Throughput Analysis of IEEE 802.16j Network

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Abstract— Relay Stations are responsible for relaying and regulating the data transmission between the Base Station and Subscriber Stations. The system performance is sensitive to the number of relays deployed and their location. An important issue is to determine the relay placement and the number of relays to be deployed in the system in order to maximise the overall system capacity and throughput. The main objective of this paper is to analyse the performance of Relay Station placement in WiMAX 802.16j in transparent mode.

Index Terms— IEEE 802.16, Relay Station, Throughput, WiMAX, Broadband

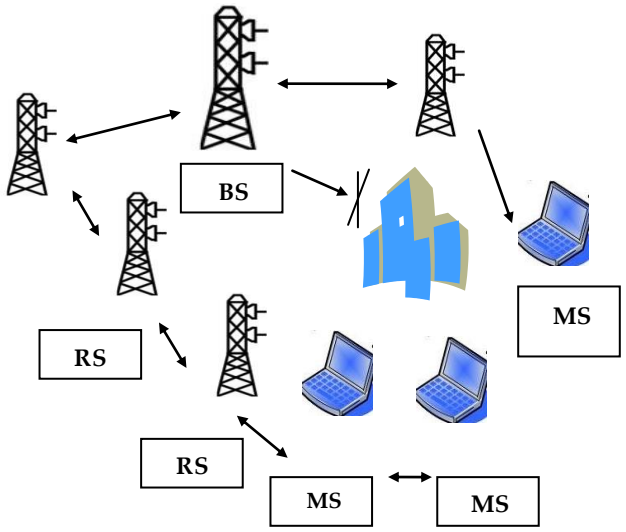
1 INTRODUCTION

The paper focuses on the issue of relay placement that arises in 802.16j WiMAX network operating in transparent mode. A key and important issue is to determine the relay placement and the number of relays to be deployed in the system in order to maximise the overall system capacity and throughput.

Based on the physical processing perspective, Relay Stations (RSs) are classified into two modes, Transparent Relay Station (T-RS) and Non-Transparent Relay Station (NT-RS).

Transparent Relay Station (T-RS) does not forward framing information and does not have scheduling capability. Communication occurs when carrier frequencies are the same. Non-Transparent Relay Station (NT-RS) has the ability to forward framing information and has scheduling capabilities. Communication can occur using the same or different frequencies also [1].

Relay Stations can be classified as Fixed, Nomadic or Mobile Relay Stations to suit different deployment scenarios or usage models. Furthermore, it is important to highlight that the metrics of WiMAX system depends on environmental conditions, WiMAX channel configurations and types of applications being used [2]. Relay Station (RS) is used for the system performance enhancement by allowing coverage extension. Fixed Relay Station (F-RS) is installed permanently at fixed location to enhance coverage, capacity or throughput to users in areas where the coverage is low. Nomadic Relay Station (N-RS) can be used in areas where temporary coverage is required for the duration of that particular event in order to provide additional coverage. It is suitable for events like sports events etc. Mobile Relay Station (M-RS) is fully mobile and can be mounted on moving vehicles such as trains, buses or cars so as to acquire connection via a Relay Station (RS) through mobile link [2].



BS – Base Station
RS – Relay Station
MS – Mobile Station
Fig 1. Multi-hop Relay Network architectures
Source: [3]

2 MATERIALS AND SCENARIO

This study provides guidelines on the design of 802.16j systems operating in transparent mode, the deployment scenario(s) and system configuration that would lead to a significant throughput gain. Different deployment scenarios containing a Host, Base station (BS), Relay station (RS) and Subscriber station (SS) were considered, all aimed at optimising throughput among their respective topology. The Relay station (RS) position was manipulated with its

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corresponding Base and Subscriber station to determine the reaction in terms of throughput.

The IEEE 802.16j network was simulated into an NCTU network simulator. NCTUns was mainly chosen because it supports both the transparent and non-transparent modes defined in the IEEE 802.16j standard and is very easy to manoeuvre and use via its highly-integrated Graphics User Interface (GUI) environment [4]. The simulator also supports the scenarios and parameters that would lead to the successful completion of the project.

3 RESULTS AND DISCUSSION

3.1 Scenario 1

The Subscriber station (SS) was at a fixed location outside the range of the Base station (BS). The Relay station (RS) was placed between the Base Station (BS) and the Subscriber station (SS). The height of the Base Station, Relay Station and the Subscriber Station was set to 20 meters, 15 meters and 1.5 meters respectively. The power of the Base Station, Relay Station and the Subscriber Station was set to 43 dbm, 43 dbm and 35 dbm respectively. The Input Output Throughput average values were recorded as shown in TABLE 1. The Average Input Output Throughput decreased as the Subscriber Station (SS) distance increased from the Relay Station (RS) up to a certain distance. The distance of 275.600 meters between the Subscriber Station (SS) and the Relay Station (RS) gave the lowest Average Input Output throughput. The distance of 225.505 meters between the Subscriber Station (SS) and the Relay Station (RS) also gave a low Average Input Output throughput. Subscriber Station (SS) was placed at a constant distance of 950 meters from the Base Station (BS).

