Trusted by 500+ Universities Across the World

NetSim®

Accelerate Network R&D

Network Simulation and Emulation Software

EDU Suite

5G NR Networks

Internet of Things

Vehicular Adhoc Networks

Satellite Comm. Networks

Network Attacks

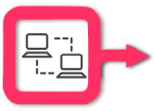
NetSim-MATLAB ML Integration

Network Emulator

WHAT IS NETSIM® AND HOW IS IT USED?

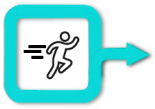
NetSim is the industry's leading network simulation software for protocol modelling and simulation, network R & D and defence applications.

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

Analyse high level results

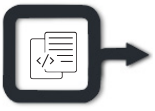
- Examine output performance metrics at multiple levels - network, sub network, link, queue, application etc.
- Study a variety of metrics such as throughput, delay, loss, packet error, link utilization etc.
- Interpret metrics using in-built plots and graphs

Drill down with Network Logs

- Record PHY layer radio data including path-loss, SINR, Shadow fading, Interference, MCS, CQI and more
- Record MAC layer resource allocation
- Seamlessly export .csv format files to spreadsheets and databases

Interface with external software

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

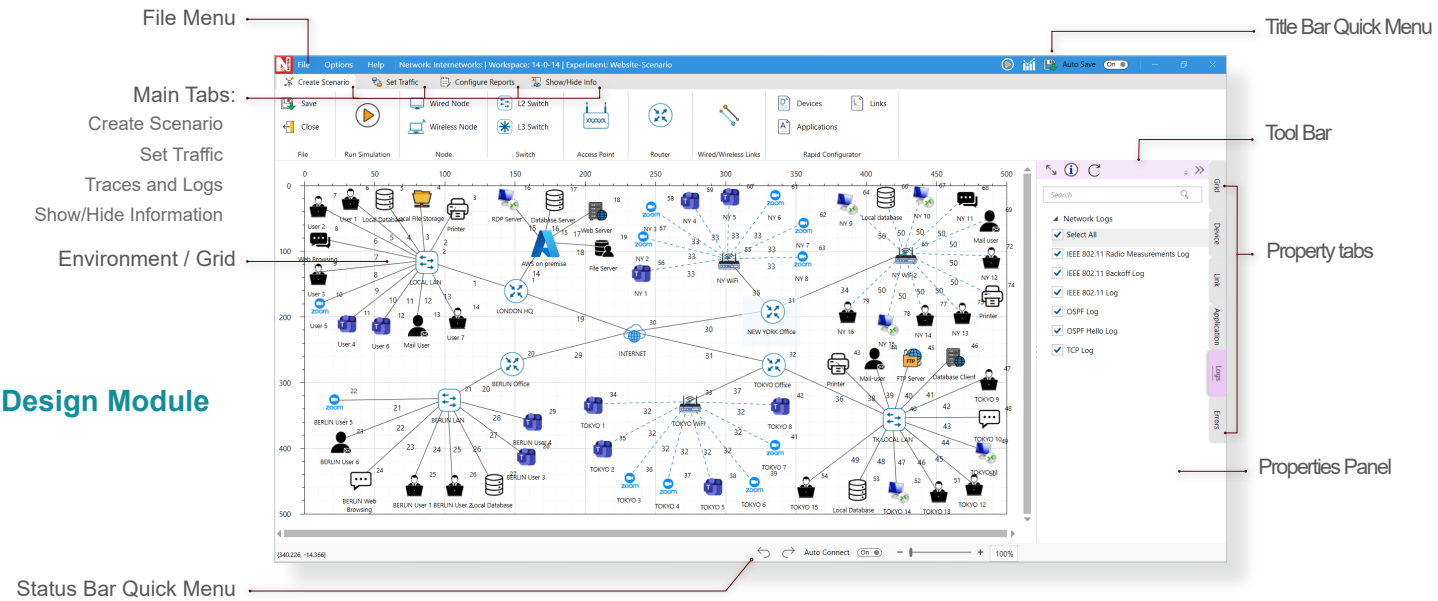


Develop your own protocol / algorithm

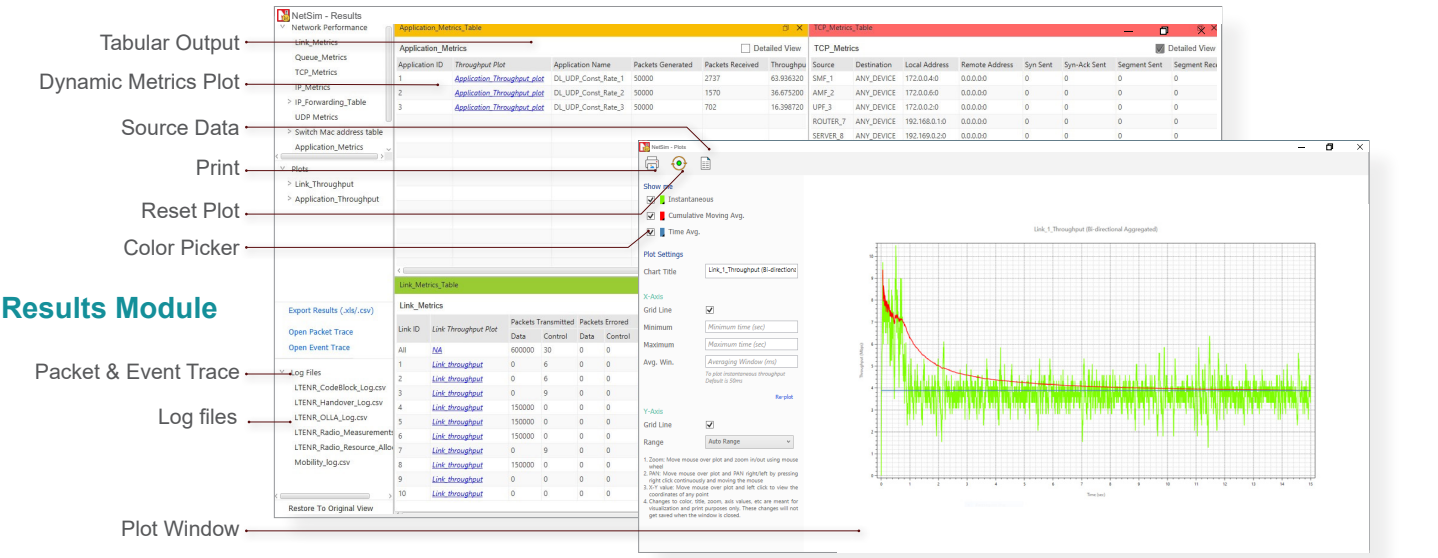
- Extend existing algorithms by modifying NetSim's source C code
- Create custom protocols using NetSim's simulation API's
- Debug your code (step-in, step-out, step-over, continue) and watch your variables in sync with simulation

WHAT DOES NETSIM'S USER INTERFACE LOOK LIKE ?

