

# Lab Session and Project Discussion

**IoT Lab Session**

# Agenda

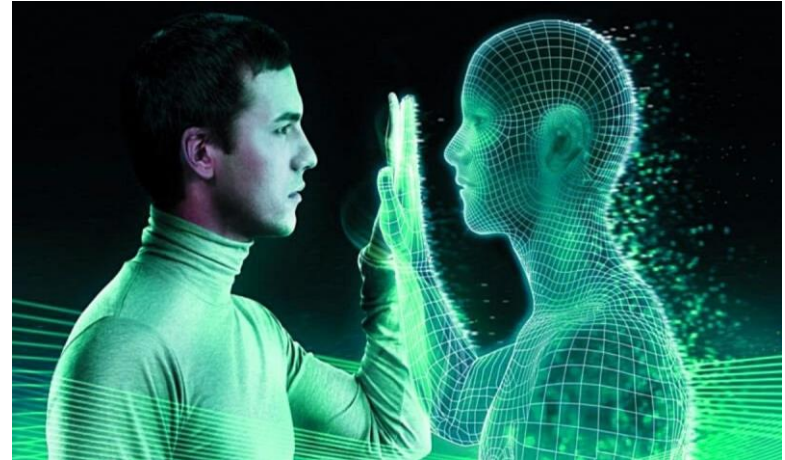
- **Simulation** Process and its importance
- Introduction to **NetSim** Simulator
- **5G and IoT integration** in NetSim environment
- **Steps to design** IoT Solution for **Specific industries**
- Capstone **Project** Preparation

# Simulation Process and its importance

**IoT Lab Session**

# Simulation Process

**Definition:** Simulation is a technique used to **mimic the behavior of real-world systems or processes through the creation of virtual models**. These models are designed to replicate the dynamics, interactions, and outcomes of the actual system under various conditions or scenarios. **By inputting different parameters and variables into the simulation**, researchers, engineers, or analysts can observe and analyze how the system would respond in different situations **without the need for physical implementation** or experimentation.



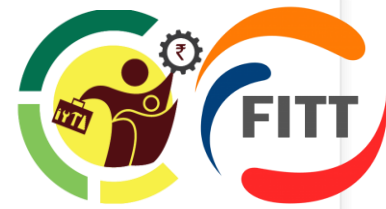
Source :  
<https://www.unrevealedfiles.com/is-the-universe-a-computer-simulation/>

# Why Simulation

The simulation process is essential for-

- Mitigating **risks**,
- Reducing **costs**,
- Evaluating **performance**,
- Supporting **decision-making**,
- Understanding complex systems,
- Facilitating training and education,
- Driving innovation,
- Enabling forecasting and planning across diverse fields and industries





# Simulation in 5G & IoT Context

- **Simulation in 5G IoT:** involves creating virtual models of real-world scenarios to emulate network behavior, device interactions, and data flows.
- **Components:** The simulation process typically includes **setting up network topologies, configuring Sensors and other devices and protocols, defining traffic patterns**, running the simulation, and analyzing results.
- **Importance:** It allows for testing and optimizing various aspects of 5G IoT networks in a controlled environment before actual

# Recap : IoT Simulators covered so far

## Wokwi:

- Wokwi is an **online platform** that offers a simulation environment for IoT development using **popular microcontrollers such as Arduino and ESP32**.
- It provides a user-friendly interface for designing and testing IoT projects, with **features like virtual hardware components, code editing, and real-time simulation feedback**.

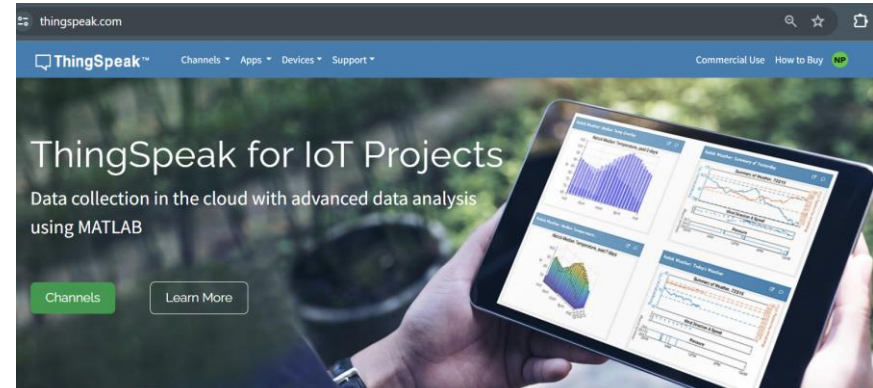


Source: <https://wokwi.com/>

# Recap : IoT Simulators covered so far

## ThingSpeak:

- ThingSpeak is an **IoT platform developed by MathWorks** that includes built-in **data analytics and visualization tools**.
- Alongside its data collection and storage capabilities, ThingSpeak offers a simulation feature allowing users to generate synthetic data for testing IoT applications and algorithms.



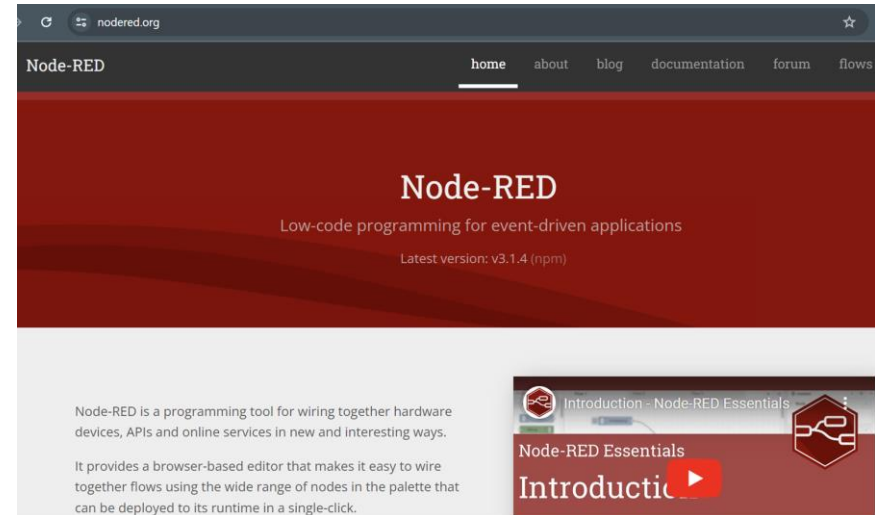
Source: <https://thingspeak.com/>



# Recap : IoT Simulators covered so far

## Node-RED:

- **Node-RED** is a **flow-based development tool** for visual programming of IoT applications, developed by IBM.
- While primarily used for IoT application development and deployment, Node-RED offers simulation capabilities through its **extensible ecosystem of nodes and plugins, enabling users to test flows and integrations before deploying them to real devices.**



Source : <https://nodered.org/>

# Let's Bring **IoT** and **5G** Together

**Introduction to NetSim Simulator For 5G and IoT integration**



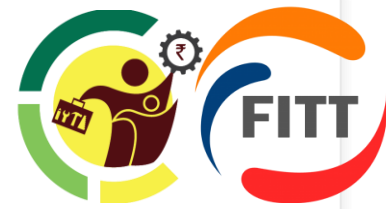
# NetSim Simulator For 5G and IoT Integration

## Introduction to NetSim Simulator:

**NetSim** is a powerful and versatile network simulation software **designed to facilitate** the **modeling, analysis, and optimization** of **communication networks**. Developed by Tetcos, NetSim provides a comprehensive platform for researchers, engineers, and educators to simulate a wide range of network technologies and scenarios, enabling them **to gain valuable insights into network behavior, performance, and efficiency**.



<https://www.tetcos.com/>



# Different Network simulation available in **Netsim**

## Choose a Network

### C1 Internetworks (Base)

Features TCP, IP, Routing, Wi-Fi, Ethernet, RF Propagation, Application Models, Network Stack, Simulation Kernel, Network Logs and Plot Engine.

