COMMUNICATION NETWORKS GROUP

Introduction to QualNet®

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Simply a (non-quite experienced) user

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COMMUNICATION NETWORKS GROUP

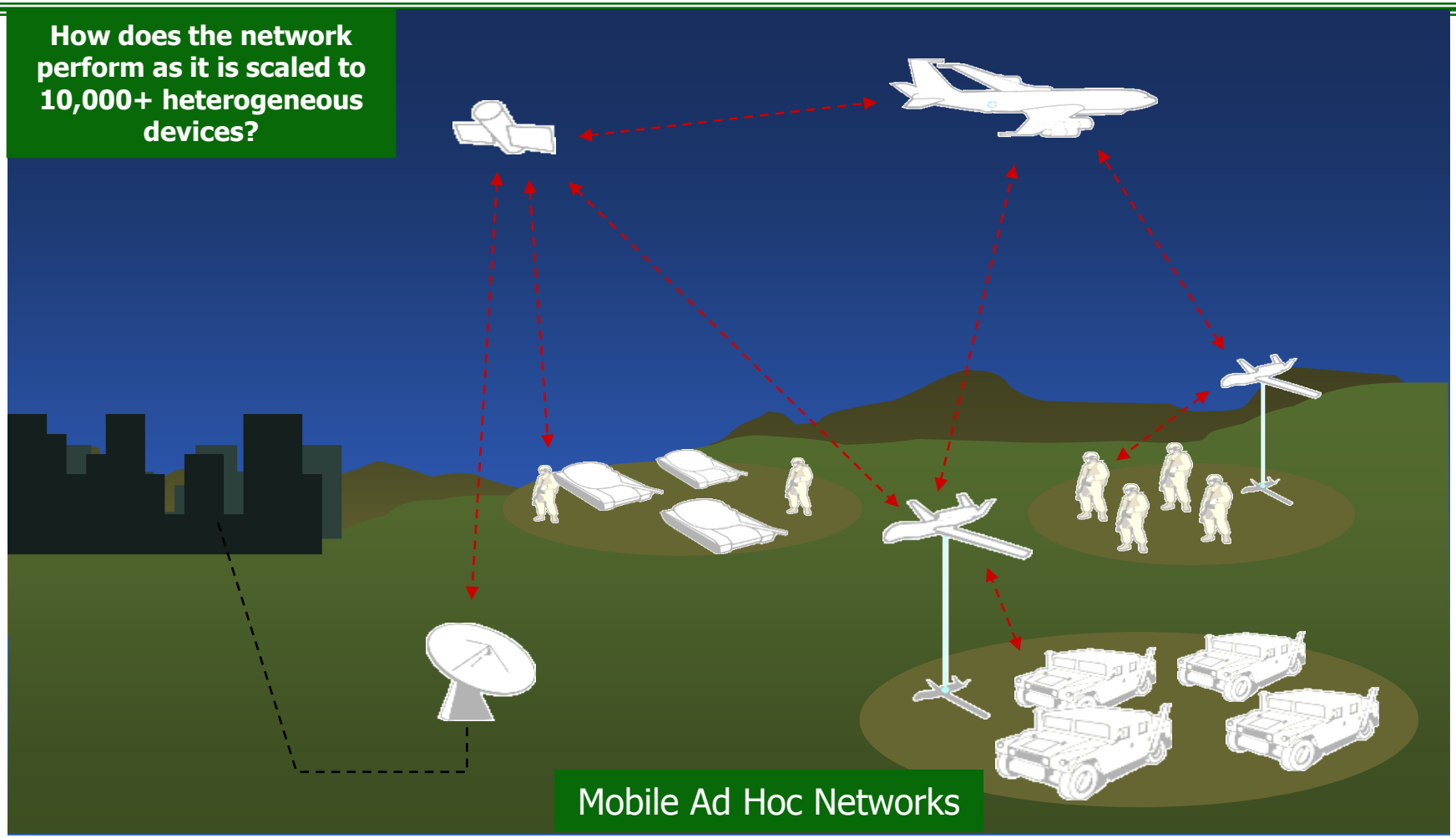
1. General Overview
2. IDE (GUI) Functional Overview
3. Command Line overview
4. Programming
5. Conclusions

What is QualNet?