TABLE 1
Throughput for a height of 20 meters and 15 meters for the Base station (BS) and Relay station (RS)

Topology	Distance between BS and RS (m)	Distance between RS and SS (m)	Average Throughput (KB/sec)	Height (m)	Power (dbm)
Series 5	874.818	75.182	1468.488	BS = 20 RS = 15 SS = 1.5	BS = 43 RS = 43 SS = 35
Series 4	829.154	120.846	1468.014	BS = 20 RS = 15 SS = 1.5	BS = 43 RS = 43 SS = 35
Series 3	785.125	164.875	1468.489	BS = 20 RS = 15 SS = 1.5	BS = 43 RS = 43 SS = 35
Series 2	724.495	225.505	904.873	BS = 20 RS = 15 SS = 1.5	BS = 43 RS = 43 SS = 35
Series 1	674.40	275.600	895.787	BS = 20 RS = 15 SS = 1.5	BS = 43 RS = 43 SS = 35

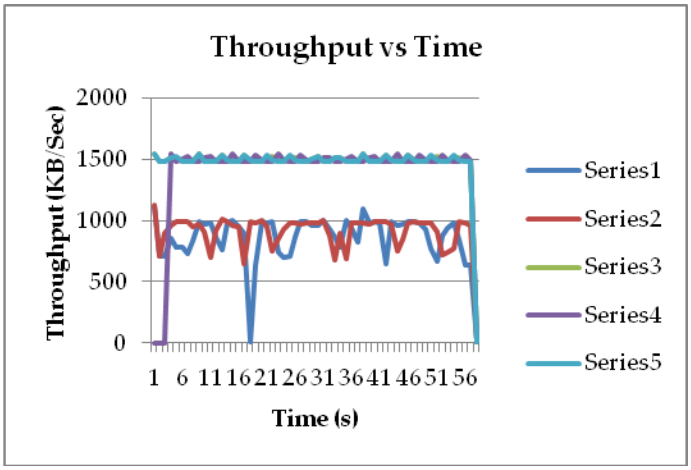

Fig 2. Graph for Table 1 Average Throughput values

3.2 Scenario 2

Scenario 2 focused mainly on increasing the height at the Base Station (BS) and Relay Station(RS) for the same distances between the Base Station (BS) and Relay Station (RS) as in TABLE 1. TABLES 2 and 3 show the Average Input Output Throughput values for change in height and distance between the BS and the RS. The heights of the Base Station(BS) and the Relay Station was increased to 30 meters and 20 meters respectively. It can be seen from TABLE 2 that the throughput increased for the distances of 275.600 and 225.505 meters with the increase in heights of the Base Station (BS) and Relay Station(RS). Table 3 shows that furthur increasing the heights of the Base Station (BS) and Relay Station(RS) to 45 meters and 35 meters improved the Average Input Output Throughput at the distances of 275.600 and 225.505 meters.

The Subscriber Station (SS) was placed at a constant distance of 950 meters from the Base Station (BS).

TABLE 2
Throughput for a height of 30 meters and 20 meters for the Base station (BS) and Relay station (RS)

Topology	Distance between BS and RS (m)	Distance between RS and SS (m)	Height (m)	Average Throughput (KB/sec)
Series 5	874.818	75.182	BS = 30 RS = 20	1468.488
Series 4	829.154	120.846	BS = 30 RS = 20	1468.493
Series 3	785.125	164.875	BS = 30 RS = 20	1467.957
Series 2	724.495	225.505	BS = 30 RS = 20	1260.736
Series 1	674.40	275.600	BS = 30 RS = 20	1253.402

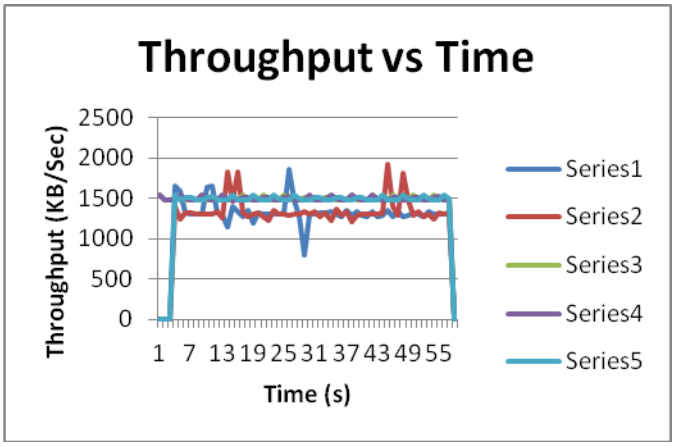

Fig 3. Graph for Table 2 Average Throughput values

TABLE 3
Throughput for a height of 45 meters and 35 meters for the Base station (BS) and Relay station (RS)