🔒 Licensed



### C2 Legacy Networks

Features Pure Aloha, Slotted Aloha, GSM and CDMA. Legacy Networks run standalone and do not interface with Internetworks library

🔒 Licensed



### C4 Mobile Adhoc Network

Features DSR, AODV, OLSR and ZRP routing protocols, and multiple MANETs with bridge nodes. MANETs interface with Internetworks library

🔒 Licensed



### C6 Wireless Sensor Networks

Based on 802.15.4 MAC/PHY interfaces with MANETs library

🔒 Licensed



### C6 Internet of Things

Features WSN, RPL and 6LoWPAN with MANET routing. IoT interfaces with Internetworks and MANETs libraries

🔒 Licensed



### C7 Cognitive Radio Networks

Based on 802.22 standard and interfaces with Internetworks library

🔒 Licensed



### C8 LTE / LTE-A

Based on 3GPP 36 series standards. LTE/LTE-A interfaces with Internetworks library

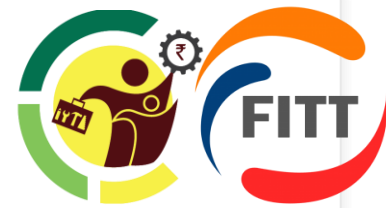
### C9 Vehicular Adhoc Networks

Based on IEEE1609 Wave and IEEE802.11p with MANET routing. VANETs interface with Internetworks and MANETs libraries and with SUMO.

### C10 5G NR

Based on 3GPP 38 series standards. 5G NR interfaces with Internetworks library and with LTE library for running 5G NSA mode.

# Different Network simulation available in **Netsim**



## Choose a Network

### **C11** Satellite Comm. Networks

Features Geo stationary satellite, TDMA in Ku Band and MF-TDMA in Ka Band per DVB S2. Interfaces with Internetworks library

 Licensed



### **C12** 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.

 Licensed



### **C3** Advanced Routing

Features VLAN, Multicast Routing: IGMP and PIM, L3 Switch, ACL and NAT. Access these features within the properties of Switches and Routers available in C1

 Licensed



### **C5** Software Defined Networks


Based on Openflow protocol. Access this feature within the properties of all L3 devices. SDN interfaces with all components except C2 and C11

 Licensed



### **Add-On** Network Emulator

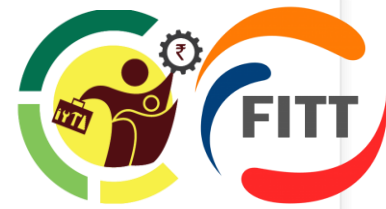
Connect real systems running live applications to NetSim. Interfaces with all components except C2. Access this feature inside Application properties.

 License not available



### **Add-On** Advanced 5G

Features advanced 5G features including DL and UL Interference, Block error rate (BLER) and Outer loop link adaptation (OLLA). Access these features within the 5G NR and LTE components.



# NetSim Simulator For 5G and IoT Integration

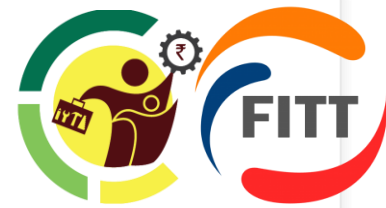
## Why NetSim for 5G and IoT:

- **Modular Architecture:** NetSim offers a modular architecture that supports the simulation of diverse network technologies, including 5G and IoT protocols.
- **Protocol Support:** NetSim provides comprehensive support for a wide range of communication protocols, including those relevant to 5G and IoT networks. From wireless standards like **NR (New Radio)** and **6LowPAN** to **IoT-specific protocols such as MQTT and CoAP**, NetSim offers a rich library of protocols for simulation.



<https://www.tetcos.com/>

# NetSim Simulator For 5G and IoT Integration



## Why NetSim for 5G and IoT:

- **Realistic Environment:** With NetSim, users can create realistic network environments by defining parameters such as **topologies, traffic patterns, mobility models, and interference scenarios**. This capability allows for the accurate emulation of real-world conditions and facilitates in-depth analysis of network performance.
- **Visualization Tools:** NetSim offers visualization tools that enable users to **visualize network topologies, packet flows, and performance metrics in real-time**. This visual representation enhances the understanding of simulation results and facilitates the identification of network bottlenecks.



<https://www.tetcos.com/>



# NetSim Simulator For 5G and IoT Integration

## Why NetSim for 5G and IoT:

- **Scalability and Performance:** NetSim is **designed to handle** simulations of varying scales, from small-scale IoT deployments to large-scale 5G networks. Its efficient simulation engine ensures scalability and high performance, enabling the **simulation of complex scenarios with thousands of nodes.**
- **Integration Capabilities:** NetSim supports the integration of different technologies and components, making it ideal for simulating the convergence of 5G and IoT.



<https://www.tetcos.com/>



# Exercise:

## IoT in NetSim

**IoT Lab Session**

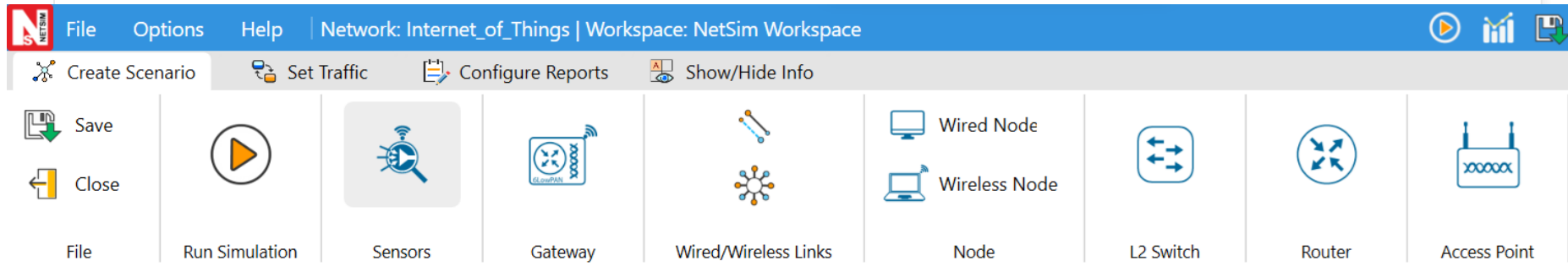
## Outcome of the Exercise



- Performance Evaluation
- Reliability and Resilience
- Traffic Analysis
- Security Assessment
- Scalability Testing
- Resource Management
- Application Behavior

Conducting IoT simulations in NetSim enables you to gain valuable insights into the behavior and performance of your IoT network, identify potential issues or optimization opportunities, and **validate design choices before deployment in real-world scenarios.**


# Available functions for IoT Network simulation in NetSim



- **Sensors**
- **Gateway**
- **Wired/Wireless links**
- **wired/Wireless nodes**

- **Switches**
- **Routers**
- **And other required components**


# Go to Internet Of things

 NetSim Home

NetSim Standard

Network Simulation/Emulation Platform

Version 14.0.34 (64 Bit)



New SimulationCtrl+N

Your WorkCtrl+O

Examples

Experiments

C1

Internetworks (Base)

Features TCP, IP, Routing, Wi-Fi, Ethernet, RF Propagation, Application Models, Network Stack, Simulation Kernel, Network Logs and Plot Engine.

Licensed

C2

Legacy Networks

Features Pure Ad Hoc, Mobile Ad Hoc, GSM and CDMA based Networks run standard and do not interface with Internetworks library

Licensed

C4

Mobile Adhoc Network

Features DSR, AODV, OLSR and ZRP routing protocols, and multiple MANETs with bridge nodes. MANETs interface with Internetworks library

Licensed

C6

Wireless Sensor Networks

Based on 802.15.4 MAC/PHY interfaces with MANETs library

Licensed

C8

Internet of Things

Features WSN, RPL and 6LoWPAN with MANET routing. IoT interfaces with Internetworks and MANETs libraries

Licensed

C10

Cognitive Radio Networks

Based on 802.22 standard and interfaces with Internetworks library

Licensed

C12

LTE / LTE-A

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Licensed

C14

Vehicular Adhoc Networks

Based on IEEE1609 Wave and IEEE802.11p standards. VANETs interface with Internetworks library and with SUMO.