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.

History

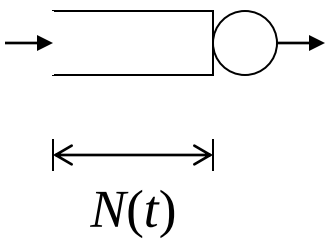


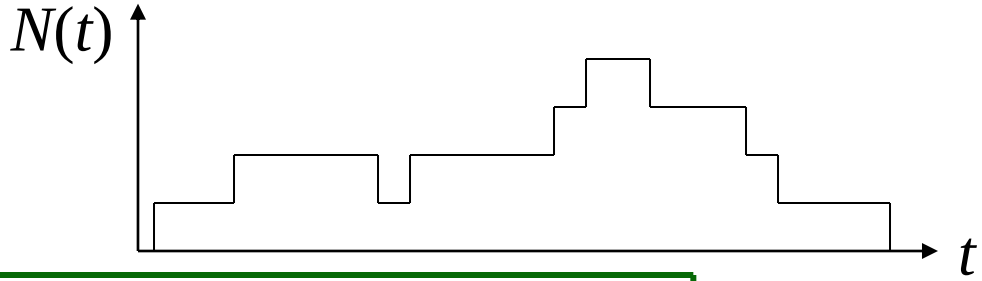
Genesis: GloMoSim, DARPA project at UCLA ('97 – '00) for efficient simulation of large heterogeneous networks. Parallel computing lab (Bragodia, Gerla and students)

