ASSIGNMENT 1: ECE 659

GROUP 12

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	IoT Stack	Data rate	Range	Frequency	Network Topology	Power Consumption
Low-rate wireless personal area networks (LR-WPANs) **IEEE 802.15.4**	Physical Layer	250 kbps for 2.4 GHz 40 kbps for 915 MHz 20 kbps for 868 MHz	10-100 m	2.4 GHz – 16 channels (2.4 – 2.4835 GHz) 915 MHz – 10 channels (902 – 928 MHz) 868 MHz – 1 channel (868 – 868.6 MHz)	Star topology Peer to peer topology Cluster-tree topology	Low
IEEE 802.11 AH	Physical Layer	0.15 – 4 Mbps for 1MHz 0.65 – 7.8 Mbps for 2 MHz	100-1000m	sub 1GHz	Star Topology Tree Topology	Low
Wireless HART **IEEE 802.15.4**	Communication/Transport Layer	250 kbps for 2.4 GHz	225-750m	2.4 GHz for 15-16 channels	Mesh Topology Star Topology	Medium

					Combination of both star and mesh topology	
Bluetooth Low Energy **BLE**	Physical Layer	LE 2M Phy: 2 Mb/S LE 1M Phy: 1 Mb/S LE Coded Phy (S=2): 500 Kb/S LE Coded Phy (S=8): 125 Kb/S	>100m	2.4GHz (40 channels with 2 MHz spacing)	Point-to-Point Broadcast Mesh Star	Low
Long-Term Evolution-Advanced **LTE-A**	Transport Layer	Downlink - 1 Gbps; Uplink - 500 Mbps.	10 miles(16093 m approx.)	>=700MHz	Network Topology Advanced Star Topology	Medium
WiFi **IEEE 802.11**	Physical and Data Link Layer	802.11n – 100mbps – 2.4GHz and 5GHz 802.11a – 54mbps – 5GHz 802.11b – 11mbps – 2.4GHz	150 feet (46 m indoors) 300 feet (92 m outdoors)	2.4 GHz 5 GHz	Star topology Point-point topology	Low

		802.11g– 54mbps – 2.4GHz				

The above table portrays the characteristics of various IoT protocols with respect to: standard, data rate, range, frequency band, topology, and power requirements.

Problem 2

No. Although MAC Protocols of the IEEE 802.11 standard can be utilized in IoT network if it is able to meet with the intensive performance requirements and demands of the IoT network. It manages to ensure coordination however,

- There no necessity to utilize a high-overhead high delay MAC Protocol when only few periodic packets need to be sent in IoT network
- It does not support energy consumption and scalability
- It also causes high network throughput and low latency

Problem 3

Given

- Bandwidth = 8 Kbps
- Propagation delay (T_p) = 100 msec
- Efficiency >= 50%

Let the required Frame Size = F bits.

Transmission Delay-

Transmission delay (T_t)

= Frame size / Bandwidth

= F bits / 8 Kbps

Value Of 'a'-

$a = T_p / T_t$

a = 100 msec / (F bits / 8 Kbps)

a = (100 msec x 8 Kbps) / F bits

Minimum Efficiency To Be 50%-

For efficiency to be minimum of 50%, we must have- a <= 1/2

Substituting the value of 'a', we get-

(100 msec x 8 Kbps) / F bits <= 1/2

F bits >= (100 msec x 8 Kbps) x 2

F bits >= (100 x 10^{-3} sec x 8 x 10^{3} bits per sec) x 2

F bits >= 100 x 8 bits x 2

F >= 1600

This concludes that the frame size must be minimum **1600 bits.**

Problem 4

Given:

Number of hosts: 25

Simulation Area: 500*500m

Simulation Time: 900s

Routing Algorithm: AODV

Standard for MAC Layer: IEEE 802.11

Data Rate: 11Mbps

Packet Size: 512 bytes

Sending Rate: 3 packets/sec

Mobility Node Speed: 1-20m/s

Ned File:

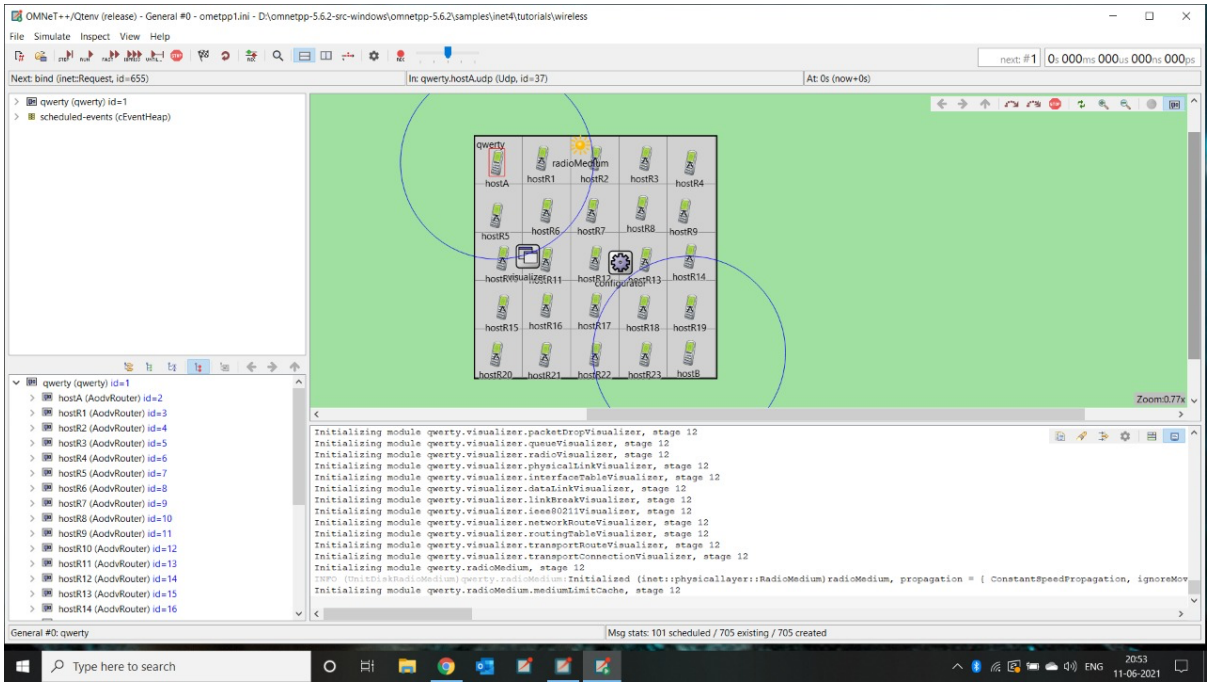
```
package inet.examples.aodv;
import inet.common.scenario.ScenarioManager;
import inet.networklayer.configurator.ipv4.Ipv4NetworkConfigurator;
```

```
import inet.networklayer.ipv4.RoutingTableRecorder;
import inet.node.aodv.AodvRouter;
import inet.physicallayer.unitdisk.UnitDiskRadioMedium;
network AODVNetwork
{
    parameters:
        int numHosts;
        @display("bgb=650,650");
    submodules:
        radioMedium: UnitDiskRadioMedium {
            parameters:
                @display("p=100,200;is=s");
        }
        configurator: Ipv4NetworkConfigurator {
            parameters:
                config = xml("<config><interface hosts='*' address='145.236.x.x'
netmask='255.255.0.0'/></config>");
                @display("p=100,100;is=s");
        }
        routingTableRecorder: RoutingTableRecorder {
            parameters:
                @display("p=100,300;is=s");
        }
        scenarioManager: ScenarioManager {
            parameters:
                script = default(xml("<scenario/>"));
                @display("p=100,400;is=s");
        }
        host[numHosts]: AodvRouter {
            parameters:
                @display("i=device/pocketpc_s;r=,,#707070");
```

