

COMP 40660 – Advances in Wireless Networking
Assignment 1 using Qualnet

Group Report

by

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We declare that all material in this assessment is our own work except where there is clear acknowledgement and appropriate reference to the work of others.

Procedure:

1. We first added “*tempBytesReceived*” as an int variable and *throughputTime* as clock type variable in the app_cbr.h file. Then we modified the app_cbr.cpp file to read the throughput in Mb every nanosecond. The code snippet is given below:

```
char tempCurrentTimeString[MAX_STRING_LENGTH];
clocktype tempCurrentTime;
tempCurrentTime = getSimTime(node);

if (tempCurrentTime - serverPtr->throughputTime >= 1000000000)
{
    TIME_PrintClockInSeconds(getSimTime(node),tempCurrentTimeString);
    printf( "\nNode: %d, Throughput: %lf, Time: %s \n",node->nodeId,
        (double)serverPtr->tempBytesReceived*8/1048576, tempCurrentTimeString);
    serverPtr->tempBytesReceived=0;
    serverPtr->throughputTime = tempCurrentTime;
}
else
{
    serverPtr->tempBytesReceived += MESSAGE_ReturnPacketSize(msg);
}
}
```

2. We then created the scenarios – the exposed node scenario is called *Infrastructure* and the hidden node is *SettingAPNode*.
3. We changed the *Infrastructure.nodes* file to include the mobility for one wireless node (Node 7) and executed the Infrastructure scenario from the command line by entering the command **qualnet Infrastructure.config >Infrastructure.results**. This outputs the time and throughput details for all the nodes into the *Infrastructure.results* file. This file also contains the simulation details, the node positions etc.,
4. We used grep command on the results file to filter the throughput and time details of the two wired nodes (5 and 6). We split each node throughput to a separate file. We saved these as *IF_Node5* and *IF_Node6* files. We entered **grep “Node: 5 Throughput: “ Infrastructure.results > IF_Node5** and **grep “Node: 6 Throughput: “ Infrastructure.results > IF_Node6**
5. We used awk command on the *IF_Node5* and *IF_Node6* files to filter the time and throughput data of each node to plot the graph. We created a *throughput.awk* file to specify the required two column filter pattern for the plot data. We entered, **awk -f “throughput.awk” IF_Node5 > throughput5** and **awk -f “throughput.awk” IF_Node6 > throughput6**
6. We then started the GNUplot and plotted the graph for each node output by entering **plot “throughput5” with lines** and **plot “throughput5” with lines**.
7. We did the same for reverse mobility of exposed node. We created a new *Infrastructure_r.nodes* file with new coordinates for mobility and used the *Infrastructure_reverese.results* file to grep the output and then used *IF_Node5_reverse* and *IF_Node6_reverse* files to awk. Then we created the

gnuplot for node 5 and node6 using *throughput5_reverse* and *throughput6_reverse* files.

8. We repeated the process for hidden node and hidden node reverse mobility.
Below is a chart of output file names at each stage.

Filename references:

Scenario	Exposed Node	Exposed Node Reverse	Hidden Node	Hidden Node Reverse
Mobility file	Infrastructure.nodes	Infrastructure_r.nodes	SettingAPNode.nodes	SettingAPNode_r.nodes
Sim output	Infrastructure.results	Infrastructure_reverse.results	SettingAPNode.results	SettingAPNode_reverse.results
grep output	IF_Node5 IF_Node6	IF_Node5_reverse IF_Node6_reverse	AP_Node5 AP_Node6	AP_Node5_reverse AP_Node6_reverse
awk output	throughput5 throughput6	throughput5_reverse throughput6_reverse	throughput5 throughput6	throughput5_reverse throughput6_reverse

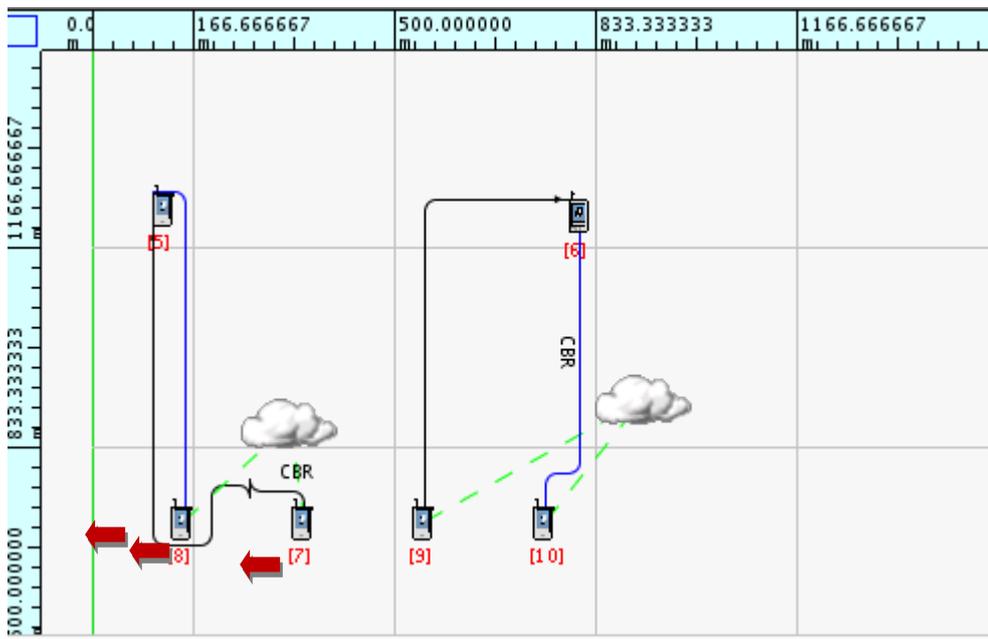
One of the challenge, we had was to identify the distances between the nodes to get an ideal scenario. We tested with 300-500m range mobility to identify a good topology. We deduced that the nodes sense each other up to 460m and can transmit well up to 230m. So we tried different distances for each scenario until we finalized the following:

For the exposed node scenario, we placed the mobile node (7) 200m from the other wireless node (9) and moved node 7 up to 500m away from node 9. For reverse mobility, we placed the mobile node (7) 520m away from the other wireless node (9) and moved it up to 150m distance from node 9.

For the hidden node scenario, we placed the mobile node (4) 550m away from the other wireless node (3) but within 300m of the AP and then moved the mobile node closer to the other wireless node (3) up to 30m from it. For reverse mobility, we started 70m from the other wireless node (3) and moved the mobile node 4 up to 470m from the wireless node 3 and 230m from the AP.

