NetSim® Pro

Network Simulation and Emulation Software

Defence Organisations
Corporate Enterprises
Network Equipment Manufacturers

Trusted by 400+ Organizations Across 25+ Countries

For Application Performance Analysis and Predictive Capacity Planning

New! Satellite Communication

New! 5G NR mm Wave

Internet of Things

Network Emulator

Software Defined Networks

Vehicular Adhoc Networks

TDMA Radio Networks

WHAT IS NETSIM® AND HOW IS IT USED?

NetSim is the industry's leading network simulation software for protocol modelling and simulation, network R & D and defence applications.

It is an end-to-end, full stack, packet level network simulator and emulator, providing researchers with a technology development environment for protocol modelling and network R&D. The behaviour and performance of new protocols and devices can be investigated in a virtual network within NetSim at significantly lower cost and in less time than with hardware prototypes.

Design the network

- Create network scenarios using NetSim's GUI or using XML config files
- Click and drop devices, links, application etc. into the environment using NetSim's GUI
- Set properties with just a click. Layer-wise parameters can be edited

Run the simulation

- Run the Discrete Event Simulation (DES) through the GUI or CLI
- Log packet trace and event trace files
- Capture packets using Wireshark

Visualize the simulation - packet animator

- Animate packet flow over wired and wireless links
- Colour variation for control packets, data packets and error packets
- Animate mobility of devices
- Control animation with play, pause and simulation time-line

Analyse the results

- Examine output performance metrics at multiple levels - network, sub network, link, queue, application etc.
- Study a variety of metrics such as throughput, delay, loss, packet error, link utilization etc.
- Interpret metrics using in-built plots and graphs
- Create pivot tables and charts for visualization

Interface with external software

- MATLAB®
- SIMULINK®
- SUMO
- WIRESHARK
- Python

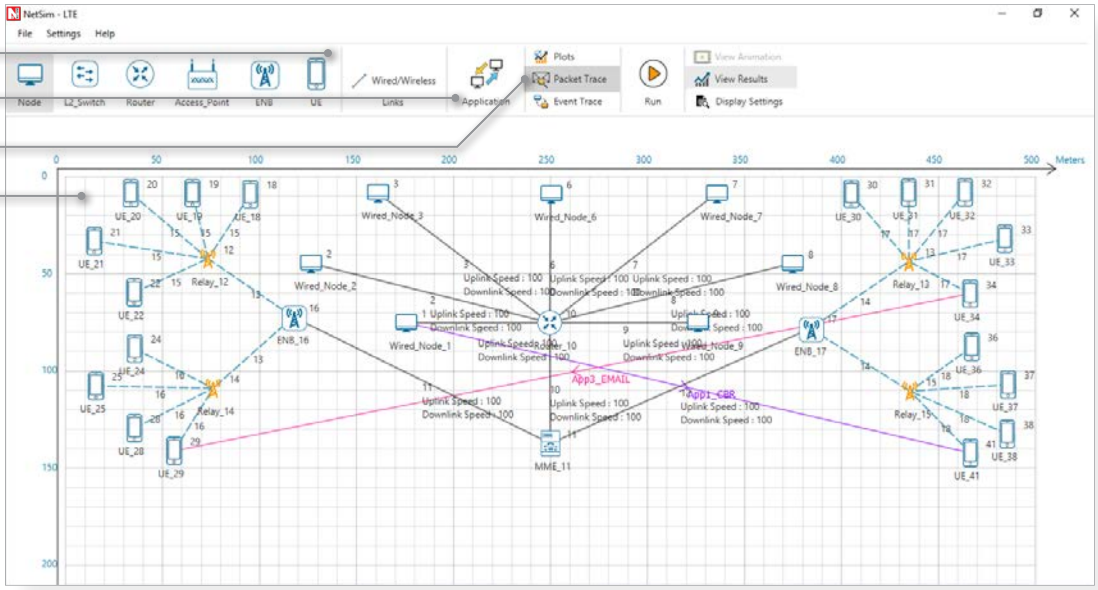
Develop your own protocol / algorithm

- Extend existing algorithms by modifying NetSim's source C code
- Create custom protocols using NetSim's simulation API's
- Debug your code (step-in, step-out, step-over, continue) and watch your variables in sync with simulation

WHAT DOES NETSIM'S USER INTERFACE LOOK LIKE ?