}

connections allowunconnected:

}

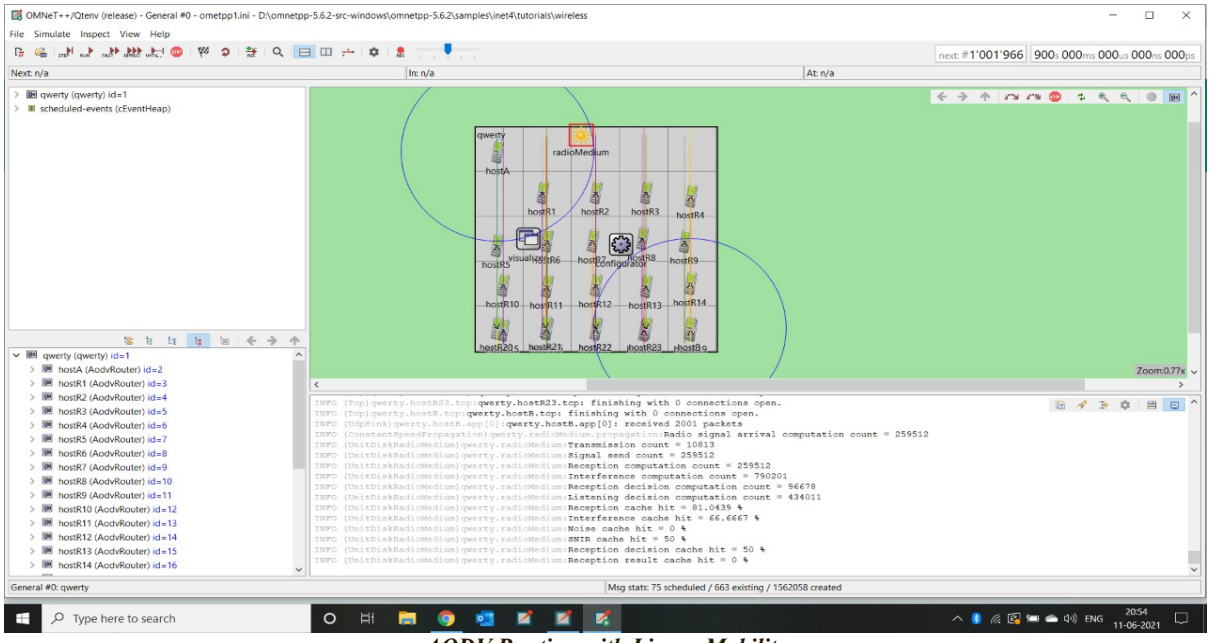


Net.ned consisting 25 hosts

Initialization File for AODV with Linear Mobility:

```
[General]

description = Question 4
network = qwerty
sim-time-limit = 900s


*.host*.ipv4.arp.typename = "GlobalArp"

**.constraintAreaMinX = 0m
**.constraintAreaMinY = 0m
**.constraintAreaMinZ = 0m
**.constraintAreaMaxX = 500m
**.constraintAreaMaxY = 500m
**.constraintAreaMaxZ = 0m


*.hostA.numApps = 1
*.hostA.app[0].typename = "UdpBasicApp"
*.hostA.app[0].startTime = uniform(1s,5s)
*.hostA.app[0].destAddresses = "hostB"
*.hostA.app[0].destPort = 5000
*.hostA.app[0].messageLength = 512B
*.hostA.app[0].sendInterval = 0.33s
```

```
*.hostA.wlan[0].radio.displayCommunicationRange = true

*.hostB.numApps = 1
*.hostB.app[0].typename = "UdpSink"
*.hostB.app[0].localPort = 5000
*.hostB.wlan[0].radio.displayCommunicationRange = true

*.host*.wlan[0].typename = "AckingWirelessInterface"
*.host*.wlan[0].mac.typename = "Ieee80211Mac"
*.host*.wlan[0].mac.useAck = true
*.host*.wlan[0].mac.fullDuplex = true
*.host*.wlan[0].radio.transmitter.communicationRange = 200m
*.host*.wlan[0].radio.transmitter.interferenceRange = 0m
*.host*.wlan[0].radio.transmitter.detectionRange = 0m
*.host*.wlan[0].radio.receiver.ignoreInterference = true
*.host*.wlan[0].mac.headerLength = 23B
*.host*.wlan[0].radio.typename = "UnitDiskRadio"
*.numHosts = 25

*.host*.**.bitrate = 11Mbps

*.host*.wlan[0].mac.ackTimeout = 300ms
*.host*.forwarding = true

*.hostR*.mobility.typename = "LinearMobility"
*.hostR*.mobility.speed = ${speed = 1..20 step 1}mps
*.hostR*.mobility.initialMovementHeading = 270deg

*.host*.wlan[0].mac.queue.packetCapacity = 10

*.visualizer.mobilityVisualizer.displayVelocities = true
*.visualizer.mobilityVisualizer.displayMovementTrails = true
*.configurator.addStaticRoutes = false

*.host*.typename = "AodvRouter"
*.visualizer.dataLinkVisualizer.packetFilter = "AODV*"
```