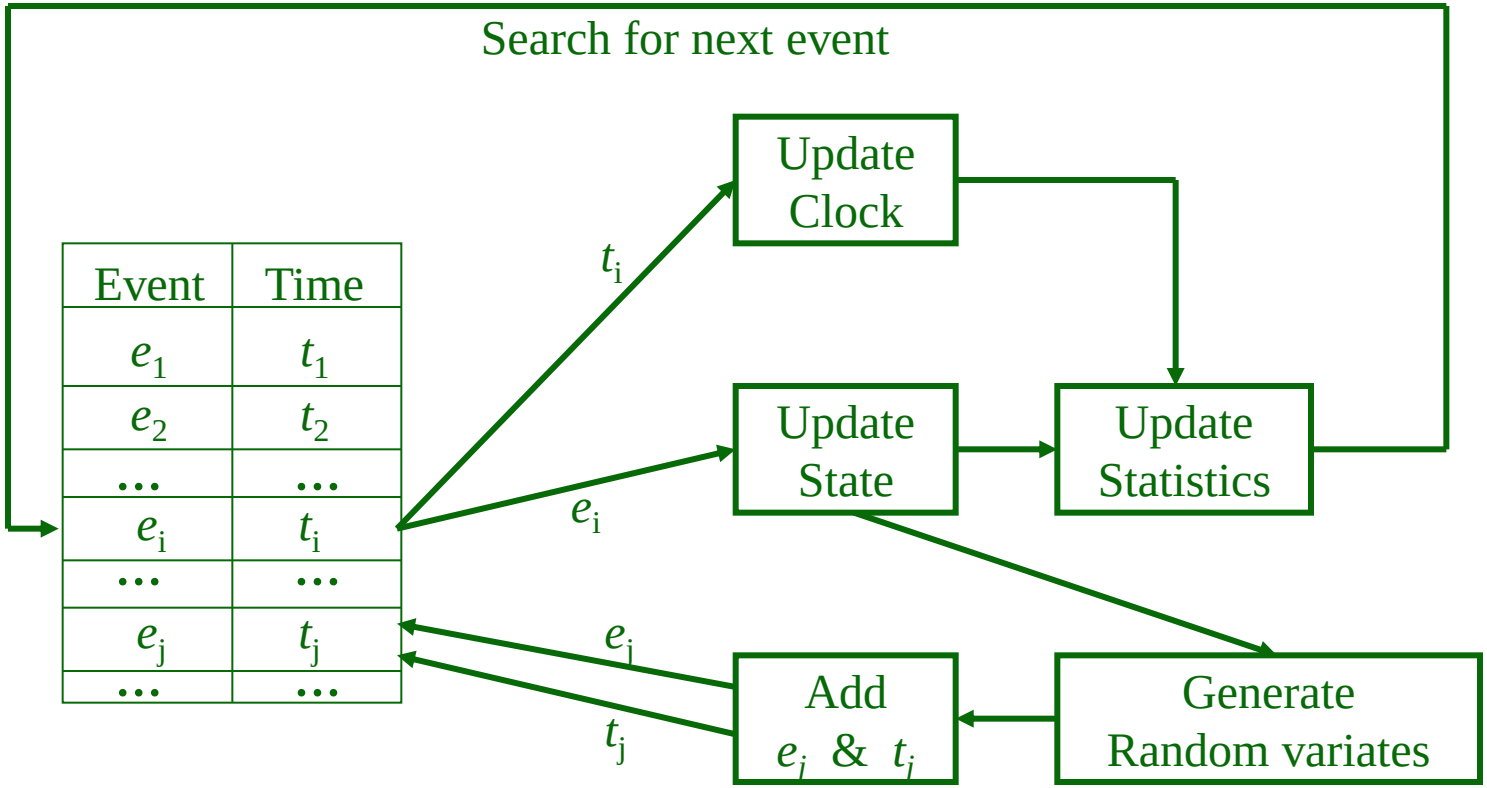
From GloMoSim to Qualnet

- **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

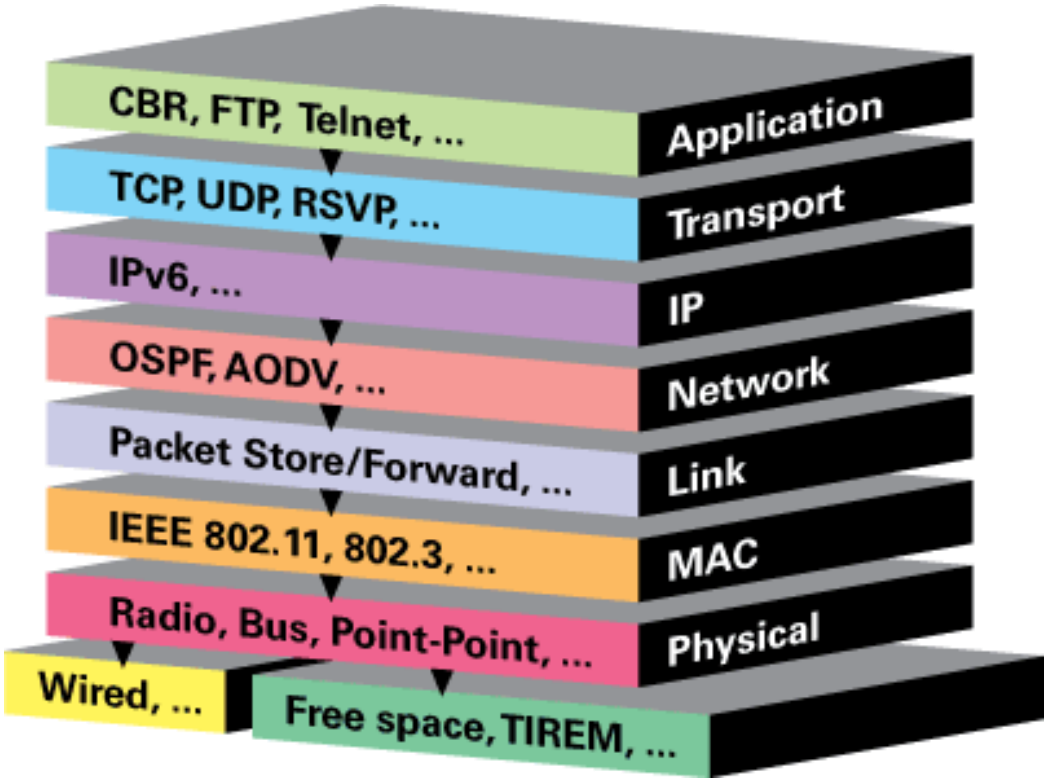






QualNet Architecture

- Layered architecture
- Well-defined APIs between adjacent layers.
- Support for native code migration between the model and operational networks.