RESULTS:

Scenario: Infrastructure (Exposed Node)

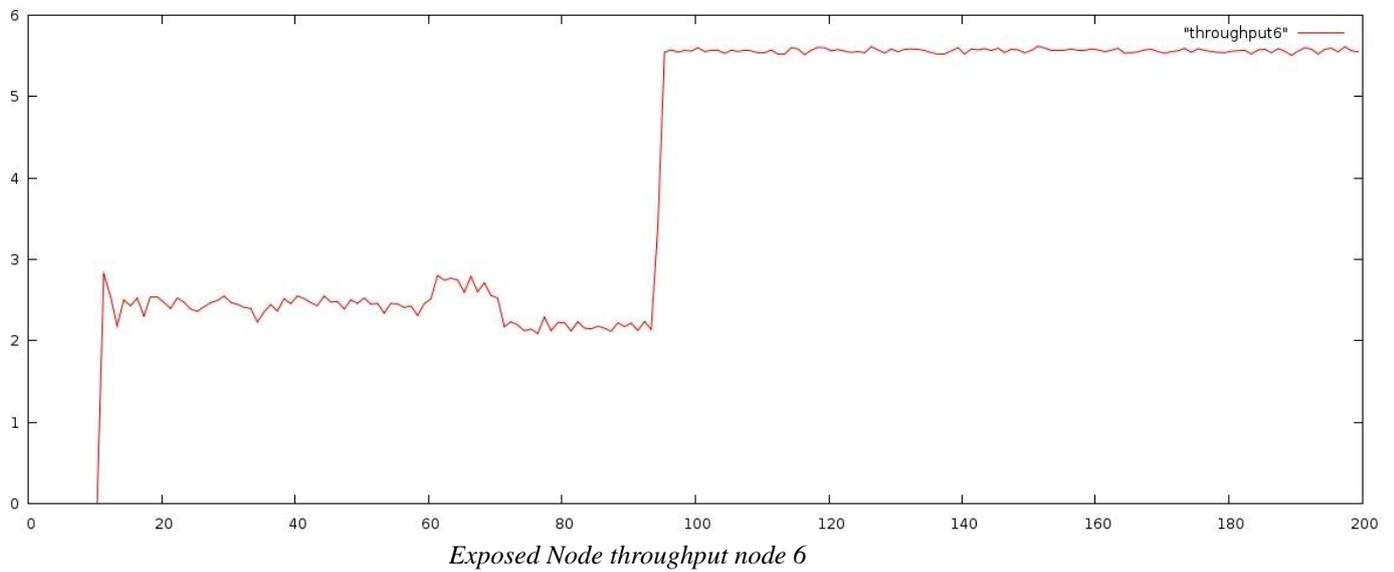
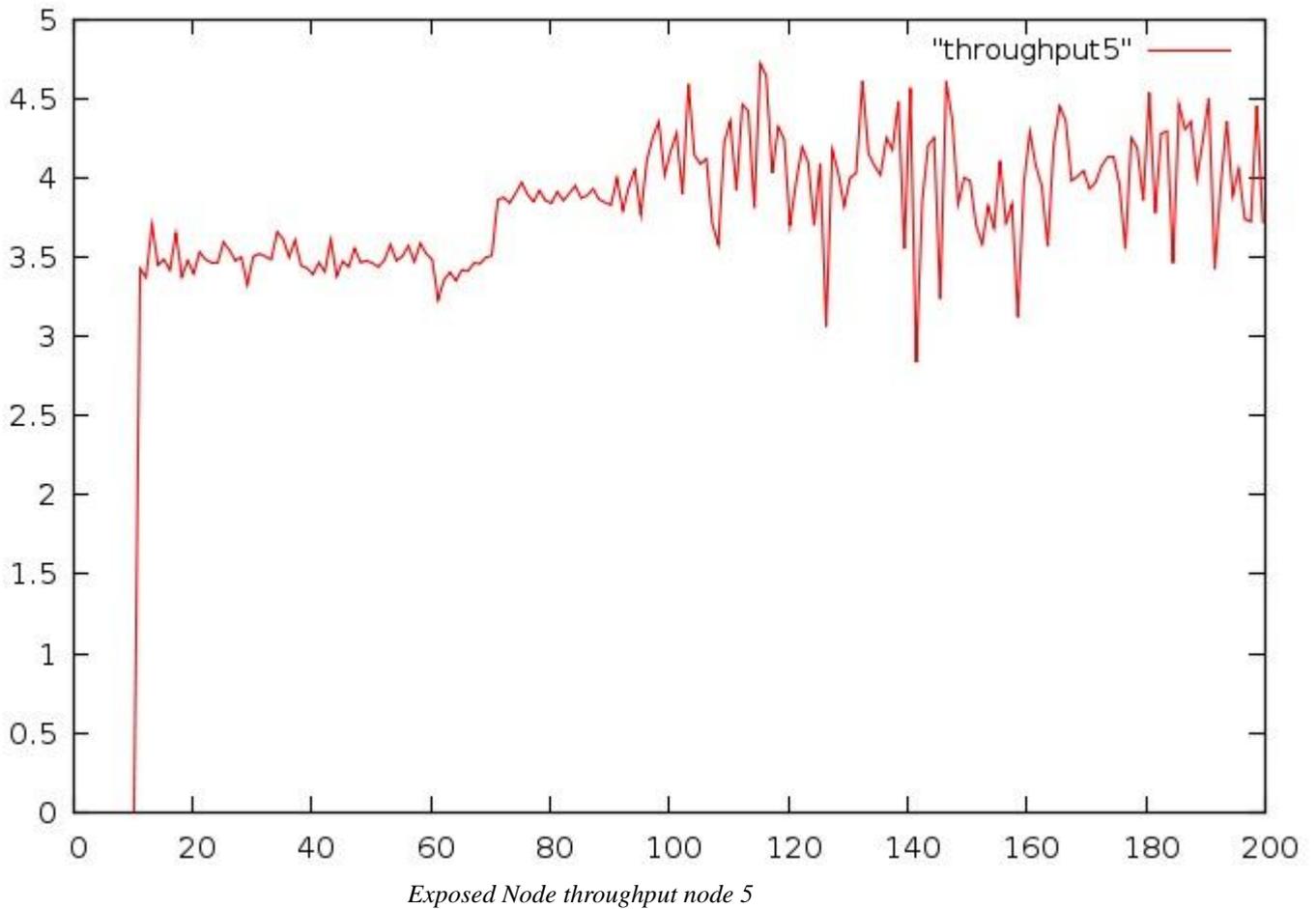


Exposed Node topology - Nodes 8 and 10 are APs, Nodes 7 and 9 are wireless, Node 7 sends CBR to 5, Node 10 sends CBR to 6, Nodes 5 and 6 are wired.

