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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

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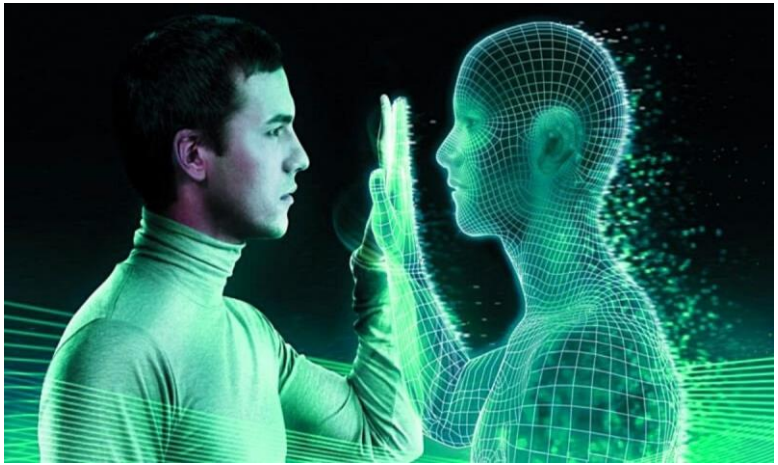
Simulation Process and its importance

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

https://medium.com/@srivathsen/simulation-driven-product-development-3bcb01728e34

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.**

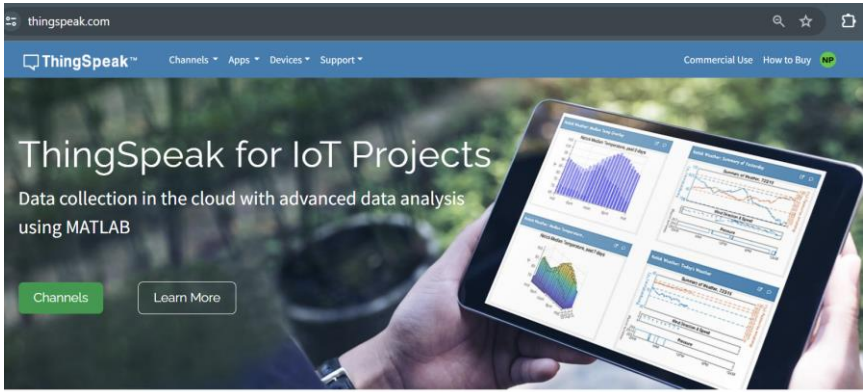
- It provides a user-friendly interface for designing and testing IoT projects, with **features** like **virtual hardware components, code editing, and real-time simulation feedback.**

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.

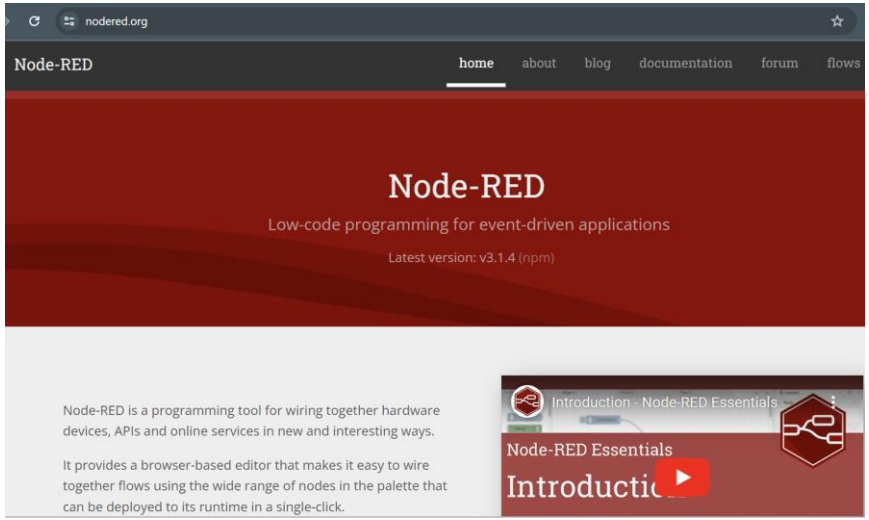


Source: https://thingspeak.com/

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/

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Let’s Bring **IoT and 5G** Together

Introduction to NetSim Simulator For 5G and IoT integration

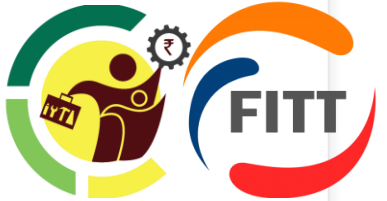
NetSim Simulator For 5G and IoT Integration

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.

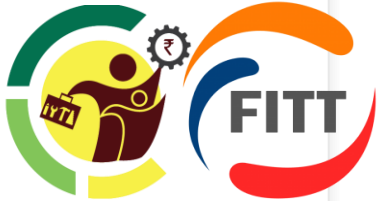
C10 5G NR

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

Current workspace: NetSim Workspace

Source: https://www.tetcos.com/

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.

Current workspace: NetSim Workspace

Source: https://www.tetcos.com/

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

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.

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Exercise:

IoT in NetSim

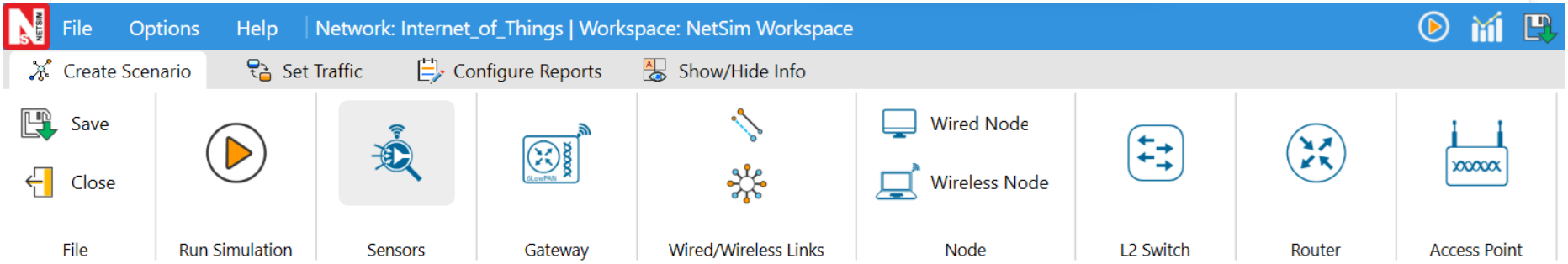
IoT Lab Session

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.**

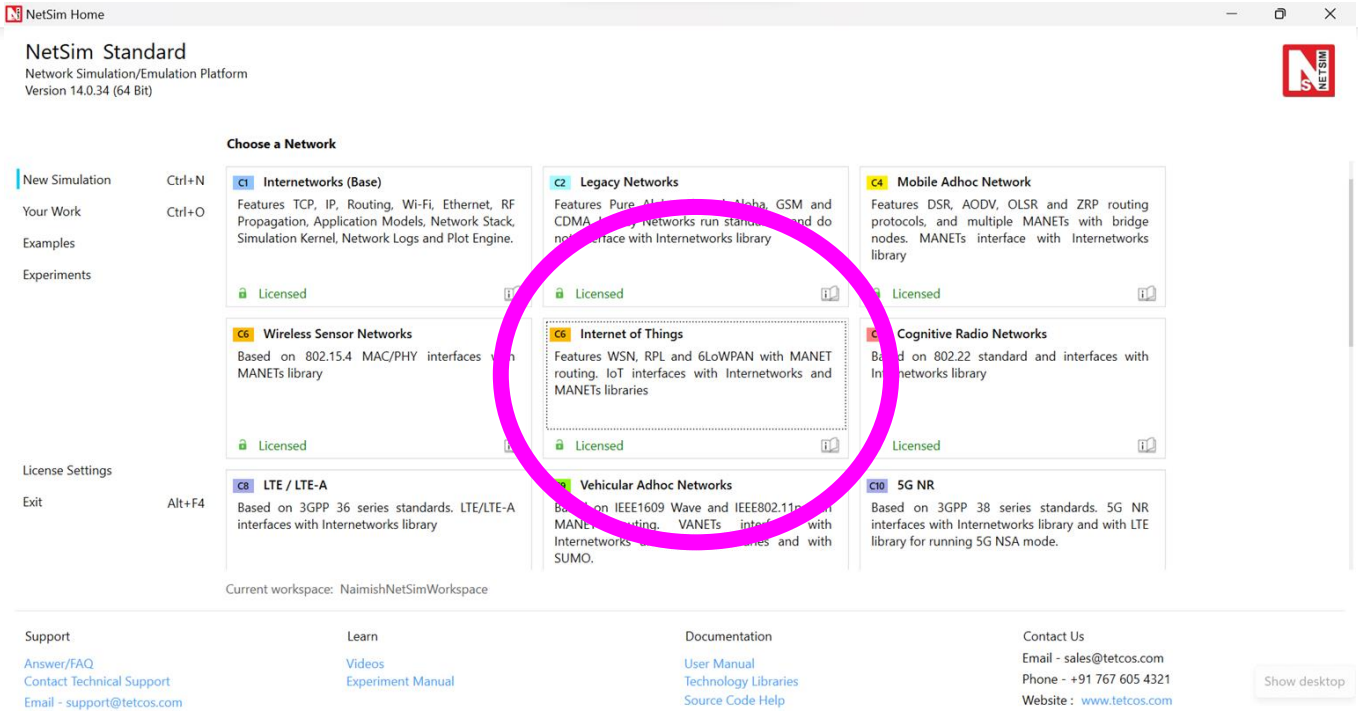
Available functions for IoT Network simulation in NetSim



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

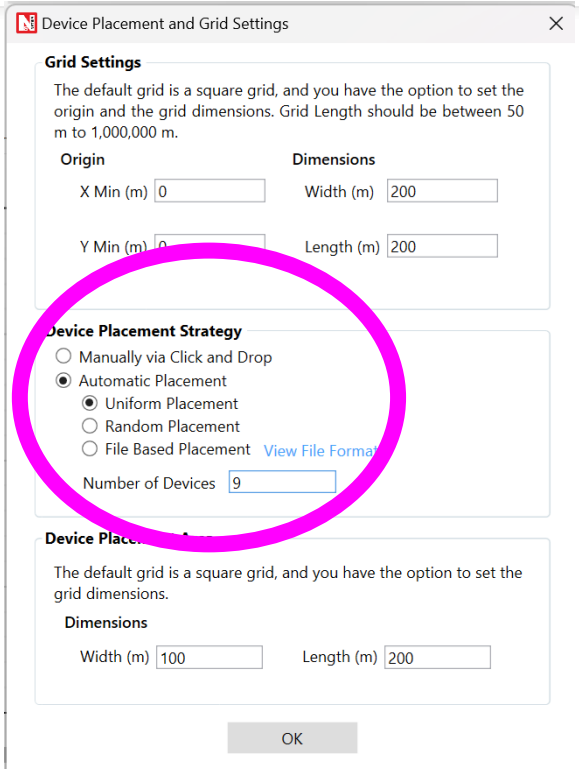
- Switches
- Routers
- And other required components

