

## **EXP:11 . QUALITY OF SERVICE (QOS) IN 802.11E BASED WLANS    ; USING NETSIM SOFTWARE**

**Aim:** To analyze and evaluate the Quality of Service (QoS) performance in 802.11e-based WLANs using NetSim software.

**Apparatus:** NETSIM V12 , PC

### **Theory:**

Quality of Service (QoS) refers to the ability of a network to provide differentiated service levels based on application requirements. In Wireless Local Area Networks (WLANs), QoS ensures that latency-sensitive applications like voice, video streaming, and online gaming receive higher priority than background data traffic.

The IEEE 802.11e standard introduces QoS enhancements to traditional WLANs by defining mechanisms for traffic prioritization at the Medium Access Control (MAC) layer.

The 802.11e standard improves QoS in WLANs through:

Enhanced Distributed Channel Access (EDCA)

Hybrid Coordination Function Controlled Channel Access (HCCA)

a) Enhanced Distributed Channel Access (EDCA)

EDCA enhances the Distributed Coordination Function (DCF) by classifying network traffic into four Access Categories (ACs):

AC\_VO (Voice): Highest priority, lowest delay.

AC\_VI (Video): High priority for real-time applications.

AC\_BE (Best Effort): Default priority for general data traffic.

AC\_BK (Background): Lowest priority, used for non-urgent tasks.

Each AC competes for medium access using different Contention Window (CW) sizes and Arbitration Inter frame Spaces (AIFS), ensuring high-priority traffic gets faster access.

b) Hybrid Coordination Function Controlled Channel Access (HCCA)

HCCA uses a centralized scheduler (Hybrid Coordinator) to allocate transmission opportunities (TXOPs) for each station. Unlike EDCA, it provides guaranteed bandwidth for high-priority applications.

IEEE 802.11e Medium Access Control (MAC) is a supplement to the IEEE 802.11 WLAN standard to support Quality-of-Service(QoS).When 802.11e is enabled high-priority traffic has a higher chance of being sent than low-priority traffic: an application with high priority traffic waits a little less before its packet is processed and compared to an application with low priority traffic.

The various application traffic generated in NetSim have the following priority and QoS values:

Application Type	Priority Value	Priority	QoS Class
Voice—Oneway	8	Medium	RTPS
Voice—Twoway	8	High	UGS
Video	6	Low	nRTPS
FTP	2	Low	BE
Database	2	Low	BE
Custom	2	Low	BE

RTPS, QoS class is available in NetSim which has a priority value of 4.

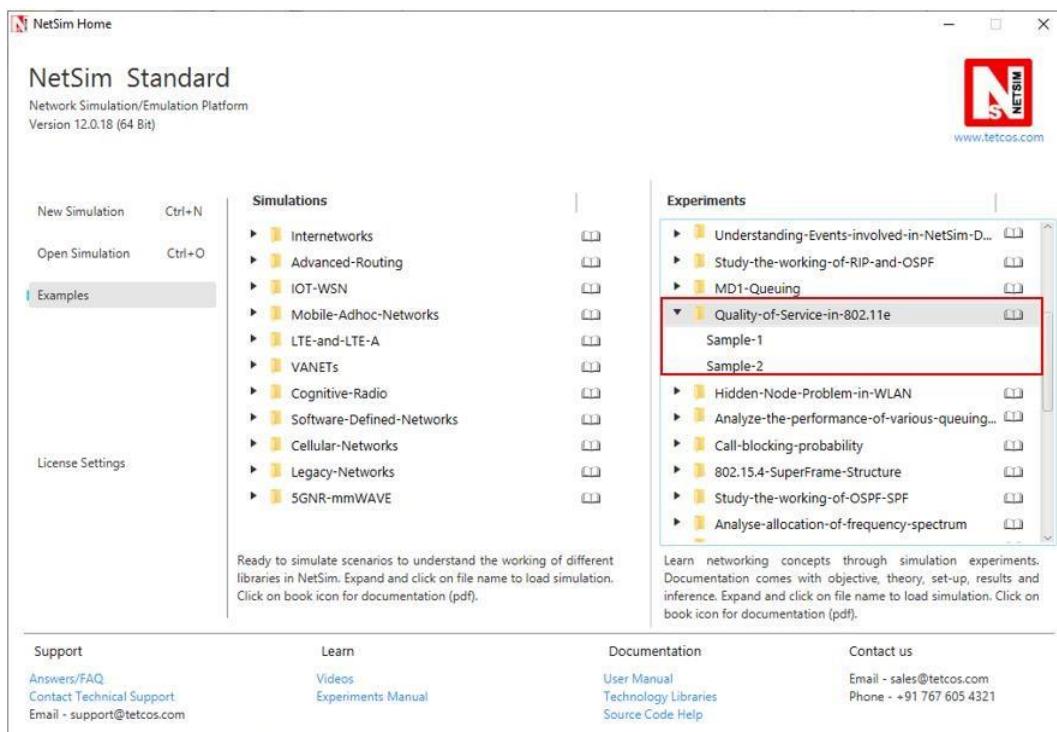
The QoS class for each application mentioned in the table above is fixed and can be changed by the user.