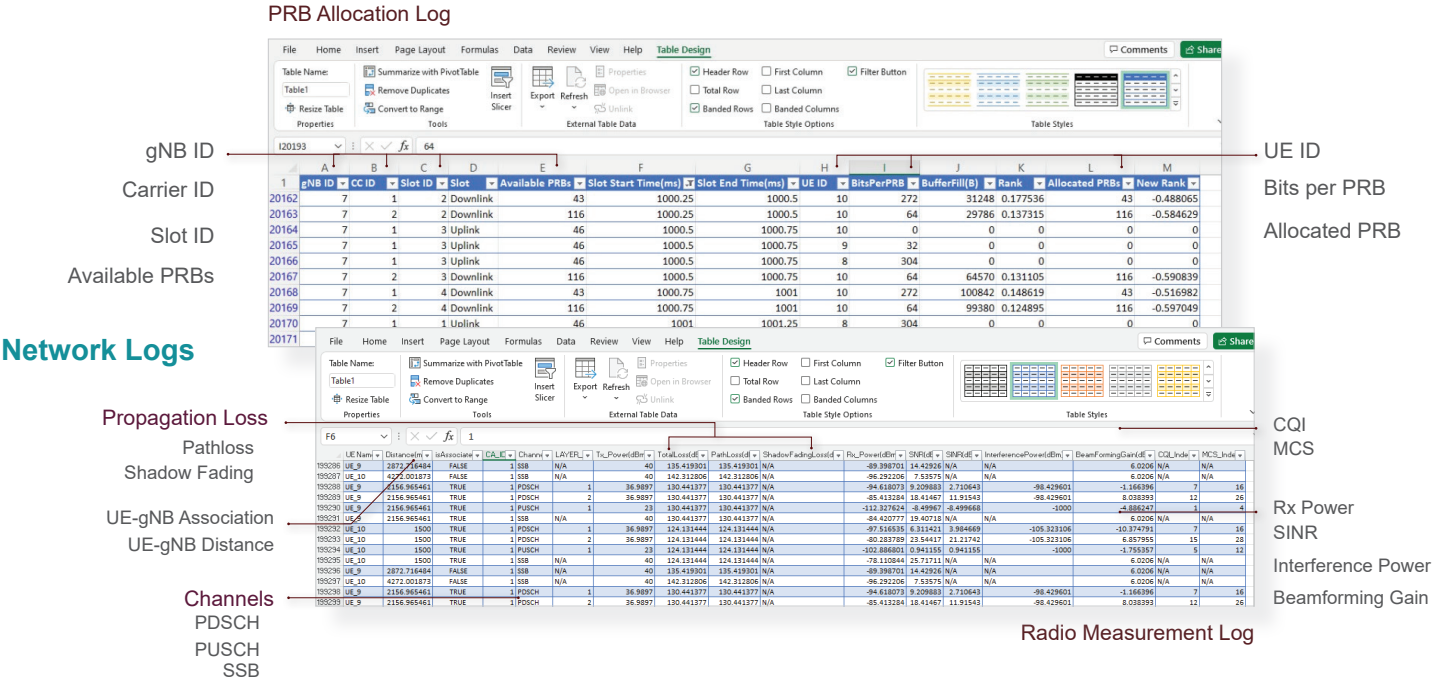
Design Module



Results Module



Network Logs



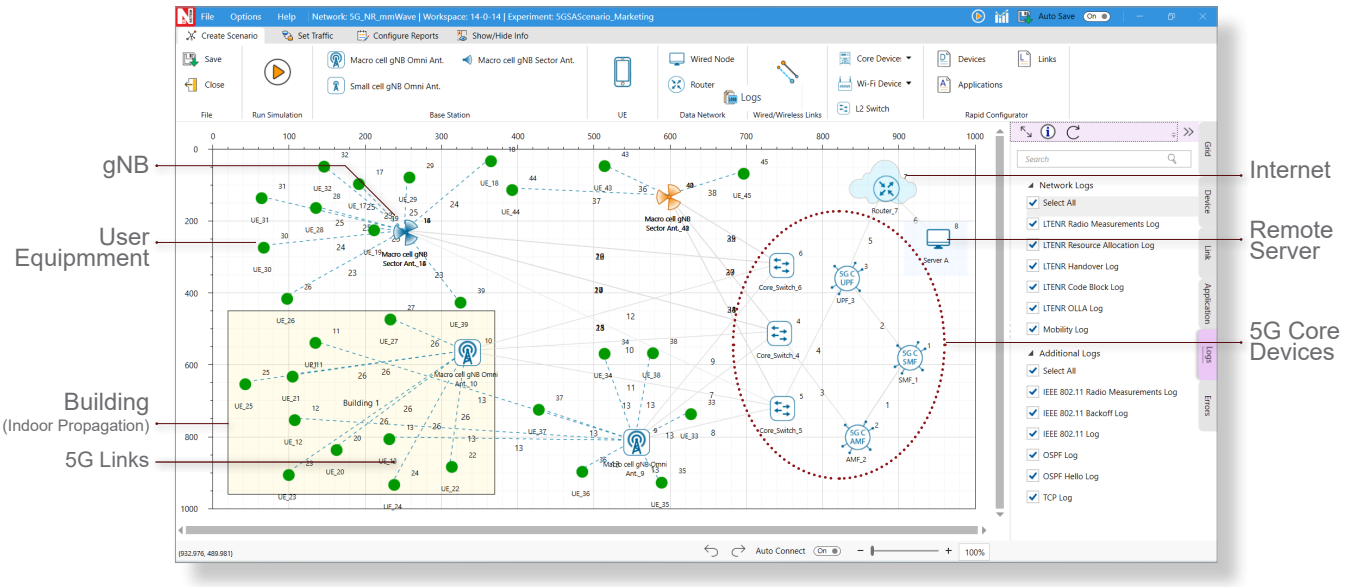
EXPLORE THE WIDE RANGE OF PRODUCT CAPABILITIES

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, Interactive Gaming and Custom; Encryption - XOR, TEA, AES, DES; Virtual Network Stack, Simulation Kernel; Command Line Interface, Metrics Engine with Packet Trace and Event Trace; Network Logs, 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
Component 10 (Requires C3 & C8)	**5G Networks**: Based on 3GPP 38.xxx Deployment: SA/NSA; Layers: SDAP, RRC, PDCP, RLC, MAC, PHY; MIMO, Beamforming, mmWave, Propagation and Channel Models
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
Component 12 (Requires C2 & C3)	**Underwater Acoustic Networks**: Features underwater communication using the acoustic PHY and Thorp propagation models. Interfaces with legacy networks for running slotted aloha in MAC layer
Network Emulator Add On	**Network Emulator**: Connect real hardware running live applications to NetSim Simulator. Interface with Raspberry Pi
Advanced 5G Add On (Requires C10)	**Advanced 5G**: Block Error Rate (BLER), UL and DL Interference, Outer Loop Link Adaptation (OLLA).

