# QualNet Network Simulator

## Make Networks Work
## Network modeling software for: Development Analysis

QualNet enables the evaluation of on-the-move communication networks faster and with more realism than any other tool. It uses a network digital twin to digitally represent the entire network, the various protocol layers, radios, antennas, and devices. QualNet employs state of the art Parallel Discrete Event Simulation (PDES) algorithms designed to leverage multi-core and parallel processors to dramatically increase the event processing rate and hence simulation execution speeds to run high-fidelity simulations of large networks at faster than real-time speeds.

- The QualNet network simulation platform (QualNet) is used by planners, analysts, IT technicians, and communication specialists to evaluate the performance of communication networks under different operational conditions and to identify and mitigate identified operational issues. The analysis proceeds by first creating a simulation model, or scenario, representing the network and its operating environment, executing the scenario and analyzing the results.

## Features of QualNet

The major features of QualNet include the following:

- QualNet can model a variety of heterogeneous networks (wired, wireless, under-water, satellite, etc.) with thousands of nodes exchanging different types of traffic. These scenarios can run at faster than real-time speed, making it possible to quickly perform "what-if" analysis of the network's performance under different operating conditions.
- QualNet supports a large number of high-fidelity models for network devices, protocols from all layers of the protocol stack, applications, terrains, propagation models, and mobility models. The model library includes models for wireless technologies (e.g., Wi-Fi and WiMax); cellular networks (e.g.,

**A typical scenario is comprised of:**

- Nodes representing network elements and endpoints (routers, switches, radios, sensors, PCs, servers, satellites, ground stations, mobile phones, access points, etc.) and the protocols running on them

- Links that connect the nodes (buses, LAN segments, radio transmissions, Wi-Fi signals, LTE connections, etc.)

- Environment in which the network operates (indoors, rural, or urban environment, weather, etc.)

- Mobility patterns, if any, of the communication devices

- Applications and other sources of traffic operating on the network

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GSM, UMTS, LTE, and 5G); military waveforms (e.g., Link-11, Link-16); satellite communications; underwater communications; devices such as routers, switches, and access points; indoor, rural, and urban terrain; and many real-world applications. Thus, real-world commercial and tactical networks operating in multiple domains can be modeled and analyzed in QualNet at a high level of fidelity.

- QualNet's Human-in-the-Loop (HITL) interface supports dynamic interactions to modify the operations of a running scenario. For example, users can activate/deactivate nodes and modify the traffic rate of certain applications via the HITL interface.

- The QualNet VR-Link interface allows QualNet to network with other constructive simulators, virtual reality applications, and Computer-Generated Force (CGF) tools, such as OTB and OneSAF, using High Level Architecture (HLA) or Distributed Interaction Simulation (DIS).

- The QualNet GUI can be used to visualize different types of packet flows as the scenario is running to provide an operational view of the network. Dynamic statistics can also be displayed while a scenario is running.

- Orientation change extension FFC for Standard SIM

- QualNet's Analyzer can be used to plot hundreds of metrics post simulation. QualNet also provides for the generation of detailed time-stamped tables in an SQL database, from which queries and reports such as connectivity among nodes, throughput, latency, path loss, packet drop, etc., can be produced. Third-party tools, such as Tableau, can also be used to create reports from the statistics database.

- QualNet's heatmap feature can be used to refine a network layout based on the signal coverage of wireless transmitters in the scenario, which can be displayed graphically.

- The QualNet framework is highly flexible and extensible: models for new protocols, devices, and applications can be easily developed and incorporated in simulation scenarios. High-fidelity models can also be developed by incorporating actual code from protocol implementation.