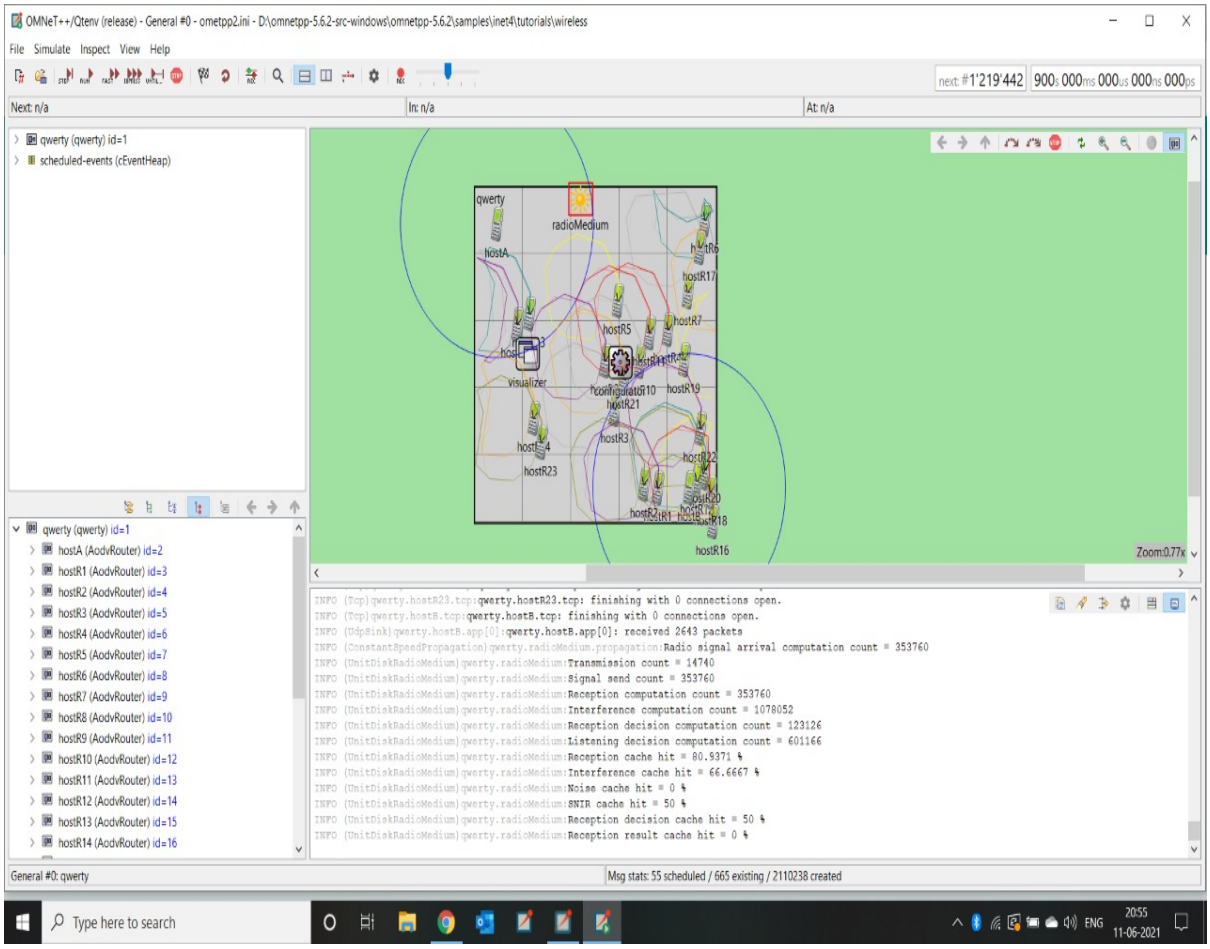


AODV Routing with Linear Mobility

Initialization File for AODV with Circular Mobility:

```
[General]

description = Question 4
network = qwerty
sim-time-limit = 900s

*.host*.ipv4.arp.typename = "GlobalArp"

**.constraintAreaMinX = 0m
**.constraintAreaMinY = 0m
**.constraintAreaMinZ = 0m
**.constraintAreaMaxX = 500m
**.constraintAreaMaxY = 500m
**.constraintAreaMaxZ = 0m

*.hostA.numApps = 1
*.hostA.app[0].typename = "UdpBasicApp"
*.hostA.app[0].startTime = uniform(1s,5s)
*.hostA.app[0].destAddresses = "hostB"
*.hostA.app[0].destPort = 5000
*.hostA.app[0].messageLength = 512B
*.hostA.app[0].sendInterval = 0.33s
*.hostA.wlan[0].radio.displayCommunicationRange = true

*.hostB.numApps = 1
*.hostB.app[0].typename = "UdpSink"
*.hostB.app[0].localPort = 5000
*.hostB.wlan[0].radio.displayCommunicationRange = true

*.host*.wlan[0].typename = "AckingWirelessInterface"
*.host*.wlan[0].mac.typename = "Ieee80211Mac"
*.host*.wlan[0].mac.useAck = true