Go to Internet Of things

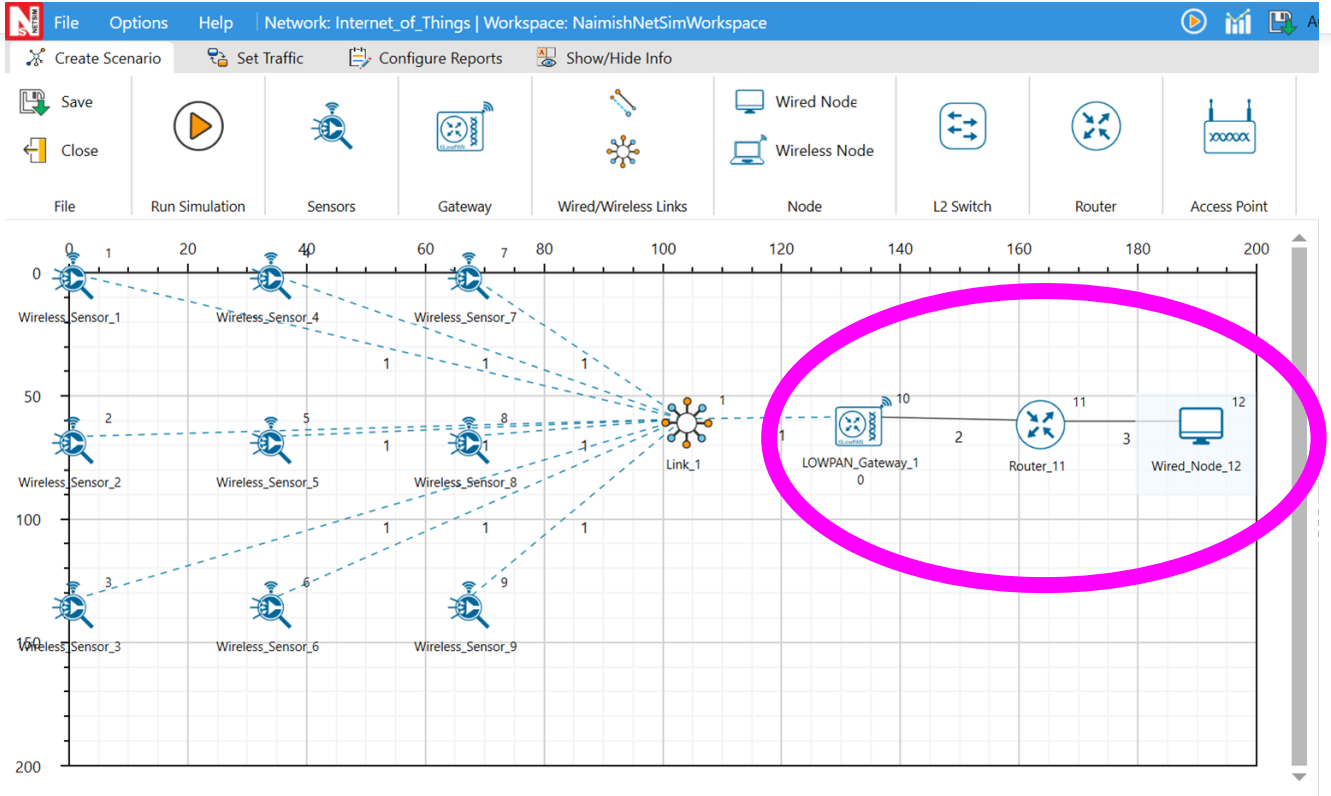


Configuration window

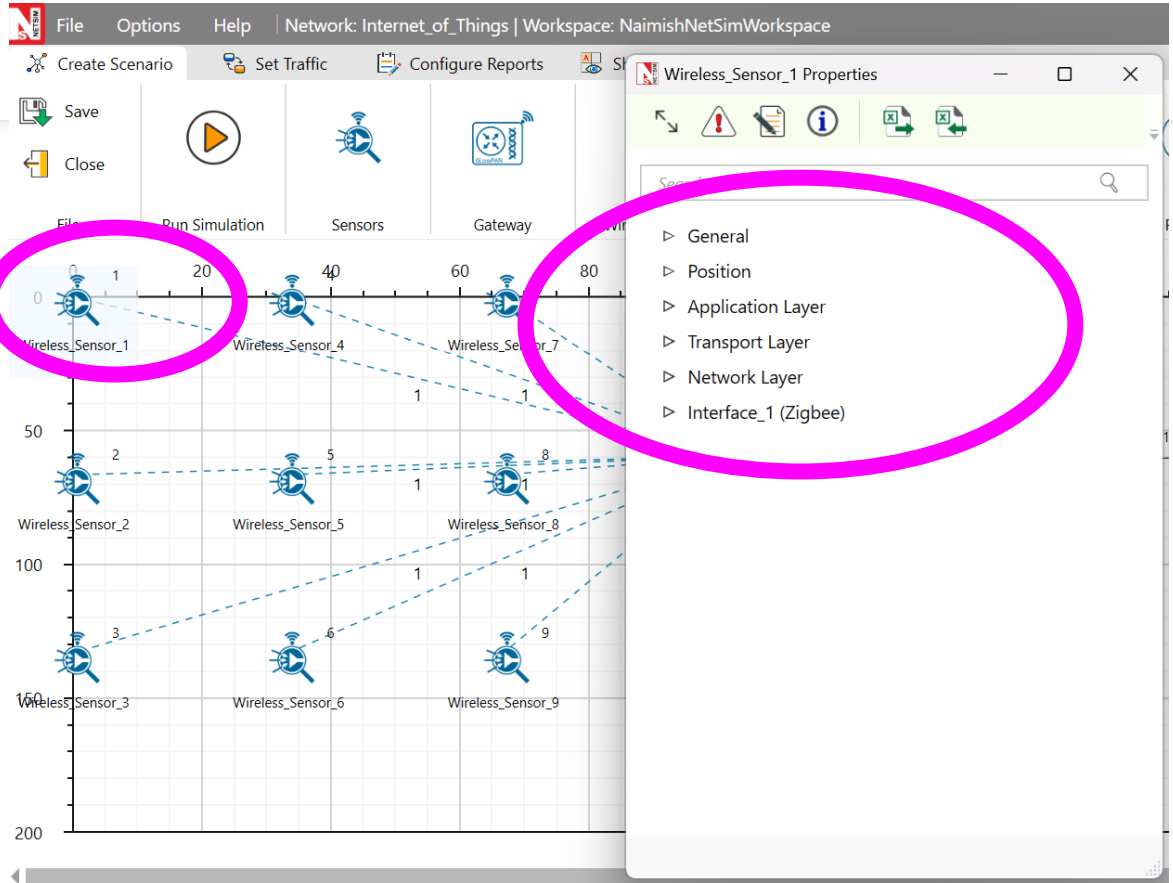
1. Update Grid dimensions
2. Select sensor placement type(Uniform/Random)
3. Enter number of devices (9)
4. Device placement area (200,100)