Devices & Links
Application
Traces
Environment

Design Window



Tabular Output
Dynamic Metrics Plot
Source Data
Print
Reset Plot
Color Picker

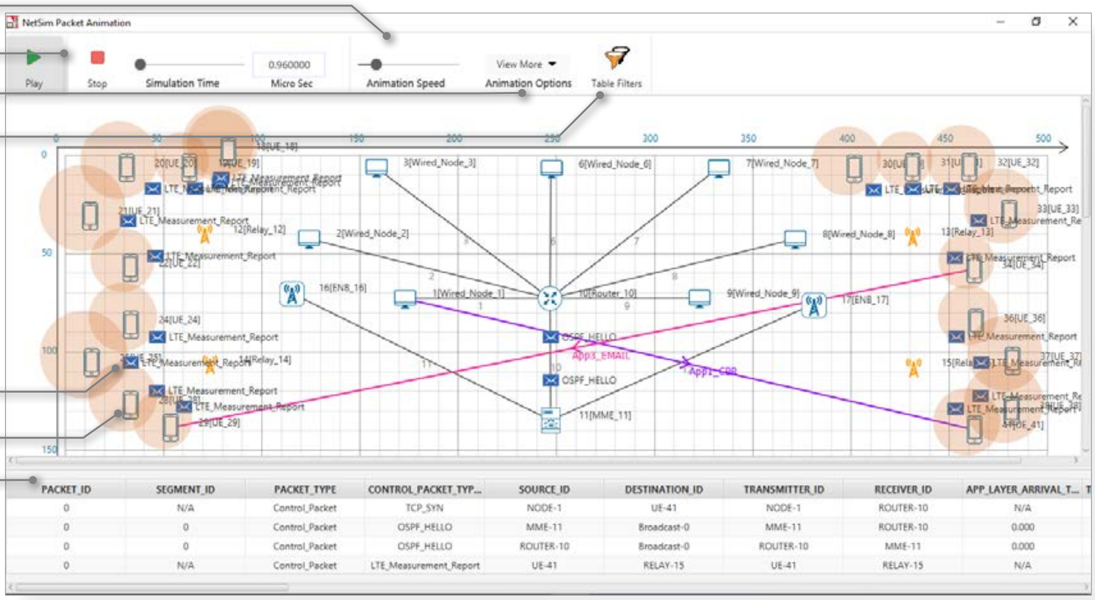
Results Window

Packet & Event Trace
Log files
Plot Window

Speed Controls
Play / Pause / Stop
Animation Options
Table Filters

Animator Window

Packet Flow
Node Mobility
25+ Fields of Packet Information



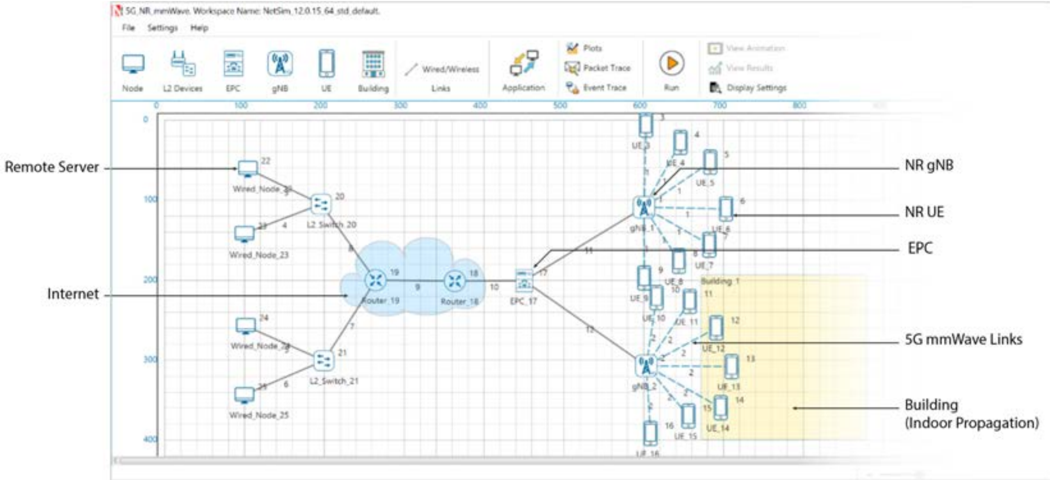
EXPLORE THE WIDE RANGE OF PRODUCT CAPABILITIES

Libraries (Toolboxes)	Networks / Protocols
Component 1 (Base. This is required for all other components to run)	**Inter-Networks:** Ethernet - Fast & Gigabit, ARP; WLAN - 802.11 a, b, g, n, ac and e Propagation - Pathloss, Shadowing, Fading; IPv4, Firewalls Routing - RIP, OSPF; Queuing - Round Robin, FIFO, Priority; TCP - Old Tahoe, Tahoe, Reno, New Reno, BIC, CUBIC, SACK, Window Scaling; UDP **Common Modules**: Applications (Traffic Generator): Voice, Video, FTP, Database, HTTP, Email, Peer-to-peer and Custom; Encryption - XOR, TEA, AES, DES; Virtual Network Stack, Simulation Kernel; Command Line Interface, Metrics Engine with Packet Trace and Event Trace; Packet Animator, Results window with dynamic plots ; Command Line Interpreter **External Interfaces**: Wireshark and MATLAB interfaces
Component 2	**Legacy & Cellular Networks**: Pure Aloha & Slotted Aloha, GSM and CDMA
Component 3	**Advanced Routing and Switching**: IGMP, PIM, VLAN, ACL, NAT, Layer 3 Switch
Component 4	**Mobile Adhoc Networks**: MANET - DSR, AODV, OLSR, ZRP; Multiple MANETs, Interfacing with Bridge Node
Component 5	**Software Defined Networks**: Open flow v1.3 Compatible
Component 6 (Requires C4)	**Internet of things**: IoT with RPL protocol Wireless Sensor Networks (WSN) LR-WPAN 802.15.4, Energy model
Component 7	**Cognitive Radio Networks**: WRAN IEEE 802.22
Component 8	**Long-Term Evolution Networks**: LTE (4G), LTE Advanced (4.5G)
Component 9 (Requires C4)	**Vehicular Adhoc Networks**: IEEE 1609 WAVE, Basic Safety Message (BSM) protocol per J2735 DSRC, Interface with SUMO for road traffic simulation
New! **Component 10** (Requires C3. Requires C8 for NSA mode)	**5G NR Networks**: Based on 3GPP 38.xxx / Rel 15 SA/NSA, SDAP, RRC, NAS, PDCP, RLC, MAC, PHY, MIMO, Beamforming, mmWave Propagation and Channel Models
New! **Component 11** (Requires C3)	**Satellite Communication Networks**: Geo Stationary Satellite. Forward link TDMA in Ku Band and Return link MF-TDMA in Ka band per DVB S2. Markov Loo Fading model
TDMA Radio Networks Add On (Requires C4)	TDMA link 16, Dynamic TDMA, Frequencies – HF/ HVF / UHF Frequency hopping, Crypto
Network Emulator Add On	**Network Emulator**: Connect real hardware running live applications to NetSim Simulator. Interface with Raspberry Pi

NETSIM 5GNR LIBRARY

Overview

- End-to-End simulation of 5G networks
- Devices: UE, gNB, EPC, Router, Switch, Server
- Interfaces with NetSim's proprietary TCP/IP stack providing simulation capability across all layers of the stack
- Application Models - FTP, HTTP, Voice, Video, Email, DB, Custom and more
- 5G Core covering AMF, SMF and UPF. SA and NSA and NSA (LTE-5G dual connectivity) deployment architectures