Some Library Components

	Application Protocols	QoS Protocols	Transport Protocols	Queueing and Scheduling Models	Network Protocols	Routing Protocols	Multicast Protocols	MAC Protocols
Developer Library ✓ : IPv6 Compliant (included with QualNet Developer)	ATM IP over ATM ✓ CBR ✓ FTP / Generic ✓ HTTP ✓ LOOKUP MCBR ✓ Super Application ✓ tcplib ✓ FTP ✓ telnet Traffic-Gen Traffic-Trace ✓ VBR		Abstract TCP ATM IP over ATM ✓ TCP ✓ TCP Dump ✓ TCP Variants ✓ Lite ✓ New Reno ✓ Reno ✓ SACK ✓ Tahoe ✓ UDP	CBQ ✓ FIFO RED RIO Round Robin SCFQ ✓ Strict Priority WFQ WRED WRR	ARP ✓ HDP ICMP ✓ ICMPv6 new IPsec IPv4 ✓ IPv6	Bellman-Ford RIP v1 v2 ✓ ng ✓ Static Routing	IGMP ✓ Static Multicast	✓ 802.3 / Wired Bus ✓ Gigabit Ethernet Abstract Satellite Faults Wired Point-to-Point Link Wireless Point-to-Point Link
Multimedia & Enterprise Library ✓ : IPv6 Compliant	VOIP H225 H323 SIP	DiffServ Per Hop Behavior MPLS LDP RSVP-TE	VOIP RTCP RTP			BGP v4 ✓ BGP v6 (MBGP) new EIGRP HSRP IGRP OSPF v2 updated ✓ OSPF v3 new Policy Based Routing QOSPF Router Access Lists Route Map	DVMRP MOSPF PIM-DM PIM-SM	✓ Detailed Switch ✓ GARP ✓ GVRP ✓ Spanning Tree ✓ VLAN ✓ Switched Ethernet

Some Library Components

	Application Protocols	QoS Protocols	Transport Protocols	Queueing and Scheduling Models	Network Protocols	Routing Protocols	Multicast Protocols	MAC Protocols
Wireless Library ✓ : IPv6 Compliant						✓ AODV updated BRP DSR ✓ DYMO new Fisheye IARP IERP LANMAR LAR1 Mobile IPv4 ✓ OLSR Inria updated ✓ OLSRv2 new STAR ZRP	ODMRP	✓ 802.11 DCF ✓ 802.11 PCF ✓ 802.11e EDCA 802.11e HCCA new Aloha ✓ CSMA Generic MAC ✓ MACA TDMA
Advanced Wireless Library (Requires Wireless Lib.)								802.16 802.16e new
Military Radios Library (Requires Wireless Lib.)	MGEN PDEF SDF Threaded Comms							Link-11 † Link-16 † EPLRS new † SINCGARS new †

Some Library Components

		Application Protocols	QoS Protocols	Transport Protocols	Queueing and Scheduling Models	Network Protocols	Routing Protocols	Multicast Protocols	MAC Protocols
Cellular Library (Requires Wireless Lib.)		GSM Cellular				Abstract Layer 3 new GSM Layer 3			GSM
Propagation Libraries Each sold separately: (Require Wireless Lib.)	ALE/ASAPS								ALE †
	TIREM								
	Urban								

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, …

Let's go to QualNet!

- 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)