NETSIM 5G LIBRARY

Overview

- End-to-End simulation of 5G networks
- Devices: UE, gNB, 5G Core, 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 (LTE-5G dual connectivity) deployment architectures



Specifications

- 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
  - HARQ with retransmissions and soft combining
  - Radio resource allocation log
- PHY Layer
  - Flexible sub-carrier spacing in the NR frame structure using multiple numerologies μ = 0, 1, 2, 3
  - FR1 and FR2, TDD and FDD, Carrier aggregation
  - Radio measurements log: SNR, RSSI, Pathloss, ShadowFading Loss, BeamformingGain, CQI, MCS
  - PHY layer modulations supported - BPSK, QPSK, 16QAM, 64QAM, 256QAM
  - MIMO
    - » gNB antenna count supported 1, 2, 4, 8, 16, 32, 64, 128
    - » UE antenna count supported 1, 2, 4, 8, 16
  - Digital and Analog Beamforming
  - Interference Models
- RF propagation (Based on 3GPPTR38.900 Channel Model)
  - Rural Macro, Urban Macro, Urban Micro, Indoor, Mixed and Open Office. LOS/NLOS. Outdoor to Indoor
- 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

MACHINE LEARNING (ML) WITH NETSIM

Machine learning algorithms can be interfaced with NetSim to support a vast array of R&D applications, including:

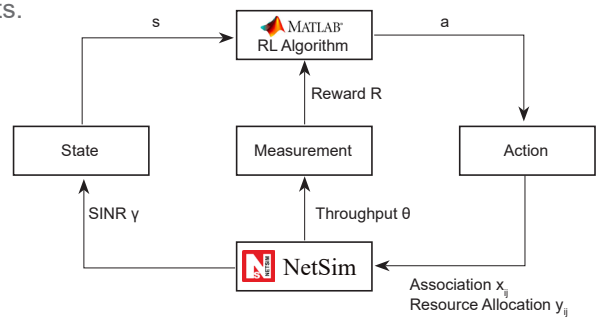
- Traffic estimation, Load balancing, Throughput prediction
- Power control, Beamforming, Interference management, Signal strength analysis
- MAC Scheduling, Quality of service (QoS) optimization

ML Algorithms

- Supervised learning: Incorporate Deep Q-Networks (DQN), Deep Neural Networks (DNN), Generative Adversarial Networks (GANs), etc., for pattern recognition and predictive analytics in wireless comm. and traffic management
- Reinforcement learning: Utilize algorithms like Multi-armed Bandit, Q-learning, and Temporal Difference (TD) learning for adaptive decision-making in dynamic network environments.

RL Control Loop using MATLAB interfacing

- NetSim transmits states and rewards to MATLAB
- ML algorithm in MATLAB processes this information.
- Post-processing, MATLAB communicates the optimal actions back to NetSim, ensuring a continuous loop of learning and adaptation.



NetSim - MATLAB RL interfacing for 5G load balancing

Generate synthetic data for ML

NetSim can generate vast amounts of perfectly labeled data that is representative of a wide variety of scenarios and edge cases. Data and output files include:

- Network Performance Metrics
- Instantaneous and average throughputs for each link and each application
- Buffer occupancy vs. time, TCP congestion window vs. time
- Packet trace: 30+ parameters for every packet as it flows through the network. These include arrival times, queuing times, departure times, payload, overhead, errors, collisions, etc
- Radio measurements: SINR, Pathloss, Shadowing, Fast fading, LOS/NLOS states, O2I Loss, MCS, CQI, UE-gNB distances, UE-gNB association.
- Radio resource allocation: Buffer fill (queue size), scheduling metric, PRB allocation

WHAT ARE SOME RESEARCH AREAS WHERE NETSIM IS USED ?

List of R&D projects with code and documentation is available at www.tetcos.com/file-exchange.html

5G Networks

» Heterogeneous networks
» MAC Scheduling and resource allocation
» PHY: MIMO, Interference, Beamforming

Internet Of Things (IoT)

» IoT security
» Energy management and sustainable operation
» 6LoWPAN based IoT design

Wireless Sensor Networks (WSN)

» Energy efficiency
» Routing, Clustering and LEACH
» Localization

Software Defined Networks (SDN)

» SDN based Wired/Wireless/MANETs/VANETs
» Performance evaluation
» SDN based traffic engineering and QoS

Vehicular Adhoc Networks(VANETs)

» v2v and v2i communication
» Mobility models and connectivity
» Clustering and routing

Underwater Acoustic Networks

» Acoustic PHY propagation
» Multi-hop routing
» Localization

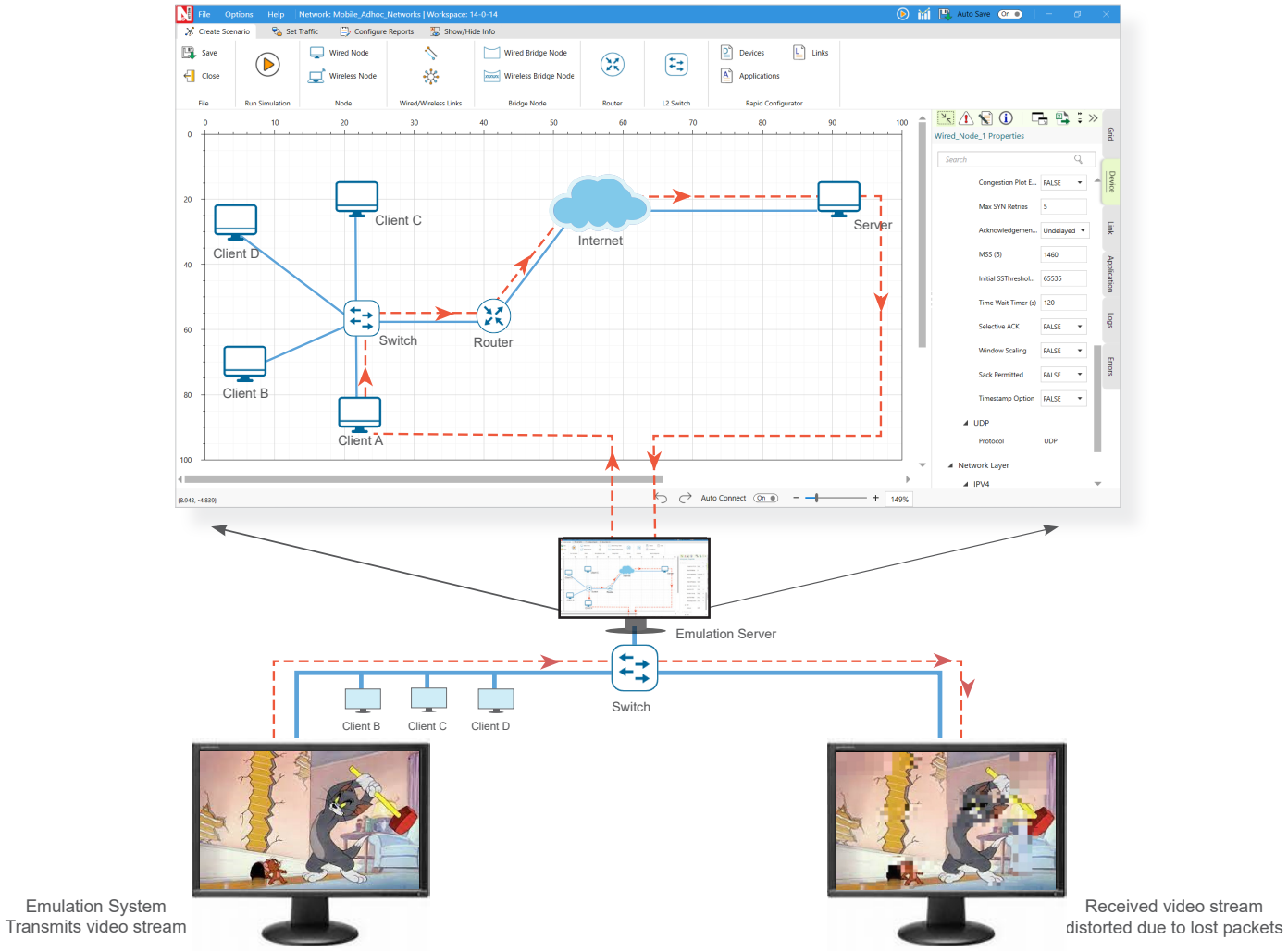
Mobile Ad hoc Networks (MANET)