### Network Setup : Open NetSim and click on Examples

NetSim UI displays the configuration file corresponding to this experiment as shown \ below

#### Procedure:

Sample1:



The following set of procedures were done to generate this sample:

Step 1: A network scenario is designed in NetSim GUI comprising of 1 Wired Node, 2 Wireless Nodes, 1 Router, and 1 Access Point in the “Internet works” Network Library.

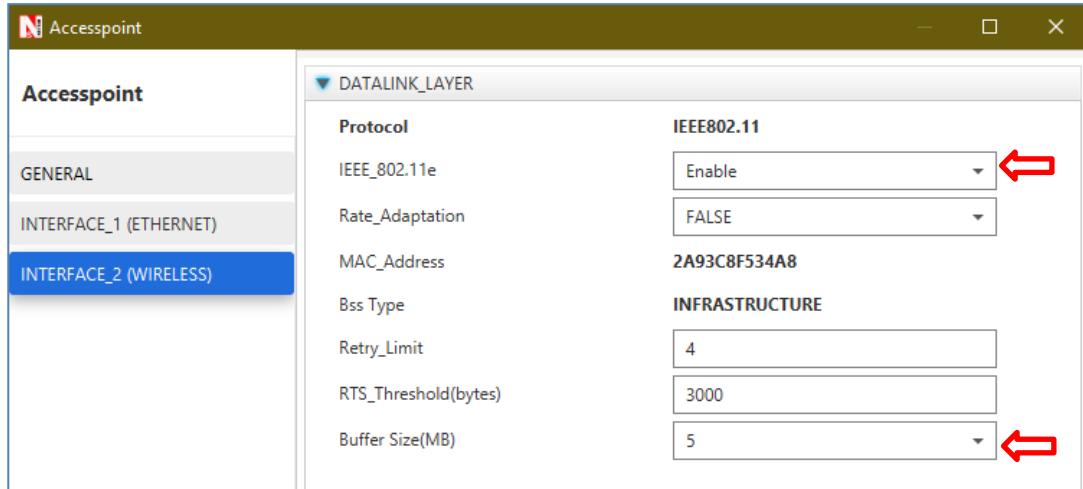
Step2: The device positions are set as per the below table:

	Access Point2	Wireless Node4	Wireless Node5
X/Lat	250	300	250
Y/Lon	100	100	150

Step3: TCP Protocol is set to Disable in all the devices.

Step4: Wired Link Properties is set as follows:

Step5: Go to Wireless Link Properties ,the “Channel is Characteristics” is set to



NO PATHLOSS.

Step6: In the Interface Wireless → Data Link Layer Properties of the Access Point ,IEEE 802.11

Step7: Right click on the Application Flow App1 VOICE or App2 CBR and select Properties or click on the Application icon present in the toolbar.