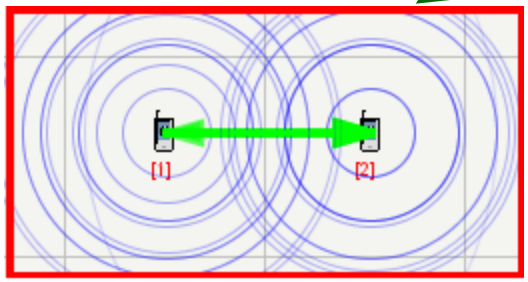
Run

.config file

QualNet Simulator

.stat file

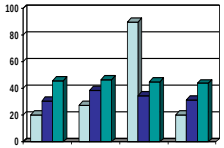
Simulator Feeds GUI



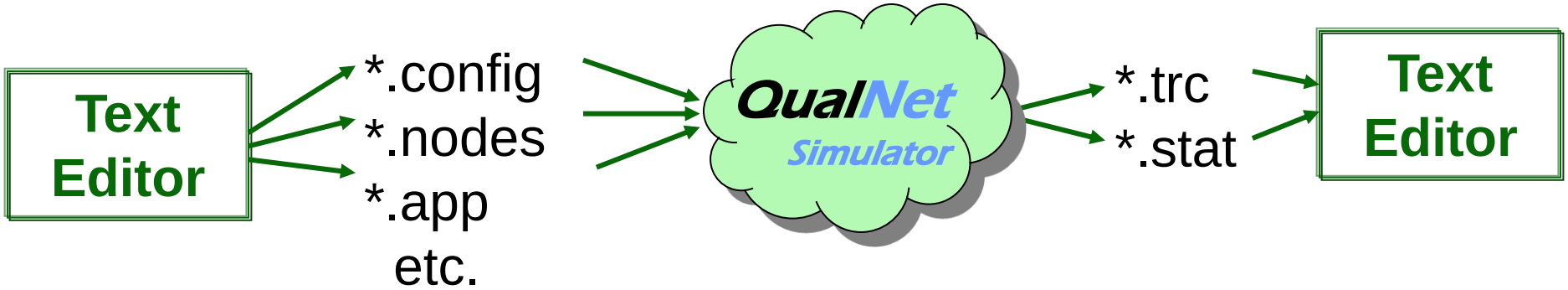
.trc file

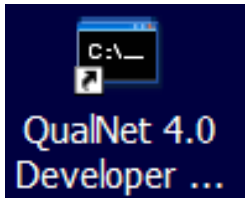
Packet Tracer

Analyzer



Configuration Files






```
C:\> qualnet  default.config
```

Configuration file

```
##########################################################################
# 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
```

Statistics file

Stat files contain column delimited information.

IP Address (optional): Usually just for queues and schedulers

Node ID

Code: Protocol specific value such as priority, port etc

Layer

Protocol

Stat

Value

```
1,          ,[1024], Application,  CBR Client,Server Address = 0.0.0.3
1,          ,[1024], Application,  CBR Client,First Packet Sent at (s) = 0.000000000
1,          ,[1024], Application,  CBR Client,Last Packet Sent at (s) = 9.000000000
1,          ,[1024], Application,  CBR Client,Session Status = Closed
1,          ,[1024], Application,  CBR Client,Total Bytes Sent = 14600
1,          ,[1024], Application,  CBR Client,Total Packets Sent = 10
1,          ,[1024], Application,  CBR Client,Throughput (bits/s) = 12977
```

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!

QualNet is a C/C++ program

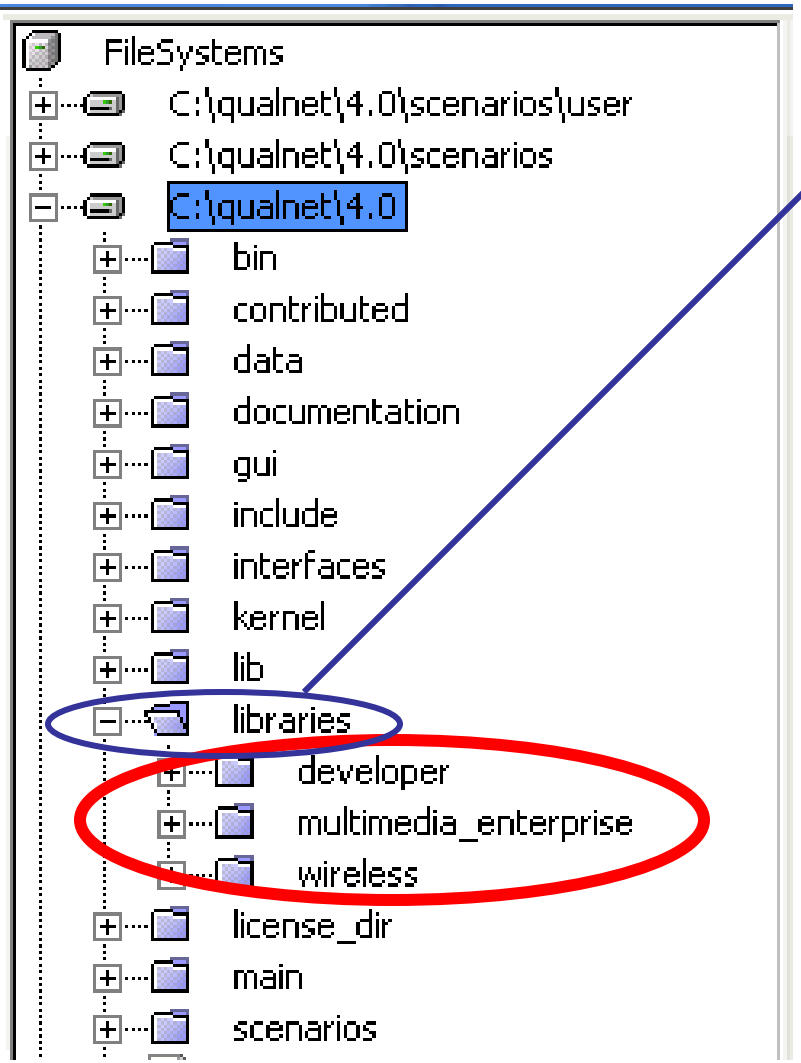
- Source files (*.cpp) and header files (*.h)
  - Some source files are precompiled – the source files aren't available in the distribution