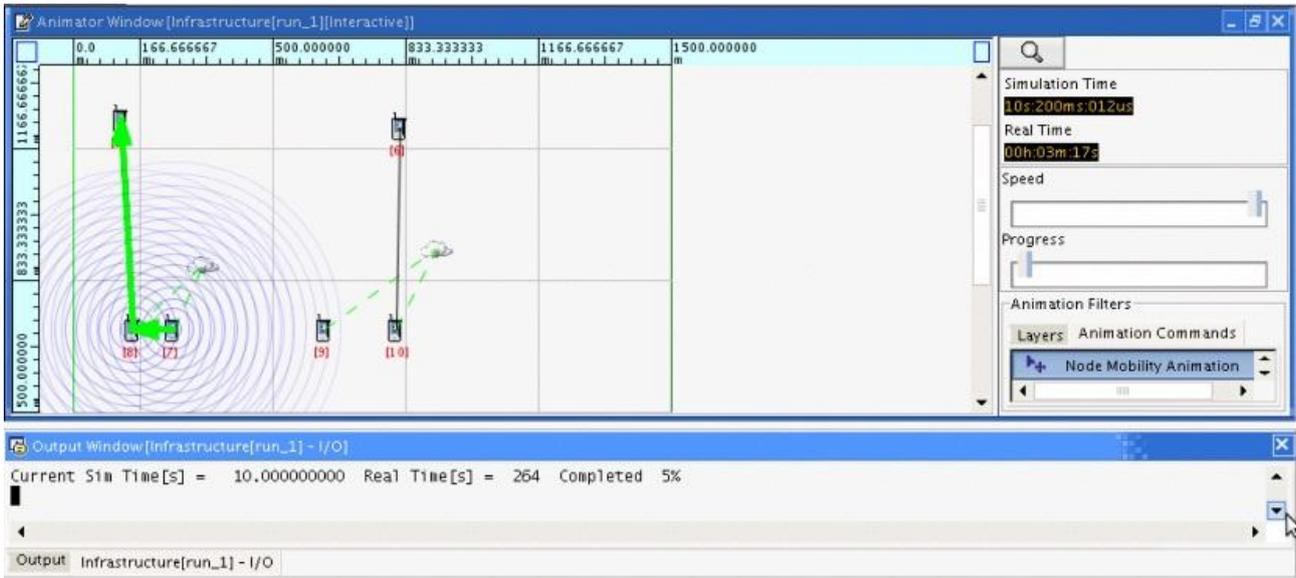
Node 7 is the mobile wireless node. It starts off 200m from the AP and 200m from the other wireless node (9). It starts moving at 20 seconds towards its own AP. At 80 seconds, it crosses to the other side of its own AP.

To begin with, node 7 is in the range of 9 – and hence it is an exposed node. The throughput is low from 20 seconds – 80 seconds of the simulation. Around 80 seconds, node 7 crosses 450m from the other wireless node (9), and so it is no longer exposed. The throughput from node 9 to node 6 increases around 80s when node 7 is not exposed anymore. During the time node 7 is exposed to node 9, throughput is low as the nodes wait for each other.

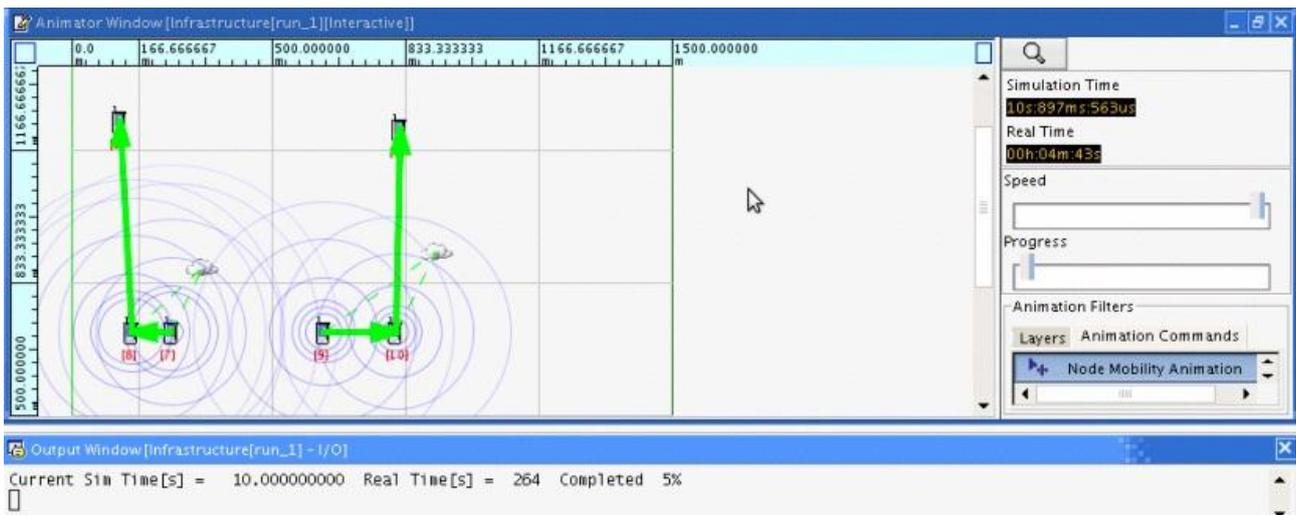
Node	Time	X	Y
5	0	118	123
6	0	807	1221
7	0	350	710
7	20	250	710
7	80	100	710
7	180	50	710
8	0	150	710
9	0	550	710
10	0	750	710



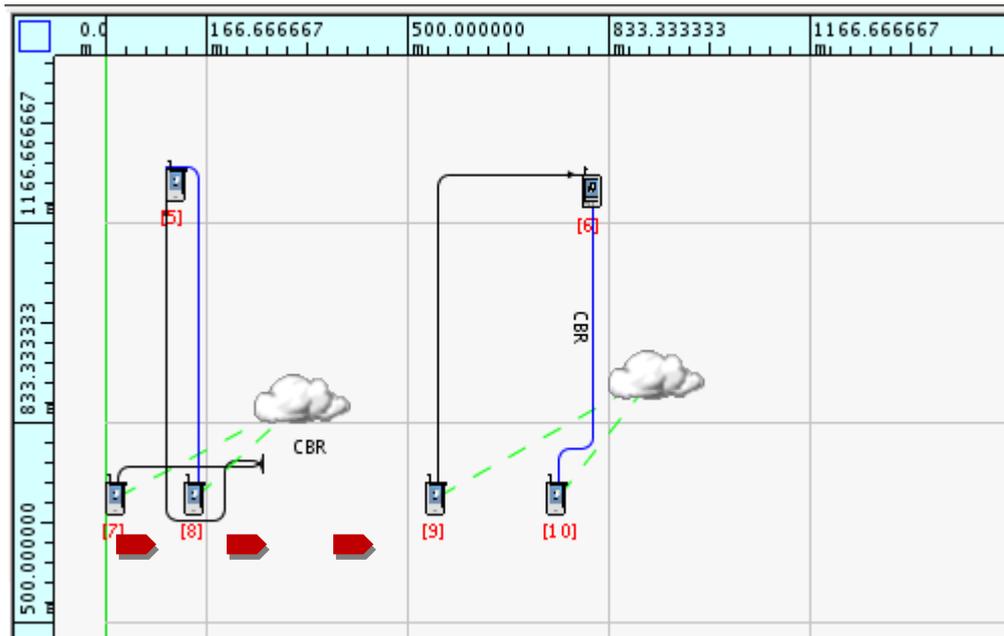
Every time Node 9 wants to transmit a packet, it senses node 7's presence and waits for CTS. This reduces the throughput to Node 6. As Node 7 moves away from 9's range, at around 100 seconds when node 7 is 400m away, the throughput increases as can be seen from our graphs.