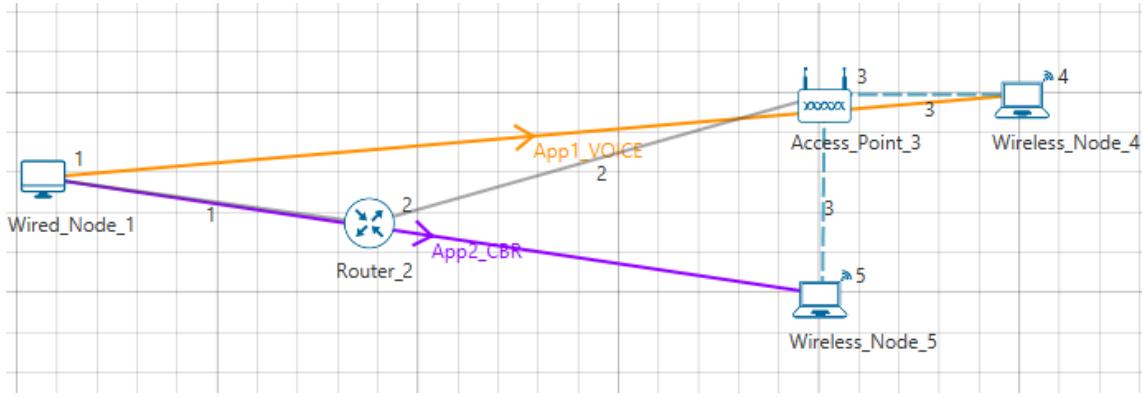
AVOICE Application is generated from Wired Node1 i.e. Source to Wireless Node4 i.e. Destination with Packet Size set to 1000 Bytes and Inter Arrival Time set to 800μs. The “Codec” parameter is set to Custom.

A CBR Application is generated from Wired Node 1 i.e. Source to Wireless Node 5 i.e. Destination with Packet Size set to 1000 Bytes and Inter Arrival Time set to 800μs.

The Packet Size and Inter Arrival Time parameters are set such that the Generation Rate equals 10 Mbps. Generation Rate can be calculated using the formula:

$$\text{GenerationRate}(Mbps) = \text{PacketSize}(Bytes) * 8 / \text{Interarrivaltime}(\mu s)$$

Step8: Run the Simulation for 10 Seconds. Note down the Application Throughput.



### Sample2:

The following changes in settings are done from the previous sample:

Step 1: In the Interface Wireless > Data link Layer Properties of the Wireless Node 5 and Access Point, IEEE 802.11e is set to Disable.

Step 2: Run the Simulation for 10 Seconds. Note down the Application Throughput

### Output:

IEEE 802.11e	Application	Generation rate(Mbps)	Throughput(Mb ps)	Delay(Micro. Sec.)
Enable(Sample1)	Voice	10	3.22	945561.8
	CBR	10	2.14	6466262.9
Disable(Sample2)	Voice	10	2.64	3672706.7
	CBR	10	2.64	3671315.4

**Result:** The simulation results indicate that IEEE 802.11e significantly improves QoS for voice applications by increasing throughput and reducing delay. However, CBR traffic experiences slightly lower throughput and higher delay, highlighting the trade-off between real-time and best-effort traffic in WLAN networks.

By using NetSim, network administrators can fine-tune QoS parameters to balance performance for different traffic classes, ensuring optimal user experience in multimedia and high-traffic environments.

## **EXP 11: PERFORMANCE EVALUATION OF AN IEEE 802.15.4 SENSOR NETWORK WITH STAR TOPOLOGY USING NETSIM SOFTWARE**

**Aim:** To analyze and evaluate the performance of an IEEE 802.15.4-based Wireless Sensor Network (WSN) with a Star Topology using NetSim software.

**Apparatus:** NETSIM V12, PC

### **Theory:**

IEEE 802.15.4 is a low-power, low-data-rate wireless communication standard designed for Wireless Sensor Networks (WSNs), Internet of Things (IoT), and industrial automation. It provides reliable data transmission with minimal energy consumption, making it ideal for smart homes, healthcare monitoring, and environmental sensing applications.

### **Star Topology in IEEE 802.15.4 Networks**

In a star topology, multiple sensor nodes (end devices) communicate directly with a central coordinator node. The coordinator acts as the central controller, managing network synchronization, data aggregation, and communication scheduling.

#### **Advantages of Star Topology:**

- Low power consumption (nodes remain idle when not transmitting).
- Reduced communication overhead (simpler routing compared to mesh networks).
- Easier network management with a single point of coordination.

#### **Limitations of Star Topology:**

- Single point of failure (if the coordinator fails, the network collapses).
- Limited range and scalability (all nodes must be within the coordinator's communication range).

### **IEEE 802.15.4 MAC Layer Operations**

IEEE 802.15.4 supports two main Medium Access Control (MAC) layer modes:

1. **Beacon-Enabled Mode:**
  - The coordinator periodically sends beacon frames for synchronization.
  - Sensor nodes communicate using Guaranteed Time Slots (**GTS**) for better reliability.
2. **Non-Beacon Mode:**
  - Nodes communicate on a contention-based Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) protocol.
  - Reduces overhead but may suffer from higher delays and packet collisions.