Specifications

- SDAP based on specification: 37.324, RLC based on specification 38.322 and PDCP based on specification 38.323
- MAC Layer based on specification 38.321
  - MAC Scheduler featuring Round Robin, Proportional Fair, Max Throughput and Strictly fair algorithms
  - Link Adaptation to change MCS based on CQI
- PHY Layer
  - Flexible sub-carrier spacing in the NR frame structure using multiple numerologies µ = 0, 1, 2, 3
  - Carrier aggregation
  - CQI - MCS - TBS
  - PHY layer modulations supported - BPSK, QPSK, 16QAM, 64QAM, 256QAM
  - MIMO operation with layer count equal to Min (Tx-antenna-count, Rx-Antenna-count).
    - » gNB antenna count supported 1, 2, 4, 8, 16, 32, 64, 128
    - » UE antenna count supported 1, 2, 4, 8, 16
  - MIMO Spatial channel model
    - » MIMO Spatial Channel Model (SCM), i.e., the channel is represented by a matrix H, whose entry (t, r) models the channel between the t-th and the r-th antenna elements at the transmitter and the receiver.
    - » Gaussian channel with Rayleigh fast fading: i.i.d Complex Normal (0, 1) channel (H-matrix) that changes independently every coherence time.
  - Beamforming gain per the eigen values of the covariance (Wishart) matrix
- RF propagation (Based on 3GPPTR38.900 Channel Model)
  - Rural Macro, Urban Macro, Urban Micro, Indoor, Mixed and Open Office. LOS/NLOS. Outdoor to Indoor
- Handover - Mobility and Handover

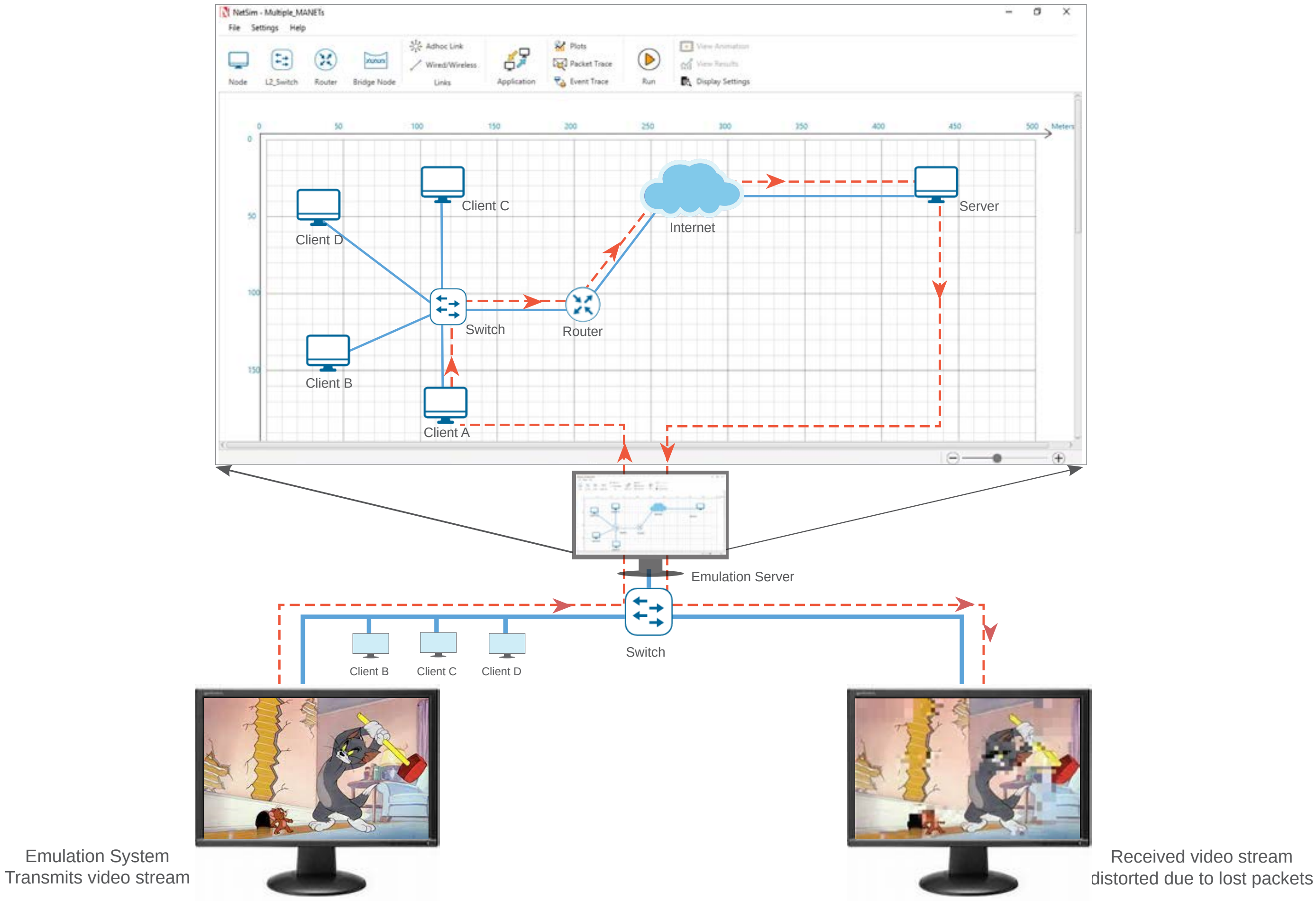
Featured Examples

- Effect of distance on pathloss for different channel models - Rural-Macro, Urban-Macro, Urban-Micro
- Effect of UE distance on throughput in FR1 and FR2
- Impact of MAC Scheduling algorithms on throughput, in a Multi UE scenario
- 5G Peak Throughput: 3.5 GHz n78 band, 26 GHz n258 band
- Impact of numerology on a RAN with phones, sensors, and cameras
- 4G vs. 5G: Capacity analysis for video downloads

HOW DO I CONNECT REAL DEVICES TO NETSIM FOR EMULATION ?