*.host*.wlan[0].mac.fullDuplex = true
*.host*.wlan[0].radio.transmitter.communicationRange = 200m
*.host*.wlan[0].radio.transmitter.interferenceRange = 0m
*.host*.wlan[0].radio.transmitter.detectionRange = 0m
*.host*.wlan[0].radio.receiver.ignoreInterference = true
*.host*.wlan[0].mac.headerLength = 23B
*.host*.wlan[0].radio.typename = "UnitDiskRadio"
*.numHosts = 25

*.host*.**.bitrate = 11Mbps

*.host*.wlan[0].mac.ackTimeout = 300ms
*.host*.forwarding = true

*.hostR*.mobility.typename = "CircleMobility"

*.hostR*.mobility.cx = uniform(0m,500m)
*.hostR*.mobility.cy = uniform(0m,500m)
*.hostR*.mobility.r = 80m
*.hostR*.mobility.speed = ${speed = 1..20 step 1}mps
*.hostR*.mobility.startAngle = 90deg

*.host*.wlan[0].mac.queue.packetCapacity = 10
```

```
*.visualizer.mobilityVisualizer.displayVelocities = true
*.visualizer.mobilityVisualizer.displayMovementTrails = true

*.configurator.addStaticRoutes = false

*.host*.typename = "AodvRouter"
*.visualizer.dataLinkVisualizer.packetFilter = "AODV*"
```