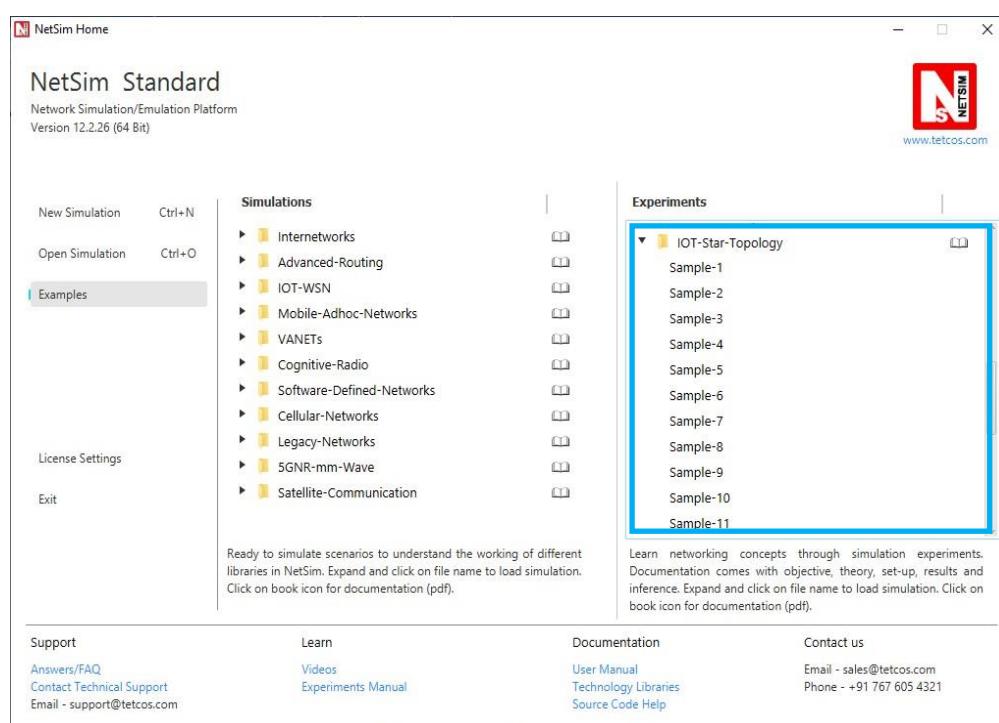
In this experiment, we will study the performance of several IEEE 802.15.4 devices each connected by a single wireless link to a sink. This would be called a “star topology” as the sensors can be seen as the spikes of a “star.”

We will set up the experiment such that every sensor can sense the transmissions from any other sensor to the sink. Since there is only one receiver, only one successful transmission can take place at any time. The IEEE 802.15.4 CSMA/CA multiple access control will take care of the coordination between the sensor transmissions. In this setting, we will conduct a saturation throughput analysis. The IoT communication buffers of the IEEE 802.15.4 devices will always be non empty, so that as soon as a packet is transmitted, another packet is ready to be sent. This will provide an understanding of how the network performs under very heavy loading. For this scenario we will compare results from NetSim simulations against mathematical analyses.

Details of the IEEE 802.15.4 PHY and MAC have been provided in the earlier IOT experiments 20 and 21, and their understanding must be reviewed before proceeding further with this experiment. In this experiment, all packets are transferred in a single hop from an IoT device to the sink. Hence, there are no routers, and no routing to be defined.

## NetSim Simulation Setup

Open NetSim and click Examples>Experiments>IOT-Star-Topology>Sample-1

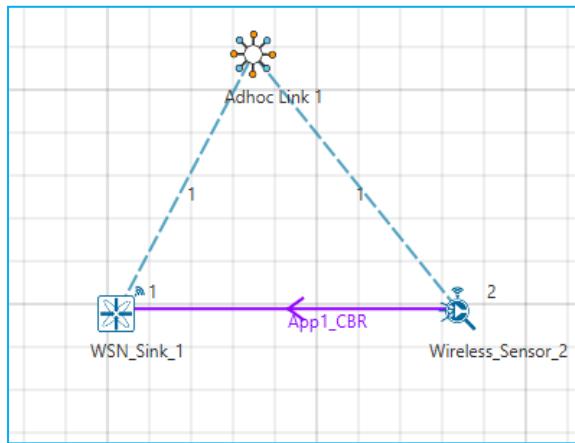


The simulation scenario consists of n nodes distributed uniformly around a sink (PAN coordinator) at the center. In NetSim the nodes associate with the PAN coordinator at the start of the simulation. CBR traffic is initiated simultaneously from all the nodes. The CBR packet size is kept as 10 bytes to which 20 bytes of IP header, 7 bytes of MAC header and 6 bytes of PHY header are added. To ensure saturation, the CBR traffic interval is kept very small; each node's buffer receives packets at intervals of 5ms.