» Location based, Power aware routing
» Sinkhole attack
» Intrusion detection systems

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
- Netwok attack simulation
- 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

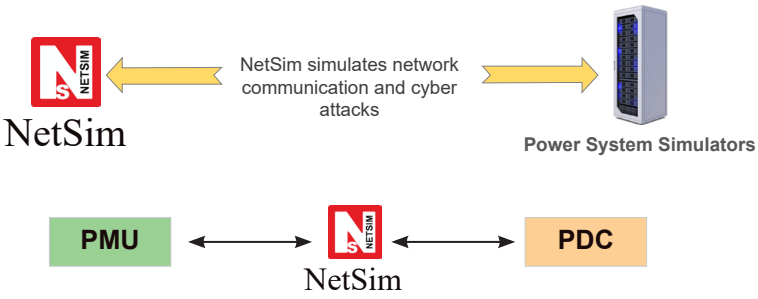
SIMULATING ATTACKS ON CYBER PHYSICAL SYSTEMS (CPS) USING NETSIM

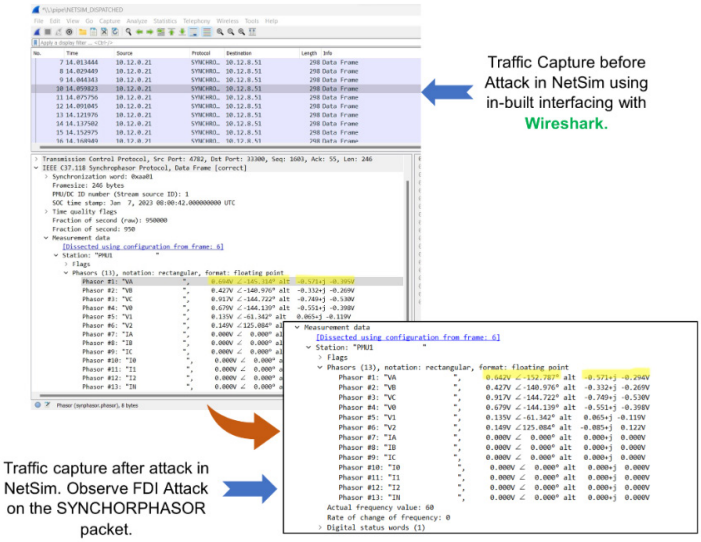
Electric power grid and CPS

- The electric power grid (EPG) or smart grid is a critical infrastructure at high risk of cyber-attacks.
- At its core are cyber-physical systems (CPS), that integrate communication and computational technologies to interact seamlessly with the physical world.
- Key CPS components like automated control systems, remote terminal units, PLCs, and IEDs are all connected to one another over a communication network.

Why choose NetSim for your cyber-physical testbed?

- Security of CPSs can be improved by using a testbed to replicate power systems operating conditions and evaluate grid operation under maliciously constructed scenarios.
- Hardware testbeds are costly, inflexible, hard to scale and demand safety considerations. Software testbeds overcome these difficulties and can function as digital twins.
- A software testbed generally comprises of a power system simulator and a network simulator. The former models all the power electronics devices, power transmission and distribution while the latter models the communications network.





Interfacing with real-time power system simulators

NetSim can interface with the following:

- OPAL-RT
- RTDS
- HYPERSIM
- PSCAD
- MATLAB

Simulating network attacks for proactive defense

Given below are some example attacks that can be simulated using NetSim:

- Denial-of-Service (DoS) Attack
- Distributed Denial-of-Service (DDoS) Attack
- Man-in-the-Middle (MitM) Attack
- Packet Sniffing
- Network Traffic Manipulation

Extensive protocol support

- IEEE C37.118 protocol (Synchrophasor Protocol)
- Generic Object-Oriented Substation Events (GOOSE), a subset of IEC 61850
- DNP3 (over TCP/IP)
- Modbus (over TCP/IP)
- IEC 60870-5-104 (over TCP/IP)

NETSIM FOR TEACHING/LABS

NetSim features in-built sample experiments to teach networking fundamentals through simulation.