NetSim emulator provides critical insights into application performance by enabling user to run their live application over an equivalent virtual network and see how the application is performing in real time.

NetSim is an IP based, data plane, flow-through network emulator; NetSim emulates the network for the data flowing between the client(s) and server(s)



What is Emulation?

» NetSim Emulator enables users to connect NetSim simulator to real hardware and interact with live applications
» Users can test the performance of real applications over a virtual network.
» If you are designing a new network or expanding an existing network then NetSim emulator will enable you to run your live application over an equivalent virtual network and see how the application is performing in real time

How does it work?

» Create the desired network in the Emulation server using NetSim GUI
» Route traffic from the PC's/VM's where your application runs, to NetSim emulation server
» Each live PC/VM corresponds to a node in the simulated network. In the simulated network map the device IP addresses per the real PC/VM
» Run your application & Measure various parameters such as throughput, delay, loss etc. for your live application using Wireshark

Where can it be used?

» Military radio networks
» Satellite link analysis
» Metro rail networks
» R&D in new protocol design

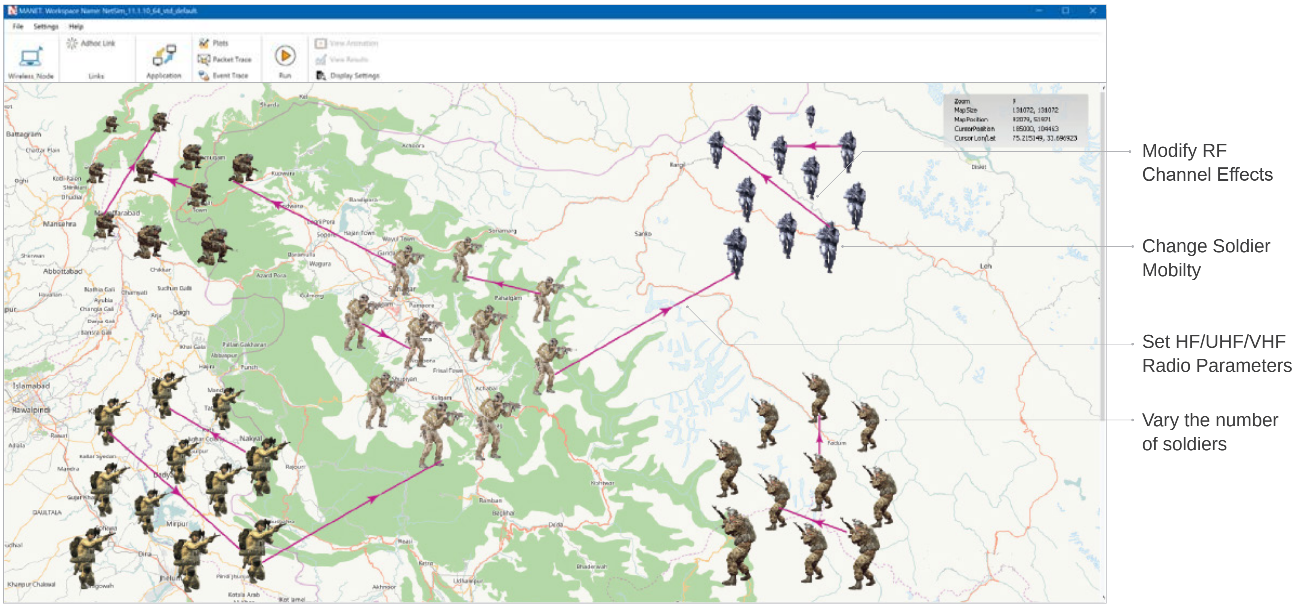
What are the benefits?

» Can be used to emulate a wide range of technologies
» Switching, Routing, MANETs, 4G-LTE networks etc.,
» NetSim Emulator is a cost effective alternative to hardware emulators that have high costs, complicated configuration requirements and limited scale

NETSIM APPLICATION - MANPACK UHF RADIOS

Model, simulate and analyse the performance of a Tactical MANET radio network

- 50 soldiers engaging the enemy, are divided into five groups with 10 in each group.
- Soldiers in each group are continuously moving. Soldiers belonging to a group move together
- Communication happens within the group, as well as across the group.(Inter and Intra communication)



- Technology: MANET over TDMA
- Simulation Environment Size: 5 Km * 5 Km
- 50 wireless nodes in 5 groups of 10
- Transport Layer: UDP
- Network layer: DSR, AODV, ZRP, OLSR
- Data Link Layer: Dynamic TDMA
- Physical Layer
  - Protocol: DTDMA
  - Band: UHF
  - Frequency Range : 476 MHz to 478 MHz
  - Channel Bandwidth (MHz): 2
  - Frequency Hopping: ON
  - Modulation: QPSK, 16-QAM, 64-QAM
  - Transmitter power: 4W
  - Receiver sensitivity: -119 dBm
- RF Propagation
  - Path Loss Model: Log distance
  - Fading Model: Rayleigh
  - Shadowing Model: Log Normal
- Applications: 13 Voice Applications
- Traffic rate:
  - 9.6 Kbps voice traffic
  - Two voice applications between the same group members.
  - One voice application between members in different groups
- Crypto: AES

