Introduction:

QualNet allows it effortless to evaluate mobile communication networks more rapidly and realistically than any other tool available. To digitally represent the complete network, the various protocol layers, radios, antennas, and devices, it uses a network digital twin to represent the entire network. QualNet uses cutting-edge Parallel Discrete Event Simulation (PDES) algorithms to run high□fidelity simulations of large networks at speeds faster than real-time. PDES algorithms have been designed to take benefit of multi-core and parallel processors to drastically boost event processing rates and, consequently, simulation execution speeds.

The performance of communication networks is assessed under various operating settings using the QualNet network simulation platform (QualNet), and operational faults are found and addressed. The process of analysis begins with the creation of a simulation model, or scenario, that represents the network and its operating environment. The scenario is then carried out, and the outcomes are analysed.

key features of the QualNet simulator:

Mobility Modelling: To simulate the movement of nodes in a network, QualNet offers mobility modelling tools. It supports a variety of mobility models, including group mobility, random waypoint, and imported mobility traces from real-world settings.

Visualisation: To visualise and analyse simulation results, the simulator provides visual tools. Users can view real-time information, plot graphs, and produce reports for performance analysis while also keeping an eye on network behaviour.

Extensibility: The ability to create and combine unique network models, protocols, and algorithms is made possible by QualNet's extensible architecture. This makes it possible for researchers to test out new theories and modelling methods. Models for new protocols, devices, and applications can be quickly created and incorporated into simulation scenarios because to the QualNet framework's high degree of flexibility and extensibility. It is also possible to create high-fidelity models by include actual protocol implementation code.

Scalability: QualNet is built to handle complicated network topologies and large-scale network simulations with many nodes. To manage the computing burden, it uses effective simulation algorithms and parallel processing techniques.

QualNet can simulate a wide range of networks that are heterogeneous with thousands of nodes exchanging all kinds of traffic, including wired, wireless, undersea, satellite, etc. Since these scenarios can run faster than real-time speed, it is possible to analyse network performance under different operating circumstances quickly.

QualNet integrates with other well-known network research tools and frameworks like MATLAB, Python, and network simulators like OPNET and ns-3.

The Human-in-the-Loop (HITL) interface in QualNet offers dynamic interactions to modify a running scenario's activities. For instance, users can alter the traffic rate of particular apps and activate/deactivate nodes via the HITL interface.

Qualnet GUI: As the operation continues to operate, the QualNet GUI can be used to visualise various packet flow types to provide a functional perspective of the network. While an operation is taking place, dynamic statistics can also be seen on the screen

Implemention of QualNet scenarios:

The simulation of the network must precisely reflect the network in order to research and analyse real-world network performance. To build network scenarios using preconfigured models of devices, link-types, and applications, QualNet offers a simple drag-and-drop interface. By changing certain parameter values via user-friendly property editors, the scenario may be further modified. Additionally, QualNet offers domain-specific "palettes" of pre-configured network elements with sophisticated features, such as subnets, widely used devices, etc. This offers a practical method of producing simulation models of networks that are under construction.

QualNet offers a number of tools for quickly simulating "as is" networks and application traffic in order to analyse existing networks. As a result, planners and analysts may be certain that the outcomes of the model simulation will also hold true for the actual network.

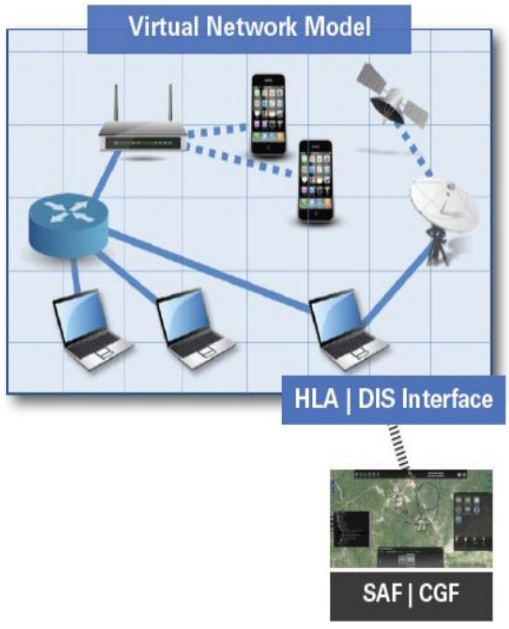
. These utilities consist of:

• Topology Converter: This programme takes a Visio-formatted network topology specification and builds a simulation model of the network from it.