These screenshots show the range of Node 7 and 9 as they transmit.



Infrastructure Reverse Mobility



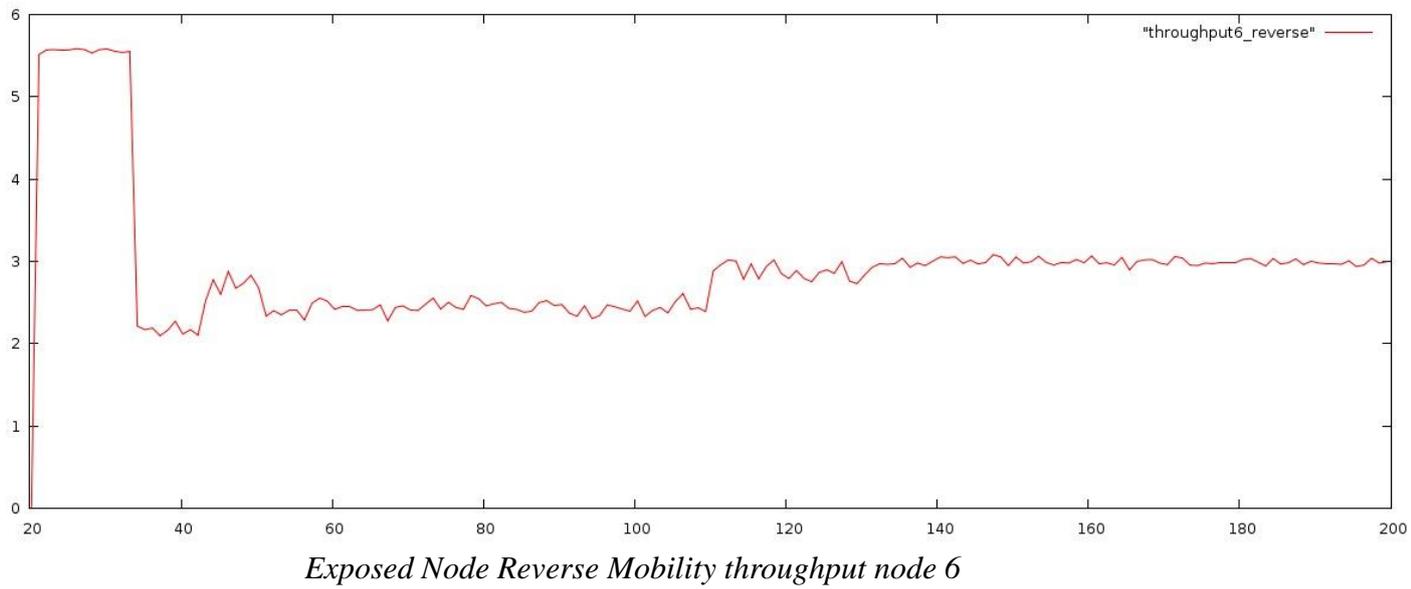
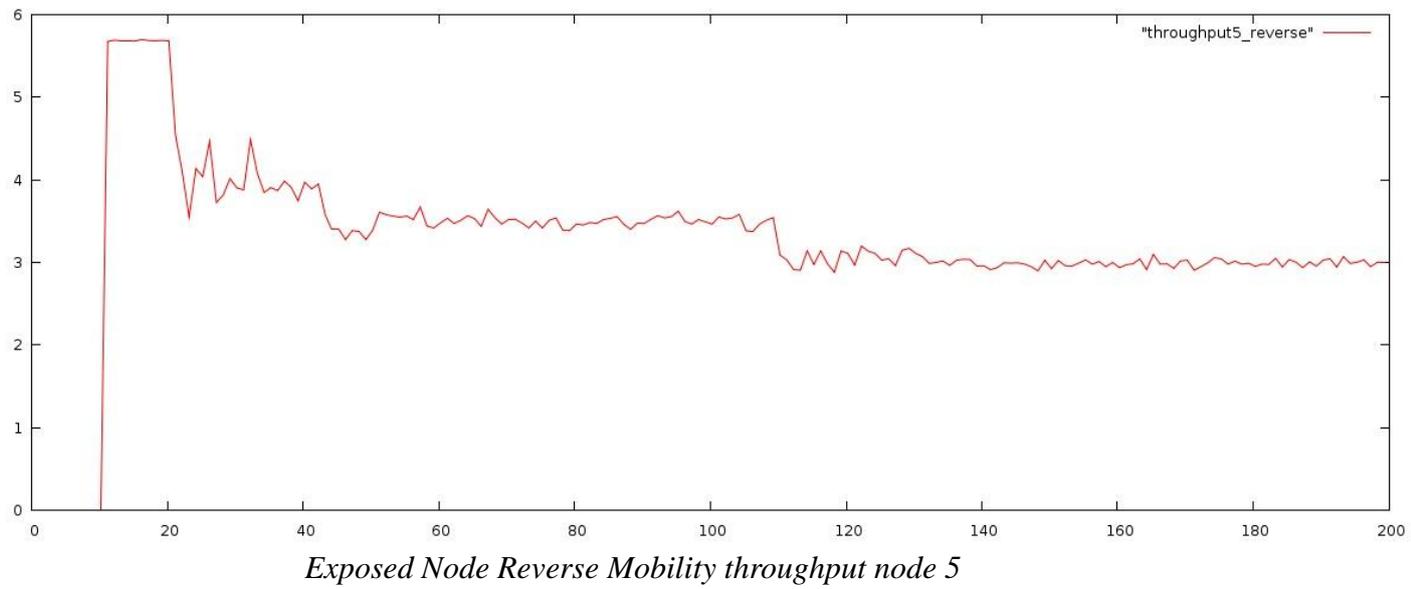
Exposed Node topology Reversed- Nodes 8 and 10 are APs, Nodes 7 and 9 are wireless, Node 7 sends CBR to 5, Node 10 sends CBR to 6, Nodes 5 and 6 are wired.