Performance Analysis

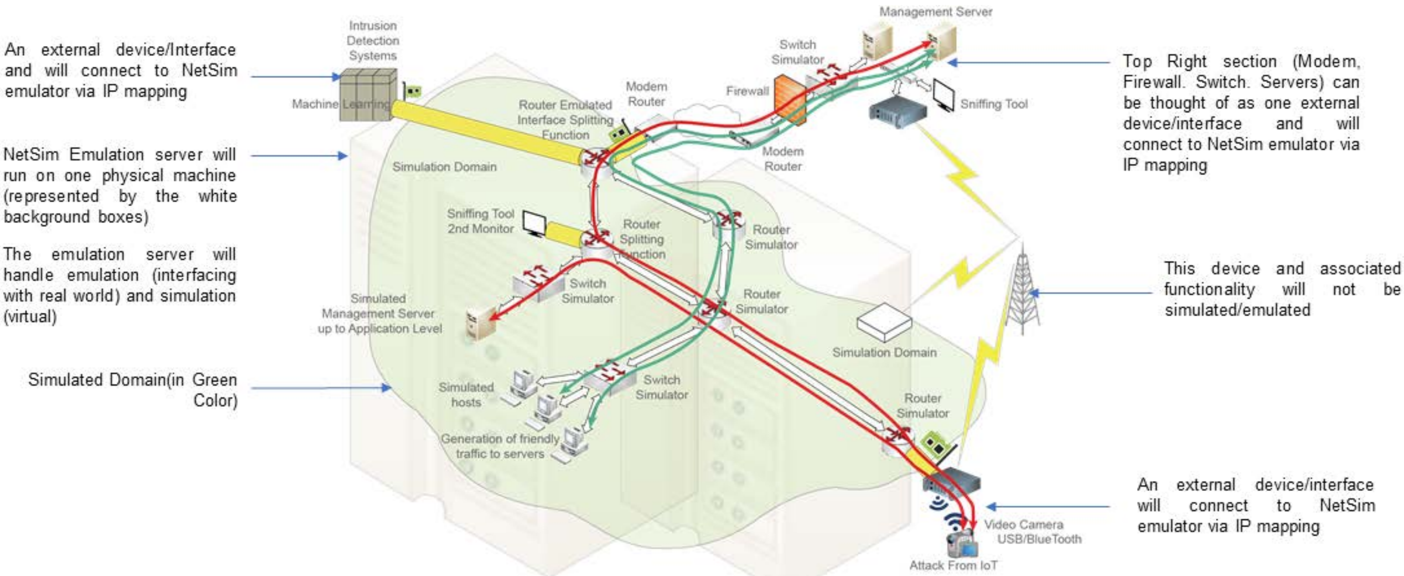
- We analyze the performance of Network layer protocols AODV and OLSR in terms of the latency experienced by the voice packets. We also analyze how multi-hop communication happens in this case, and estimate the route acquisition times

Conclusions

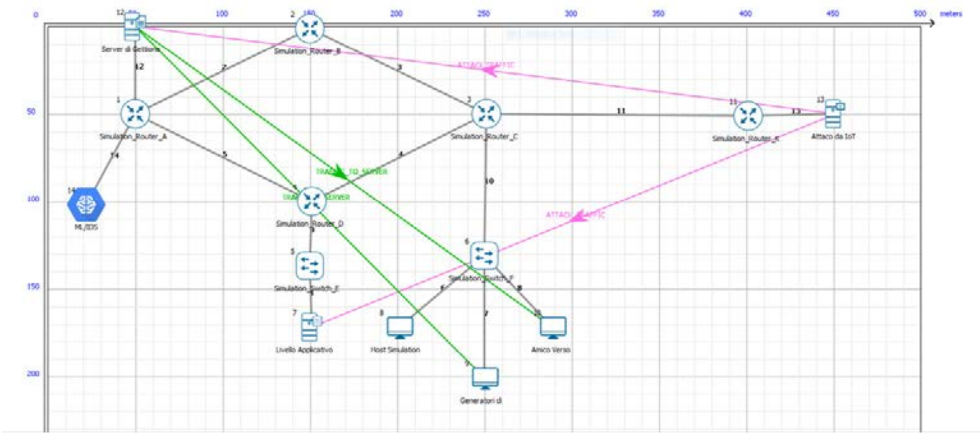
- AODV protocol has lower latency when compared to OLSR, and hence the preferred protocol to use
- The latency exceeds acceptable threshold when there are more than four hops involved
- Route acquisition time increases drastically with higher soldier mobility and with large RF propagation losses

NETSIM APPLICATION - EMULATION OF ATTACKS IN A IOT NETWORK

Model, simulate and analyse the performance of a network using a platform offering simulation and emulation capabilities. Combine a simulation scenario populated with virtual devices and emulated (Real Hardware) devices, and on the periphery of the network are physical IoT devices interfaced through a specific gateway.



- Red represents attack traffic from a penetrated video camera
- Green represents normal traffic to the server in the emulation domain
- A machine learning system gets data from the simulator through a virtual interface of the router simulation model.
- The tower indicates a wireless data connectivity through LTE etc

