Create A300 (air node) at location (41.000005, 46.000005, 5.0) at time 10.
CreatePlatform A300 10.0 X 41.00005 Y 46.000005 Z 5.0 TYPE 1

# Command for node A100 to send 512-byte TCP messages to node A200 every
# 2 seconds, starting at time 150 seconds.
CommEffectsRequest  A100  A200 150.0  INTERVAL 2.0 ID1 1 ID2 0 TCP SIZE 512
DESCRIPTION “HELLO”

# Command for node A200 to send 512-byte TCP messages to node A100 every
# 2 seconds, starting at time 150 seconds.
CommEffectsRequest A200 A100 150.0 INTERVAL 2.0 ID1 1 TCP SIZE 512 DESCRIPTION
“HI”

# Command for node A300 to change its position at time 200 seconds.
# This command will result in an error because the coordinates are out
# of range.
UpdatePlatform A300 200.0 X 100.0 Y 400.0 Z 0.0

# Command to damage node A200 at 250.0 seconds.
UpdatePlatform A200 250.0 DamageState 1

# Command for node A100 to send 512-byte TCP messages to node A200 every
# 2 seconds, starting at time 350 seconds.
# This command will result in a failure because node A200 is damaged.
CommEffectsRequest A100 A200 350.0 INTERVAL 2.0 ID 1 TCP SIZE 512 DESCRIPTION
“BYE”
# Command to end simulation at time 600.
StopSimulation 600.0
```

FIGURE A-2. MTS Configuration File for Sample Scenario

A.3.3.2.2 QualNet Configuration File

To run MTS with QualNet, in addition to the parameters needed for stand-alone QualNet operation, several other parameters need to be specified in the QualNet configuration file. For the sample scenario described in Section A.3.3.1, the additional parameters that need to be specified are shown in Figure A-3. Comments before each parameter describe the purpose of the parameter. It is assumed that the parameter `COORDINATE-SYSTEM` is set to `LANLOTALT` in the QualNet configuration file. This is needed because the coordinates specified in the MTS configuration file in Section A.3.3.2.1 are in the Lat/Lon/Alt format.

```
# Indicate that Socket Interface will be used to communicate with another
# program.
SOCKET-INTERFACE YES

# Wait 15 seconds before sending a CommEffectsResponse FAILURE for
# a UDP message.
SOCKET-INTERFACE-UDP-FAILURE-TIMEOUT 15S

# Wait 90 seconds before sending a CommEffectsResponse FAILURE for a TCP
# message.
SOCKET-INTERFACE-TCP-FAILURE-TIMEOUT 90S

# Print per-packet statistics for each CommEffectsRequest to specified file.
SOCKET-INTERFACE-PRINT-PER-PACKET-STATS ./mts-demo.stats

# Specify the name of the entity mapping file.
SOCKET-INTERFACE-ENTITY-MAPPING-FILE ./mts-demo.entities

# Specify the number of ports Socket Interface should open for connection.
SOCKET-INTERFACE-NUM-PORTS 2

# Specify the ports to listen for the external program connection.
SOCKET-INTERFACE-PORT[0] 5032
SOCKET-INTERFACE-PORT[1] 5033

# Log all output to files.
SOCKET-INTERFACE-LOG FILE

# Base output statistics on simulation time (specify ‘0’ as value).
SOCKET-INTERFACE-STATS-PRINT-REAL-TIME 0

# Set the interval to output statistics to 20 seconds.
SOCKET-INTERFACE-STATS-PRINT-INTERVAL 20

# Base the graph log file on simulation time (specify ‘0’ as value).
SOCKET-INTERFACE-GRAPH-PRINT-REAL-TIME 0

# Set the interval to output the graph log file to 60 seconds.
SOCKET-INTERFACE-GRAPH-PRINT-INTERVAL 20S
```

FIGURE A-3. Parameters to be Added to QualNet Configuration File for Sample Scenario

A.3.3.2.3 Entity Mapping File

For the sample scenario described in Section A.3.3.1, the entity mapping file is shown in Figure A-4. The entity mapping file is called mts-demo.entities. The left column corresponds to the MTS entity and the right column corresponds to the QualNet node identifier that the MTS entity maps to.

```
# Entity ID   QualNet Node ID

A100                5
"A200"             10
"A300"             "16"
```

FIGURE A-4. Entity Mapping File for Sample Scenario

A.3.3.3 Output Files

In this section, we examine the output files produced by running the scenario described in Section A.3.3.1.

A.3.3.3.1 File driver.log

Figure A-5 shows the file driver.log corresponding to the sample scenario described in Section A.3.3.1. See Section 4.4.1 for a description of the syntax of the file driver.log.

- Each line starts with a timestamp (simulation time enclosed in square brackets).
- The first three lines correspond to simulation initialization.
- The next line corresponds to QualNet running in time managed fast mode with a time advance to 5.0 seconds.
- The next three lines correspond to the creation of the three nodes.
- The next several lines correspond to simulation time advancing by 5.0 seconds each time.
- Following that, the next line corresponds to the first (`Id2` value is 0) request to send data of size 512 bytes from node A100 to node A200. This corresponds to the following line from mts-config.txt (see Figure A-2):

```
CommEffectsRequest  A100  A200 150.0  INTERVAL 2.0 ID1 1 ID2 0 TCP SIZE
512  DESCRIPTION "HELLO"
```

- Most of the remaining lines correspond to exchange of data between node 100 and node 200 and to the advancing of the simulation clock. The value of `Id2` is incremented for each data unit exchanged between nodes.
- Figure A-5 also shows lines corresponding to update the position of node A300 and the command to stop the simulation.