Shows movement of node 7

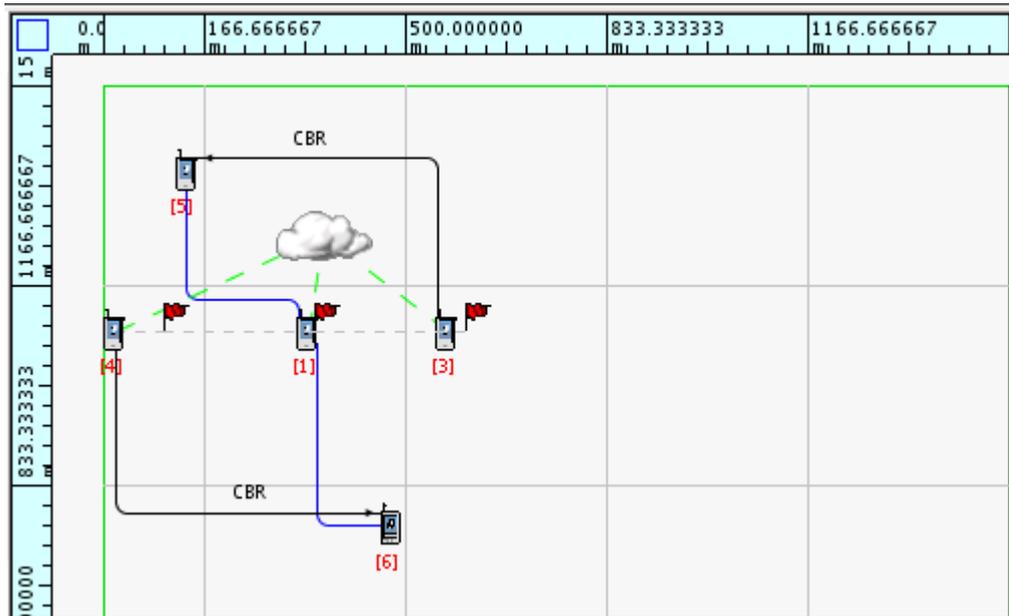
Node 7 starts off 20m from the AP (8) and 570m from the other wireless node (9). It starts moving at 20 seconds towards node 9. At 80 seconds, it comes 300m closer to node 9. Between 80 and 180 seconds, it is within 200m of node 9 and hence becomes exposed.

To begin with, we see a high throughput until node 7 becomes exposed around 20 seconds. The throughput of both nodes 5 and 6 drop considerably when node 7 comes into range of node 9 after 20 seconds when Node 7 is about 460m away from Node 9. As long as node 7 is exposed the throughput is low for both node 5 and 6.

Node	Time	X	Y
5	0	118	123
6	0	807	1221
7	0	20	710
7	20	50	710
7	80	250	710
7	180	400	710
8	0	150	710
9	0	550	710
10	0	750	710



Scenario: Setting AP Node (Hidden Node)



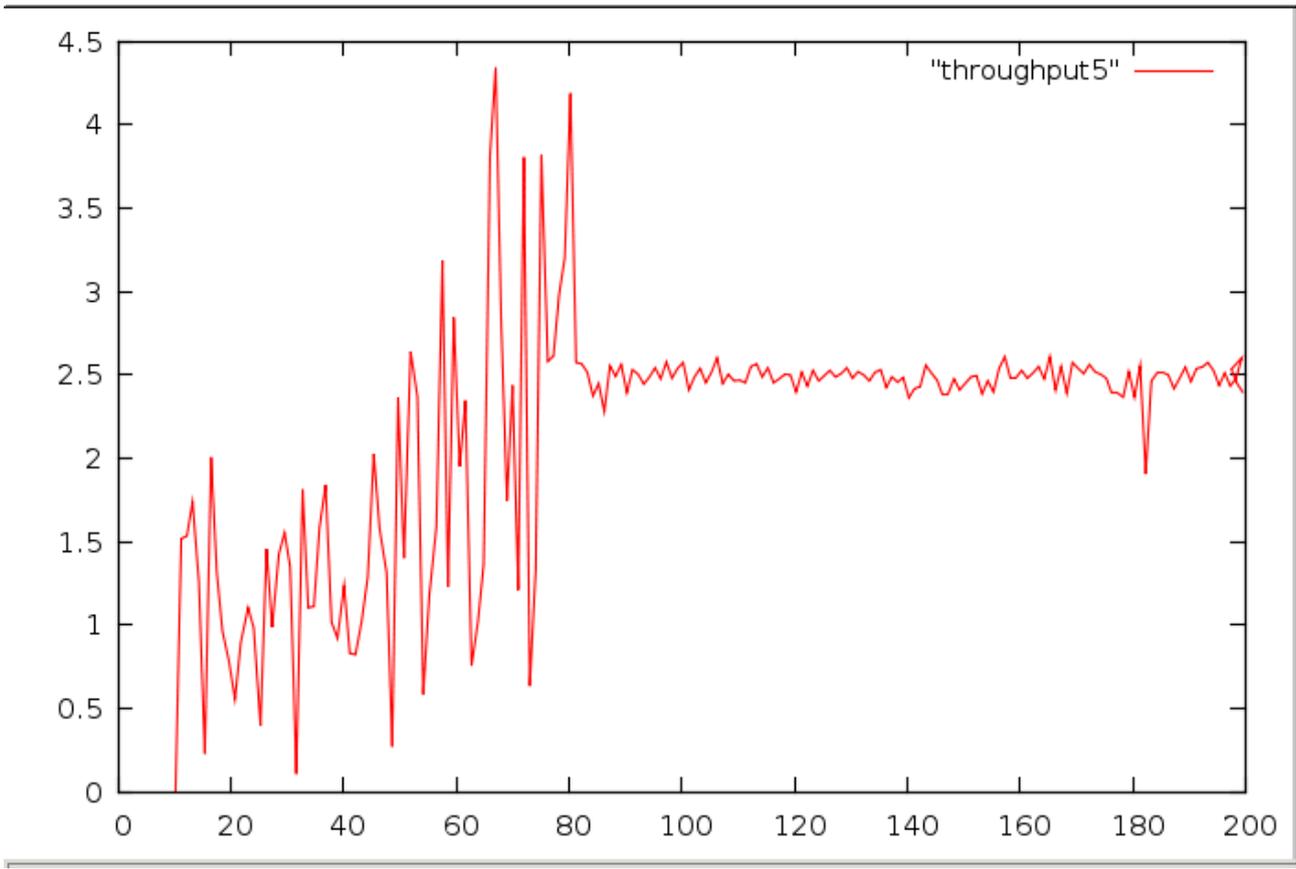
Hidden Node topology – Node 1 is an AP, Nodes 3 and 4 are wireless, Node 3 sends CBR to 5, Node 4 sends CBR to 6, Nodes 5 and 6 are wired.

Node 4 is the mobile wireless node. It starts off 320m from the AP and 550m from the other wireless node (3). It starts moving at 80 seconds towards the AP and node 3. It crosses to the other side of the AP and the wireless node 3 after 100 seconds.