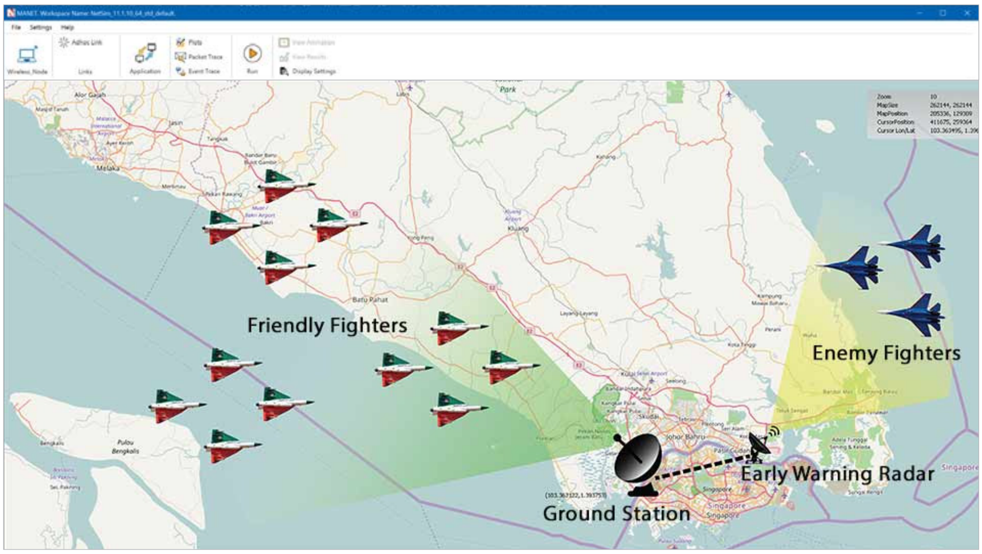


NetSim Emulator Working and Conclusions

- The 'entire network (real + virtual)' was created in NetSim. And then a mapping of real devices to equivalent simulated devices in NetSim was done through the NetSim UI
- The balance virtual devices, in the simulation domain, were purely virtual. Real traffic 'interacted' with 'virtual' traffic inside NetSim, underwent network effects (delay, loss, error etc) and then was transmitted out from NetSim again into the real world.
- A pcap capture was logged from the 'virtual router' in NetSim.
- The Machine Learning system analysed the logged pcap files and suggested suitable configuration changes

NETSIM APPLICATION - TACTICAL DATA LINKS

Model, simulate and analyse the performance of a tactical data link for a national aerospace company



- A Ground Station (GS) is connected to the Early Warning Radar (EWR), via ground network infrastructure.
- The GS starts up the network, does the time slot assignment, generates the crypto key and the frequency hopping pattern
- GS then broadcasts the Air Picture to all friendly aircraft
- Friendly aircraft broadcast their positions periodically to one another and to the GS
- When enemy aircraft is detected by the EWR it transmits information to the GS
- GS in turn broadcasts the updated Air Picture to friendly aircraft, which then engage the enemy

Parameter	Value
Grid Length	300x300 km
Slot Duration	50 ms
Encryption	AES256
Bits per slot	2500 bits
RF Power	20 W
Modulation	QPSK
RX Sensitivity	-108 dbm

Performance Analysis

A set of simulation runs covering a wide range of input parameters were run to study the system performance. Some of the observations discovered after an in-depth analysis of the simulation results were -

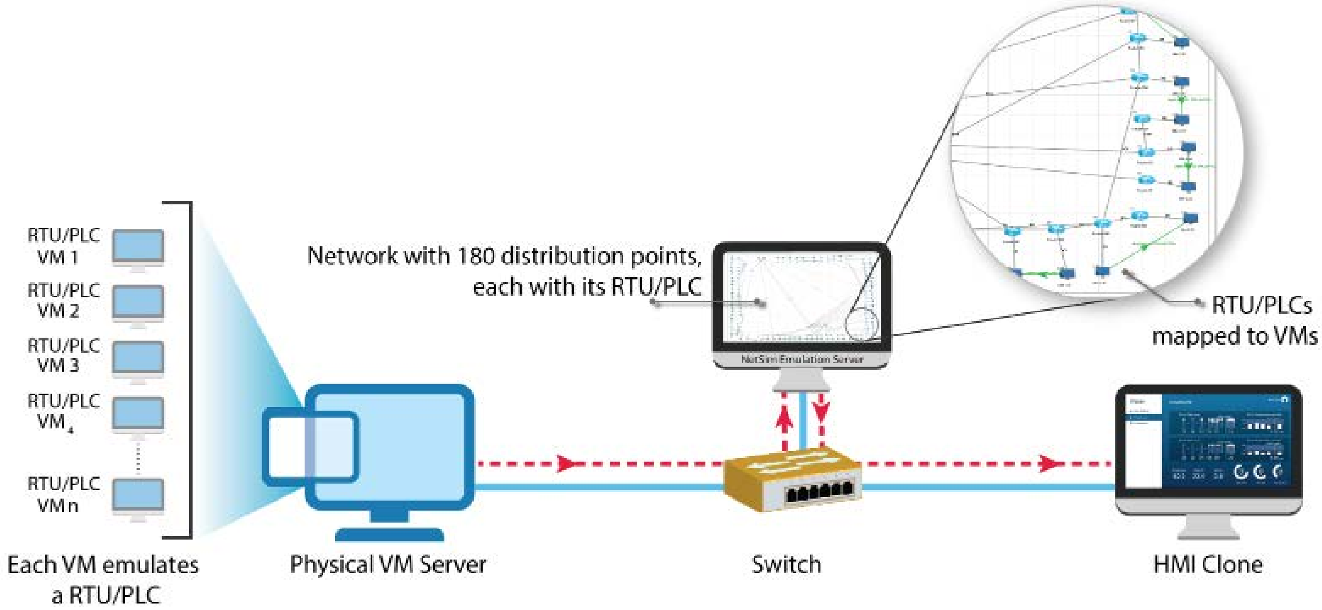
- With the low bit rates available and with RF propagation losses too many Air Picture packets
- Time slots were not immediately available for the GS given the round robin slot allocation

Conclusions

- Reduce the Recognized Air Picture (RAP) packet size
- Move from a round robin to demand based slot allocation
- Layer 3 routing could be added in the future for communication between nets

NETSIM APPLICATION - UTILITIES DISTRIBUTION

Emulate and study the performance of a radio network for a SCADA system, for water distribution



The water distribution network comprises of three components

- Remote Terminal Units (RTU) which are field operational units performing local process control
- Central Human Machine Interface (HMI) which provides visualization and control of RTU activity individually and collectively from a central location
- An interconnecting network comprising of radios, switches, routers and transport media.

Each RTU has a router which acts as a layer-3 device and includes a gateway and a firewall. Each RTU will also be a separate IP subnet to facilitate encoding of location and other information in the IP addressing. The HMI is a redundant pair of SCADA nodes running as virtual machines on two physical servers at a single location which are also fire-walled from the other network components.

Simulation Environment

This real-world system was first tested in a virtual laboratory environment comprising of hardware, software and interconnections as close to the actual system as possible.

The HMI VM was cloned into the sim environment. The RTU PLCs are modelled using Rockwell Automation's SoftLogix. A VM was used for each instance of SoftLogix. Each SoftLogix simulated six controllers in a single 17 slot virtual rack. NetSim emulator was used to interconnect these two components and to emulate the 3rd component i.e. the radio network.