## QualNet Platform Architecture

Virtual Network Model

HLA | DIS Interface

SAF | CGF
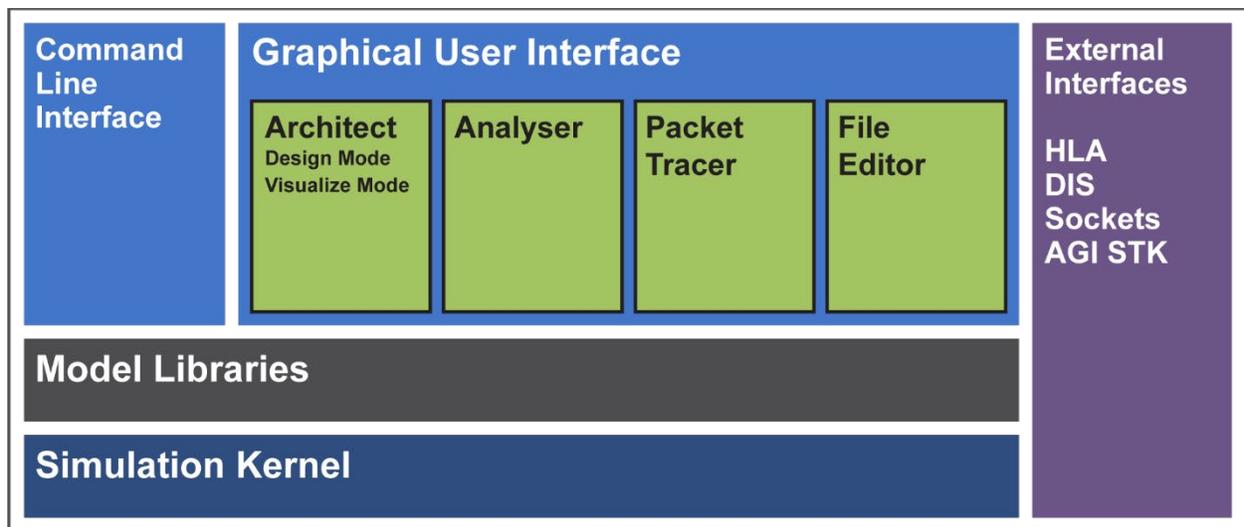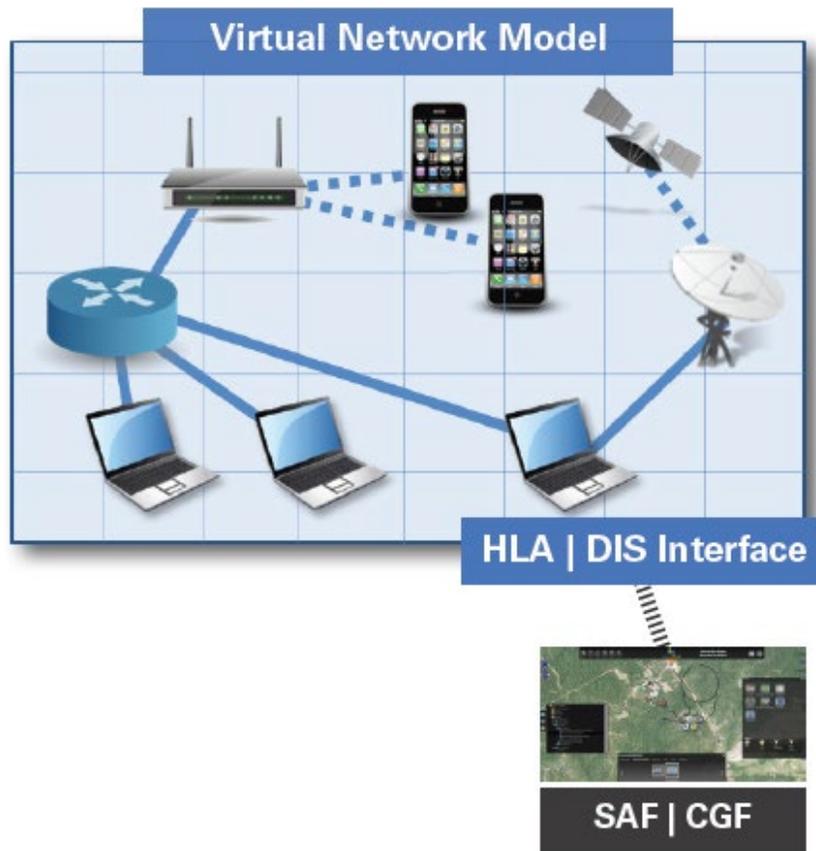
## Creating QualNet Scenarios

To study the performance of and analyze real-world networks, it is critical that the network be accurately represented in the simulation. QualNet provides an intuitive, drag-and-drop interface to create network scenarios using pre-configured models of devices, link-types, and applications. The scenario can be further refined by setting specific parameter values in easy-to-use property editors. QualNet also provides domain-specific "palettes" of pre-configured network components with advanced functionalities, such as subnets, commonly used devices, etc. This provides a convenient way of creating simulation models of networks that are in the planning stage.