List of Experiments

I. Introduction to network simulation and NetSim
   1. Introduction to NetSim
   2. Understand the working of basic networking commands - ping, route add/delete/print, ACL
   3. Understand the events involved in NetSim discrete event simulation in simulating flow of one packet from a wired node to a wireless node

II. Network performance
   1. Data traffic types and network performance measures
   2. Simulating link failure
   3. Delay and Little's law
   4. Throughput and bottleneck server analysis

III. Routing & Switching
   1. Study the working and routing table formation of interior routing protocols, RIP and OSPF
   2. Understand working of ARP and IP forwarding within a LAN and across a router
   3. Simulate and study the spanning tree protocol.
   4. Understanding VLAN operation in L2 and L3 switches
   5. Understanding access and trunk links in VLANs
   6. Understanding public IP address & Network Address Translation (NAT)
   7. M/D/1 and M/G/1 queues
   8. Understand the working of OSPF

IV. Transmission control protocol (TCP)
   1. Introduction to TCP connection management
   2. Reliable data transfer with TCP
   3. Mathematical modelling of TCP throughput performance
   4. TCP congestion control algorithms
   5. Understand the working of TCP BIC congestion control algorithm, simulate, and plot the TCP congestion window.

V. Wi-Fi: IEEE 802.11
   1. Wi-Fi: Throughput variation with distance
   2. Wi-Fi: UDP download throughput
   3. How many downloads can a Wi-Fi access point simultaneously handle?
   4. Multi-AP Wi-Fi networks: channel allocation
   5. Wi-Fi multimedia extension (IEEE 802.11e)

VI. Internet of things (IoT) and wireless sensor networks
   1. One hop IoT network over IEEE 802.15.4
   2. IoT multi-hop sensor-sink path
   3. Performance evaluation of a star topology IoT network
   4. Study the 802.15.4 Superframe structure and analyze the effect of superframe order on throughput

VII. Cognitive radio
   1. To analyze how the allocation of frequency spectrum to primary and secondary users affects throughput

VIII. Cellular Networks
   1. Study how call blocking probability varies as the load on a GSM network is continuously increased

IX. 5G NR
   1. Understanding the 5G NR PHY
   2. MIMO Beamforming in 5G: A start with MISO and SIMO
   3. Understanding 5G NR (3GPP) pathloss models
   4. Performance of OFDMA SU-MIMO in 5G
   5. 5G Numerologies and their impact on end-to-end latencies
   6. MIMO Communication: Channel Matrix Asymptotic Analysis
   7. Impact of Interference in 5G Networks
   8. On the Study of MAC Scheduling algorithms in 5G Communications
   9. Study of 5G Handover procedure

View complete Experiments manual online at: https://tetcos.com/downloads/v14/NetSim_Experiment_Manual.pdf

HOW DOES NETSIM COMPARE WITH OPEN SOURCE SIMULATORS ?

	Open Source Simulators	NetSim™ Standard
Install	Complicated installation process. Requires knowledge of various compilers and support packages for Python, QT, Doxygen, Mercurial, TCP Dump, and more	Two minute click-through installation
OS/Compiler Support	Linux gcc / g++	Windows Visual Studio (community Edition)
Ease of Use	Write hundreds of lines of script code to create network scenarios. Need to know various scripting and programming languages	Easy to use GUI allows users to simply drag and drop devices, links and applications
Simulation Output	Analyse and write code to extract performance results from multi megabyte files	Results dashboard provides appealing simulation performance reports with tables & graphs
Data Visualization	Fragmented tools with each requiring users to write programs for visualization	Inbuilt graphing with extensive formatting (axes, colours, zoom, titles etc)
Technologies	Limited technologies Stand alone	Wide range of technologies including the latest in 5G, IoT, WSN, MANET, VANET, SDN, LTE-Adv Cognitive Radio, 802.11 n / ac.. and more. Libraries work together
Lab Experimentation	Unsure of the quality of the build / patch you have used and if the results are even valid at the end	Comes with a pre-built set of 30-experiments covering important networking concepts
External Interface	Spend many days researching how to link to external software	Inbuilt interfaces to external software like MATLAB®, SUMO and Wireshark
Easy Debug	Code tens of printf statements to debug your code	Online debug capability and ability to 'watch' all variables.
Support	No personalized ontime support Users dependent on online resources which require advanced programming knowledge	Professional support via email, helpdesk, remote desktop and phone