```
[  0.000000] InitializeSimulation: TimeManagementMode = TimeManaged,
CoordinateSystem = LatLonAlt
[  0.000000] PauseSimulation
[  0.000000] ExecuteSimulation
[  0.000000] AdvanceTime: TimeAllowance = 5.000000
[  5.000000] CreatePlatform: EntityId = A300, Position = (41.000050, 46.000005,
5.000000), State = Undamaged, CreateTime = 10.000000, Type = 1
[  5.000000] CreatePlatform: EntityId = A100, Position = (41.000050, 46.000005,
0.000000), State = Undamaged, CreateTime = 10.000000, Type = 0
[  5.000000] CreatePlatform: EntityId = A200, Position = (41.000050, 46.000005,
0.000000), State = Undamaged, CreateTime = 10.000000
[  5.000000] AdvanceTime: TimeAllowance = 10.000000
[ 10.000000] AdvanceTime: TimeAllowance = 15.000000
[ 15.000000] AdvanceTime: TimeAllowance = 20.000000
...
[140.000000] AdvanceTime: TimeAllowance = 145.000000
[140.000435] CommEffectsRequest: Id1 = 1, Id2 = 0, Protocol = TCP, Size = 512,
Sender = A200, Receiver = A100, RequestTime = 150.000000, Description = HI
[140.000435] CommEffectsRequest: Id1 = 1, Id2 = 0, Protocol = TCP, Size = 512,
Sender = A100, Receiver = A200, RequestTime = 150.000000, Description = HELLO
[145.000000] AdvanceTime: TimeAllowance = 150.000000
[145.004444] CommEffectsRequest: Id1 = 1, Id2 = 1, Protocol = TCP, Size = 512,
Sender = A200, Receiver = A100, RequestTime = 152.000000, Description = HI
[145.004708] CommEffectsRequest: Id1 = 1, Id2 = 1, Protocol = TCP, Size = 512,
Sender = A100, Receiver = A200, RequestTime = 152.000000, Description = HELLO
[145.004708] CommEffectsRequest: Id1 = 1, Id2 = 2, Protocol = TCP, Size = 512,
Sender = A200, Receiver = A100, RequestTime = 154.000000, Description = HI
[145.007252] CommEffectsRequest: Id1 = 1, Id2 = 2, Protocol = TCP, Size = 512,
Sender = A100, Receiver = A200, RequestTime = 154.000000, Description = HELLO
[150.000000] AdvanceTime: TimeAllowance = 155.000000
...
[195.000000] UpdatePlatform: EntityId = A300, UpdateTime = 200.000000, Position
= (100.000000, 400.000000, 0.000000)
[195.000000] CommEffectsRequest: Id1 = 1, Id2 = 25, Protocol = TCP, Size = 512,
Sender = A200, Receiver = A100, RequestTime = 200.000000, Description = HI
[195.000000] CommEffectsRequest: Id1 = 1, Id2 = 25, Protocol = TCP, Size = 512,
Sender = A100, Receiver = A200, RequestTime = 200.000000, Description = HELLO
[195.000000] AdvanceTime: TimeAllowance = 200.000000
...
[595.000000] StopSimulation: StopTime = 600.000000
[595.000000] CommEffectsRequest: Id1 = 1, Id2 = 225, Protocol = TCP, Size =
512, Sender = A200, Receiver = A100, RequestTime = 600.000000, Description = HI
[595.000000] AdvanceTime: TimeAllowance = 600.000000
...
```

FIGURE A-5. File driver.log for Sample Scenario

A.3.3.3.2 File errors.log

Figure A-6 shows the file errors.log corresponding to the sample scenario described in Section A.3.3.1. See Section 4.4.2 for a description of the syntax of the file errors.log.

In this scenario, the file errors.log records only one error which corresponds to the command to update Node A300's position to out-of-range coordinates.

```
[  0.000000] Socket Interface Errors Logfile
[200.000000] ErrorMessage: InvalidCoordinates, Error = Latitude out of range:
100.000000 (maximum is 42.000000), OriginatingMessage = UpdatePlatform:
EntityId = A300, UpdateTime = 200.000000, Position = (100.000000, 400.000000,
0.000000)
```

FIGURE A-6. File errors.log for Sample Scenario

A.3.3.3.3 File graph.log

Figure A-7 shows the file graph.log corresponding to the sample scenario described in Section A.3.3.1. See Section 4.4.3 for a description of the syntax of the file graph.log.

Figure A-7 shows the connectivity graph at time 280.010899. It shows the status of each node. All three nodes are gateways of subnet 100. It also shows that node A300 is a RAP and there are no other nodes in its region.

```
...
[280.010899] ==============================================================
[280.010899] EntityID: A100               NodeID: 5
[280.010899]     Location: X = 41.000050, Y = 46.000005, Z = 145.426000
[280.010899]     Type: Ground
[280.010899]     Interface: 192.0.0.5     Subnet Id: 100
[280.010899]     Is Gateway:  Yes, subnets 100
[280.010899]     Multicast Groups: 224.0.0.5 224.0.0.1 224.0.0.2 224.0.0.13
[280.010899] EntityID: A200               NodeID: 10
[280.010899]     Location: X = 41.000050, Y = 46.000005, Z = 145.426000
[280.010899]     Type: Ground
[280.010899]     Interface: 192.0.0.10     Subnet Id: 100
[280.010899]     Is Gateway:  Yes, subnets 100
[280.010899]     Multicast Groups: 224.0.0.5 224.0.0.1 224.0.0.2 224.0.0.13
[280.010899] EntityID: A300               NodeID: 16
[280.010899]     Location: X = 41.000050, Y = 46.000005, Z = 5.000000
[280.010899]     Type: Air
[280.010899]     Interface: 192.0.0.16     Subnet Id: 100 [RAP]    Members:
[280.010899]     Is Gateway:  Yes, subnets 100
[280.010899]     Multicast Groups: 224.0.0.5 224.0.0.1 224.0.0.2 224.0.0.13
[280.010899] Region Summary.  Platforms in parenthesis are RAPs.
[280.010899]     Subnet 100, gateways A100 A200 A300
[280.010899]         (A300)
[300.012106] ==============================================================
...
```

FIGURE A-7. File graph.log for Sample Scenario

A.3.3.3.4 File responses.log

Figure A-8 shows the file responses.log corresponding to the sample scenario described in Section A.3.3.1. See Section 4.4.4 for a description of the syntax of the file responses.log.

- Each line starts with a timestamp (simulation time enclosed in square brackets).
- The first few lines correspond to simulation initialization.
- The next several lines correspond to responses to command to advance time.
- The next several lines, the first one with timestamp 151.310207, correspond to successful responses communication effects requests.
- At time 256.000435, a response indicating a failure is sent. Note that this response corresponds to the request which was received 90.000435 seconds earlier. This latency is due to the TCP timeout being set to 90 seconds in the QualNet configuration file.