- *Although QualNet is C++, it currently doesn't use the more complicated features of C++*

Programming Qualnet

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.

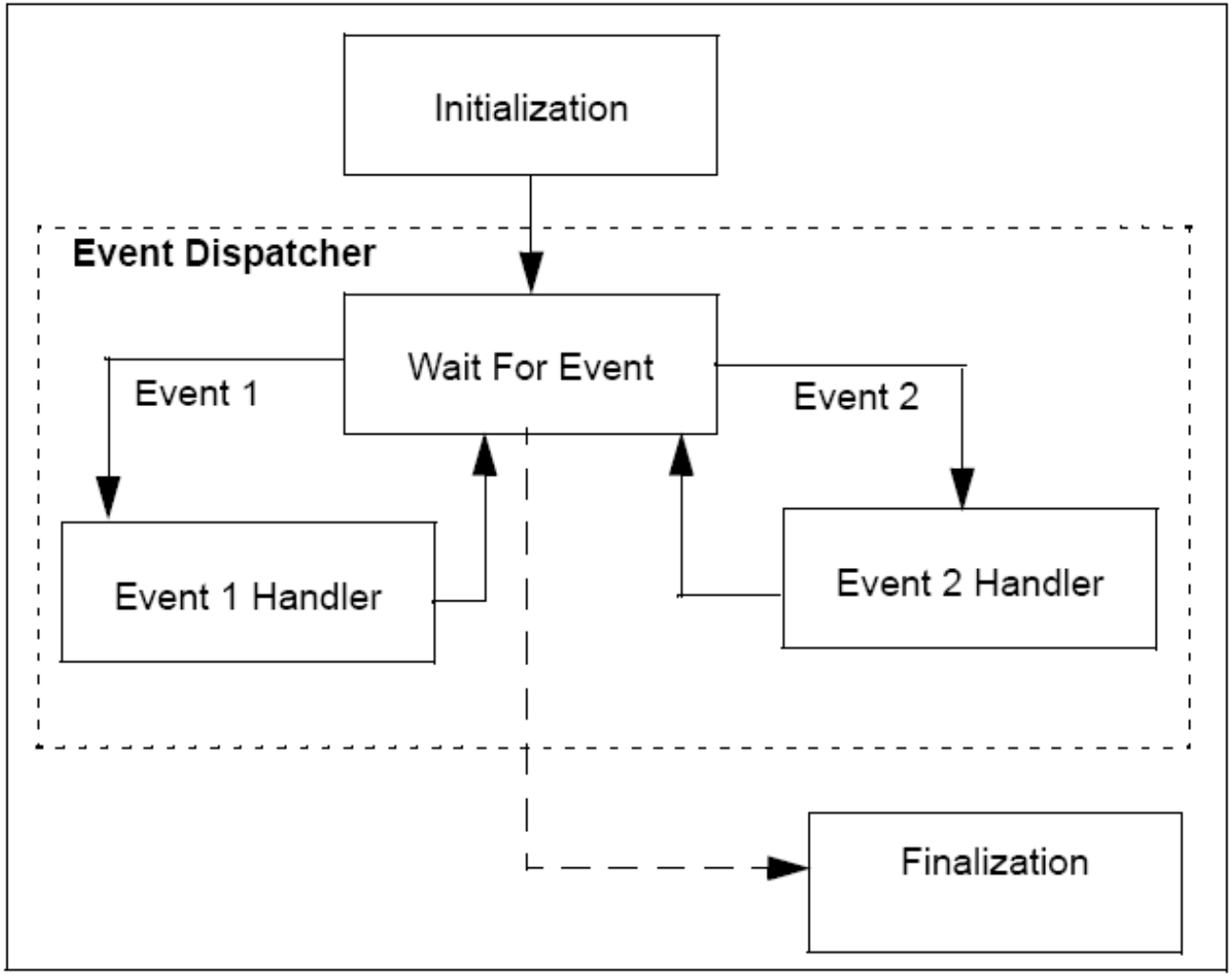