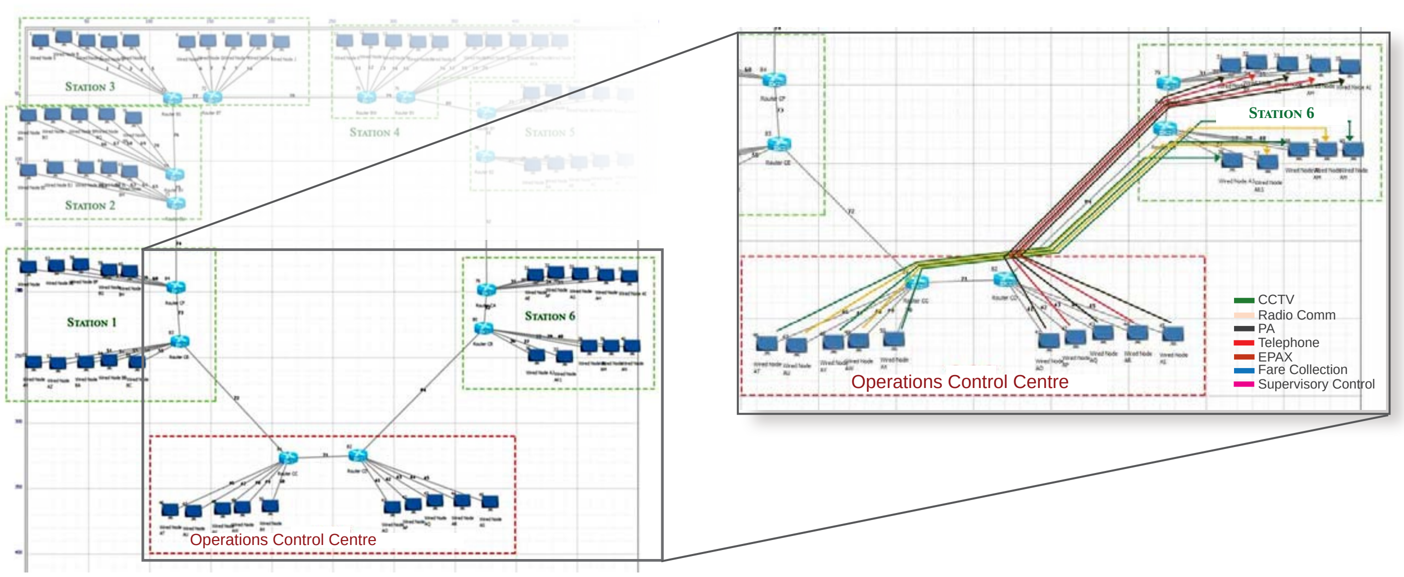
Conclusions

In this virtual lab, numerous test scenarios were constructed and executed repetitively for normal operation as well as perturbed operation. Impairment scenarios were studied which included escalating latency, bandwidth constriction at various points, jitter tolerance, packet loss, packet reordering, route loss, fail-overs and single point of failure identification. An optimal design was then arrived at based on the simulation results.

NETSIM APPLICATION - METRO RAIL COMMUNICATION NETWORK

Simulate the communication network of a metro railway line and develop a detailed traffic model to meet the system design of all of the sub-systems to make an assessment of:

- Traffic patterns and the required minimum network capacity
- Resulting bandwidth to satisfy the communication needs of each site and each sub-system
- Minimum 25% spare capacity, available at each site, for future expansion



The overall railway communication network is composed of four rings, which was simulated and analyzed. Traffic models were created for:

- CCTV
- Radio Communication
- PA
- Telephone
- EPAX
- Fare Collection
- Supervisory Control

Simulation Assumptions

- The link error rate assumed is Bit Error Rate (BER) of 10^{-6} which is higher than the typical rate of 10^{-9} thereby giving us a more conservative estimate of throughput
- The propagation delay in the links is 5µs seconds and the packet size is 1500 bytes.
- All traffic modelled was unicast traffic flowing from Control Centre to stations

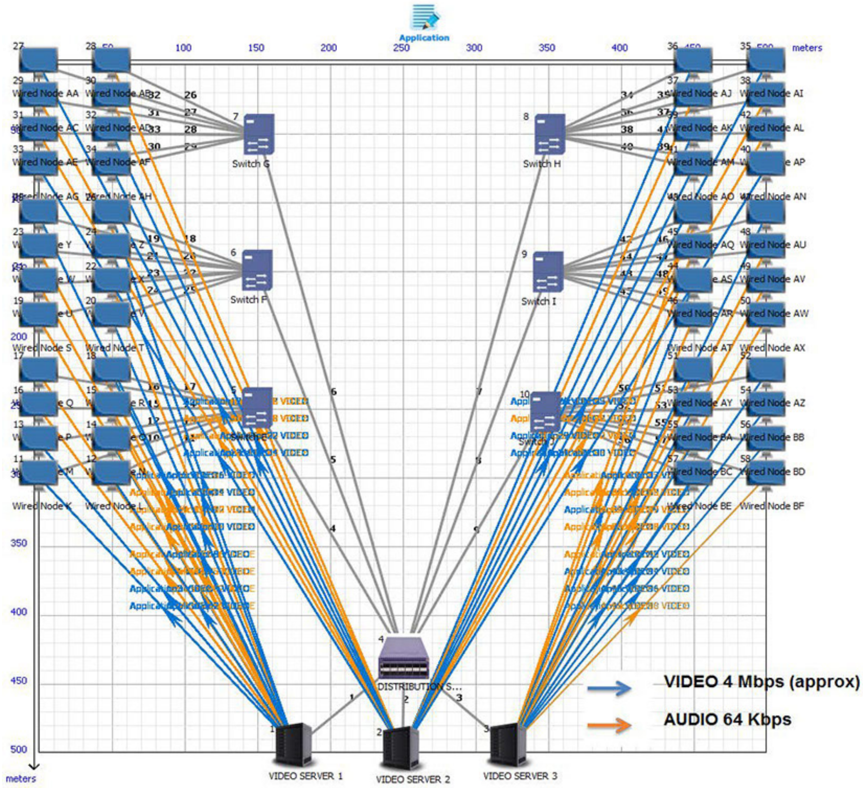
Conclusions

NetSim simulation was run during which 2 million packets and 22 million events were processed.