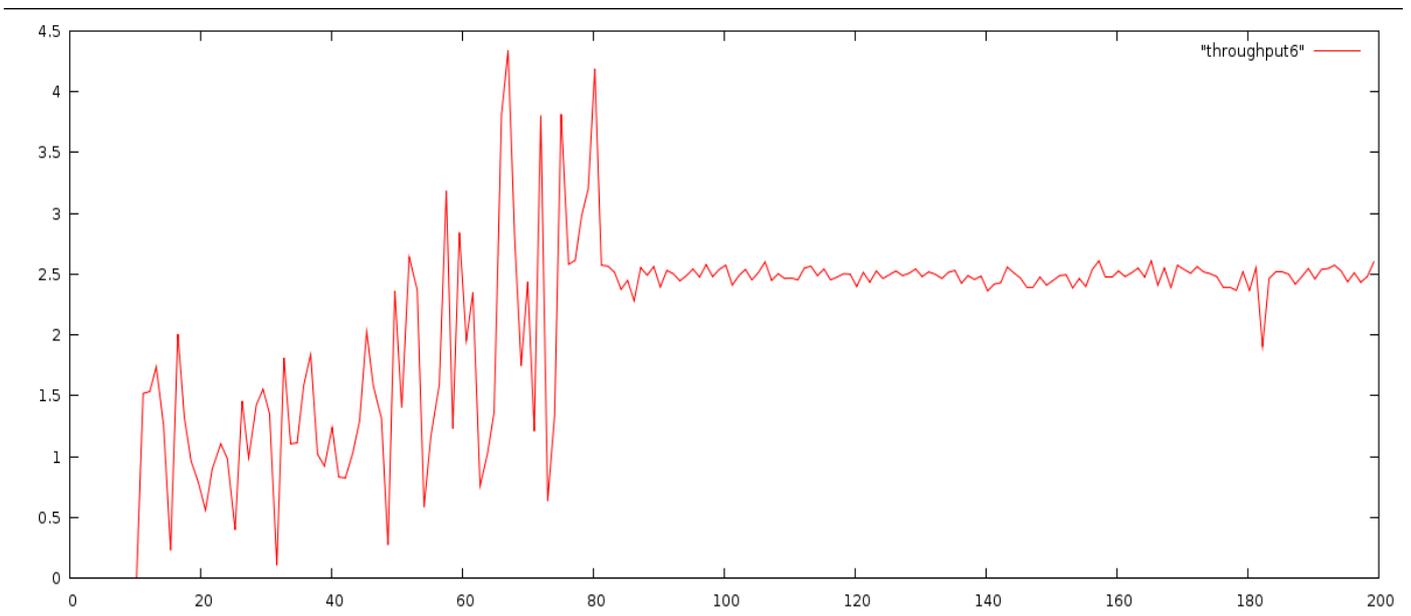
To begin with, node 4 is not in the range of 3 but it is hidden (because both node 3 and node 4 are within range of the AP which is node 1). As node 4 is a hidden node of 3 they transmit simultaneously causing a lot of collisions and unsuccessful transmissions. This can be seen from the graph.

After 80 seconds, node 4 moves closer to the AP and in the range of node 3. The throughput is low but stable from 80 seconds when node 4 comes within the range of 3. We can see this from the graph.

Node	Time	X	Y
1	0	340	1090
3	0	570	1090
4	0	20	1090
4	80	100	710
4	100	350	710
4	180	600	710
5	0	139	1356
6	0	477	764

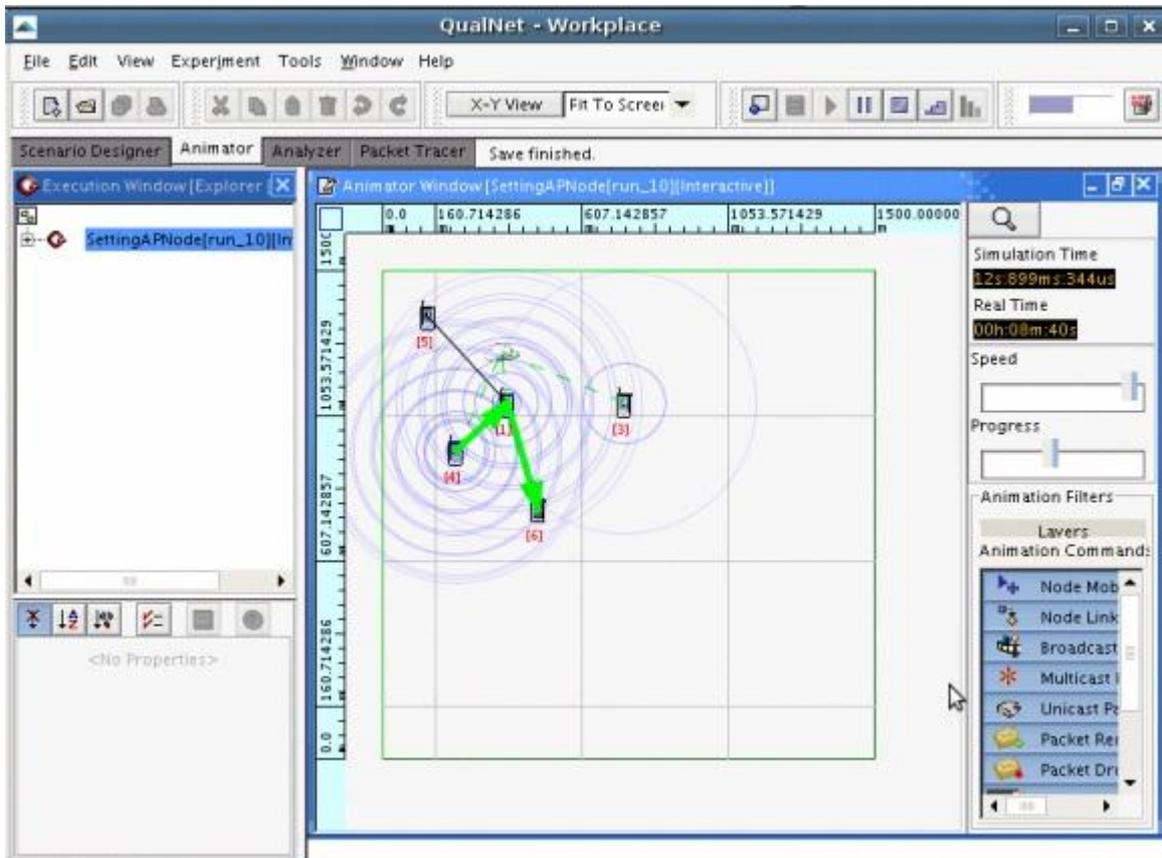
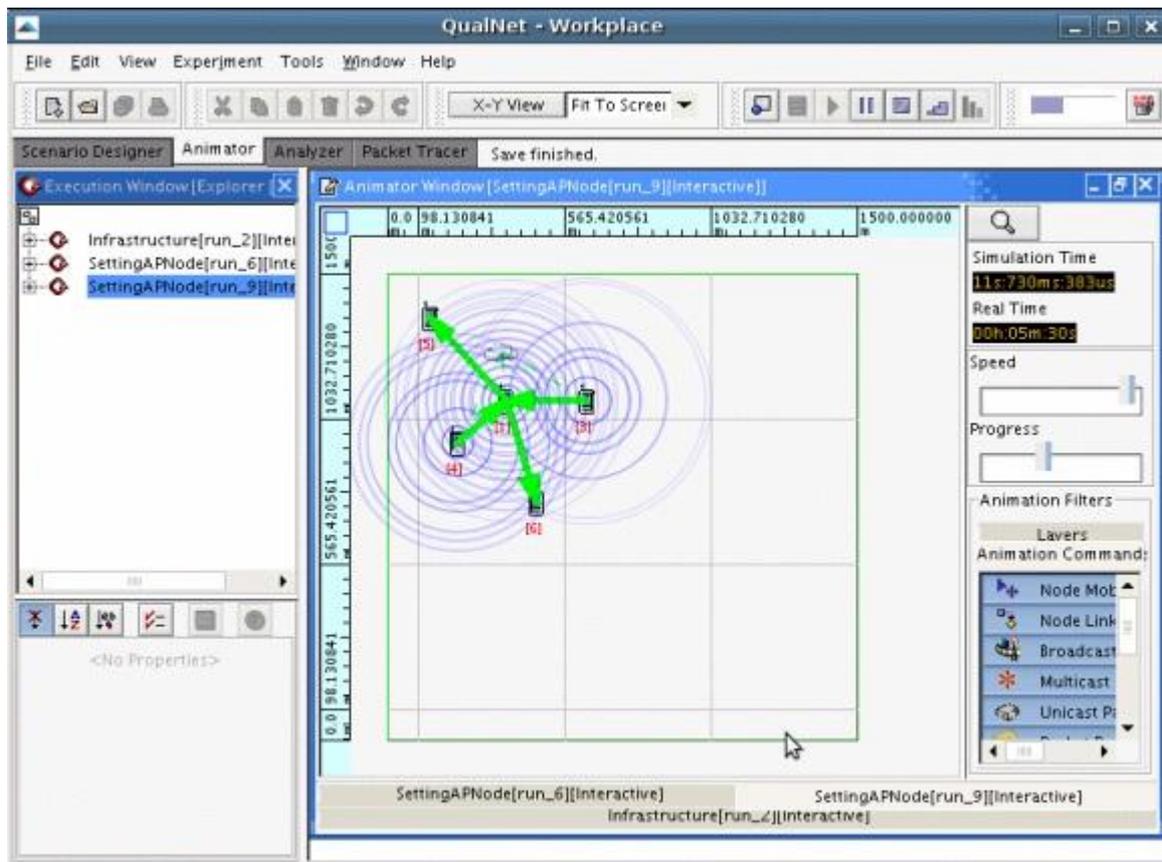