```
...
[  0.000000] Socket Interface Respones Logfile
[  0.000000] SimulationState: State = Standby, OldState = Initialized
[  0.000000] SimulationState: State = Initialized, OldState = Paused
[  0.000000] SimulationState: State = Paused, OldState = Executing
[  4.998801] SimulationIdle: CurrentTime = 4.998801
[  9.999403] SimulationIdle: CurrentTime = 9.999403
[ 14.998114] SimulationIdle: CurrentTime = 14.998114
...
[149.999423] SimulationIdle: CurrentTime = 149.999423
[151.310207] CommEffectsResponse: Id1 = 1, Id2 = 0, Sender = A200, Receiver =
A100, Status = Success, ReceiveTime = 151.310207, Latency = 1.310207
[151.728266] CommEffectsResponse: Id1 = 1, Id2 = 0, Sender = A100, Receiver =
A200, Status = Success, ReceiveTime = 151.728266, Latency = 1.728266
[152.630395] CommEffectsResponse: Id1 = 1, Id2 = 1, Sender = A100, Receiver =
A200, Status = Success, ReceiveTime = 152.630395, Latency = 0.630395
[152.660400] CommEffectsResponse: Id1 = 1, Id2 = 1, Sender = A200, Receiver =
A100, Status = Success, ReceiveTime = 152.660400, Latency = 0.660400
...
[164.310064] CommEffectsResponse: Id1 = 1, Id2 = 7, Sender = A200, Receiver =
A100, Status = Success, ReceiveTime = 164.310064, Latency = 0.310064
[164.999260] SimulationIdle: CurrentTime = 164.999260
...
[254.999954] SimulationIdle: CurrentTime = 254.999954
[256.000435] CommEffectsResponse: Id1 = 1, Id2 = 8, Sender = A200, Receiver =
A100, Status = Failure, ReceiveTime = 256.000435, Latency = 90.000435,
Description = HI
[256.000435] CommEffectsResponse: Id1 = 1, Id2 = 8, Sender = A100, Receiver =
A200, Status = Failure, ReceiveTime = 256.000435, Latency = 90.000435,
Description = HELLO
...
```

FIGURE A-8. File responses.log for Sample Scenario

A.3.3.3.5 File stats.log

Figure A-9 shows the file stats.log corresponding to the sample scenario described in Section A.3.3.1. See Section 4.4.5 for a description of the syntax of the file stats.log.

- The first line states that the statistics printed on the following lines are for the time interval from the start of simulation to simulation time 200.000070 seconds.
- The second line shows the simulation time and real time elapsed.
- The next line shows how many platforms have been created (number of `CreatePlatform` messages processed), how many platforms have been updated (number of `UpdatePlatformState` messages processed), how many communication requests have been modeled (number of `CommEffectsRequest` messages processed), and the total number of `CreatePlatform`, `UpdatePlatformState`, and `CommEffectsRequest` messages processed.
- The next line shows how many communication responses (`CommEffectsResponse` messages) were generated as well as how many of those were successful and how many were failures. (Note that some communication requests may be outstanding.)
- The next line shows the average number of messages that were received since the beginning of the simulation (`Avg Mesg/Sec`) as well as the average number `CommEffectsResponse` messages sent as successes (`Succ`) and failures (`Fail`).

  The last item printed on the same line is the average number of late packets, i.e., `CommEffectsResponse` messages that were designated as failures but would have been successes if the failure timeout window were larger. For example, if a packet takes 20 seconds to reach its destination but the failure timeout window is 15 seconds, then the packet is marked as a failure even though it was received successfully.
- The next line shows the average number of messages (`Last Mesg/Sec`), the average number `CommEffectsResponse` messages sent as successes (`Succ`) and failures (`Fail`), and the number of late packets in the period from the time of the last statistics log to the current simulation time.
- The final line shows the average real time speed since the beginning of simulation (`Avg Real Time Speed`) and average real time speed in the period from the time of the last statistics log to the current simulation time (`Last Real Time Speed`). This indicates the speedup of QualNet versus real time. A real time speed of 10 means QualNet is running 10 times faster than real time.

