Introduction to QualNet®

Marco A. Alzate
Simply a (non-quite experienced) user
May 16th, 2007
1. General Overview
2. IDE (GUI) Functional Overview
3. Command Line overview
4. Programming
5. Conclusions
Let us read from SNT, the manufacturers:

• QualNet is a set of comprehensive tools with all the components for custom network modeling and simulation projects
• QualNet's unparalleled speed, scalability, and fidelity make it easy for modelers to optimize existing networks through quick model setup and in-depth analysis tools.
• Models in source form provide developers with a solid library on which to build and experiment with new network functionality.
• Extensive library from wired LANs and WANs, to cellular, satellite, WLANs and mobile ad hoc networks, for VoIP, telnet, ftp, http, etc.
How does the network perform as it is scaled to 10,000+ heterogeneous devices?

Genesis: GloMoSim, DARPA project at UCLA ('97 – '00) for efficient simulation of large heterogeneous networks. Parallel computing lab (Bragodia, Gerla and students)
• Commercial derivative of GloMoSim
  – Substantially expanded **MANET** models:
    AODV, DSR, OLSR, 802.11 DCF, 802.11 PCF, 802.11a, directional antennas, …
  – **GUI-based** model design, animation, & analysis
  – **Commercial** protocol & device models
  – **Military** comm models
  – Training, support, custom services

• SNT Focus: **accurate, real-time** network simulation & management
  – **Accuracy** via high-fidelity models (incorporating production code to model protocols) & detailed validation
  – **Speed** and **scalability** via research into efficient scheduling and (parallel) simulation algorithms
Discrete Event System Simulation

$N(t)$

$N(t)$

Event     Time
---
$e_1$     $t_1$
$e_2$     $t_2$
...       ...
$e_i$     $t_i$
...       ...
$e_j$     $t_j$
...       ...

Search for next event

Update Clock

Update State

Update Statistics

Add $e_i$ & $t_i$

Generate Random variates
• Layered architecture
• Well-defined APIs between adjacent layers.
• Support for native code migration between the model and operational networks.
## Some Library Components

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<td>Abstract TCP</td>
<td>CBQ</td>
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<td>(IPv6 Compliant)</td>
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<td>(included with QualNet Developer)</td>
<td>H323</td>
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<td>RSVP-TE</td>
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**Multimedia & Enterprise Library**

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<td>PIM-DM</td>
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<td>PIM-SM</td>
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**Communication Networks Group**

Introduction to Qualnet  Marco A. Alzate  May 16th, 2007
## Some Library Components

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**COMMUNICATION NETWORKS GROUP**

**Introduction to Qualnet**  Marco A. Alzate  May 16th, 2007

**USF UNIVERSITY OF SOUTH FLORIDA**
## Some Library Components

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<td>ALE †</td>
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(Requires Wireless Lib.)
QualNet Components

• QualNet Simulator
  – A state-of-the-art discrete event system simulator for large, heterogeneous networks and the distributed applications that execute on those networks.

• QualNet Scenario Designer
  – A model setup tool that allows users to set up geographical distribution, physical connections, protocols, traffic and functional parameters, using intuitive click and drag operations.

• QualNet Animator
  – A graphical experiment animation tool that allows users to watch traffic flowing and critical performance metrics while a simulation is running.

• QualNet Analyzer
  – A statistical graphing tool to display customized graphs of simulation statistics, including multi-experiment reports, exportable to spreadsheets.

• QualNet Packet Tracer
  – A packet-level visualization tool for viewing the contents of a packet as it goes up and down the network stack (Tcpdump, ethereal, …)

• Others
  – 3D visualization, emulation interfaces, …
• Review the IDE:
  – Use the Scenario Designer to:
    • Place some nodes
    • Add some applications
    • Set some parameters
  – Use the Animator to:
    • Run interactive simulations
  – Use Analyzer to:
    • Review the Results of a Scenario
• Compare design alternatives
Configuration Files

GUI Editable Scenario (.scn)

Run

.config file

.QualNet Simulator

.stat file

Analyzer

Simulator Feeds GUI

.trc file

Packet Tracer

Run Simulator Feeds GUI

0
20
40
60
80
100
Configuration Files

Text Editor

* .config
* .nodes
* .app
etc.