Licensed

C16

5G NR

Based on 3GPP 38 series standards. 5G NR interfaces with Internetworks library and with LTE library for running 5G NSA mode.

Licensed

Current workspace: NaimishNetSimWorkspace

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[Source Code Help](#)

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[Email - sales@tetcos.com](#)

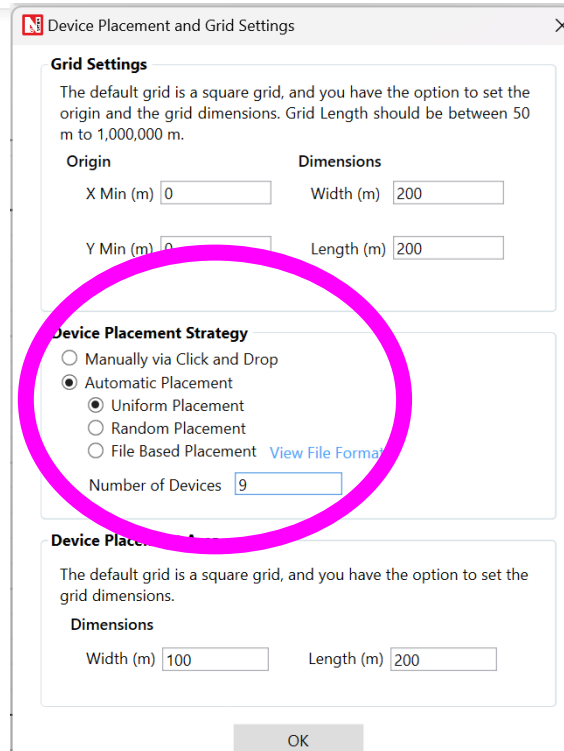
[Phone - +91 767 605 4321](#)

[Website - www.tetcos.com](#)

Show desktop

# Configuration window

1. Update Grid dimensions
2. Select sensor placement type(Uniform/Random)
3. Enter number of devices (9)
4. Device placement area (200,100)

A screenshot of the 'Device Placement and Grid Settings' window. The window is divided into two main sections. The top section, 'Grid Settings', contains a text description and input fields for 'Origin' (X Min, Y Min) and 'Dimensions' (Width, Length). The bottom section, 'Device Placement Strategy', contains radio buttons for 'Manually via Click and Drop', 'Automatic Placement' (selected), and 'File Based Placement'. Below this is a 'Number of Devices' input field. The 'Automatic Placement' section is highlighted with a pink oval. The 'File Based Placement' option has a link to 'View File Format'. The 'Device Placement' section at the bottom is partially visible and contains a text description and input fields for 'Dimensions' (Width, Length). An 'OK' button is located at the bottom right of the window.

**Device Placement and Grid Settings**

**Grid Settings**

The default grid is a square grid, and you have the option to set the origin and the grid dimensions. Grid Length should be between 50 m to 1,000,000 m.

**Origin**

X Min (m)  Y Min (m)

**Dimensions**

Width (m)  Length (m)

**Device Placement Strategy**

☐ Manually via Click and Drop

☒ Automatic Placement

☒ Uniform Placement

☐ Random Placement

☐ File Based Placement [View File Format](#)

Number of Devices

**Device Placement**

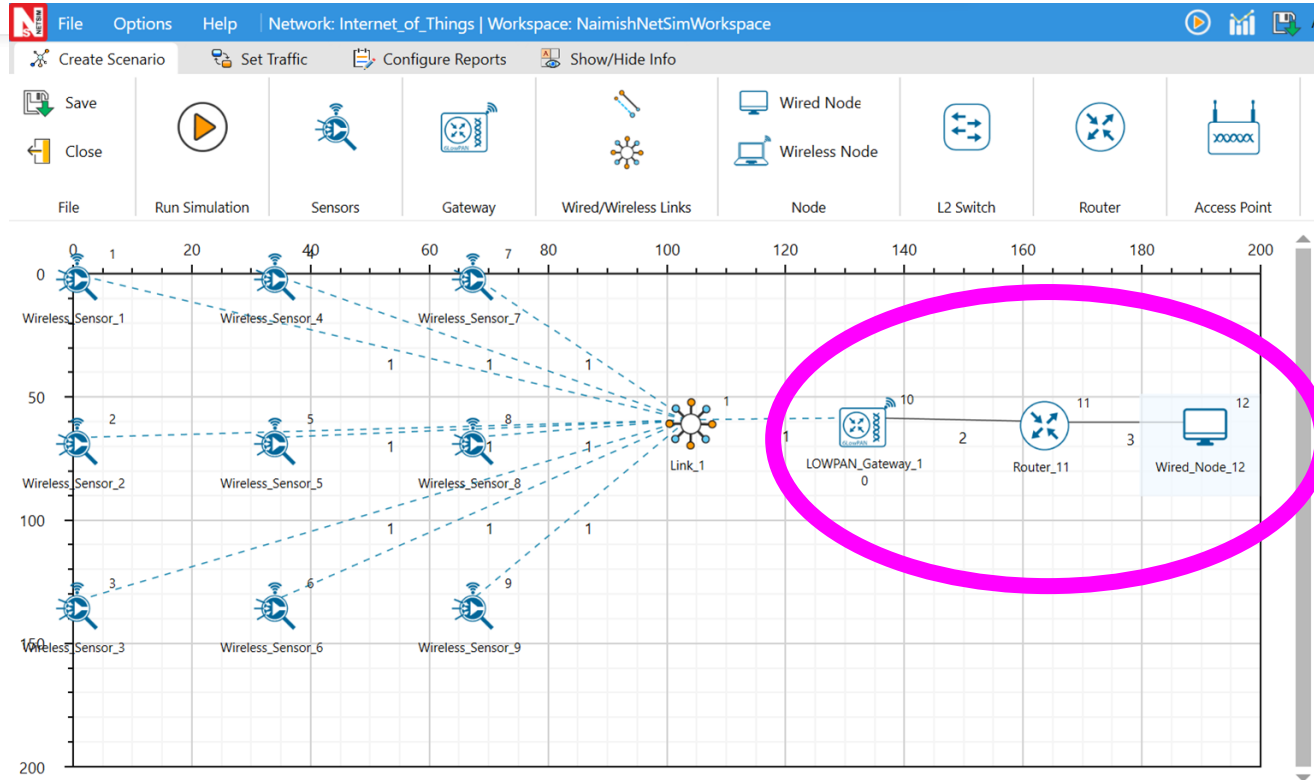
The default grid is a square grid, and you have the option to set the grid dimensions.

**Dimensions**

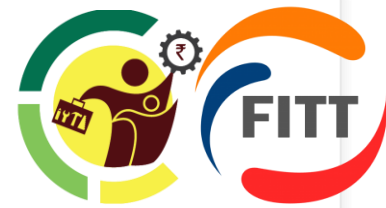
Width (m)  Length (m)

OK

# Add Gateway, Router and Wired Node



# Configure sensors properties



File Options Help | Network: Internet\_of\_Things | Workspace: NaimishNetSimWorkspace

Create Scenario Set Traffic Configure Reports

Save Close Run Simulation Sensors Gateway

0 1 20 40 60 80

Wireless\_Sensor\_1 Wireless\_Sensor\_4 Wireless\_Sensor\_7

50

2 5 8

Wireless\_Sensor\_2 Wireless\_Sensor\_5 Wireless\_Sensor\_8

100

3 6 9

Wireless\_Sensor\_3 Wireless\_Sensor\_6 Wireless\_Sensor\_9

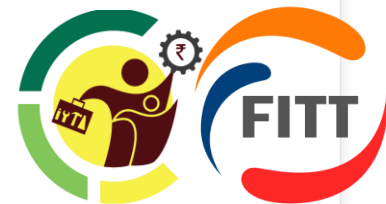
150

200

Wireless\_Sensor\_1 Properties

- General
- Position
- Application Layer
- Transport Layer
- Network Layer
- Interface\_1 (Zigbee)