```
...
[200.000070] Performance Stats for Time Interval: SimTime = 200.000070
[200.000070] Current Sim Time[s] =         200.00  Real Time[s] =    2.85
[200.000070]     Creates = 3, Updates = 0, Requests = 62, Messages = 65
[200.000070]     Responses = 16, Successes = 16, Failures = 0
[200.000070]     Avg  Mesg/Sec = 22.84, Succ = 5.62, Fail = 0.00 (0.00 late)
[200.000070]     Last Mesg/sec = 77.01, Succ = 0.00, Fail = 0.00 (0.00 late)
[200.000070]    Avg  Real Time Speed = 43.35, Last Real Time Speed = No Packets
[220.000435] Performance Stats for Time Interval: SimTime = 220.000435
[220.000435] Current Sim Time[s] =         220.00  Real Time[s] =    3.12
[220.000435]     Creates = 3, Updates = 0, Requests = 82, Messages = 85
[220.000435]     Responses = 16, Successes = 16, Failures = 0
[220.000435]     Avg  Mesg/Sec = 27.23, Succ = 5.13, Fail = 0.00 (0.00 late)
[220.000435]     Last Mesg/sec = 76.21, Succ = 0.00, Fail = 0.00 (0.00 late)
[220.000435]    Avg  Real Time Speed = 43.35, last Real Time Speed = No Packets
...
```

FIGURE A-9. File stats.log for Sample Scenario

B Inter-Simulation Communication Protocols

This appendix describes the details of the protocols used for inter-simulation communication. It is intended for programmers who want to interface their simulator with QualNet using HLA or DIS.

B.1 Real-time Platform Reference Federation Object Model (RPR FOM) 1.0

RPR FOM is popular as it is based on the Distributed Interactive Simulation (DIS) protocol, which preceded HLA as a popular standard for simulation interoperability. RPR FOM and DIS are typically used in force-on-force simulations (dismounted infantry, ground, and airborne platforms with blue, red, and neutral forces).

The version of RPR FOM used is RPR FOM 0.5 and 1.0. Only RPR FOM 1.0 support is described in this section. (0.5 contains all the functionality of 1.0 as far as QualNet is concerned, although some parameter and object names may be different and in different places.)

Section B.2 also contains details on how some of the RPR-FOM elements are used.

This section describes the necessary set of classes for the QualNet HLA interface. It is possible to use other FOMs that support these classes. The following sections describe objects and interactions used by QualNet.

Attribute descriptions are from the OMT file for RPR FOM 1.0, available at http://www.sisostds.org.

B.1.1 Objects

QualNet subscribes to the Physical Entity objects shown in Table B-1.

TABLE B-1. Physical Entity Objects

Object Classes and Attributes	Description
BaseEntity.PhysicalEntity	A base class of all discrete platform scenario domain participants.
BaseEntity attributes	
EntityIdentifier	The unique identifier for the entity instance.
EntityType	The category of the entity.
Orientation	The angles of rotation around the coordinate axes between the entity's attitude and the reference coordinate system axes (calculated as the Tait-Bryan Euler angles specifying the successive rotations needed to transform from the world coordinate system to the entity coordinate system).
VelocityVector	The rate at which an entity's position is changing over time.
WorldLocation	Location of the entity.
BaseEntity.PhysicalEntity attributes	
DamageState	The state of damage of the entity.
ForceIdentifier	The identification of the force that the entity belongs to.
Marking	A unique marking or combination of characters used to distinguish the entity from other entities. (In practice, each RPR FOM federate may handle duplicate Marking values differently - using the first unique value and ignoring subsequent ones, exiting the program, unexpected program behavior, etc.)

QualNet subscribes to the Radio Transmitter Objects shown in Table B-2.

TABLE B-2. RadioTransmitter Objects

Object Classes and Attributes	Description
EmbeddedSystem.RadioTransmitter	A device that sends out information encoded in electromagnetic waves in the radio frequency range.
EmbeddedSystem attributes	
EntityIdentifier	The Entity Identifier of the object which this embedded system is a part of.
RelativePosition	The position of the embedded system, relative to the host object's position.
EmbeddedSystem.RadioTransmitter attributes	
Frequency	The radio frequency of transmitted radio signals.
RadioIndex	A number that uniquely identifies this radio transmitter from other transmitters on the host entity.
RadioSystemType	The type of radio transmitter.
TransmitterOperationalStatus	The state of the radio transmitter.

B.1.2 Interactions

QualNet subscribes to the ApplicationSpecificRadioSignal interactions shown in Table B-3.

TABLE B-3. ApplicationSpecificRadioSignal Interactions

Interaction Classes and Parameters	Description
RadioSignal.ApplicationSpecificRadio Signal	A form of radio signal, which uses an application specific encoding scheme.
RadioSignal.ApplicationSpecificRadioSignal parameters	
HostRadioIndex	The ID of the radio transmitting this signal. (This is actually the object name, in string form, of the hosting RadioTransmitter object - not the same as the RadioIndex parameter.)
DataRate	The rate at which the data is being transmitted.
SignalDataLength	The length of the signal data.
SignalData	The signal data.
TacticalDataLinkType	The type of tactical data link used to transmitted this signal (if any).
TDLMessageCount	The number of tactical data link messages contained in this signal.
UserProtocolID	The ID of the user protocol in use.

QualNet subscribes and publishes the data interactions shown in Table B-4.

TABLE B-4. Data Interactions

Interaction Classes and Parameters	Description
Data	A Simulation Management (SIMAN) interaction designed to acknowledge either a) a DataQuery interaction (in which case the Data interaction contains the results of the query) or b) a SetData interaction (in which case the Data interaction contains the data that the federate was able to set).
Data.OriginatingEntity	The DIS entity ID of the entity or application sending the interaction.
Data.ReceivingEntity	The DIS entity ID of the entity or application which is the intended recipient of the interaction.
Data.RequestIdentifier	This field matches this response with the specific SetData or DataQuery interaction sent by the simulation manager.
Data.FixedDatums	The set of data items (types and values), of fixed length, that the recipient can return for this interaction.
Data.VariableDatumSet	The set of data items (types and values) associated with the interaction.

B.2 QualNet HLA Interface RPR-FOM 1.0 Extensions Interface Communications Document (ICD)

The "client" is a client federate which sends HLA interactions to QualNet to request modeling of communication effects. QualNet sends HLA interactions to the client to report on results of communications.

uint16 refers to a 16-bit unsigned integer; float32 refers to a 32-bit point floating point number; and so on, using the standard representations in C and C++. All fields are in network byte order (most significant byte occurring first).

HLA RPR FOM 1.0 is assumed in this document, although the interface also supports version 0.5 (the names of some attributes, etc., may be slightly different), and probably will support 2.0 with some modifications.

The QualNet HLA interface does not define any new object or interaction classes to be added to RPR FOM 1.0, per se, but rather uses existing interaction classes, except containing QualNet specific data. To determine that an interaction is specific to itself, QualNet uses the UserProtocolID parameter for ApplicationSpecificRadioSignal interactions, and the DatumID field for Data interactions.

It is assumed that the client federate will create the necessary object instances that correspond to the simulation entities sending and receiving communications.

B.2.1 ApplicationSpecificRadioSignal Interaction

The client sends the ApplicationSpecificRadioSignal interaction to request communication effects modeling from QualNet. The interaction parameters should have the values shown in Table B-5.

TABLE B-5. ApplicationSpecificRadioSignal Interaction

Parameter Name	Value
DataRate	(as defined in RPR FOM)
HostRadioIndex	(as defined in RPR FOM)
SignalDataLength	(as defined in RPR FOM)
SignalData	Message string (the format is described below)
TacticalDataLinkType	Unused
TDLMessageCount	Unused
UserProtocolID	10000

Note: QualNet uses the UserProtocolID parameter to recognize that the interaction is specific to QualNet.

The **HostRadioIndex** parameter can be used to identify the DIS entity ID and RadioIndex which is the source of a message.

This document uses the "Entity ID" term to be synonymous with the RPR-FOM 1.0 EntityIdentifier attribute: three unsigned 16-bit integers consisting of the SiteID, the ApplicationID, and the EntityNumber. The Entity ID term shares similar heritage to the Entity Identifier record defined in DIS. (The term "Entity ID" is also sometimes used to refer to the RPR FOM 1.0 EntityType attribute - the seven unsigned fields used to indicate the specific type of entity, e.g., specific tank type, dismounted infantry, etc. - but this usage is not employed in this document.)

Message String

The client should set the message string using the following format (all values in ASCII):