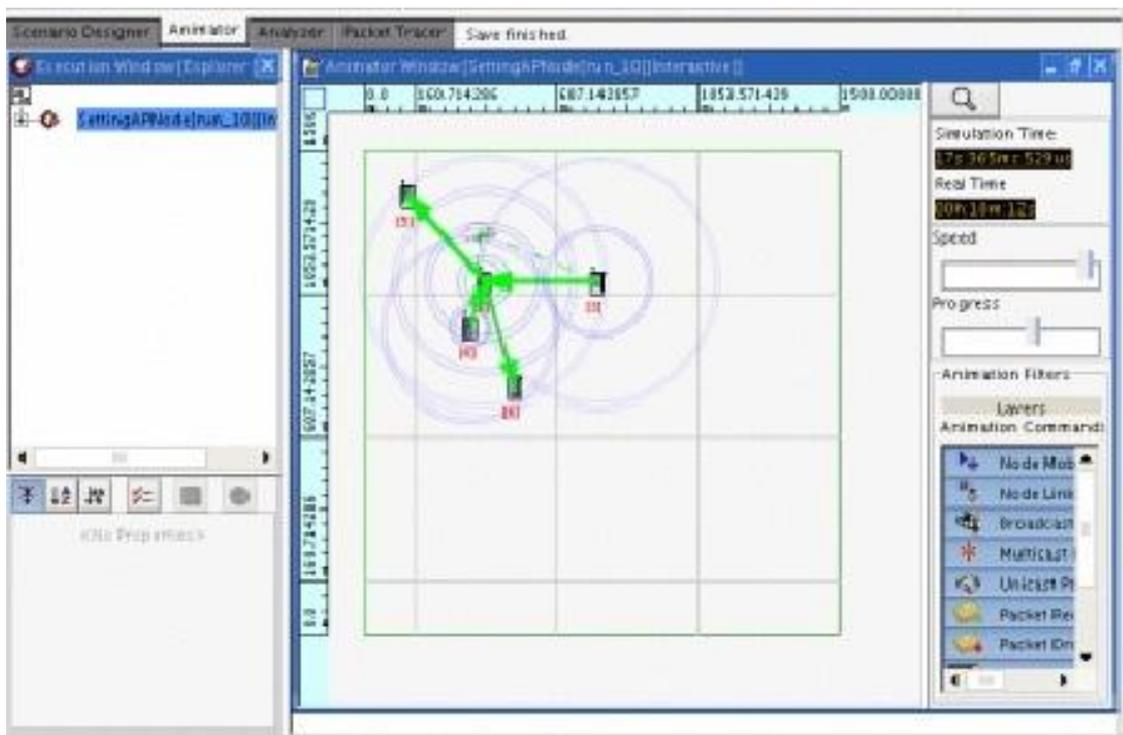
Hidden Node throughput node 5



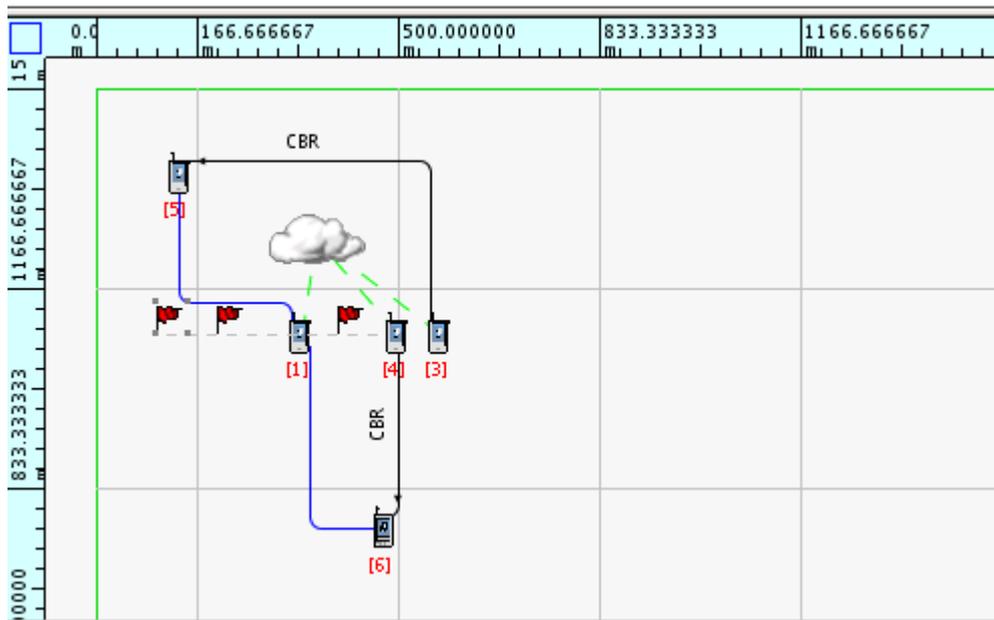
Hidden Node throughput node 6

The following are some of the screenshots in the hidden node scenario.