# Configure LOWPAN gateway properties



The screenshot shows the 'LOWPAN\_Gateway\_10 Properties' dialog box in the background and a network diagram in the foreground. The dialog box has a toolbar with icons for undo, redo, save, and help, which are circled in pink. The 'General' tab is selected, showing the following properties:

Property	Value
Device Name	LOWPAN_Gateway_10
Device Id	10
Type	SINKNODE
Interface Count	2

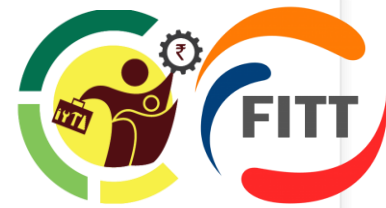
The left sidebar of the dialog box lists the following categories:

- General
- Graphics
- Position
- Application Layer
- Transport Layer
- Network Layer
- Interface\_1 (Zigbee)
- Interface\_2 (WAN)
  - Network Layer
  - Datalink Layer
  - Physical Layer

The network diagram in the foreground shows a grid with a node labeled 'LOWPAN\_Gateway\_1' circled in pink. The node is connected to a dashed line representing a network topology. The diagram also shows a 'Node' legend with 'Wired Node' and 'Wireless Node' icons.



# Configure Application properties



Workspace: NaimishNetSimWorkspace

Auto Save On

Reports Show/Hide Info

Waypoint, Wired/Wireless Links, Node, L2 Switch, Router, Access Point, Devices, Applications, Links, Rapid Configuration

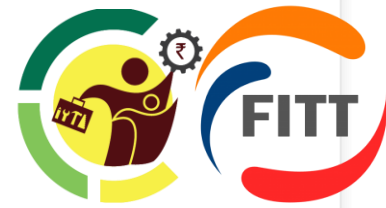
LOWPAN\_Gateway\_10 Properties

- General
- Position
- Application Layer
- Transport Layer
- Network Layer
- Interface\_1 (Zigbee)
- Interface\_2 (WAN)

Grid, Device, Link, Application

The screenshot displays the NaimishNetSim workspace with a network diagram. The top toolbar includes buttons for 'Waypoint', 'Wired/Wireless Links', 'Node', 'L2 Switch', 'Router', 'Access Point', 'Devices', 'Applications' (highlighted with a pink oval), 'Links', and 'Rapid Configuration'. The network diagram shows a central 'Link\_1' connected to 'LOWPAN\_Gateway\_10', which is connected to 'Router\_11', which is connected to 'Wired\_Node\_12'. There are also three sensors connected to 'Link\_1'. The 'LOWPAN\_Gateway\_10 Properties' panel is open on the right, showing tabs for 'Grid', 'Device', 'Link', and 'Application'. The 'Application' tab is selected, showing a list of properties: 'General', 'Position', 'Application Layer', 'Transport Layer', 'Network Layer', 'Interface\_1 (Zigbee)', and 'Interface\_2 (WAN)'.

# Configure Application properties



NetSim - Rapid Application Configurator

New Application Delete Selected Export list to Excel Import list from Excel Close

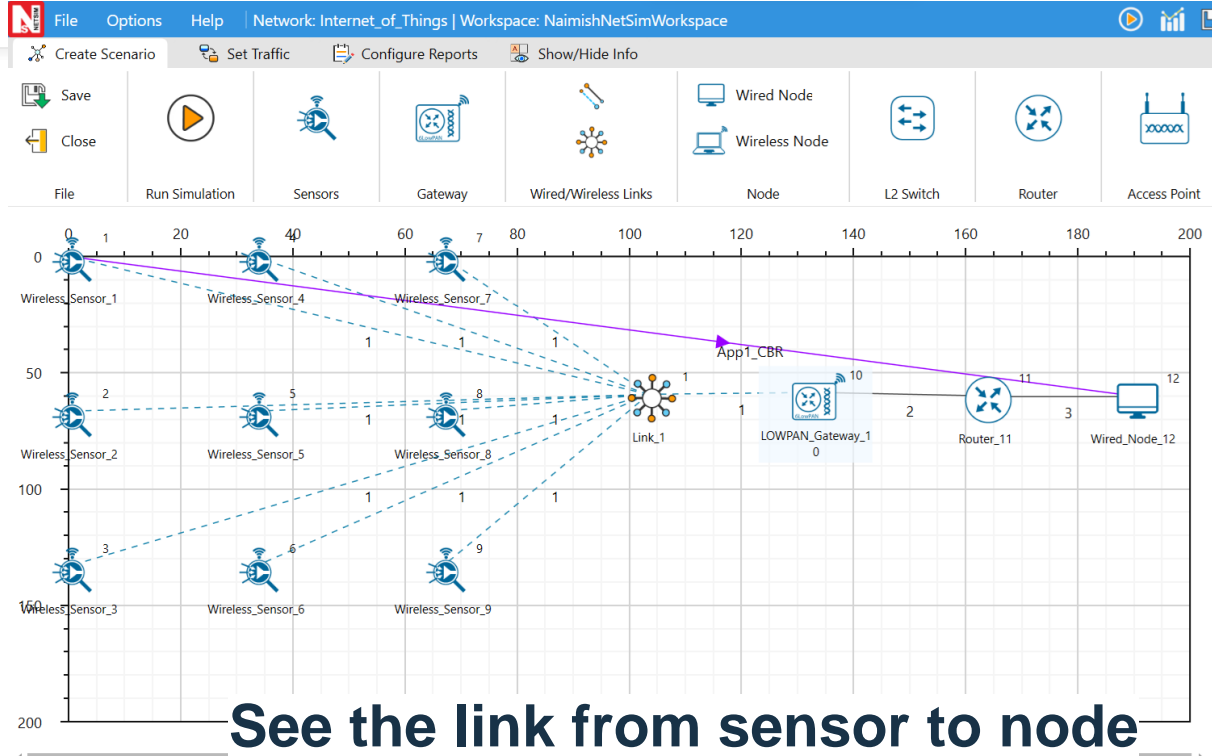
CBR Custom Voice Video FTP HTTP E-mail DataBase Gaming

	Application ID	Application Name	Source ID	Destination ID	Packet Size (B)	Interarrival Time (μs)	Generation rate
<input checked="" type="checkbox"/>	1	App1_CBR	1	2	1460	20000	584 kbps

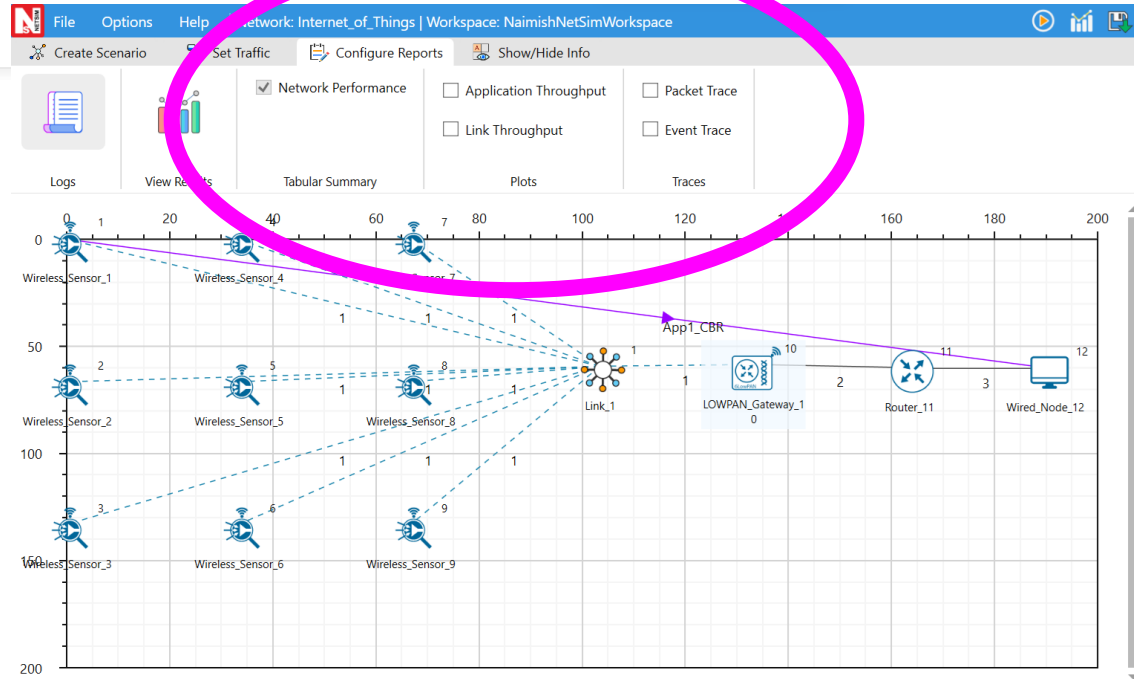
Three white arrows point upwards to the Source ID, Destination ID, and Packet Size (B) columns of the table.