### **Procedure:**

*Sample 1:*

NetSim UI displays the configuration file corresponding to this experiment as shown below:



The following set of procedures were done to generate this sample:

**Step 1:** Go to New Simulation → Wireless Sensor Network

A network scenario is designed in NetSim GUI comprising of 1 Sink Node, and 1 wireless sensor in the “WSN” Network Library. Distance between the Sink Node and Wireless Sensor is set to 8m.

**Step 2:** Right click on Adhoc link and select Properties, Channel Characteristics is set to No\_Pathloss

**Step 3:** Right click on Wireless sensor properties in the network layer the static route is configured as shown below table.

Network Destination	Gateway	Subnet Mask	Metrics	Interface ID
11.1.1.0	11.1.1.1	255.255.255.0	1	1

**Step 4:** Right click on the Application Flow App1 CBR and select Properties or click on the Application icon present in the top ribbon/toolbar.

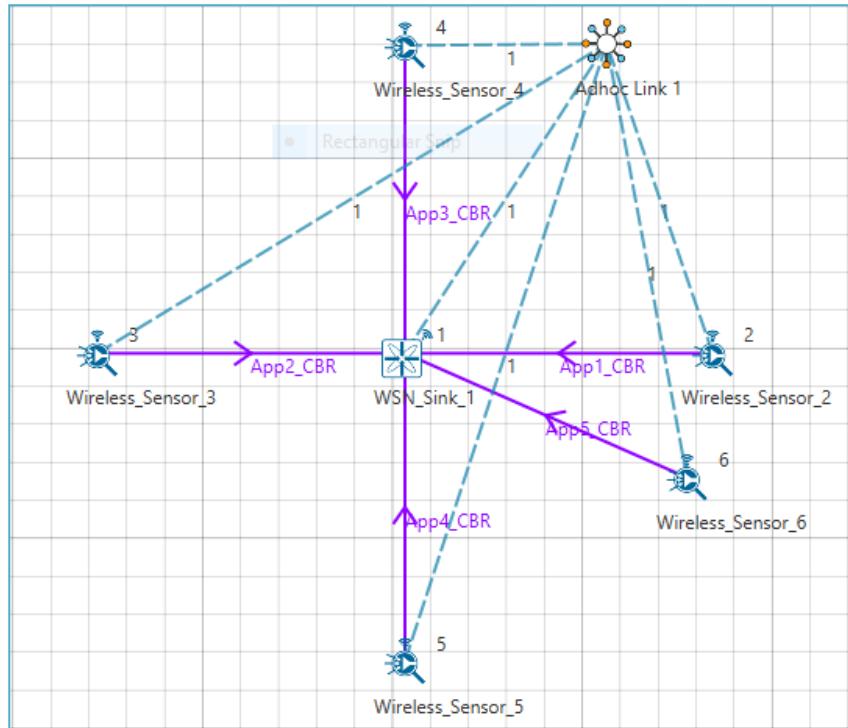
A CBR Application is generated from Wireless Sensor 2 i.e. Source to Sink Node 1 i.e. Destination with Packet Size remaining 10Bytes and Inter Arrival Time remaining 5000  $\mu$ s. Start time is set to 5s. Transport Protocol is set to UDP instead of TCP.

**Step 5:** Plots are enabled in NetSim GUI. Click on Run simulation. The simulation time is set to 100 seconds

Increase wireless sensor count to 2, 3, and 4 with the same above properties to design Sample 2, 3, and 4.

*Sample 2:*

NetSim UI displays the configuration file corresponding to this experiment as shown below:



The following set of procedures were done to generate this sample:

Step1: Right click on Wireless sensors properties in the network layer the static route is configured as shown below table.

Network Destination	Gateway	Subnet Mask	Metrics	Interface ID
11.1.1.0	11.1.1.1	255.255.255.0	1	1

Step2: Click on the Application icon present in the top ribbon/toolbar. The following application properties is set shown in below table.