+ Per publicly available information at time of print

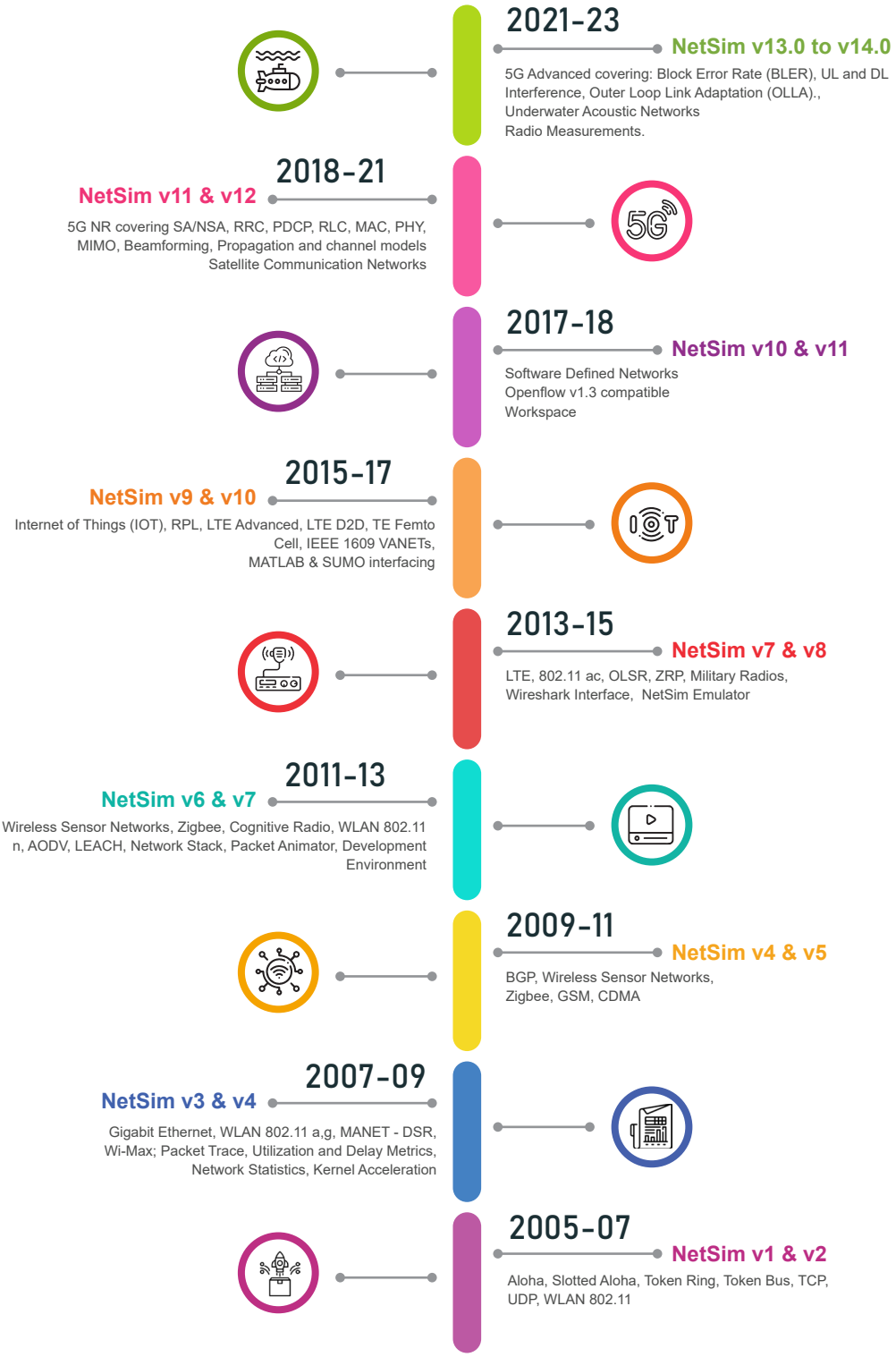
HOW DO THE DIFFERENT VERSIONS OF NETSIM COMPARE ?

NetSim Standard and NetSim Academic are targeted at educational institutions. NetSim Pro is supplied to Defence and Industry. Please visit www.tetcos.com for more information on NetSim Pro.

Technology Coverage	NetSim® Academic	NetSim® Standard
Internetworks	✓	✓
Legacy Networks	✓	✓
SDN	✓	✓
MANETs	✓	✓
Cellular Networks	✓	✓
Wireless Sensor Networks	✓	✓
Internet Of Things	✓	✓
Cognitive Radio Networks	✓	✓
LTE/LTE-A Networks	✓	✓
VANETs	✗	✓
5G NR	✗	✓
5G Advanced	✗	✓
Satellite Communication Networks	✗	✓
Underwater Acoustic Networks	✗	✓
Performance Reporting Performance metrics available for Network and Sub-network	✓	✓
Packet Trace Available in csv format for easy post processing	✓	✓
Protocol Library Source Codes with Documentation Protocol C source codes with extensive documentation	✗	✓
External Interfacing Interfacing with SUMO, MATLAB and Wireshark	✗	✓
Integrated Debugging Write and link code to NetSim and debug using Visual Studio	✗	✓
Event Trace Logs every event processed by NetSim's discrete event engine	✗	✓
Dynamic Metrics Allows users to graph the values of parameter over simulation time	✗	✓
Simulation Scale	100 Nodes	500 Nodes
Target Users and Segment	Educational (Lab use)	Educational (Research)
Emulator (Add on) Connect to real hardware running live applications	✗	✓

OUR JOURNEY

Our customers benefit from our 17+ years of experience in the field of network simulation.