**Set source Id(2) for sensor, destination ID (12) for wired node and other parameters**

# Configure Application properties

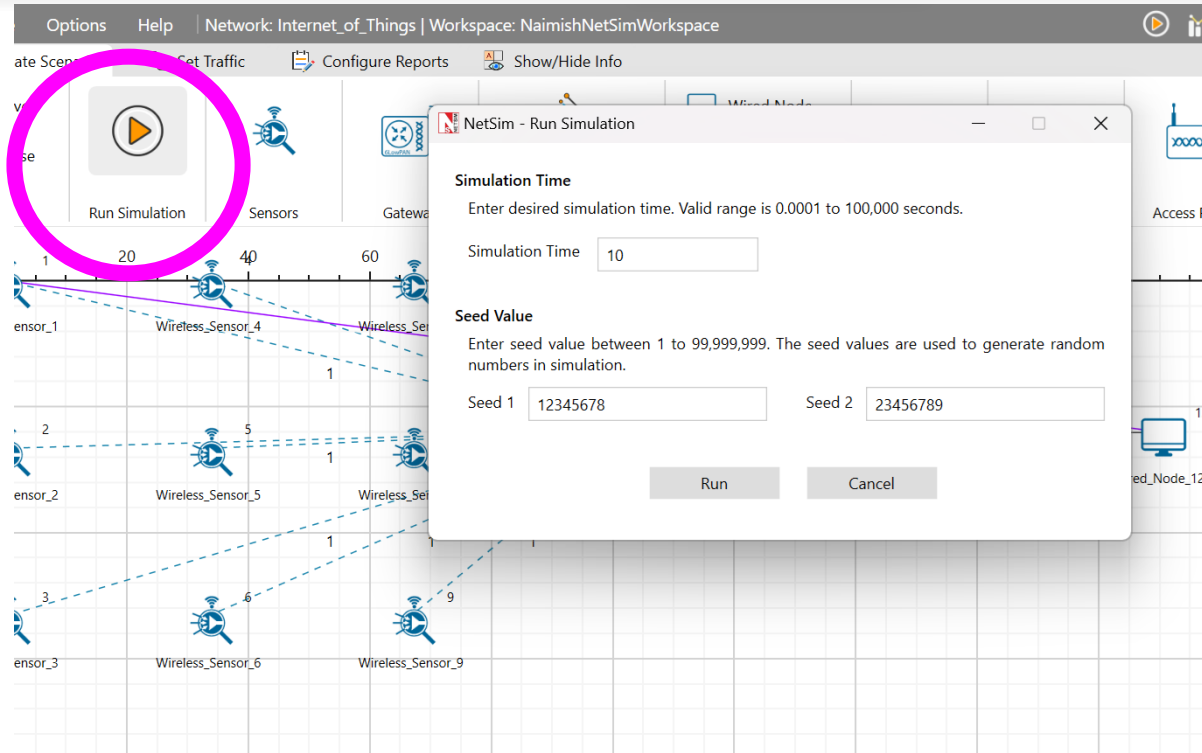


# Lets Simulate



Enable Packet Trace and other parameters you want to observe under configure reports

# Lets Simulate



**Click on run  
simulation  
and set  
parameters**

# This window will appear



```
C:\Program Files\NetSim\Star  x  +  v
Today's date is "Feb 09 2024.15:04:20"
Binary build date is "Oct 26 2023.18:22:05"

-appath is not defined...
Setting current path as app path.
App path = C:\Program Files\NetSim\Standard_v14_0\bin\bin_x64\workspace\NaimishNetSimWorkspace\bin_x64
NetSim License Manager will first check for node lock licenses.
If not available, it will then check for floating/cloud licenses
NetSim License Manager Start. Checking for licenses available (this may take upto 2 min) -

License Manager Output. Product>Edition>Maj_ver>Min_ver>Lic_type>Components>
netsim>std>14>0>rlm_hw>111111111111>00100>
NetworkStack loaded from path- C:\Program Files\NetSim\Standard_v14_0\bin\bin_x64\workspace\NaimishNetSimWorkspace\bin_x
64/NetworkStack.dll

***
NetSim start
Network Stack loaded
Error in creating C:\Users\naimi\AppData\Local\Temp\NetSim\std_14.0\log directory. Error number 17
Initializing simulation
|
```

[illegible]

Simulation Results	Application_Metrics_Table					TCP_Metrics_Table																																																																																																																																																																							
<ul style="list-style-type: none"> <li>Network Performance               <ul style="list-style-type: none"> <li>Link_Metrics</li> <li>Queue_Metrics</li> <li>TCP_Metrics</li> <li>IP_Metrics</li> </ul> </li> <li>&gt; IP_Forwarding_Table</li> <li>UDP Metrics</li> <li>AODV Metrics</li> <li>&gt; IEEE802.15.4_Metrics               <ul style="list-style-type: none"> <li>Application_Metrics</li> </ul> </li> <li>Plots               <ul style="list-style-type: none"> <li>&gt; Link_Throughput</li> <li>&gt; Application_Throughput</li> </ul> </li> </ul> <p>Export Results (.xls/.csv)</p> <p>Open Packet Trace</p> <p>Open Event Trace</p> <p>Restore To Original View</p>	Application_Metrics <input type="checkbox"/> Detailed View <table border="1"> <thead> <tr> <th>Application ID</th><th>Throughput Plot</th><th>Application Name</th><th>Packets Generated</th><th>Packets Received</th></tr> </thead> <tbody> <tr> <td>1</td><td><a href="#">Application Throughput plot</a></td><td>App1_CBR</td><td>7500</td><td>1370</td></tr> <tr><td> </td><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td><td> </td></tr> </tbody> </table>					Application ID	Throughput Plot	Application Name	Packets Generated	Packets Received	1	<a href="#">Application Throughput plot</a>	App1_CBR	7500	1370																																														TCP_Metrics <input type="checkbox"/> Detailed View <table border="1"> <thead> <tr> <th>Source</th><th>Destination</th><th>Segment Sent</th><th>Segment Received</th><th>Ack Sent</th><th>Ack Received</th></tr> </thead> <tbody> <tr><td>WIRELESS_SENSOR_1</td><td>ANY_DEVICE</td><td>0</td><td>0</td><td>0</td><td>0</td></tr> <tr><td>WIRELESS_SENSOR_2</td><td>ANY_DEVICE</td><td>0</td><td>0</td><td>0</td><td>0</td></tr> <tr><td>WIRELESS_SENSOR_3</td><td>ANY_DEVICE</td><td>0</td><td>0</td><td>0</td><td>0</td></tr> <tr><td>WIRELESS_SENSOR_4</td><td>ANY_DEVICE</td><td>0</td><td>0</td><td>0</td><td>0</td></tr> <tr><td>WIRELESS_SENSOR_5</td><td>ANY_DEVICE</td><td>0</td><td>0</td><td>0</td><td>0</td></tr> <tr><td>WIRELESS_SENSOR_6</td><td>ANY_DEVICE</td><td>0</td><td>0</td><td>0</td><td>0</td></tr> <tr><td>WIRELESS_SENSOR_7</td><td>ANY_DEVICE</td><td>0</td><td>0</td><td>0</td><td>0</td></tr> <tr><td>WIRELESS_SENSOR_8</td><td>ANY_DEVICE</td><td>0</td><td>0</td><td>0</td><td>0</td></tr> <tr><td>WIRELESS_SENSOR_9</td><td>ANY_DEVICE</td><td>0</td><td>0</td><td>0</td><td>0</td></tr> <tr><td>LOWPAN_GATEWAY_10</td><td>ANY_DEVICE</td><td>0</td><td>0</td><td>0</td><td>0</td></tr> </tbody> </table>						Source	Destination	Segment Sent	Segment Received	Ack Sent	Ack Received	WIRELESS_SENSOR_1	ANY_DEVICE	0	0	0	0	WIRELESS_SENSOR_2	ANY_DEVICE	0	0	0	0	WIRELESS_SENSOR_3	ANY_DEVICE	0	0	0	0	WIRELESS_SENSOR_4	ANY_DEVICE	0	0	0	0	WIRELESS_SENSOR_5	ANY_DEVICE	0	0	0	0	WIRELESS_SENSOR_6	ANY_DEVICE	0	0	0	0	WIRELESS_SENSOR_7	ANY_DEVICE	0	0	0	0	WIRELESS_SENSOR_8	ANY_DEVICE	0	0	0	0	WIRELESS_SENSOR_9	ANY_DEVICE	0	0	0	0	LOWPAN_GATEWAY_10	ANY_DEVICE	0	0	0	0																																									
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WIRELESS_SENSOR_8	ANY_DEVICE	0	0	0	0																																																																																																																																																																								
WIRELESS_SENSOR_9	ANY_DEVICE	0	0	0	0																																																																																																																																																																								
LOWPAN_GATEWAY_10	ANY_DEVICE	0	0	0	0																																																																																																																																																																								
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# Simulation Result Throughput Plot