Modify source code and re-compile



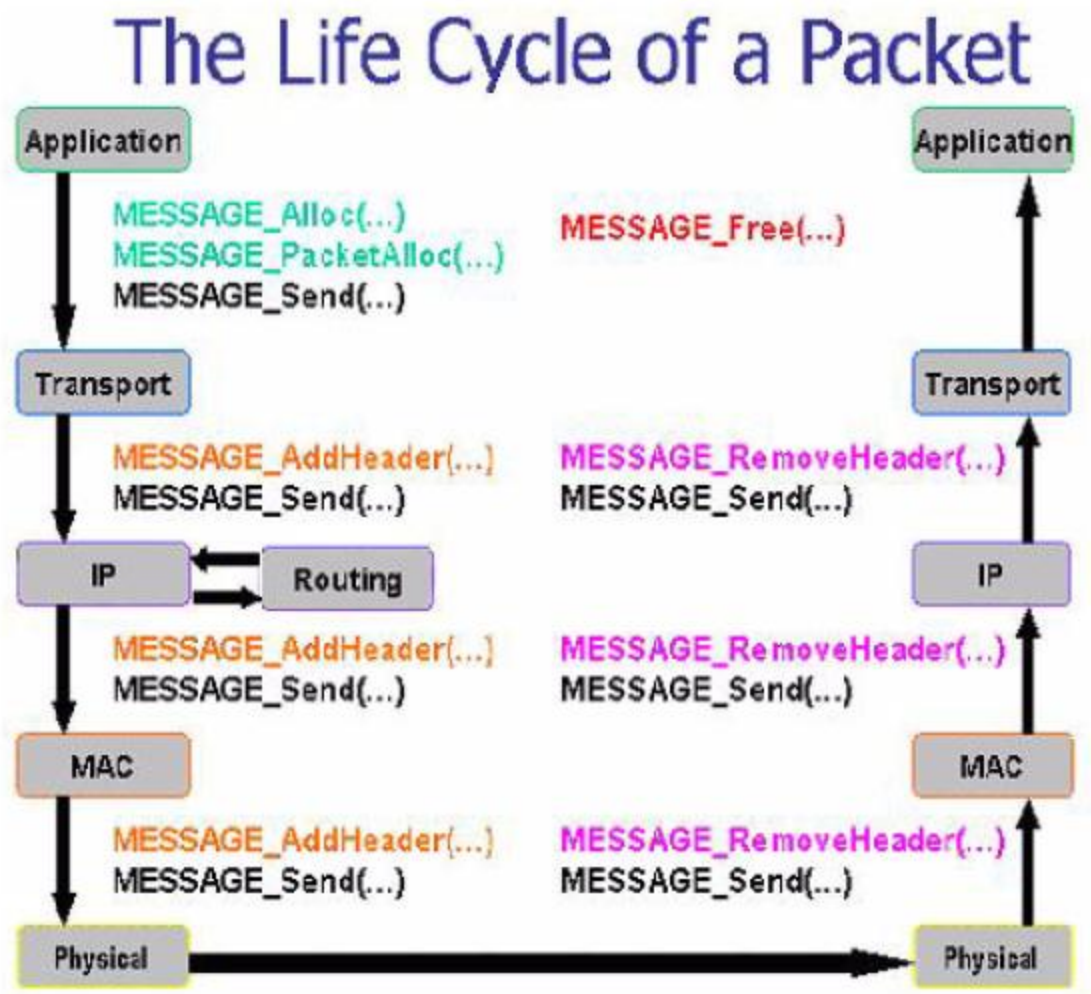
Here is the open source code for applications, transport, network, link, MAC and physical protocols

```
> cd ..\bin
> nmake
> qualnet
MiEscenario.config
```