```
HEADER
<attribute>=<value>
<attribute>=<value>
…
EOH
<Arbitrary data>
```

The header section starts with the string `HEADER` in the first line, followed by attribute-value pairs (each in a new line), and ends with the string `EOH` in a new line, finally followed by optional data. The possible attribute-value pairs are listed shown in Table B-6, and can occur in any order.

TABLE B-6. Possible Attribute-Value Pairs

Name	Description	Value	Example

receiver	Destination Entity ID (only for unicast messages) optional	3 x uint16, separated by periods	receiver=1.1.1001
			receiver=2.3.1005

size	Size of the message, in bytes or seconds	uint32 bytes, or float64 seconds	size=4000 bytes
			size=10 seconds

timeout	Number of seconds the client should wait for QualNet before discarding the message	float64	timeout=180
			timeout=75

timestamp	Unique ID.	32-bit value represented in 0x12345678 hexadecimal format	timestamp=0x0A4B22E1
			timestamp=0x000013DE

Note: The receiver field is optional, depending on whether the communication to be modeled is broadcast or unicast. All other fields are required.

The timestamp field can be any 32-bit value, but should be sent as a hexadecimal string. For a given ApplicationSpecificRadioSignal interaction, the same timestamp value is stored in the Timestamp field of the Process Message and Timeout interactions. In other words, this value is used to uniquely match up result interactions to the original communications modeling *request* interaction.

B.2.2 Data Interaction

QualNet uses the Data interaction to define three different types of messages:

- Process Message interaction
- Timeout interaction
- Ready To Send Signal (RTSS) interaction

The DatumID field is used to distinguish among the above message types for a given Data interaction. In all cases, the VariableDatums field should not exceed 1,000 bytes. Multiple interactions can be sent in such cases.

B.2.2.1 Process Message Interaction

QualNet sends the Process Message interaction (actually a Data interaction) when QualNet determines that one or more entities has successfully received a message. Table B-7 shows the values set by QualNet.

TABLE B-7. Process Message Interaction Values

Field	Value				
OriginatingEntity	The Entity ID of the entity sending the radio signal.				
ReceivingEntity	Nothing				
RequestIdentifier	Nothing				
FixedDatums	Nothing				
VariableDatumSet	**Field**	**Value**			
	NumberOfVariableDatums	1			
	VariableDatums	**Field**	**Value**		
		DatumID	60,001		
		DatumLength	Length in bits of the DatumValue field, excluding PaddingTo64.		
		DatumValue	**Field**	**Value**	**Size**
			Source Entity ID	Entity ID (previously received from client)	6 bytes
			Transmitter radio index	uint16 (previously received from client)	2 bytes
			Timestamp	32-bit arbitrary data type (previously received from client)	4 bytes
			Number of receiving entities	uint32	4 bytes
			Entity 1 ID	Entity ID	6 bytes
			Entity 1 Delay	float64	8 bytes
			Entity 2 ID	Entity ID	6 bytes
			Entity 2 Delay	float64	8 bytes
			...	...	...
		PaddingTo64	Padding to 64 bits		

Note: A positive delay represents the time it took, in seconds, for the message since its transmission to reach its recipient. A negative delay value means the message is undeliverable (this is currently not supported but may be at a future date; instead, the lack of a Process Message interaction for one or more destinations by the time a Timeout interaction is issued, should be interpreted by the client as a failure for those destinations).

B.2.2.2 Timeout Interaction

QualNet sends the Timeout interaction (actually a Data interaction) when the processing of a message is complete (no further Process Message interactions will be sent for a specific request after the Timeout interaction is sent). If a Process Message interaction has not been sent for a given destination by the time the Timeout interaction is issued, the client should assume the message could not be delivered to that destination. Table B-8 shows the values set by QualNet.

TABLE B-8. Timeout Interaction Values

Field	Value				
OriginatingEntity	The Entity ID of the entity sending the radio signal.				
ReceivingEntity	Nothing				
RequestIdentifier	Nothing				
FixedDatums	Nothing				
VariableDatumSet	**Field**	**Value**			
	NumberOfVariableDatums	1			
	VariableDatums	**Field**	**Value**		
		DatumID	60,002		
		DatumLength	Length in bits of the DatumValue field, excluding PaddingTo64.		
		DatumValue	**Field**	**Value**	**Size**
			Source Entity ID	Entity ID (previously received from client)	6 bytes
			Radio index	uint16 (previously received from client)	2 bytes
			Timestamp	32-bit arbitrary data type (previously received from client)	4 bytes
			Number of packets	uint32	4 bytes
			Number of receiving entities	uin32	4 bytes
			Entity 1 ID	Entity ID	6 bytes
			Entity 1 Status	bool8	1 byte
			Entity 2 ID	Entity ID	6 bytes
			Entity 2 Status	bool8	1 byte
			...	...	...
		PaddingTo64	Padding to 64 bits		

Note: A status with a value of 0 means FALSE. All other status values mean TRUE.

B.2.2.3 Ready to Send Signal (RTSS) Interaction

QualNet sends the Ready To Send Signal (RTSS) interaction (actually a Data interaction) to indicate to the client that it can send an ApplicationSpecificRadioSignal interaction for a specific network. The RTSS interaction is used optionally depending on the QualNet scenario configuration. Table B-9 shows the RTSS interaction values.

TABLE B-9. Ready to Send Signal (RTSS) Interaction Values

Field	Value				
OriginatingEntity	The Entity ID of the entity sending the radio signal				
ReceivingEntity	Nothing				
RequestIdentifier	Nothing				
FixedDatums	Nothing				
VariableDatumSet	**Field**	**Value**			
	NumberOfVariableDatums	1			
	Padding	Padding to 64 bits			
	VariableDatums	**Field**	**Value**		
		DatumID	60,010		
		DatumLength	Length in bits of the DatumValue field, excluding PaddingTo64.		
		DatumValue	**Field**	**Value**	**Size**
			Source Entity ID	Entity ID	6 bytes
			Source Radio index	uint16	2 bytes
			Timestamp	float32	4 bytes
			Window Time	(currently unused)	4 bytes
		PaddingTo64	Padding to 64 bits		

The Timestamp field above is an actual HLA timestamp value, and does not correspond with the timestamp and Timestamp fields used in all of the other interactions.

B.3 QualNet HLA Dynamic Statistics Interface Communications Document (ICD)

The purpose of the HLA dynamic statistics interface is to allow subscribing federates to receive communications statistics from QualNet in real time as they are updated during the simulation.

B.3.1 Enabling HLA Dynamic Statistics in QualNet

Dynamic statistics over HLA can be enabled only if the QualNet GUI is used. See Chapter 5 of *QualNet User's Guide* for details of enabling dynamic statistics in the GUI.

The parameters to configure HLA statistics are described in Section 2.2.2.1.

B.3.2 Comment Interaction

QualNet sends the Comment interaction to report dynamic statistics. Table B-10 lists the parameters of the Comment interaction. Note that although all three parameters are sent by QualNet, only the VariableDatumSet parameter contains useful information. (Any relevant EntityIDs are sent in the VariableDatumSet parameter.)

TABLE B-10. Comment Interaction Parameters

Parameter Name	Description
OriginatingEntity	The DIS entity ID of the entity or application sending the interaction. Sent as all zeroes by QualNet.
ReceivingEntity	The DIS entity ID of the entity or application which is the intended recipient of the interaction. Sent as all zeroes by QualNet.
VariableDatumSet	The set of data items (types and values) associated with the interaction.

The following three types of Comment interactions are sent by QualNet:

- nodeId Description notification
- Metric Definition notification
- Metric Update notification

Each type of Comment interaction is distinguished by the DatumID field of VariableDatumSet parameter of the Comment interaction.

VariableDatumSet Structure

Table B-11 shows the format for the VariableDatumSet parameter for all dynamic statistics related Comment interactions sent by QualNet. NumberOfVariableDatums will always be 1. The DatumValue field will always be a null-terminated string (and the size of the null byte is included in DatumLength).

TABLE B-11. VariableDatumSet Structure

Field	Value		
VariableDatumSet	Field	Value	
	NumberOfVariableDatums	1	
	VariableDatums (One VariableDatum, shown to right)	Field	Value
		DatumID	60,101 or 60,102 or 60,103
		DatumLength	Size in bits of DatumValue
		DatumValue	Null-terminated string
		PaddingTo64	Padding to DatumValue to 64 bits

Notes:
1. The VariableDatums field will not exceed 1000 bytes
2. DatumLength is specified in bits.
3. DatumLength is the size of DatumValue, and excludes the size of the PaddingTo64 field.

B.3.3 nodeId Description Notification

The nodeId Description notification is used to convey RPR-FOM object attributes associated with specific QualNet node IDs. This notification sends the node ID to MarkingData and node ID to RadioIndex mappings from the scenario Radios file (see Section 2.2.2.1.2). nodeId Description interactions are not sent unless the parameter `HLA-DYNAMIC-STATISTICS-SEND-NODEID-DESCRIPTIONS` is set to `YES` (see Section 2.2.2.1).

The DatumID field for a nodeId Description notification is set to `60,101`. The following format is used for the DatumValue field:

```
DatumValue string:
nodeId "markingData" radioIndex<CRLF>
nodeId "markingData" radioIndex<CRLF>
...
```

While each field is sent in string form (ASCII) in the Comment interaction, the Type column in the table indicates how each field can be stored internally by subscribing federates. For a Type of char[n], n includes space for a terminating null (for example, if n=11, that's 10 bytes of useful data plus one null character); when n is not specified, the string length can be arbitrarily large. See Table B-12.

TABLE B-12. nodeId Description Notification

Field	Type	Description
nodeId	uint32	Unique identifier for QualNet nodes.
markingData	char[11]	BaseEntity.PhysicalEntity.Marking.MarkingData. (It is assumed the MarkingEncodingType indicates an ASCII-encoded MarkingData.) When no valid MarkingData is available (such as when reporting statistics for a QualNet node that is not associated with any BaseEntity object), "" is printed.
radioIndex	uint16	BaseEntity.RadioTransmitter.RadioIndex.

The QualNet simulation starts with the first federation object it discovers (a PhysicalEntity or RadioTransmitter object). Immediately after this occurs, QualNet will issue one or more nodeId Description notifications. It's important that any federate monitoring for dynamic statistics be joined to the federation and subscribed to Comment interactions when this occurs, since interactions are not buffered by the RTI when time management services are not used.

B.3.4 Metric Definition Notification

The Metric Definition notification is used to define metrics sent by QualNet using a unique metric ID. Metric Definition interactions are not sent unless the parameter `HLA-DYNAMIC-STATISTICS-SEND-METRIC-DEFINITIONS` is set to `YES` (see Section 2.2.2.1).

Note: Metric IDs may change if new dynamic metrics are added to QualNet source code using the GUI_DefineMetric() function. Developers should not rely on metric IDs remaining static between simulation executions.

The DatumID field for a Metric Definition notification is set to `60,102`. The following format is used for the DatumValue field:

```
DatumValue string:
metricId "name" layerId dataType<CRLF>
metricId "name" layerId dataType<CRLF>
...
```

Table B-13 shows the fields in the Metric Definition notifications.

TABLE B-13. Fields in the Metric Definition Notification

Field	Type	Description
metricId	int32	Unique identifier for QualNet metrics.
name	char[ ]	Brief string description of the metric; can include spaces.
layerId	int32	QualNet layer at which the metric resides. 0 Mobility 1 Channel 2 Physical 3 Data-link/MAC 4 Network 5 Transport 6 Application 7 Routing 8 Any (currently not used)
dataType	int32	Data type of metric. 0 int32 1 double 2 uint32

Soon after the nodeId Description notifications are sent out, one or more Metric Definition notifications will be issued by QualNet. It is possible for Metric Definition notifications to occur later in the simulation, as well. QualNet may also send out duplicate definitions.

Note: QualNet only issues Metric Definition notifications at the beginning of the simulation. All GUI_DefineMetric() calls must occur before the first QualNet event.

B.3.5 Metric Update Notification

The Metric Update notification is used to convey new metric values to subscribing federates.

The DatumID field for a Metric Update notification is set to `60,103`. The format of the DatumValue field depends on the value of the parameter `HLA-DYNAMIC-STATISTICS-METRIC-UPDATE-MODE` (see Section 2.2.2.1). If `HLA-DYNAMIC-STATISTICS-METRIC-UPDATE-MODE` is set to `VERBOSE`, the following format is used:

```
DatumValue string:
nodeId "markingData" entityId radioIndex metricId "name" layerId
dataType value time<CRLF>
nodeId "markingData" entityId radioIndex metricId "name" layerId
dataType value time<CRLF>
...
```

If `HLA-DYNAMIC-STATISTICS-METRIC-UPDATE-MODE` is set to `BRIEF`, the following format is used for the DatumValue field:

```
DatumValue string:
nodeId metricId value time<CRLF>
nodeId metricId value time<CRLF>
...
```

Many of the fields are the same as those for nodeId Description and Metric Definition notifications. The additional fields are described in Table B-14.

TABLE B-14. Additional Fields in the Metric Update Notification

Field	Type	Description
nodeId	uint32	Unique identifier for a QualNet node.
entityId	uint16[3]	BaseEntity.EntityIdentifier for the RPR-FOM BaseEntity (and subclasses) object, if any, associated with a QualNet node. Printed as a triplet of integers delimited by periods, for example., 1.23.456 (SiteID = 1, ApplicationID = 23, EntityNumber = 456). When no valid EntityID is available (such as when reporting statistics for a QualNet node that is not associated with any BaseEntity object), this field is printed as -1 (no extra integers).
radioIndex	uint32	EmbeddedSystem.RadioTransmitter.RadioIndex for the RPR-FOM RadioTransmitter object, if any, associated with a QualNet node. When no valid RadioIndex is available, this field is printed as -1.
metricId	int32	Unique identifier for a QualNet metric.
value	Depends on Type	Metric value expressed as an ASCII string, as usual. The value can be stored according to the dataType assigned to the metric in the Metric Definition notification.
time	uint64	QualNet simulation time in units of nanoseconds (expressed as an integer in string form) at which the metric update is valid. Note that QualNet simulation time starts at zero when QualNet discovers the first PhysicalEntity or RadioTransmitter object. Note: While this value can be stored as a uint64 by subscribing federates, federates can also opt to convert it into a double, by casting to double and then dividing by 1e9 (ending up with 1.0 = 1 second of QualNet simulation time).

Notice that in Verbose mode, the client federate does not need to parse Metric Definition notifications since all the information is present in Metric Update notifications. In Brief mode, the Metric Definition notifications need to be parsed by the client federate in order to associate metric ID values with the metric name, layer, and data type; whereas.

Metric Update notifications are sent by QualNet throughout simulation execution. They are sent every 1 second of simulation time (if there is any updated metric), or when the size threshold of 1,000 bytes of VariableDatums field is exceeded.

A reporting interval is also specified in the GUI (by going to **Animation > Dynamic Statistics > Scenario Statistics** and setting the parameter **Update Interval Time**). At these intervals, the GUI_Send{Integer,Unsigned,Real}Data() functions are called; these functions load data into the buffer used for Metric Update notifications. Therefore, if the user is mainly interested in dynamic statistics over HLA (i.e., not really interested in the GUI display), the user should set a reporting interval at or around 1 second.

Notes:

1. The GUI_Send{...}Data() calls currently repeat metric values even when those values have not changed. This can be improved to minimize federation bandwidth consumption.
2. Metric Update notifications can be sent for node IDs for which a nodeId Description notification has not been sent. These correspond to QualNet nodes which do not map to any federation object (PhysicalEntity or RadioTransmitter).

B.4 DIS PDUs

In DIS, data messages are sent as Protocol Data Units (PDUs). The PDU types used by QualNet are:

- Entity State PDU: This PDU is sent by external simulators and describes the entities in the simulation exercise. QualNet does not send Entity State PDUs.
- Transmitter PDU: This PDU is sent by external simulation applications and is used to indicate the transmitter state.
- Signal PDU: This PDU is sent by external simulation applications and is used to request communications effects modeling.
- Data PDU: This PDU is sent by QualNet and used to pass the radio communication results to the requesting applications

B.5 QualNet DIS Extensions ICD

The "client" is an external simulation application which sends DIS Signal PDUs to QualNet to request modeling of communication effects. QualNet sends DIS Data PDUs to the client to report on results of communications.

uint16 refers to a 16-bit unsigned integer; float32 refers to a 32-bit point floating point number; and so on, using the standard representations in C and C++. All fields are in network byte order (most significant byte occurring first).

The QualNet DIS interface does not define any new PDUs, but rather uses existing PDUs containing QualNet specific data. To determine that a PDU is specific to itself, QualNet uses the UserProtocolID parameter for Signal PDUs with Application-Specific Data, and the DatumID field for Data PDUs.

It is assumed that the client will create the necessary object instances that correspond to the simulation entities sending and receiving communications.

B.5.1 Signal PDU

The client sends the Signal PDU to request communication effects modeling from QualNet. The interaction parameters should have the values shown in Table B-5.

TABLE B-15. Signal PDU

Field	Value	
PDU Header	As defined by the DIS Standard	
Entity ID	Entity ID of the source enity	
Radio ID	Radio index of the source radio	
Encoding Scheme Record	**Field**	**Value**
	Encoding Class	Application-specific Data (2)
	Encoding Type	Not used
Sample Rate	Requested data rate	
Data length	Number of bytes in the message string	
Samples	**Field**	**Value**
	UserProtocolID	10000
	Message String	Text

Note: QualNet uses the UserProtocolID parameter to recognize that the PDU is specific to QualNet and will ignore all other Signal PDUs.

Message String

The client should set the message string using the following format (all values in ASCII):