Topology	Distance between BS and RS (m)	Distance between RS and SS (m)	Height (m)	Average Through put (KB/sec)
Series 5	874.818	75.182	BS = 45 RS = 35	1468.489
Series 4	829.154	120.846	BS = 45 RS = 35	1468.488
Series 3	785.125	164.875	BS = 45 RS = 35	1468.488
Series 2	724.495	225.505	BS = 45 RS = 35	1747.455
Series 1	674.40	275.600	BS = 45 RS = 35	1780.495

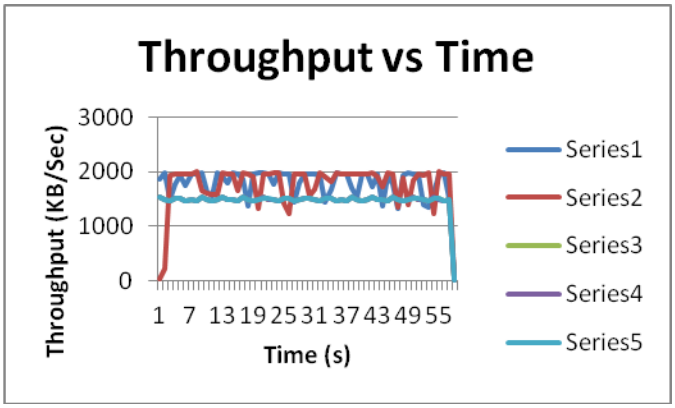

Fig 4. Graph for Table 3 Average Throughput values

3.3 Scenario 3

Scenario 3 focused mainly on increasing the power at the Base station (BS) and Relay station (RS) so as to determine the RS placement which yields the maximum throughput. TABLE 4 shows the throughput for change in power by furthur increasing the power of the Base Station (BS) and Relay Station(RS) to 55 dbm and 55 dbm. The Average Input Output Throughput at the distances of 275.600 and 225.505 meters showed a large increase. The Subscriber Station (SS) was placed at a constant distance of 950 meters from the Base Station (BS).

TABLE 4

Throughput for a power of 55 dbm and 55 dbm for the Base station (BS) and Relay station (RS)

Topology	Distance between BS and RS (m)	Distance between RS and SS (m)	Power (dbm)	Average Throughput (KB/sec)
Series 5	874.818	75.182	BS = 55 RS = 55	1468.489
Series 4	829.154	120.846	BS = 55 RS = 55	1468.489
Series 3	785.125	164.875	BS = 55 RS = 55	1468.88
Series 2	724.495	225.505	BS = 55 RS = 55	2549.655
Series 1	674.40	275.600	BS = 55 RS = 55	2695.53

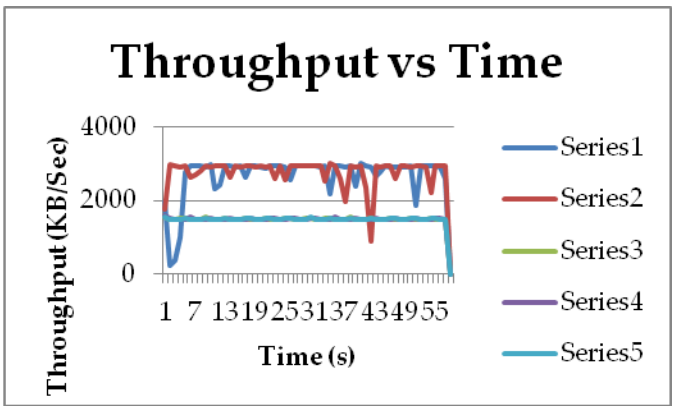

Fig 5. Graph for Table 4 Average Throughput values

4 Conclusion

Thus from the specific scenarios conducted above, it was seen in Scenario 1, that as the distance between the Relay Station and the Subscriber Station was increased the Average Input Output Throughput decreased up to a certain distance, when the distance between the Relay Station (RS) and the Subscriber Station (SS) was large as shown in TABLE 1. At the same distances of the Relay Station (RS) and Subscriber Station (SS) placements, with increase in the heights and transmit power of the Base and Relay stations significant increase in throughput was found for distances as shown in TABLES 2,3 and 4 at distances where the distance between the Relay Station (RS) and the Subscriber Station (SS) was large. Thus, this implies height and power are significant factors when distance between Base and Relay Station is large.

4 Future Work

WiMAX IEEE 802.16j is an evolving technology and there is a lot of room for research. The following are a few suggestions for future work:

- Operating in a Non-Transparent mode RS (NT-RS) environment. This mode allows for hops greater than two.
- Applying a variety of modulation schemes to the relay-based network, both in Transparent mode RS (T-RS) and NT-RS. These include Phase Shift Key (PSK), Quadrature Phase Shift Key (QPSK) and Quadrature Amplitude modulation (QAM).

References

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