For analyzing existing networks, QualNet provides several utilities to easily replicate "as is" networks and application traffic in QualNet. Thus, planners and analysts can have a high degree of confidence that the results obtained by simulating the model are applicable to the real network as well. These utilities include:

- **Topology Converter:** This tool imports a network topology specified in a Visio format and creates a simulation model of the network based on the topology.
- **Packet Capture (PCAP) Traffic Mapper:** This utility converts traffic captured from a real network, with a tool such as Wireshark, into equivalent simulated application traffic that can be used in a QualNet simulation to analyze network performance.
- **NetFlow Importer:** This tool also creates simulation models of real network traffic, but instead of using information from captured packets, it uses traffic flow statistics advertised in NetFlow packets.

- **Router Configuration Importer:** This tool imports the actual configuration files used to configure physical routers from popular vendors, such as Cisco, and uses them to directly configure the corresponding routers in the simulation models.

## Components of QualNet

The major components of QualNet are:

- **Simulator:** At the heart of QualNet is a simulator, which uses state-of-the-art techniques to run simulations of large networks at a fast speed without compromising accuracy. QualNet is based on a highly specialized kernel and efficient memory management techniques that result in very high simulation speeds. Furthermore, QualNet exploits the computing power available on multi-processor platforms by employing efficient PDES techniques and smart partitioning, i.e., dividing the workload optimally among the processors.

- **QualNet GUI:** The QualNet GUI provides an easy-to-use platform to create, visualize, and analyze network scenarios.

  - **Design Mode:** This mode is used to create virtual network models via an intuitive point-and-click drag-and-drop graphical interface. Virtual network models can include communication devices, wired and wireless links, mobility patterns of wireless users, physical characteristics such as terrain and buildings, protocols at all layers of the stack, etc. Different types of applications and services that run on the network can be applied.

  - **Visualize Mode:** This mode is used to observe and analyze network behavior as the simulation is running. Users can watch packets at various layers flow through the network and view dynamic graphs of real-time statistics.

  - **Analyzer:** After the simulation completes, Analyzer is used to plot and analyze a large number of statistics collected during the simulation.

- **Statistics Database:** In addition to a statistics file, QualNet provides a high-performance database interface that allows time-series and statistical data to be stored in a database during
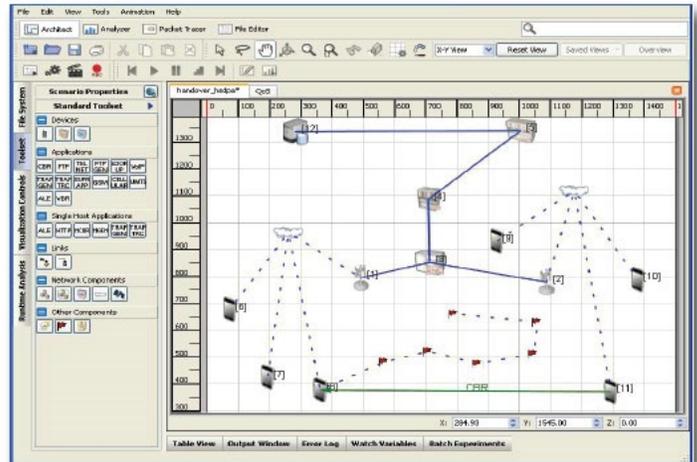