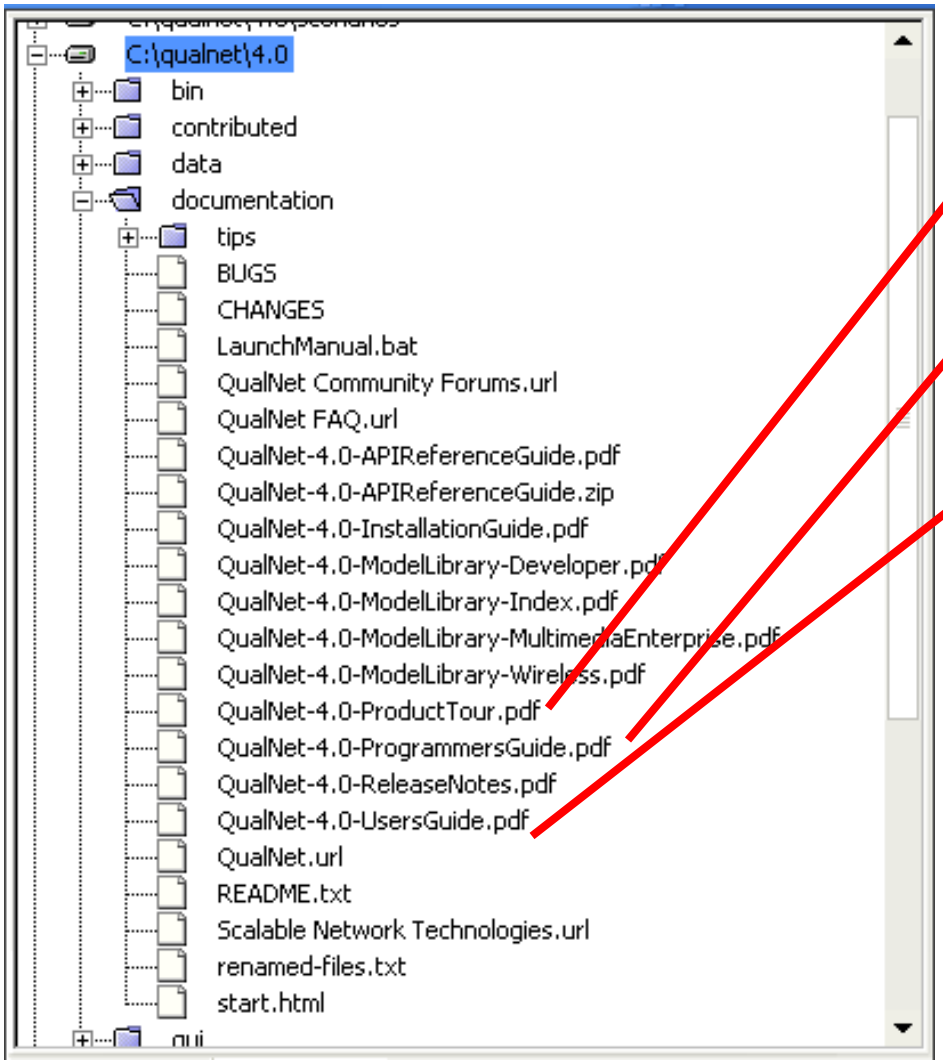
Protocol Model in QualNet



Event = Message = Packet (...or timer)



Nice Documentation



Quickly get acquainted with basic IDE features

A complete reference to protocol development

A more detailed review of basic IDE features

Conclusions

- 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. $)