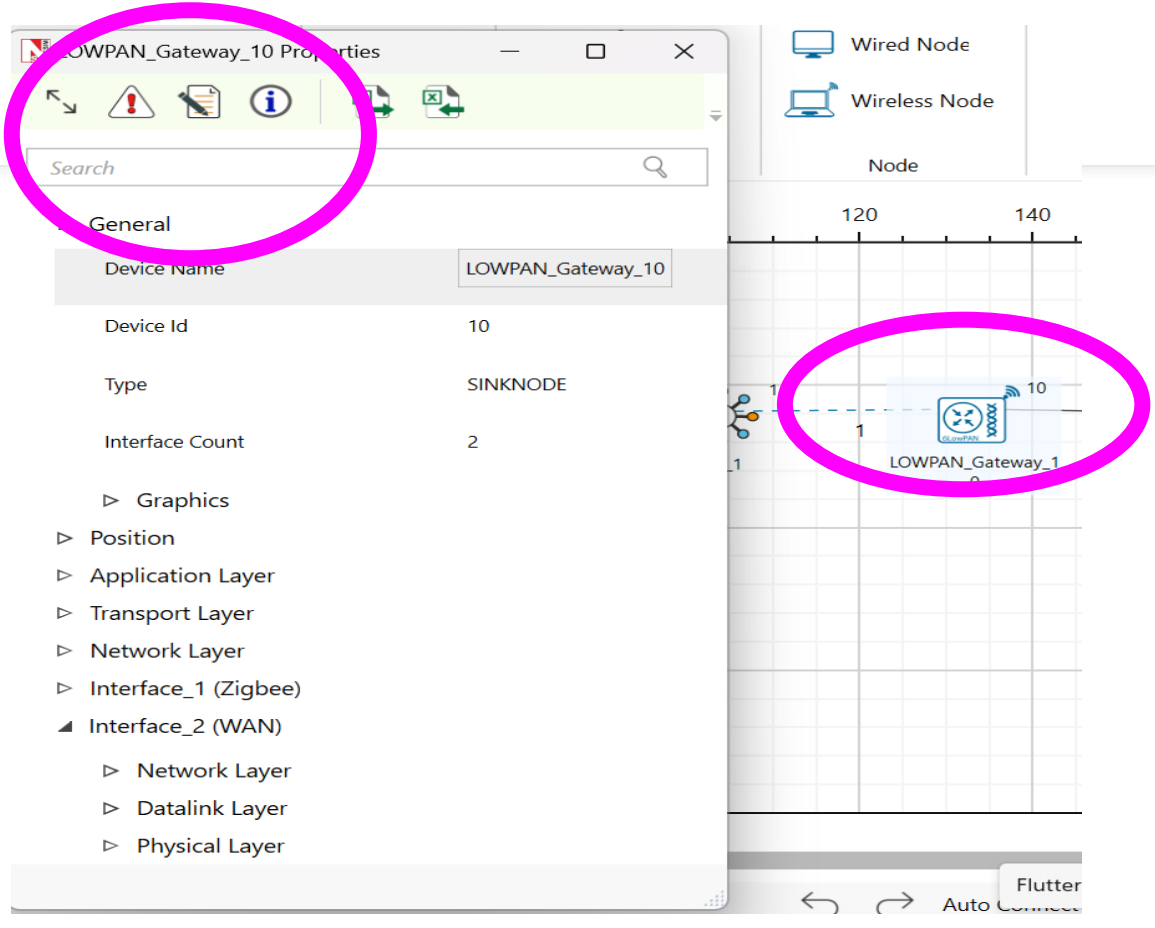
Add Gateway, Router and Wired Node



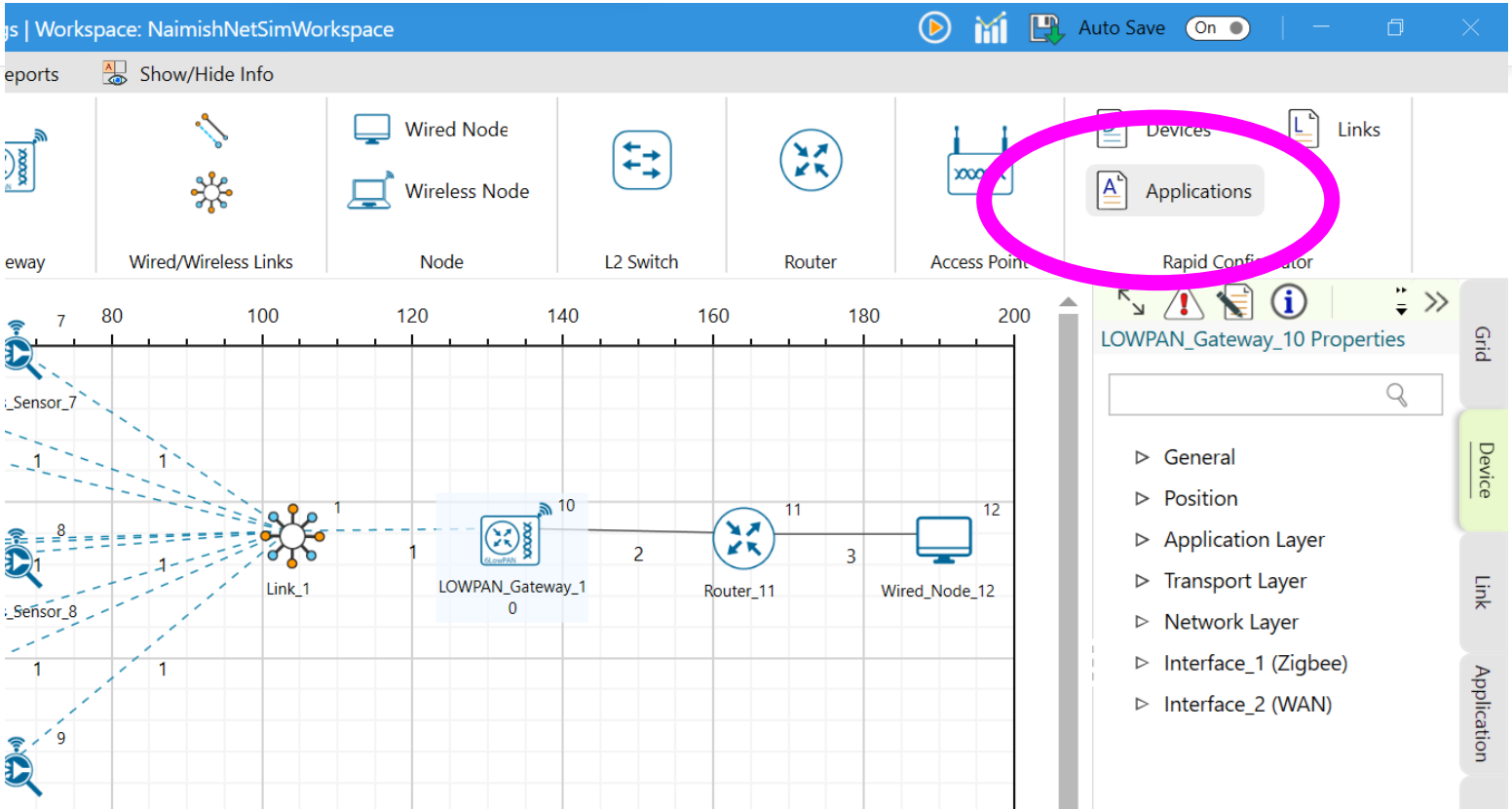
Configure sensors properties



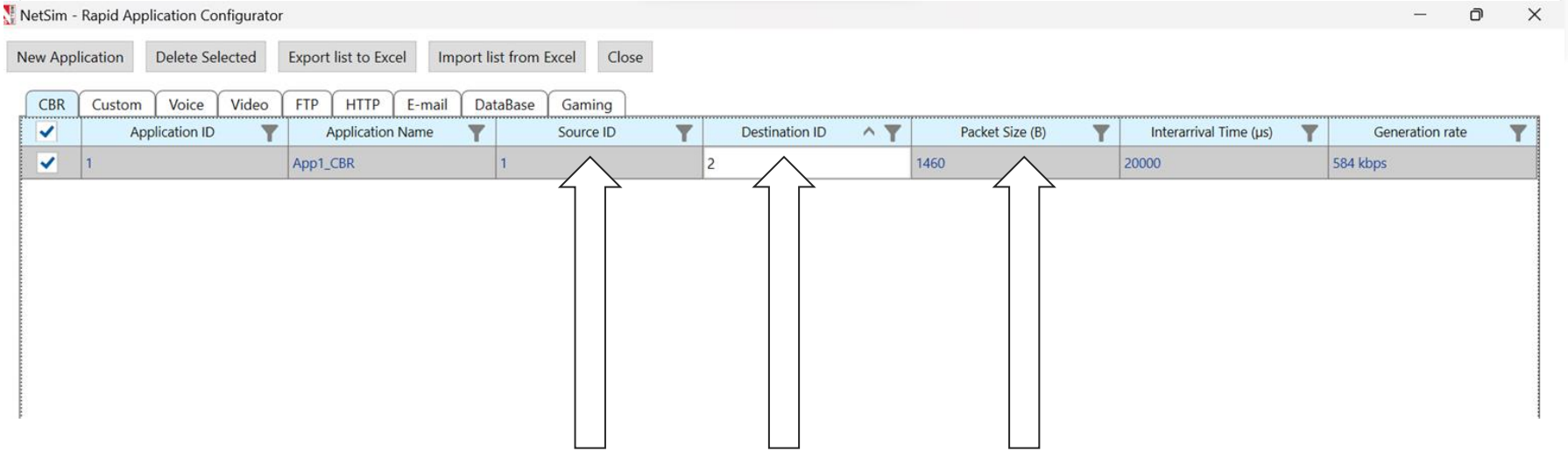
Configure LOWPAN gateway properties