Design Modee
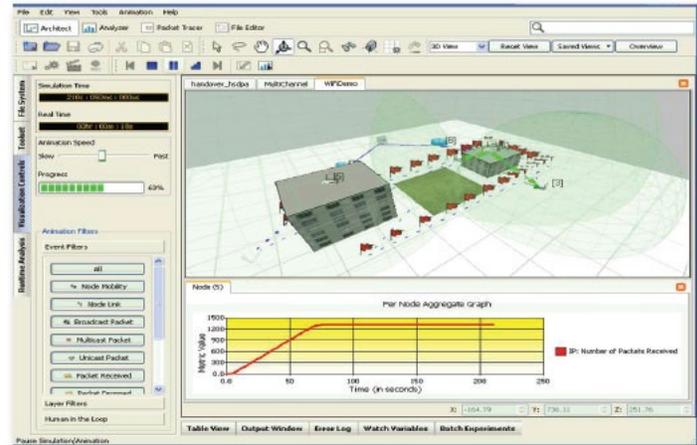


Visualize Modee
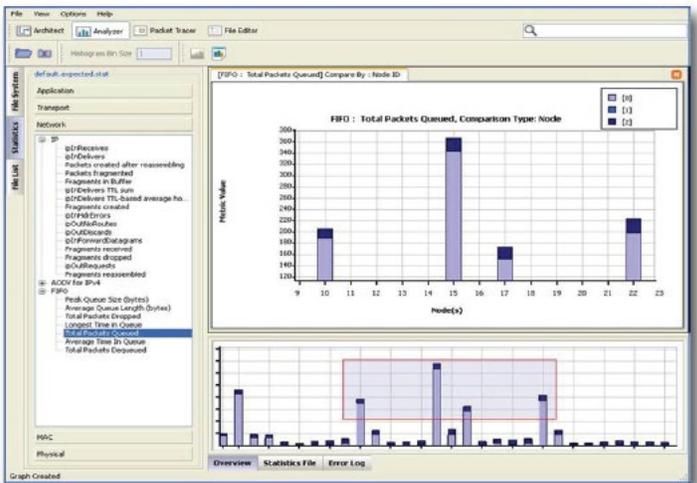


Analyzer

the simulation run. Statistics can be collected at different levels of granularity: from summary statistics at the system level to detailed statistics at the event level. The statistics database can be used to perform after-experiment review and generate reports.

- **External Interfaces:** QualNet has the capability to federate seamlessly with other simulators, such as kinetic battlefield simulators, via High Level Architecture (HLA), Distributed Interaction Simulation (DIS), AGI's System Tool Kit (STK), and Socket interfaces.

- **Model Libraries:** QualNet includes an extensive set of high-fidelity models of communication devices, wired and wireless links, communication protocols, environmental factors such as terrain and buildings, and real-world applications. These models are divided into a number of standard and optional libraries.

  - Standard libraries
    - Developer
    - Multimedia and enterprise
    - Wireless

  - Optional libraries
    - Advanced wireless
    - Cellular
    - Federation interfaces
    - LTE
    - Military Radios [ITAR]
    - Sensor networks
    - TIREM propagation interface (requires third party software)
    - Universal Mobile Telecommunications Service (UMTS)
    - Underwater communication networks
    - Urban propagation

# System Requirements

## CPU

- 64-bit (x86-64 compatible) processor

## Memory

- 512 MB free for LAN-size simulations without GUI
- 2 GB free for LAN-size simulations with GUI
- 2-4 GB for large networks (1000+ nodes)

## Disk

1 GB free disk space

## Video Card

Discrete graphics card with at least 128 MB memory supporting hardware 3D acceleration

## Display

1024 x 768 or better resolution

## Operating System

- Windows
  - Windows 10 Home or Windows 10 Pro (64-bits only)
- Linux (64-bits only):
  - CentOS version 7.6
  - Red Hat Enterprise Linux (RHEL) version 7.6
  - Ubuntu versions 16.04 LTS and 18.04 LTS

## Compiler (needed only if you want to modify the code)

- Windows
  - Microsoft Visual Studio 2017
  - Microsoft Visual Studio Community 2017 for Windows Desktop
- Linux

| Distribution | glibc Version | gcc Version |
|---|---|---|
| CentOS 7.6 | 2.17 | 4.8 |
| RHEL 7.6 | 2.17 | 4.8 |
| Ubuntu 16.04 LTS | 2.23 | 5 |
| Ubuntu 18.04 LTS | 2.27 | 7 |

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