Hidden Node Reverse Mobility

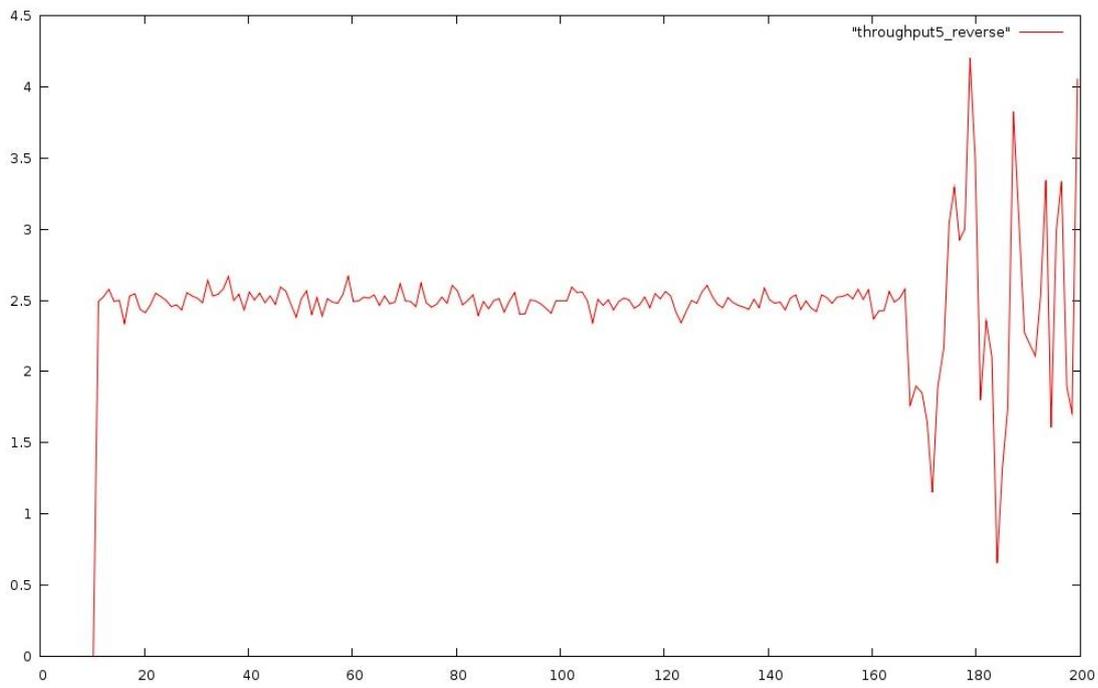


Hidden Node Reverse Mobility topology – Node 1 is an AP, Nodes 3 and 4 are wireless, Node 3 sends CBR to 5, Node 4 sends CBR to 6, Nodes 5 and 6 are wired.

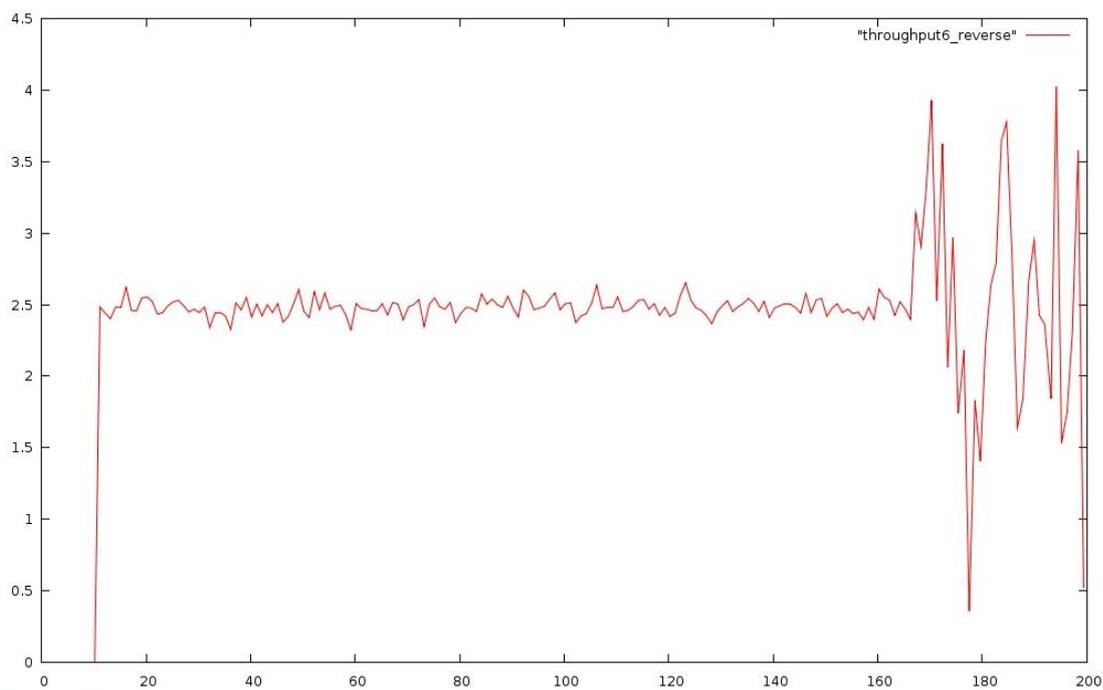
Node 4 starts off as an unhidden node for Node 3. It is in the range of node 3. It is placed 70m from node 3 and 260m from the AP (1). It starts to move away from node 3 from 20 seconds and moves away from node 3. At 80s it is 370 m away from node 3 and 140 m from the AP. At 180s it is 470m away from node 3 and 240 m from the AP. At this point it becomes a hidden node.

From the graph we can see that while node 4 is in the range of node 3, the throughput is low but stable. When node 4 becomes hidden, the throughput to node 5 increases at 180seconds and the throughput to node 6 increases at 160seconds causing a lot of collision and unsuccessful transmission. In the hidden node scenario, the nodes transmit at the same time causing a lot of collision.

Node	Time	X	Y
1	0	340	1090
3	0	570	1090
4	0	500	1090
4	20	400	710
4	80	200	710
4	180	100	710
5	0	139	1356
6	0	477	764



Hidden Node Reverse Mobility throughput node 5



Hidden Node Reverse Mobility throughput node 6