Configure Application properties

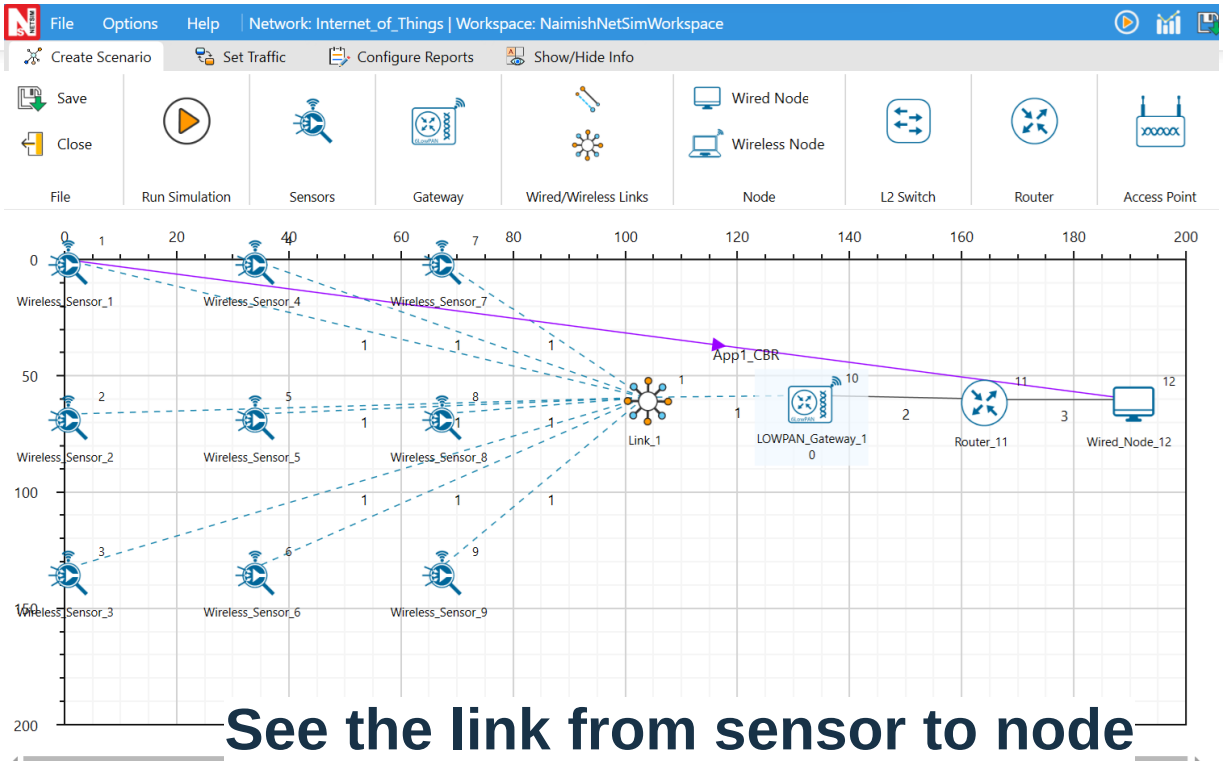


Configure Application properties



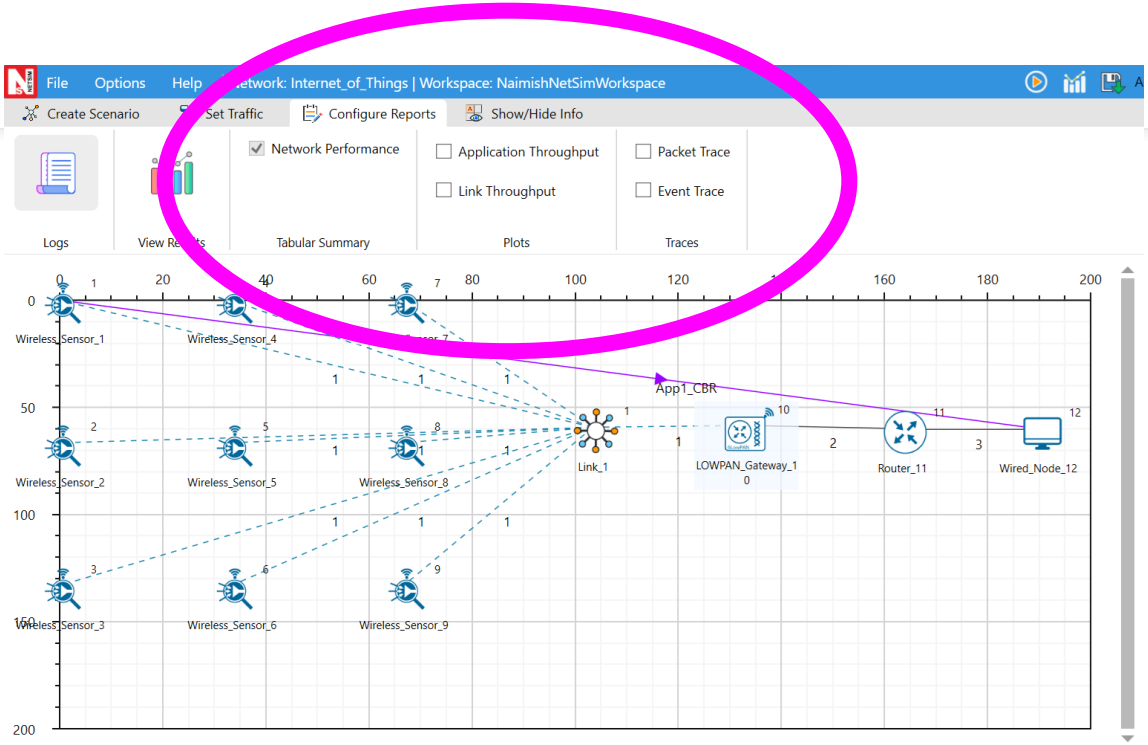
Set source Id(2) for sensor, destination ID (12) for wired node and other parameters