SUPPORT ECOSYSTEM

Support Portal | **Webinars** | **Videos** | **File Exchange** | **Knowledgebase/FAQ** | **GitHub Repo**

SELECT LIST OF EDUCATION CUSTOMERS

Education - India

AC College of Technology, Karaikudi
Agra Engg. College, Agra
Aliah University, Kolkata
Aligarh Muslim University, Aligarh
Anna University College of Engg., Chennai
Army Institute of Technology, Pune
Assam University, Silchar
A.U College of Engg. Vizag
B.C.Roy Engg. College, West Bengal
Basaveshvar College of Engg., Karnataka
Bhilai Institute of Technology, Chattisgarh
BIT, Mesra, Patna Campus
BITS, Pilani, Goa Campus
BITS, Pilani, Hyderabad Campus
BITS, Pilani, Pilani Campus
BVCOEP, Pune
Central Institute of Technology, Kokrajhar
CIT, Coimbatore
College of Engg. and Tech, Bhubaneswar
College of Engg., Pune
DAIICT, Ahmedabad
DCRUST, Murthal
Delhi Technical University, Delhi
Dibrugarh University, Assam
Dr. D.Y Patil Inst of Engg. and Tech, Pune
FGIET, Bariely
GNDEC, Ludhiana
Govt College of Technology, Coimbatore
Govt Engineering College, Farmagudi, Goa
Govt Engineering College, Idukki, Kerala Govt Engineering College, Kannur, Kerala
Govt Engineering College, Raipur
Guru Nanak Dev University, Amritsar
Gwalior Engg. College, Gwalior
Haldia Institute of Technology, Kolkata
IFTM University, Moradabad
IGIT, Dhenkanal, Orissa
IIEST, Shibpur
IIIT, Allahabad
IIIT, Bangalore
IIIT, Guwahati
IIIT, Gwalior
IIIT, Raipur
IIST, Trivandrum
IIT, Bhubaneswar
IIT, Delhi
IIT, Dhanbad
IIT, Goa
IIT, Kanpur
IIT, Kharagpur
IIT, Patna
IIT, Roorkee
Institute of Tech & Management, Gwalior
Jabalpur Engineering College, Jabalpur
Jadavpur University, Kolkata
JNTU College of Engg., Ananthapur
JNTU College of Engg., Hyderabad
JNTU College of Engg., Kakinada
K.K Wagh College of Engineering, Nashik
Kongu Engg.. College, Erode
Kumaon Engineering College, Uttarakhand
M.M.M College of Engineering, Gorakhpur
Malnad College of Engg., Hassan
MIT, Chennai
MIT, Pune
Mizoram University, Aizawl
Motihari College of Engineering, Bihar
MS University, Tirunelveli
Mukesh Patel College of Engg., Mumbai
NEC, Kovilpatti
NERIST, Itanagar
NIT, Agartala
NIT, Bhopal
NIT, Calicut
NIT, Delhi
NIT, Durgapur
NIT, Hamirpur
NIT, Jaipur
NIT, Jalandhar
NIT, Kurukshetra
NIT, Manipur
NIT, Meghalaya
NIT, Nagaland
NIT, Nagpur
NIT, Rourkela
NIT, Sikkim
NIT, Silchar
NIT, Surat
NIT, Suratkal
NIT, Trichy
NIT, Yupia
NITTR, Chandigarh
PEC, Chandigarh
Pondicherry Engg. College, Puducherry
Pondicherry University, Puducherry
PSG College of Technology, Coimbatore
Punjab College of Engineering, Chandigarh
RGPV, Bhopal
Sant Longowal Inst of Technology, Punjab
Sastra University, Thanjavur, TN
Sree Chitra Tirunal Engg. College, Trivandrum
Shivaji University, Kolhapur
Sinhgad College of Engineering, Pune
SMVDU, Katra
SPIT, Mumbai
Thanthai Periyar Govt Inst of Tech, TN
Thapar University, Patiala
TIT, Tripura
UIET, Chandigarh
University of Calcutta, Kolkata
VES Institute of Technology Mumbai
VIT, Andhra Pradesh
VIT Chennai
VIT, Vellore
VJTI, Mumbai
VNR VJIET, Hyderabad
Walchand College of Engineering, Sangli

Education - International

Al Nahrain University, Iraq
Alberta University, Canada
Allepo University, Syria
Anglia Ruskin University, UK
Asia Pacific University, Malaysia
BITS Pilani, Dubai
Canterbury Christ Church University, UK
Concordia University, Canada
Education University of HK, Hong Kong
FREA - AIST, Japan
Gannon University, USA
GIST, Korea
Greenwich University, UK
Ingolstadt University, Germany
INTI, Malaysia
Kent University, UK
KFUPM, Saudi Arabia
KUET, Bangladesh
Leeds Beckett Univ, UK
Liverpool John Moores University, UK
Miguel Hernandez University, Spain
IHP Microelectronics , Germany
Zhejiang University, China
Polytechnique Montreal, Canada
Electronics and Telecommunications Research Institute (ETRI), Korea
Edith Cowan University, Australia
Universidad de los Andes-School of Electrical and Electronics Engineering, Colombia
California State University, Bakersfield (CSUB), USA
London South Bank University, UK
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