```
HEADER
<attribute>=<value>
<attribute>=<value>
…
EOH
<Arbitrary data>
```

The header section starts with the string `HEADER` in the first line, followed by attribute-value pairs (each in a new line), and ends with the string `EOH` in a new line, finally followed by optional data. The possible attribute-value pairs are listed shown in Table B-16, and can occur in any order.

TABLE B-16. Possible Attribute-Value Pairs

Name	Description	Value	Example

receiver	Destination Entity ID (only for unicast messages) optional	3 x uint16, separated by periods	receiver=1.1.1001
			receiver=2.3.1005

size	Size of the message, in bytes or seconds	uint32 bytes, or float64 seconds	size=4000 bytes
			size=10 seconds

timeout	Number of seconds the client should wait for QualNet before discarding the message	float64	timeout=180
			timeout=75

timestamp	Unique ID.	32-bit value represented in 0x12345678 hexadecimal format	timestamp=0x0A4B22E1
			timestamp=0x000013DE

Note: The receiver field is optional, depending on whether the communication to be modeled is broadcast or unicast. All other fields are required.

The timestamp field can be any 32-bit value, but should be sent as a hexadecimal string. For a given Signal PDU, the same timestamp value is stored in the Timestamp field of the Process Message and Timeout results. In other words, this value is used to uniquely match up results to the original communications modeling *request* PDU.

B.5.2 Data PDU

QualNet uses the Data PDU to define three different types of messages:

- Process Message result
- Timeout result
- Ready To Send Signal (RTSS) result

The DatumID field is used to distinguish among the above message types. In all cases, the VariableDatums field should not exceed 1,000 bytes. Multiple PDUs can be sent in such cases.

B.5.2.1 Process Message Result

QualNet sends the Process Message result (actually a Data PDU) when QualNet determines that one or more entities has successfully received a message. Table B-17 shows the values set by QualNet.

TABLE B-17. Data PDU for Process Message Result

Field	Value			
PDU Header	As defined by the DIS standard.			
OriginatingEntity ID	The Entity ID of the entity sending the radio signal.			
ReceivingEntity ID	Nothing			
Request ID	Nothing			
Number of Fixed Data Records	0			
FixedDatums	Not Fixed Datums			
NumberofVariable Dataums	1			
VariableDatums	**Field**	**Value**		
	DatumID	60,001		
	DatumLength	Length in bits of the DatumValue field, excluding PaddingTo64.		
	DatumValue	**Field**	**Value**	**Size**
		Source Entity ID	Entity ID (previously received from client)	6 bytes
		Transmitter radio index	uint16 (previously received from client)	2 bytes
		Timestamp	32-bit arbitrary data type (previously received from client)	4 bytes
		Number of receiving entities	uint32	4 bytes
		Entity 1 ID	Entity ID	6 bytes
		Entity 1 Delay	float64	8 bytes
		Entity 2 ID	Entity ID	6 bytes
		Entity 2 Delay	float64	8 bytes
		...	...	...
		PaddingTo64	Padding to 64 bits	

Note: A positive delay represents the time it took, in seconds, for the message since its transmission to reach its recipient. A negative delay value means the message is undeliverable (this is currently not supported; instead, the lack of a Process Message result for one or more destinations by the time a Timeout result is issued, should be interpreted by the client as a failure for those destinations).

B.5.2.2 Timeout Result

QualNet sends the Timeout result (actually a Data PDU) when the processing of a message is complete (no further Process Message results will be sent for a specific request after the Timeout result is sent). If a Process Message result has not been sent for a given destination by the time the Timeout result is issued, the client should assume the message could not be delivered to that destination. Table B-18 shows the values set by QualNet.

TABLE B-18. Data PDU for Timeout Result

Field	Value			
PDU Header	As defined by the DIS standard.			
OriginatingEntity ID	The Entity ID of the entity sending the radio signal.			
ReceivingEntity ID	Nothing			
Request ID	Nothing			
Number of Fixed Data Records	0			
FixedDatums	Not Fixed Datums			
NumberofVariable Dataums	1			
VariableDatums	**Field**	**Value**		
	DatumID	60,002		
	DatumLength	Length in bits of the DatumValue field, excluding PaddingTo64.		
	DatumValue	**Field**	**Value**	**Size**
		Source Entity ID	Entity ID (previously received from client)	6 bytes
		Transmitter radio index	uint16 (previously received from client)	2 bytes
		Timestamp	32-bit arbitrary data type (previously received from client)	4 bytes
		Number of receiving entities	uint32	4 bytes
		Entity 1 ID	Entity ID	6 bytes
		Entity 1 Status	Bool8	1 byte
		Entity 2 ID	Entity ID	6 bytes
		Entity 2 Status	Bool8	1 byte
		...	...	...
		PaddingTo64	Padding to 64 bits	

Note: A status with a value of 0 means FALSE. All other status values mean TRUE.

B.5.2.3 Ready to Send Signal (RTSS) Result

QualNet sends the Ready To Send Signal (RTSS) result (actually a Data PDU) to indicate to the client that it can send a Signal PDU for a specific network. The RTSS result is used optionally depending on the QualNet scenario configuration. Table B-19 shows the RTSS result values.

TABLE B-19. Data PDU for RTSS Result

Field	Value			
PDU Header	As defined by the DIS standard.			
OriginatingEntity ID	The Entity ID of the entity sending the radio signal.			
ReceivingEntity ID	Nothing			
Request ID	Nothing			
Number of Fixed Data Records	0			
FixedDatums	Not Fixed Datums			
NumberofVariable Dataums	1			
VariableDatums	**Field**	**Value**		
	DatumID	60,0102		
	DatumLength	Length in bits of the DatumValue field, excluding PaddingTo64.		
	DatumValue	**Field**	**Value**	**Size**
		Source Entity ID	Entity ID	6 bytes
		Source radio index	uint16	2 bytes
		Timestamp	float32	4 bytes
		Window Time	(Currently not used)	4 bytes
		Number of receiving entities	unit32	4 bytes
		PaddingTo64	Padding to 64 bits	

The Timestamp field above is an actual DIS timestamp value, and does not correspond with the timestamp and Timestamp fields used in all of the other PDUs.