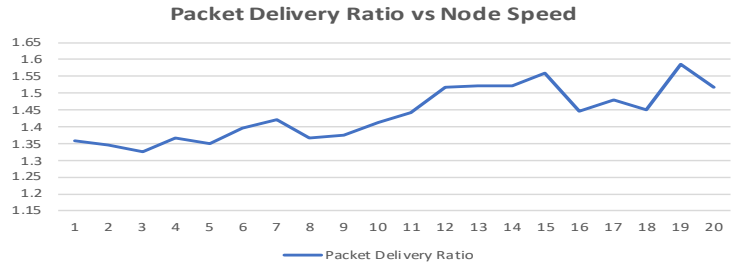


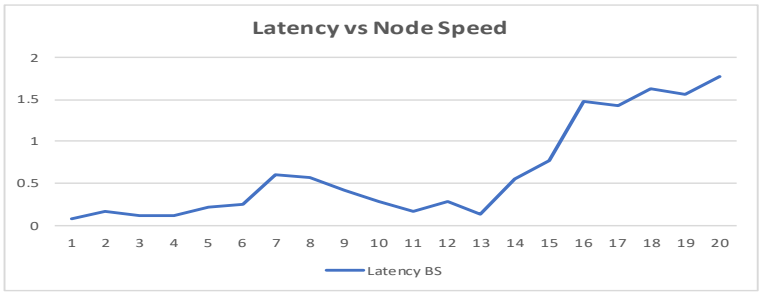
AODV Routing with Circular Mobility

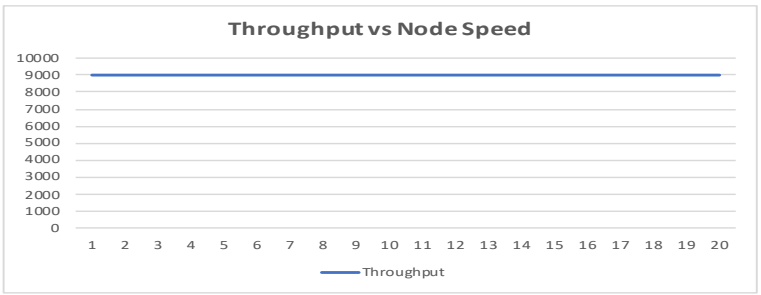
The above screenshots show the implementation of the source codes simulated in OMNET++.

RESULTS:

Node Speed	Packets Sent	Packets Received	Throughput	Latency	Packet Delivery Ratio	Latency BS
1	2715	2001	9000	0.0409	1.356821589	0.0818
2	2713	2014	9000	0.0867	1.347070506	0.1734
3	2713	2047	9000	0.0605	1.325354177	0.121
4	2715	1987	9000	0.0574	1.36638148	0.1148
5	2723	2020	9000	0.1093	1.348019802	0.2186
6	2715	1945	9000	0.1253	1.395886889	0.2506
7	2722	1914	9000	0.303	1.42215256	0.606
8	2721	1991	9000	0.2871	1.366649925	0.5742
9	2722	1980	9000	0.2118	1.374747475	0.4236
10	2719	1922	9000	0.1409	1.414672216	0.2818
11	2719	1888	9000	0.0877	1.440148305	0.1754
12	2717	1789	9000	0.141	1.518725545	0.282
13	2714	1783	9000	0.0687	1.522153674	0.1374
14	2714	1784	9000	0.281	1.521300448	0.562
15	2717	1743	9000	0.3826	1.558806655	0.7652
16	2718	1879	9000	0.7367	1.446514103	1.4734
17	2724	1842	9000	0.709	1.478827362	1.418
18	2715	1873	9000	0.811	1.449546183	1.622
19	2719	1714	9000	0.7802	1.586347725	1.5604
20	2720	1792	9000	0.886	1.517857143	1.772