- **Increase link capacity**: The result of the performed simulation showed that the worst case scenario caused traffic loaded to cross 1 Gbps and hence the original link dimensioning had to increase to factor this in.
- **Use multicast where possible:** These results were based on simulation of unicast traffic. If the path between server and client traverses h3 router hops and h2 switch hops, the “unicast” video would consume 1.5 x n x h3 Mbps of router bandwidth, plus 1.5 x n x h2 Mbps of switch bandwidth, where n is the number of unicast clients. However in a multi cast environment, a single video stream is replicated as required by the network’s multi cast routers and switches to allow an arbitrary number of clients to subscribe to the multi cast address and receive the broadcast. Within the network, the multi cast transmission would consume only 1/nth of the bandwidth of the unicast solution.

NETSIM APPLICATION - IN-FLIGHT ENTERTAINMENT SYSTEM

Simulate the in-flight entertainment system network and analyse for bottlenecks



The customer was testing their new system for an aircraft having a total of 48 display tablets.

- There are 3 video servers connected to an Ethernet LAN switch
- This LAN switch connects to 6 access switches
- Each access switch connected to 8 passenger display tablets and thus a total of 48 display tablets
- All links have 1 Gbps links throughput
- Video load would be split equally between all three servers

Based on the performance of this system, they expected to scale it up-to 1000 display tables in their subsequent versions of the system

Traffic flow in the network

- Server 1 to display units 11-26 through Access Switches E and F
- Server 2 to display units 27-42 through Access Switches G and H
- Server 3 to display units 43-58 through Access Switches I and J
- 48 voice and 48 video applications
- Each server handles 16 + 16 = 32 applications

Traffic load

- Worst case scenario for simultaneous video usage by all passengers (MPEG movie model)
- Simultaneous audio via an audio codec model

Conclusions

- The network is able to handle the load for 48 video display units
- Link capacity is sufficient to handle traffic loads hence no buffer drops
- Application delays (~ 2 ms) were within generally acceptable tolerances for video
- However a what-if analysis with increased switch latency led to delays beyond acceptable tolerance of 3 ms

HOW DOES NETSIM COMPARE WITH COMMERCIAL SIMULATORS ?

	Commercial Simulators	NetSim® Professional
Modeling and Simulation		
Military Radio	✗	✓
5G NR	✗	✓
Internet of Things (IoT)	✗	✓
Software Defined Networks	✗	✓
Vehicular Adhoc Networks	✗	✓
Cognitive Radio Networks	✗	✓
Special utilities: Config file generator, Batch simulation manager, Multi-parameter sweeper	✗	✓
Special modules for LEACH, Node Failure, Intrusion detection and Sink hole attacks	✗	✓
Results dashboard with plots of simulation parameters over time	✗	✓
Core Architechture		
Protocol Source Code	C++	C
Writing and building custom code	Re-build entire tool every time	Build only your primitives code
De-bugging custom code	Off line debug. No visibility of protocol variables	Simulation-in-the-loop debug, visibility of protocol variables
Packet Animation	Available, but no packet information provided	Available with packet information
Workspaces: for multiple code bases (and associated experiments)	✗	✓
Licensing		
License validity	Annual	Annual/Perpetual
Cloud Licenses	✗	✓
Documents and Projects		
Sample Projects based on referenced IEEE papers	✗	✓
Project Source Code	✗	✓
External Interfaces		
MATLAB® Interface	✗	✓
SUMO Interfacing for VANETs	✗	✓
Wireshark interface	✗	✓
Support and Training		
E-mail & Phone Support	Internet Forum only. E-mail / Telephone extra	✓
On-site Support & Training	On site support from OEM not available	✓

+ per publicly available information at time of print

OUR JOURNEY

Our customers benefit from our 15+ years of experience in the field of network simulation.

2018-21
NetSim v11, v12 & v13

3GPP 38.xxx / Rel 15, SA/NSA, SDAP, RRC, NAS, PDCP, RLC, MAC, PHY, MIMO, Beamforming, mmWave Propagation and Channel Models

Satellite Comm. Networks

2017-18
NetSim v10 & v11

Software Defined Networks
Openflow v1.3 compatible
Workspace

2015-17
NetSim v9 & v10

Internet of Things (IOT), RPL, LTE Advanced, LTE D2D, TE Femto Cell, IEEE 1609 VANETs, MATLAB & SUMO interfacing

2013-15
NetSim v7 & v8

LTE, 802.11 ac, OLSR, ZRP, Military Radios, Wireshark Interface, NetSim Emulator

2011-13
NetSim v6 & v7

Wireless Sensor Networks, Zigbee, Cognitive Radio, WLAN 802.11 n, AODV, LEACH, Network Stack, Packet Animator, Development Environment

2009-11
NetSim v4 & v5

BGP, Wireless Sensor Networks, Zigbee, GSM, CDMA

2007-09
NetSim v3 & v4

Gigabit Ethernet, WLAN 802.11 a,g, MANET - DSR, Wi-Max; Packet Trace, Utilization and Delay Metrics, Network Statistics, Kernel Acceleration

2005-07
NetSim v1 & v2

Aloha, Slotted Aloha, Token Ring, Token Bus, TCP, UDP, WLAN 802.11

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sales@tetcos.com

TETCOS #214, 7th Main, 39th A Cross, Jayanagar 5th Block, Bangalore Pin - 560 041, India.

Tel-fax : +91 80 2663 0624 Tech Support : +91 76760 54321