	App1	App2	App3	App4	App5
Application	CBR	CBR	CBR	CBR	CBR
Source ID	2	3	4	5	6
Destination ID	1	1	1	1	1
Start time	5s	5s	5s	5s	5s
Transport protocol	UDP	UDP	UDP	UDP	UDP
Packet Size	10bytes	10bytes	10bytes	10bytes	10bytes
Inter-Arrival Time	5000µs	5000µs	5000µs	5000µs	5000µs

Step3: Plots are enabled in NetSim GUI. Click on Run simulation. The simulation time is set to 100 seconds

Increase wireless sensor count to 10, 15, 20, 25, 30, 35, 40, and 45 with the same above properties to design Sample 6, 7, 8, 9, 10, 11, 12, and 13.

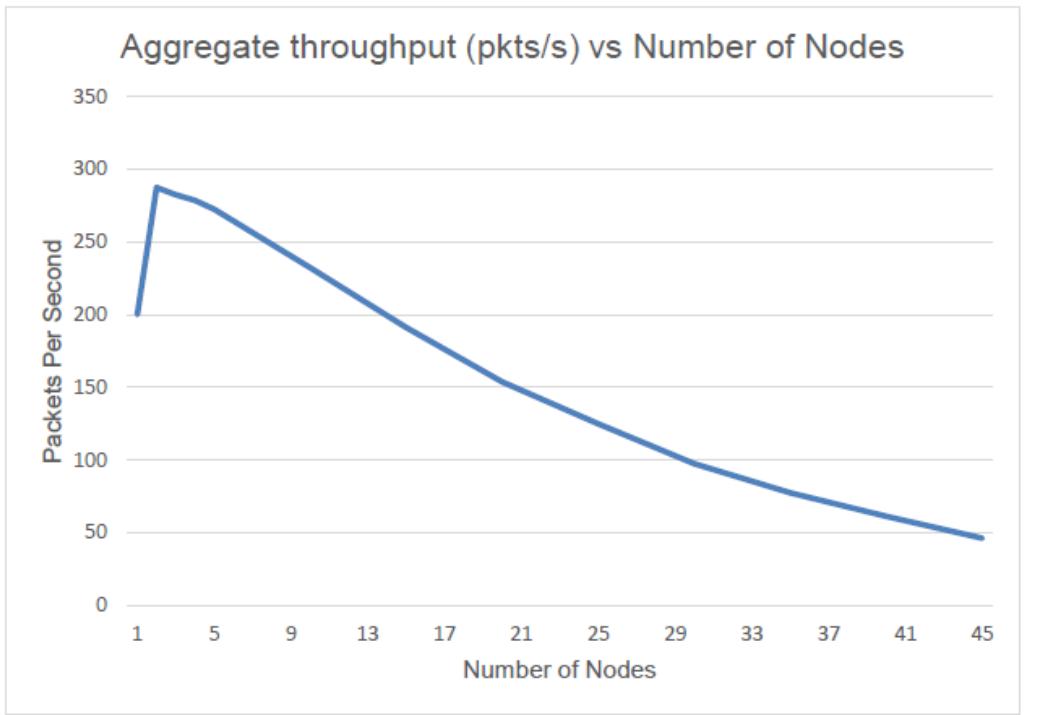
## **Output:**

The aggregate throughput of the system can be got by adding up the individual throughput of the applications. NetSim outputs the results in units of kilobits per second (kbps). Since the packet size is 80 bits we convert per the formula

$$\text{AggregateThroughput (pkts/sec)} = \frac{\text{AggregateThroughput (kbps)} * 1000}{80}$$

Number of Nodes	Aggregate Throughput (Kbps)	Aggregate Throughput (pkts/s)
1	16.0	200
2	23.0	287.5
3	22.6	282.5
4	22.3	278.75
5	21.8	272.5
10	18.6	232.5
15	15.3	191.25
20	12.3	153.75
25	10.0	125
30	7.8	97.5
35	6.2	77.5
40	4.9	61.25
45	3.7	46.25

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**Fig 3:** Plot of Aggregated throughput (packets/s) vs Number of Nodes Activate Wi-Fi Go to Settings

**Result:** From the simulation results, IEEE 802.15.4 in a star topology performs well for low-density networks, but its efficiency deteriorates as the number of nodes increases. To enhance scalability and maintain throughput, network optimization techniques such as adaptive channel access mechanisms and energy-efficient scheduling should be considered.