Configure Application properties



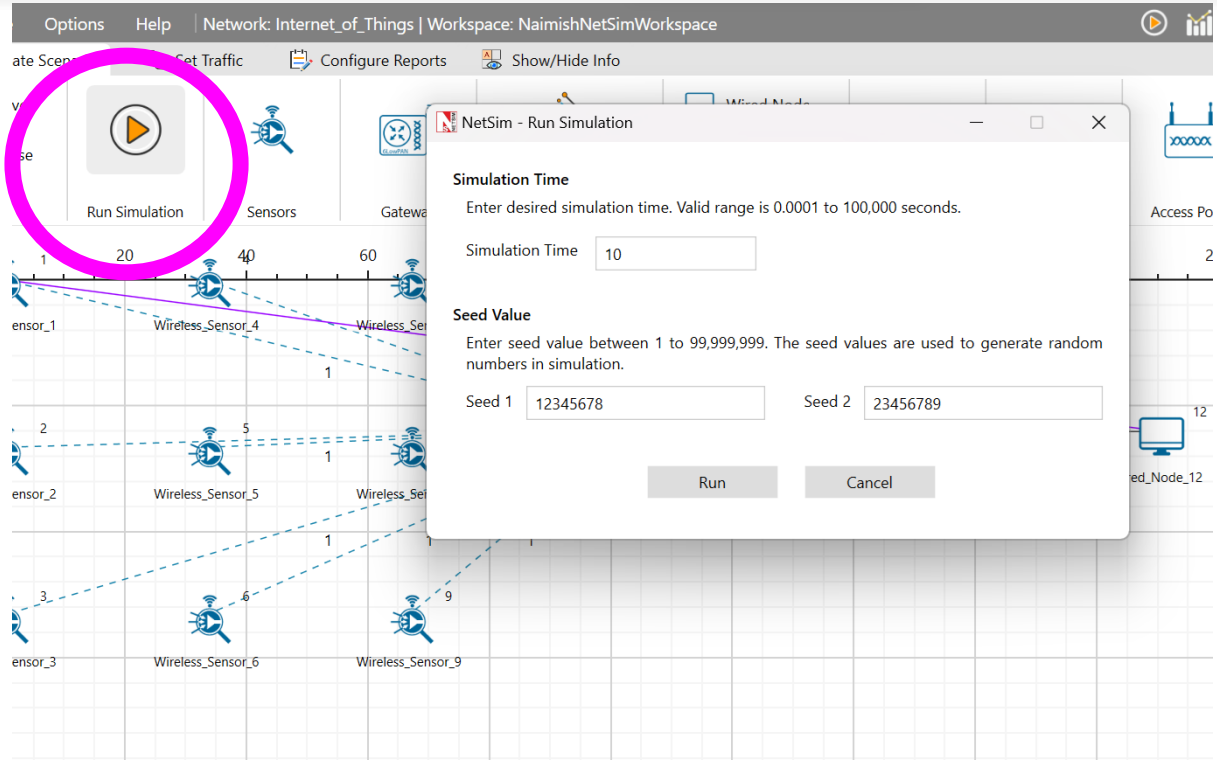
See the link from sensor to node

Lets Simulate



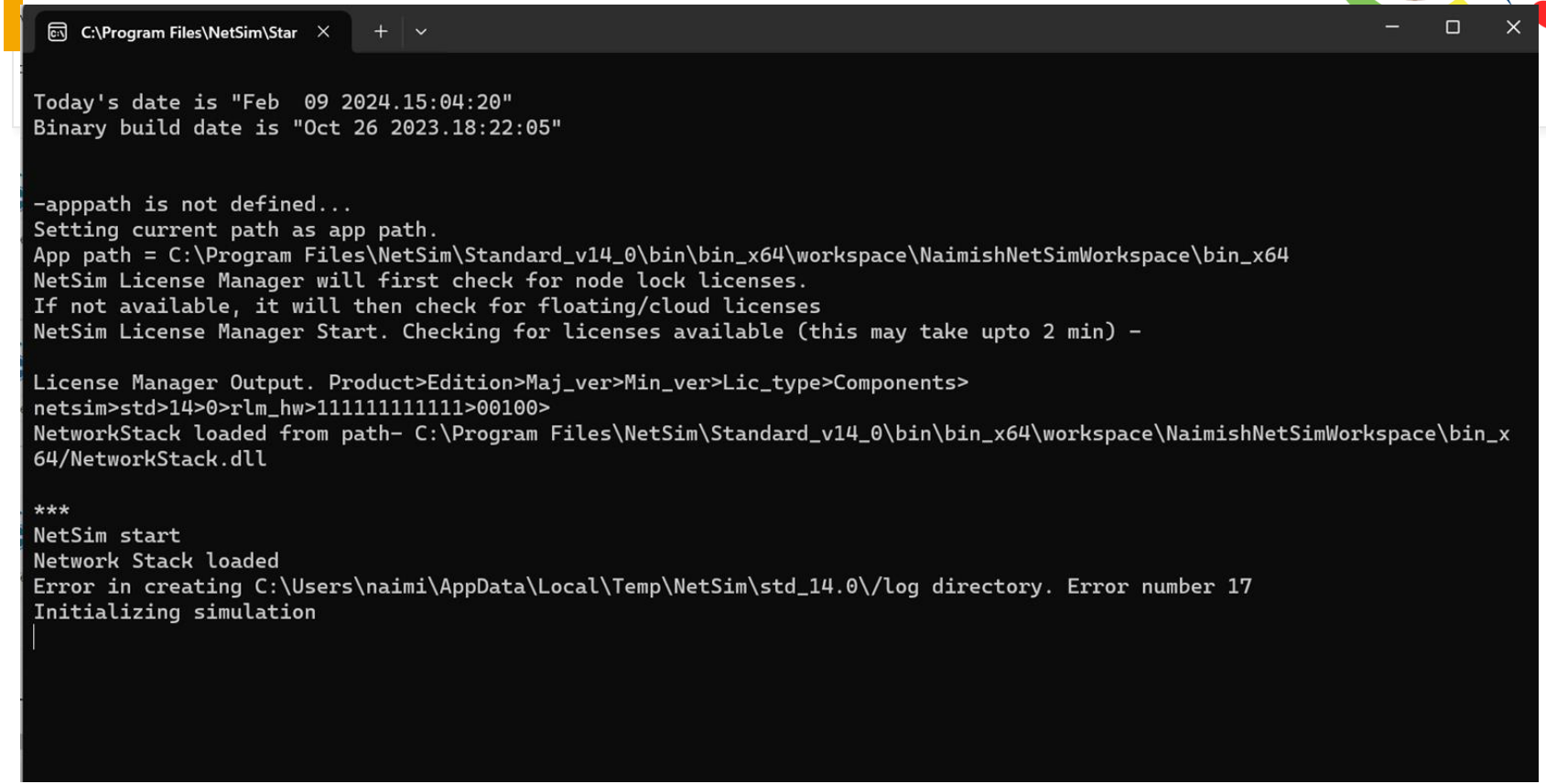
Enable Packet Trace and other parameters you want to observe under configure reports