NetSim - Plots



Show me

- ☒ Instantaneous
- ☒ Cumulative Moving Avg.
- ☒ Time Avg.

Plot Settings

Chart Title

X-Axis

Grid Line ☒

Minimum

Maximum

Avg. Win.

To plot instantaneous throughput  
Default is 50ms

Re-plot

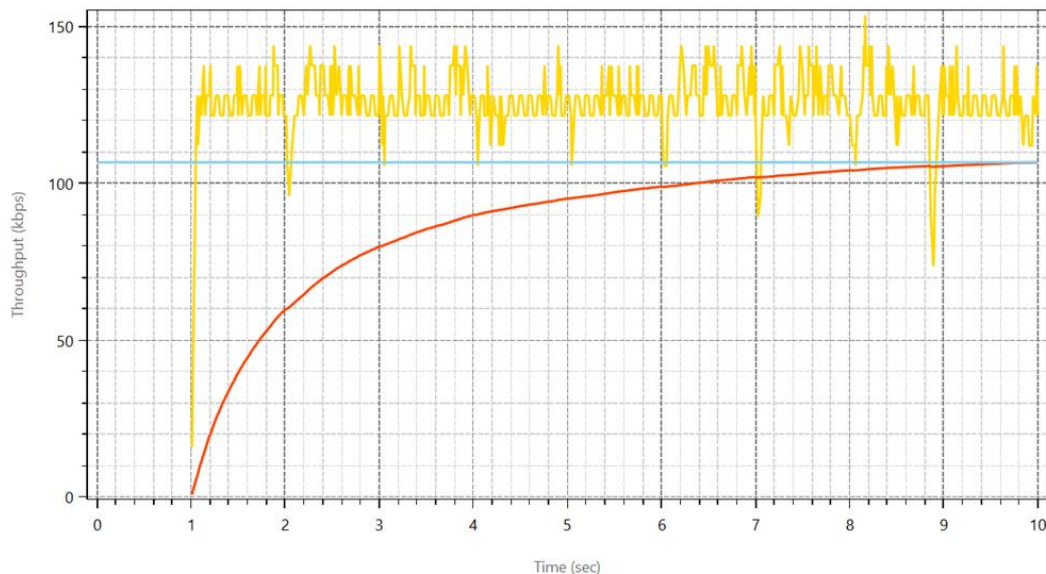
Y-Axis

Grid Line ☒

Range

1. Zoom: Move mouse over plot and zoom in/out using mouse wheel
2. PAN: Move mouse over plot and PAN right/left by pressing right click continuously and moving the mouse
3. X-Y value: Move mouse over plot and left click to view the coordinates of any point
4. Changes to color, title, zoom, axis values, etc are meant for visualization and print purposes only. These changes will not get saved when the window is closed.