• Packet Capture (PCAP) Traffic Mapper: With the help of a programme like Wireshark, this software transforms network traffic into equal simulated application traffic that can be used in a QualNet simulation to assess network performance.

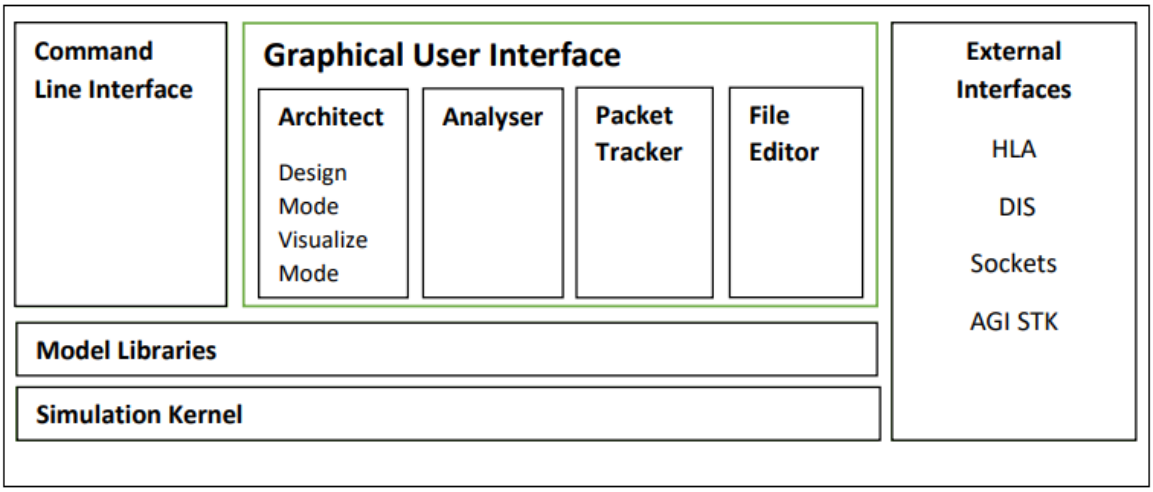
• NetFlow Importer: This programme similarly generates simulation models of actual network traffic, but it does so using traffic flow statistics reported in NetFlow packets rather than data from intercepted packets.

• Router Configuration Importer: In order to directly configure the relevant routers in the simulation models, this programme imports the real configuration files used to setup physical routers from well-known suppliers, such as Cisco.



Virtual Networking Model:

Qualnet Platform Architecture:



Components of QualNet:

The major components of QualNet are:

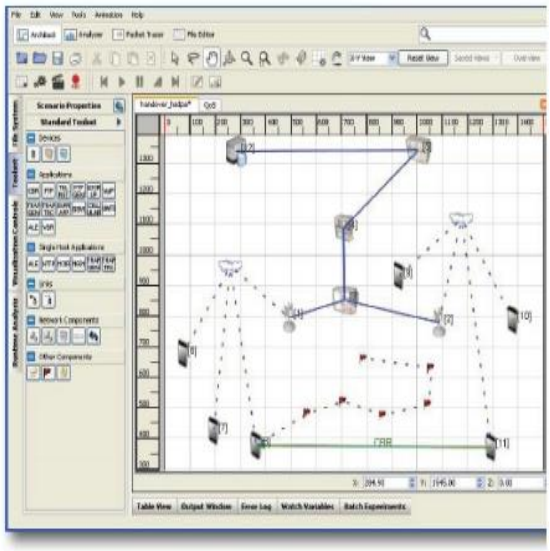
• Simulator: The simulator at the centre of QualNet employs cutting-edge methods to execute simulations of massive networks quickly without sacrificing accuracy. QualNet's foundation includes a highly specialised kernel and effective memory management strategies, which produce extremely fast simulation speeds.