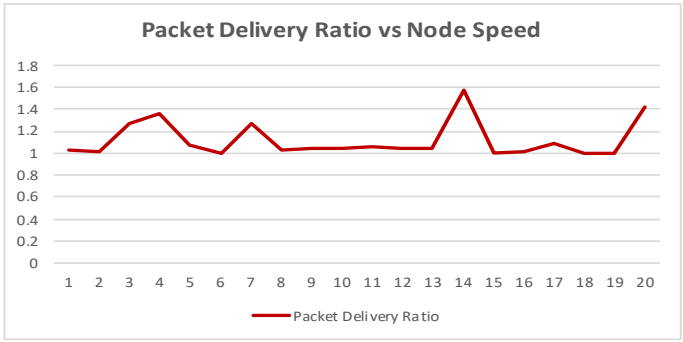


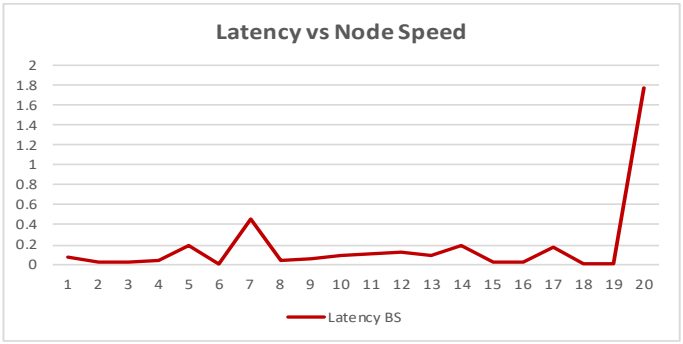


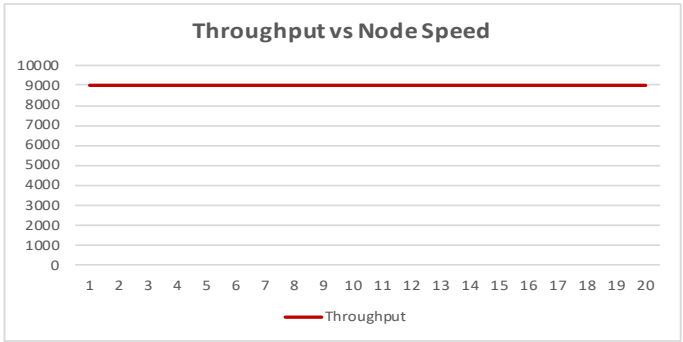


Linear Mobility Graphs for 3 parameters

Node Speed	Packets Sent	Packets Received	Throughput	Latency	Packet Delivery Ratio	Latency BS
1	2715	2643	9000	0.039	1.027241771	0.078
2	2713	2686	9000	0.0118	1.010052122	0.0236
3	2713	2141	9000	0.0102	1.267164876	0.0204
4	2715	1998	9000	0.018	1.358858859	0.036
5	2723	2528	9000	0.0987	1.077136076	0.1974
6	2715	2707	9000	0.0032	1.002955301	0.0064
7	2722	2138	9000	0.2307	1.273152479	0.4614
8	2721	2641	9000	0.0222	1.030291556	0.0444
9	2722	2600	9000	0.031	1.046923077	0.062
10	2719	2594	9000	0.0424	1.048188126	0.0848
11	2719	2572	9000	0.0503	1.057153966	0.1006
12	2717	2619	9000	0.0605	1.037418862	0.121
13	2714	2602	9000	0.0478	1.043043812	0.0956
14	2714	1724	9000	0.0985	1.57424594	0.197
15	2717	2711	9000	0.01668	1.002213205	0.03336
16	2718	2686	9000	0.0115	1.011913626	0.023
17	2724	2503	9000	0.0886	1.088294047	0.1772
18	2715	2708	9000	0.0056	1.002584934	0.0112
19	2719	2708	9000	0.0052	1.004062038	0.0104
20	2720	1924	9000	0.8864	1.413721414	1.7728







Circular Mobility Graphs for 3 parameters