App1\_CBR\_Throughput



# Exercise:

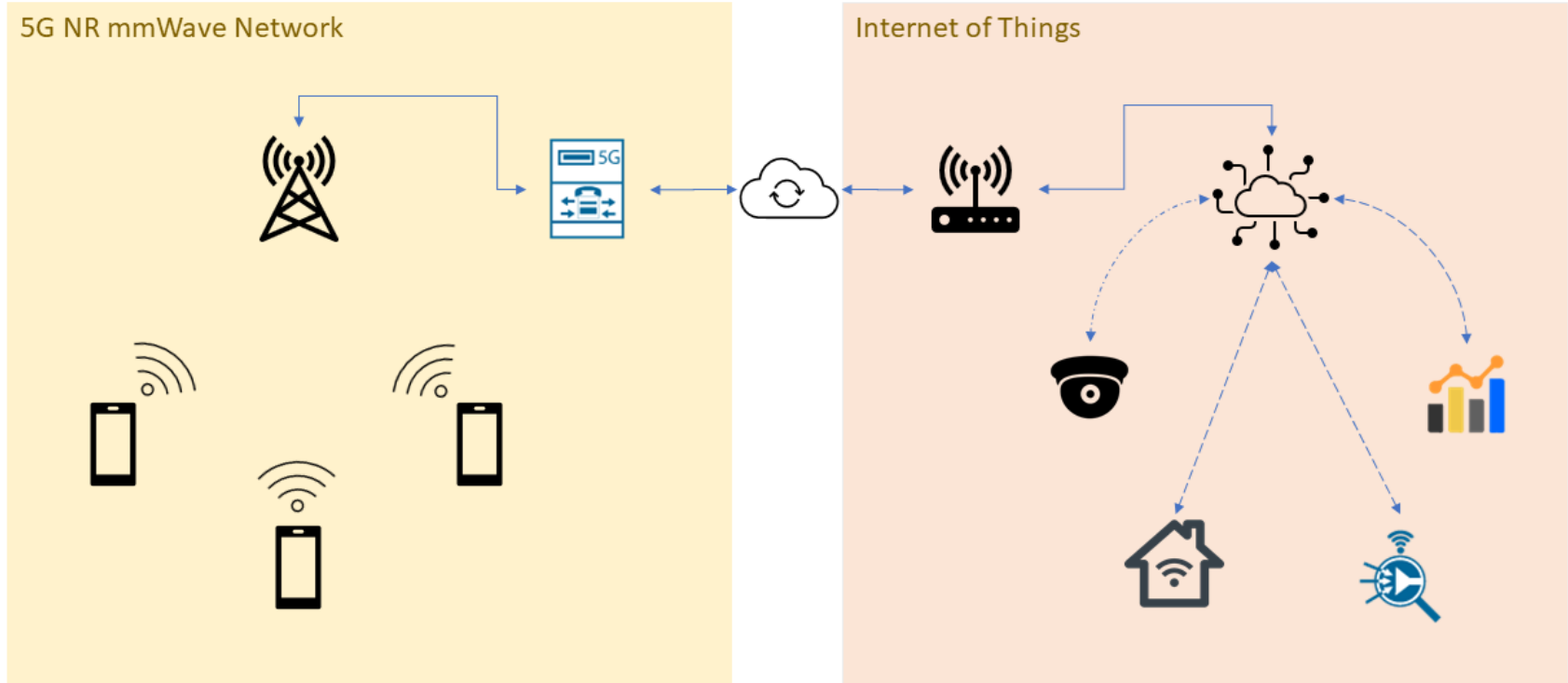
## Combine 5G and IoT in NetSim

**IoT Lab Session**

# Exercise : Combining IoT and 5G networks/protocols in NetSim simulations



Infographics: Combination of IoT and 5G



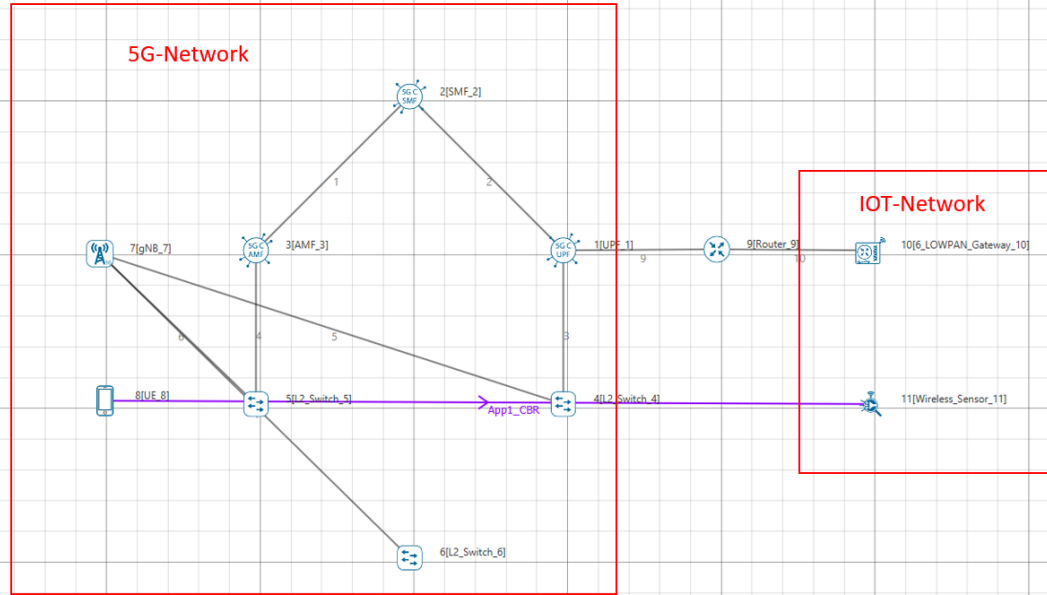
# Combining IoT and 5G networks/protocols in NetSim simulations



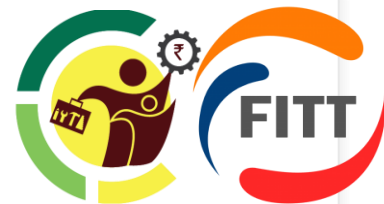
## NetSim Scenario

In this example, we are creating a scenario that is equivalent to the topology shown below. The **flow of traffic** is

**UE->gNB->UPF->Router->6LowPAN\_Gateway->Sensor.**

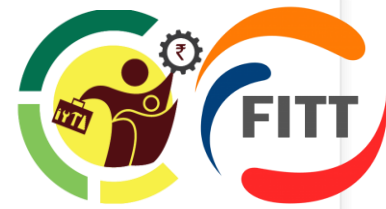


# Network Configuration parameter settings



## Network Configuration

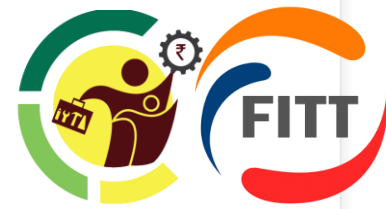
6_lowPan_Gateway Properties	
Routing Protocol	RPL
Router Properties	
Routing Protocol	OSPF
5G-CORE Properties	
All Default Properties	
gNB Properties	
All Default Properties	
UE Properties	
All Default Properties	



# Application Configuration parameter settings

## Application Configuration

Application Type	CBR
Source ID	8( <i>i.e UE</i> )
Destination ID	11( <i>i.e Wireless Sensor</i> )
Packet Size	1460 Bytes
Inter Arrival Time	1 s



## Configuration File Structure:

NetSim **GUI** does not allow combining the **IoT** and **5G** toolboxes. Therefore, this combining is done via the configuration file.

Different sections of configuration file -

- **Device** Configuration
- **Connection** Configuration
- **Application** Configuration

# Configuration File Structure:

**Device Configuration:** This section of the configuration file contains all the **device properties** used for this exercise

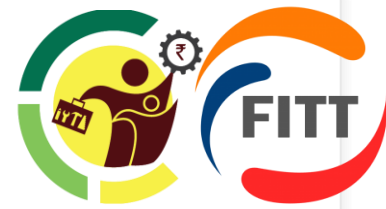
```
<DEVICE_CONFIGURATION DEVICE_COUNT="11">
<DEVICE DEFAULT_DEVICE_NAME="UPF" DEVICE_ID="1" DEVICE_IMAGE="UPF.png" DEVICE_NAME="UPF_1" DEVICE_TYPE="UPF" INTERFACE_COUNT="3" TYPE="UPF">...
</DEVICE>
<DEVICE DEFAULT_DEVICE_NAME="SMF" DEVICE_ID="2" DEVICE_IMAGE="SMF.png" DEVICE_NAME="SMF_2" DEVICE_TYPE="SMF" INTERFACE_COUNT="2" TYPE="SMF">...
</DEVICE>
<DEVICE DEFAULT_DEVICE_NAME="AMF" DEVICE_ID="3" DEVICE_IMAGE="AMF.png" DEVICE_NAME="AMF_3" DEVICE_TYPE="AMF" INTERFACE_COUNT="2" TYPE="AMF">...
</DEVICE>
<DEVICE DEFAULT_DEVICE_NAME="L2_Switch" DEVICE_ID="4" DEVICE_IMAGE="L2Switch.png" DEVICE_NAME="L2_Switch_4" DEVICE_TYPE="L2_SWITCH_UPF" INTERFACE_COUNT="2" TYPE="SWITCH">...
</DEVICE>
<DEVICE DEFAULT_DEVICE_NAME="L2_Switch" DEVICE_ID="5" DEVICE_IMAGE="L2Switch.png" DEVICE_NAME="L2_Switch_5" DEVICE_TYPE="L2_SWITCH_AMF" INTERFACE_COUNT="2" TYPE="SWITCH">...
</DEVICE>
<DEVICE DEFAULT_DEVICE_NAME="L2_Switch" DEVICE_ID="6" DEVICE_IMAGE="L2Switch.png" DEVICE_NAME="L2_Switch_6" DEVICE_TYPE="L2_SWITCH_gNB" INTERFACE_COUNT="1" TYPE="SWITCH">...
</DEVICE>
<DEVICE DEFAULT_DEVICE_NAME="gNB" DEVICE_ID="7" DEVICE_IMAGE="gNB.png" DEVICE_NAME="gNB_7" DEVICE_TYPE="LTE_gNB" INTERFACE_COUNT="4" TYPE="GNB">...
</DEVICE>
<DEVICE DEFAULT_DEVICE_NAME="UE" DEVICE_ID="8" DEVICE_IMAGE="UserEquipment.png" DEVICE_NAME="UE_8" DEVICE_TYPE="LTE_NR_UE" INTERFACE_COUNT="1" TYPE="UE" WIRESHARK_OPTION="Disable">...
</DEVICE>
<DEVICE DEFAULT_DEVICE_NAME="Router" DEVICE_ID="9" DEVICE_IMAGE="InternalRouter.png" DEVICE_NAME="Router_9" DEVICE_TYPE="ROUTER" INTERFACE_COUNT="2" TYPE="ROUTER" WIRESHARK_OPTION="Disable">...
</DEVICE>
<DEVICE DEFAULT_DEVICE_NAME="Gateway" DEVICE_ID="10" DEVICE_IMAGE="6LowPANGateway.png" DEVICE_NAME="6_LOMPAN_Gateway_10" DEVICE_TYPE="LOWPAN_Gateway" INTERFACE_COUNT="2" TYPE="SINKNODE">...
</DEVICE>
<DEVICE DEFAULT_DEVICE_NAME="Sensor" DEVICE_ID="11" DEVICE_IMAGE="WirelessSensor.png" DEVICE_NAME="Wireless_Sensor_11" DEVICE_TYPE="IOT_Sensors" INTERFACE_COUNT="1" TYPE="SENSOR" WIRESHARK_OPTION="Disable">...
</DEVICE>
```