Lets Simulate

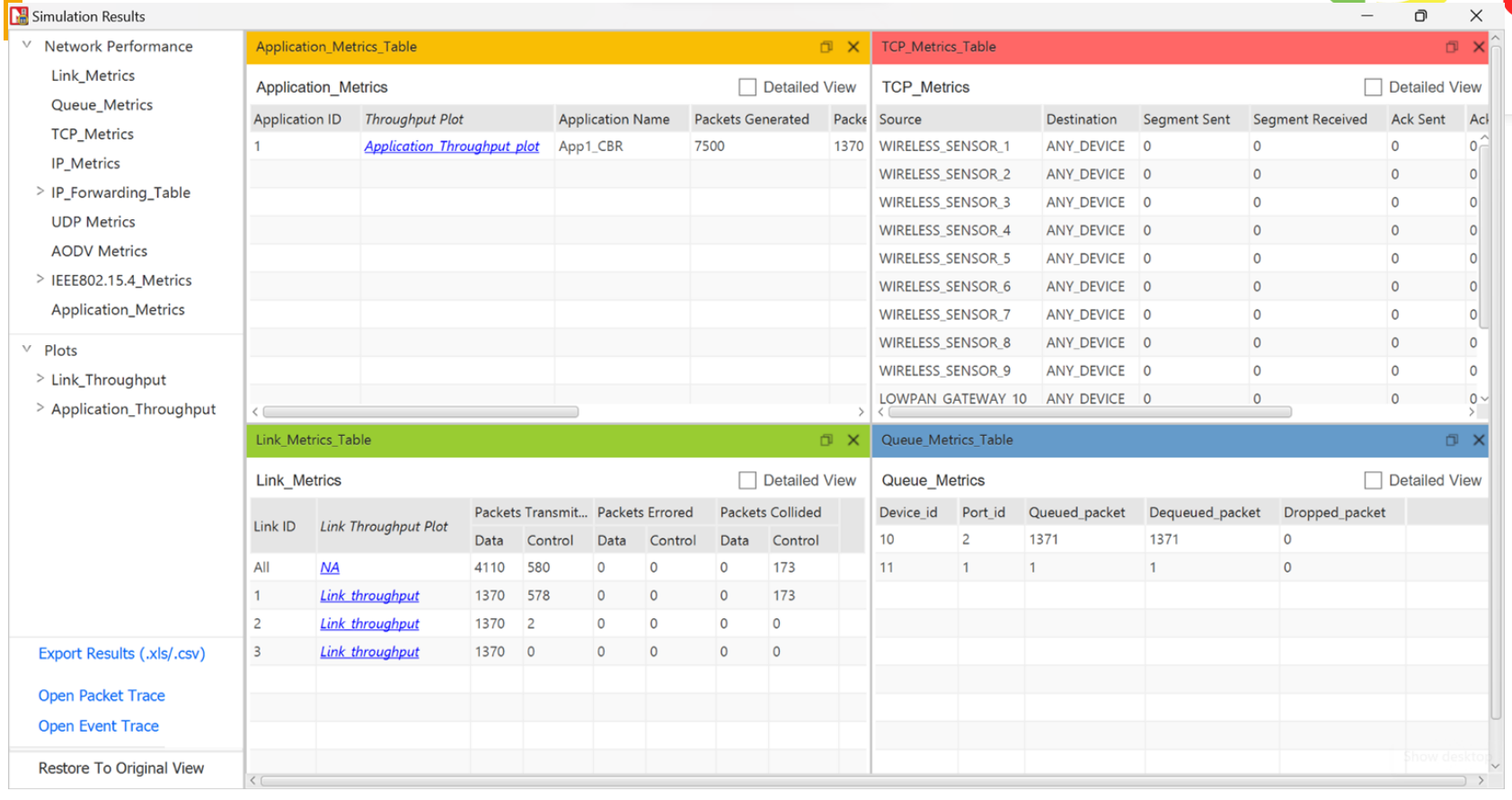


Click on run simulation and set parameters

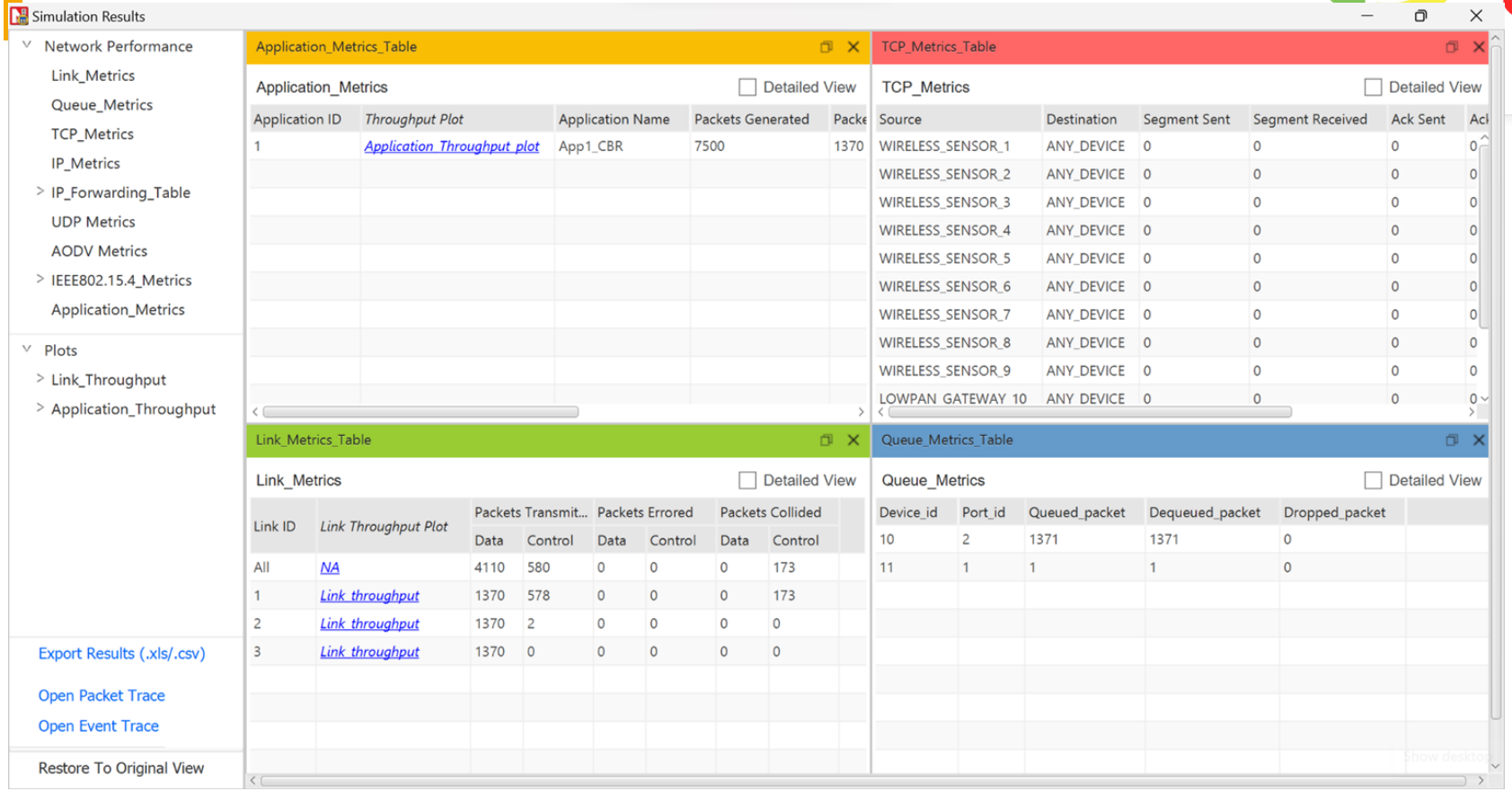
This window will appear



Simulation Result Matrix



Simulation Result Matrix



Simulation Result Throughput Plot

NetSim - Plots

Show me

- [x] Instantaneous
- [x] Cumulative Moving Avg.
- [x] Time Avg.

Plot Settings

Chart Title: App1_CBR_Throughput

X-Axis

Grid Line: [x]

Minimum: *Minimum time (sec)*

Maximum: *Maximum time (sec)*

Avg. Win.: *Averaging Window (ms)*

To plot instantaneous throughput Default is 50ms

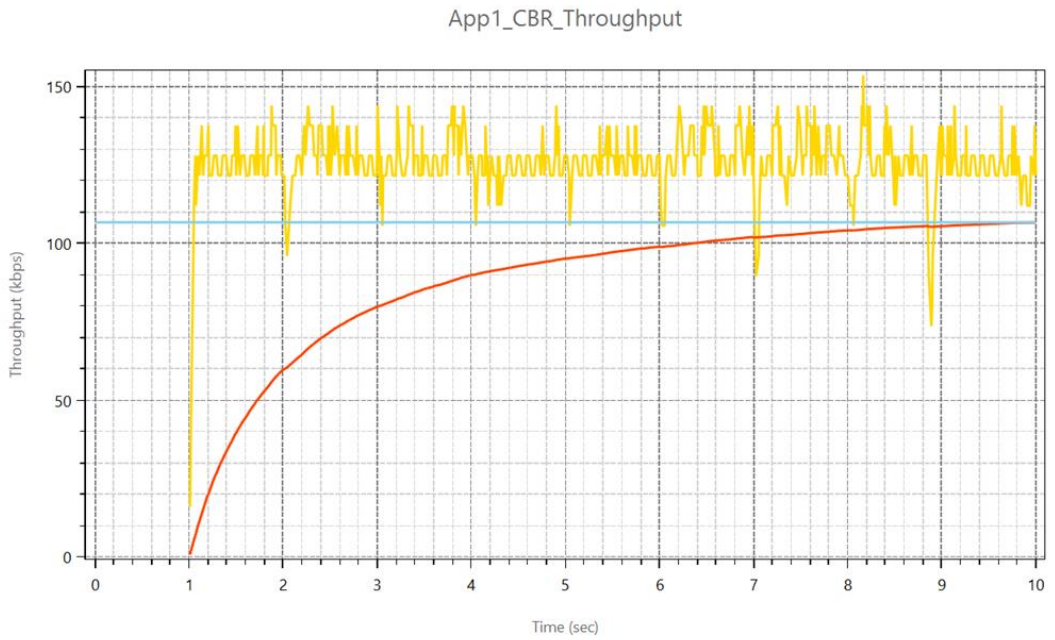
Re-plot

Y-Axis

Grid Line: [x]

Range: Auto 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.



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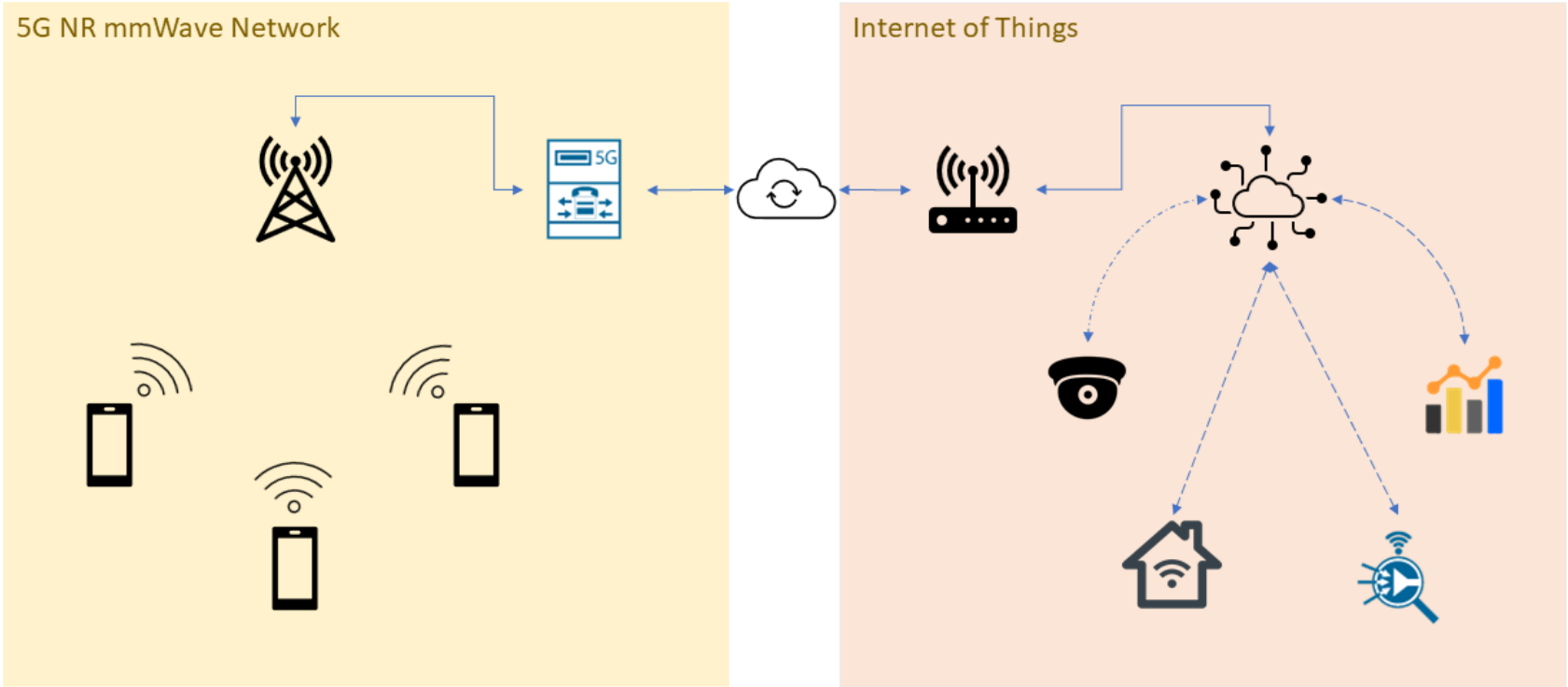
Exercise:

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

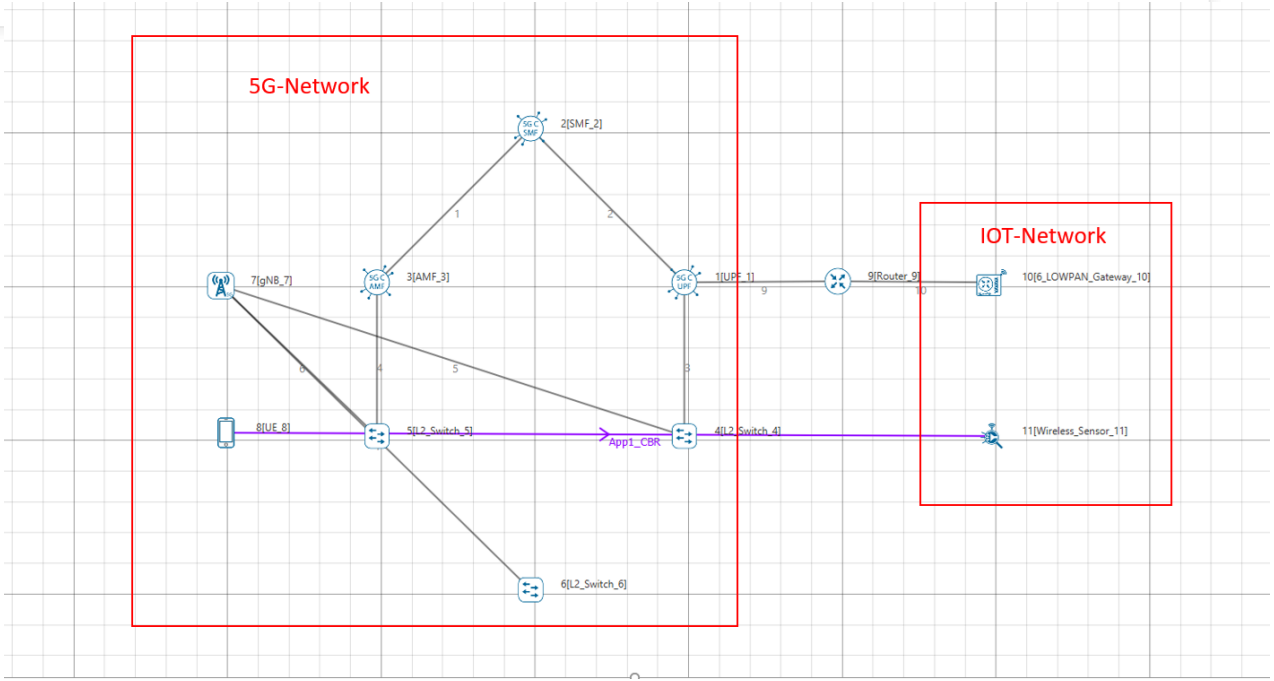


Source: https://support.tetcos.com/support/solutions/articles/14000121446-combining-iot-and-5g-networks-protocols-in-netsim-simulations

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.e UE*)
Destination ID	11(i.e *Wireless Sensor*)
Packet Size	1460 Bytes
Inter Arrival Time	1 s

Configuration File Structure:

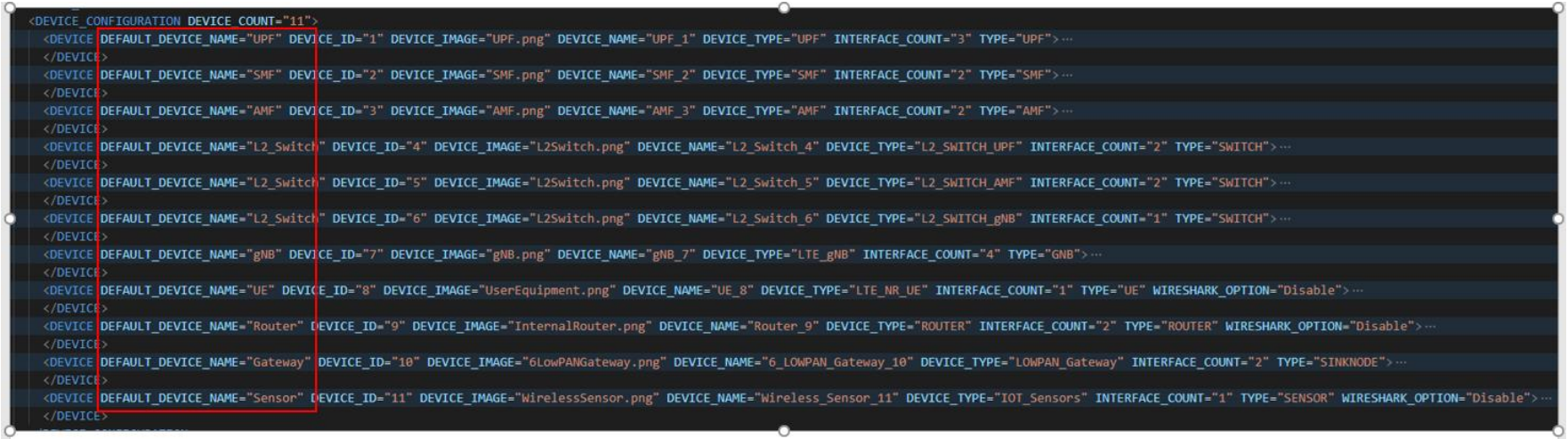
NetSim **GUI does not allow combining the IoT and 5G** toolboxes. Therefore, t**his combining is done via the configuration file.**

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



```
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  </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>
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  </DEVICE>
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  </DEVICE>
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  </DEVICE>
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  </DEVICE>
  <DEVICE DEFAULT_DEVICE_NAME="Gateway" DEVICE_ID="10" DEVICE_IMAGE="6LowPANGateway.png" DEVICE_NAME="6_LOWPAN_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

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</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_MULTIPOINT" X="28.387458006718926" 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).

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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

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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