QualNet also makes the most of the computational power offered by multi-processor systems by utilising effective PDES algorithms and smart partitioning, which involves evenly distributing the workload across the processors.

• QualNet GUI: The QualNet GUI offers a user-friendly platform for creating, viewing, and analysing network situations.

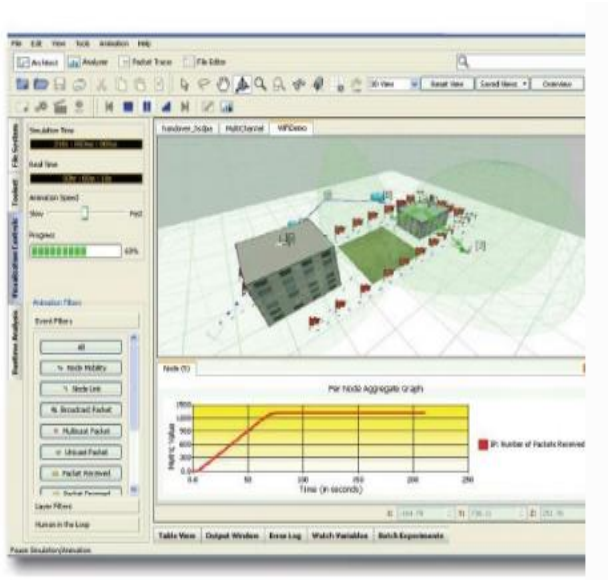
o Design Mode: This mode uses a simple point-and-click, drag-and-drop graphical interface to design virtual network models.

Virtual network models may incorporate communication equipment, wired and wireless links, wireless users' mobility patterns, physical features like topography and structures, protocols at all stack tiers, etc. There are several apps and services that may be used on the network.



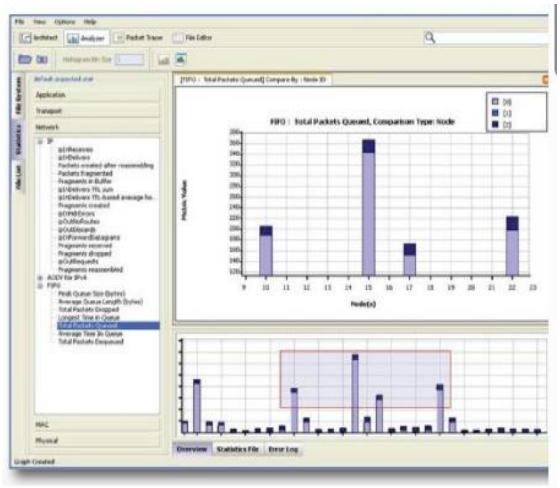
Design Mode

o Visualize Mode: Users may examine dynamic graphs of real-time data while watching packets at different tiers of the network flow across the network in this mode, which is intended to observe and analyse network behaviour while the simulation is running.



Vizualize Mode

o Analyzer: Analyzer is used to plot and analyse a huge amount of statistics gathered throughout the simulation after it is finished.



Analyzer

• Statistics Database: QualNet offers a high-performance database interface that enables time-series and statistical data to be kept in a database during the simulation run in addition to a statistics file. Different levels of granularity can be used to gather statistics, ranging from summary statistics at the system level to detailed information at the event level. The statistics database may be used to create reports and do post-experiment analysis.

• External Interfaces: Through High Level Architecture (HLA), Distributed Interaction Simulation (DIS), AGI's System Tool Kit (STK), and Socket interfaces, QualNet can federate with various simulators like kinetic warfare simulations without any issues.

• Model Libraries: Numerous detailed high-fidelity models of communication tools, wired and wireless connections, communication protocols, ambient elements including topography and structures, and real-world applications are all part of QualNet. There are several standard and optional libraries made up of these models.