# Configuration File Structure:

**Connection Configuration:** This section of the configuration file contains all the **connection properties** from one device to another as shown in the scenario

```
<LINK DEVICE_COUNT="2" LINK_COLOR="" LINK_ID="1" LINK_MODE="FULL_DUPLEX" LINK_NAME="1" LINK_SPEED_DOWN="10000" LINK_SPEED_UP="10000" LINK_WIDTH="2.0" MEDIUM="WIRED" TYPE="POINT_TO_POINT"> ...
</LINK>
<LINK DEVICE_COUNT="2" LINK_COLOR="" LINK_ID="2" LINK_MODE="FULL_DUPLEX" LINK_NAME="2" LINK_SPEED_DOWN="10000" LINK_SPEED_UP="10000" LINK_WIDTH="2.0" MEDIUM="WIRED" TYPE="POINT_TO_POINT"> ...
</LINK>
<LINK DEVICE_COUNT="2" LINK_COLOR="" LINK_ID="3" LINK_MODE="FULL_DUPLEX" LINK_NAME="3" LINK_SPEED_DOWN="10000" LINK_SPEED_UP="10000" LINK_WIDTH="2.0" MEDIUM="WIRED" TYPE="POINT_TO_POINT"> ...
</LINK>
<LINK DEVICE_COUNT="2" LINK_COLOR="" LINK_ID="4" LINK_MODE="FULL_DUPLEX" LINK_NAME="4" LINK_SPEED_DOWN="10000" LINK_SPEED_UP="10000" LINK_WIDTH="2.0" MEDIUM="WIRED" TYPE="POINT_TO_POINT"> ...
</LINK>
<LINK DEVICE_COUNT="2" LINK_COLOR="" LINK_ID="5" LINK_MODE="FULL_DUPLEX" LINK_NAME="5" LINK_SPEED_DOWN="10000" LINK_SPEED_UP="10000" LINK_WIDTH="2.0" MEDIUM="WIRED" TYPE="POINT_TO_POINT"> ...
</LINK>
<LINK DEVICE_COUNT="2" LINK_COLOR="" LINK_ID="6" LINK_MODE="FULL_DUPLEX" LINK_NAME="6" LINK_SPEED_DOWN="10000" LINK_SPEED_UP="10000" LINK_WIDTH="2.0" MEDIUM="WIRED" TYPE="POINT_TO_POINT"> ...
</LINK>
<LINK DEVICE_COUNT="2" LINK_COLOR="" LINK_ID="7" LINK_MODE="FULL_DUPLEX" LINK_NAME="7" LINK_SPEED_DOWN="10000" LINK_SPEED_UP="10000" LINK_WIDTH="2.0" MEDIUM="WIRED" TYPE="POINT_TO_POINT"> ...
</LINK>
<LINK DEVICE_COUNT="2" LINK_COLOR="1885ad" LINK_ID="8" LINK_MODE="HALF_DUPLEX" LINK_NAME="8" LINK_WIDTH="2.0" MEDIUM="WIRELESS" TYPE="POINT_TO_MULTIPPOINT"> ...
</LINK>
<LINK DEVICE_COUNT="2" LINK_COLOR="" LINK_ID="9" LINK_MODE="FULL_DUPLEX" LINK_NAME="9" LINK_SPEED_DOWN="10000" LINK_SPEED_UP="10000" LINK_WIDTH="2.0" MEDIUM="WIRED" TYPE="POINT_TO_POINT"> ...
</LINK>
<LINK DEVICE_COUNT="2" LINK_COLOR="" LINK_ID="10" LINK_MODE="FULL_DUPLEX" LINK_NAME="10" LINK_SPEED_DOWN="100" LINK_SPEED_UP="100" LINK_WIDTH="2.0" MEDIUM="WIRED" TYPE="POINT_TO_POINT"> ...
</LINK>
<LINK DEVICE_COUNT="2" LINK_COLOR="1885ad" LINK_ID="11" LINK_MODE="HALF_DUPLEX" LINK_NAME="11" LINK_WIDTH="2.0" MEDIUM="WIRELESS" TYPE="MULTIPOINT_TO_MULTIPPOINT" X="28.387458086718926" Y="6.83090705487122"> ...
</LINK>
```



## Configuration File Structure:

**Application Configuration:** This section of the configuration file contains information about the **application properties**. i.e. in this example its CBR Application from UE to Sensor.

```
APPLICATION_CONFIGURATION COUNT="1"  
<APPLICATION APPLICATION_COLOR="0x9000ffff" APPLICATION_METHOD="UNICAST" APPLICATION_TYPE="CBR" APPLICATION_WIDTH="2.0" DESTINATION_COUNT="1" DESTINATION_ID="11" ENCRYPTION="NONE" END_TIME="100000" ID="1" NAME="  
  <PACKET_SIZE DISTRIBUTION="CONSTANT" VALUE="1460"/>  
  <INTER_ARRIVAL_TIME DISTRIBUTION="CONSTANT" VALUE="20000"/>  
</APPLICATION>
```

## Analyzing results and viewing NetSim animation:



Once the **configuration file is set up correctly**, the simulation is then **run via CLI**(Command Line Interface).

1. Simulate the scenario via CLI
2. For opening Result Dashboard open command prompt in NetSim Installation directory and run command that given below (version might differ)-

```
NetSimMetrics.exe %appdata%\NetSim\std_13.1
```



## Analyzing results and viewing NetSim animation:

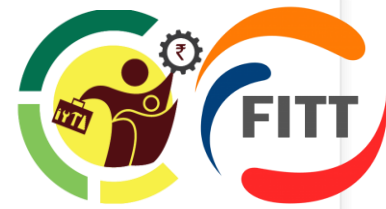
3. After opening Result Dashboard, open Animation window by running command that given below,

```
NetSimAnimation.exe %appdata%\NetSim\std_13.1
```

3. Result Dashboard and Animation window can be opened in NetSim UI as well(Both should be enabled in configuration file).

# Steps to design IoT Solution for Specific industries

**IoT Lab Session**



# Steps to design IoT Solution

1. Identify Industry Needs and Use Cases
2. Define Requirements
3. Select IoT Devices and Sensors
4. Choose Connectivity Options
5. Design Data Collection and Communication Architecture
6. Implement Security Measures
7. Develop Application Software
8. Test and Validate
9. Deploy and Scale
10. Provide Support and Maintenance
11. Continuous Improvement

# Capstone Project Discussion

**IoT Lab Session**



# Capstone Project Discussion

## Problem Statements:

- Configure a Sensor with a microcontroller, capture readings and send this data to any cloud platform and visualise it.
- Create Publisher and Subscriber scenario and use open source broker to demonstrate the data transfer.
- Implement client and server based data protocol and showcase transmission of data packets
- Explore open source data and Perform data analysis /mining using concepts of ML
- Design your own IoT solution in any Domain (Agriculture/Manufacturing/Healthcare/Smart City)
- Design Security solutions demonstrating encryption and decryption.
- Demo any IoT Network testing tools, IoT Platforms AWS, MS Azure Hub, Hardware Project related to IoT, Data Analytics tool, etc