QualNet Simulator

*.trc
*.stat

Text Editor

C:\> qualnet default.config
# General simulation properties

# Name of experiment. Results are written to EXPERIMENT-NAME.stat.

EXPERIMENT-NAME default

# Simulation time. Units:

# 100NS - 100 nanoseconds 100 - 100 seconds (default case)
# 100US - 100 microseconds 100M - 100 minutes
# 100MS - 100 milliseconds 100H - 100 hours
# 100S  - 100 seconds    100D  - 100 days

SIMULATION-TIME 15M

# Value used to seed the random number generator. The random number generator is used in several models, such as the UNIFORM and RANDOM node-placement models.

SEED 1
Stat files contain column delimited information.

<table>
<thead>
<tr>
<th>Node ID</th>
<th>Code: Protocol specific value such as priority, port etc</th>
<th>Layer</th>
<th>Protocol</th>
<th>Stat</th>
<th>Value</th>
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<tbody>
<tr>
<td>1, [1024], Application, CBR Client, Server Address = 0.0.0.3</td>
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<td>1, [1024], Application, CBR Client, First Packet Sent at (s) = 0.000000000</td>
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<td>1, [1024], Application, CBR Client, Throughput (bits/s) = 12977</td>
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</table>
Let’s go to QualNet!

- Review the configuration file
  - Change some parameters
- Review the application file
  - Add some new application
- Review the nodes file
  - Add some new nodes
- Run the simulator
  - Review the statistics file
- Use Matlab for the whole process!
• Source files (*.cpp) and header files (*.h)
  – Some source files are precompiled – the source files aren’t available in the distribution

• Although QualNet is C++, it currently doesn’t use the more complicated features of C++
### Addons
Components developed as custom addons for specific customers

### Bin
Executable and other runtime files such as DLLs

### Contributed
Models contributed by QualNet customers

### Data
Data files for the Wireless library, including antenna configurations, modulation schemes and sample terrain files.

### Documentation
User Guide, release notes, etc.

### GUI
Graphical components including icons, Java class files, and GUI configuration.

### Include
QualNet kernel header files

### Interfaces
Code to interface QualNet to 3rd party tools or external networks, such as HLA, STK, or IP networks.

### Kernel
QualNet kernel objects used during the build process.

### Lib
3rd party software libraries used during the build process

### Libraries
Source code for QualNet’s model libraries such as Developer, Multimedia & Enterprise, and Wireless.

### License_dir
License files and license libraries required for the build process.

### Main
Kernel source files and Makefiles.

### Scenarios
Sample scenarios.
Here is the open source code for applications, transport, network, link, MAC and physical protocols:

```bash
> cd ..\bin
> nmake
> qualnet
MiEscenario.config
```
Event = Message = Packet (...or timer)

The Life Cycle of a Packet

Application
MESSAGE_Alloc(...)
MESSAGE_PacketAlloc(...)
MESSAGE_Send(...)

Transport
MESSAGE_AddHeader(...)
MESSAGE_Send(...)

IP
MESSAGE_AddHeader(...)
MESSAGE_Send(...)

Routing
MESSAGE_RemoveHeader(...)
MESSAGE_Send(...)

MAC
MESSAGE_AddHeader(...)
MESSAGE_Send(...)

Physical
MESSAGE_RemoveHeader(...)
MESSAGE_Send(...)

Application
MESSAGE_Free(...)

Transport
MESSAGE_RemoveHeader(...)
MESSAGE_Send(...)

IP
MESSAGE_RemoveHeader(...)
MESSAGE_Send(...)

MAC
MESSAGE_RemoveHeader(...)
MESSAGE_Send(...)
Quickly get acquainted with basic IDE features

A complete reference to protocol development

A more detailed review of basic IDE features
• Qualnet is flexible, accurate and fast, three characteristics that were supposed not to be achievable simultaneously.
• Easy to use from the GUI. Relatively fast learning curve for protocol development
• It has been very useful for me, specially since I can control it from Matlab 😊.
• ns-2? Opnet? Qualnet? Maybe we require more criteria than simply the technical ones (e.g. $)