Chapter 5

Relay Station Selection Algorithm and Scheduling Algorithm for IPTV based Services in IEEE 802.16j MMR WiMAX Networks

Summary

Television over Internet Protocol (IPTV) is an emerging multimedia service which provides ubiquitous TV access. WiMAX technology is one of the access technologies that enables transmission of IPTV services. Transmitting IPTV over WiMAX aims to make IPTV services available to users anywhere, anytime and on any IP based device. In order to satisfy the stringent quality of service (QoS) requirements of IPTV, the IEEE 802.16j mobile multi-hop relay (MMR) WiMAX networks are suitable for IPTV transmission. The IPTV service providers offers different types of services (HDTV, SDTV, Web TV and mobile TV) using different video servers for each IPTV service type, which increases the bandwidth required for IPTV transmission. In this chapter, a relay selection algorithm and scheduling algorithms are proposed for IPTV services in order to reduce the bandwidth requirement and average delay in MMR WiMAX network. The performance of proposed algorithm is evaluated through simulation by considering bandwidth used, delay and throughput as metrics.
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5.1 Introduction

Mobile communication has experienced an exponential growth in the usage, services and applications. IEEE 802.16 standard also known as Worldwide Interoperability for Microwave Access (WiMAX) is one of the access technologies, which is enabling new multimedia services by offering high datarates [1]. WiMAX has witnessed a tremendous growth and evolved as one among the potential broadband wireless access (BWA) technology. The IEEE 802.16e standard [2] introduces the mobility to WiMAX and a user can access the network ubiquitously. The new amendment IEEE 802.16j standard introduces relay stations [RS] to enhance the throughput and coverage performance of earlier IEEE 802.16e networks [3]. It has been proven that subscriber stations (SSs) can reach higher throughput and/or lower energy consumption with the help of RSs [4].

Television over Internet Protocol (IPTV) describes a system capable of transmitting, receiving and displaying a video stream representing a TV channel and being encoded as a series of IP packets [5]. IPTV enables users to transmit and receive TV program data through IP-based wired and wireless networks [6]. IPTV is undoubtedly a killer application and it is one of the fastest growing services in the Internet. This rapid growth is due to the advances in media encoding and compression techniques (e.g., H.264/AVC) along with the enormous improvement of networking technologies [7]. To provide ubiquitous delivery, IPTV service providers have to pay special attention to wireless broadband technologies as their access networks.

Mobile multi-hop relay (MMR) WiMAX technology is an appropriate choice to provide broadcast TV services for both fixed and mobile users because it supports QoS-based multicasting functionality. Users will be able to access and consume a rich set of multimedia content over dynamic networks and heterogeneous devices. In this chapter, an attempt is made to improve the network performance for IPTV based services by reducing the bandwidth required for IPTV transmission and average delay of IPTV services. A relay selection algorithm and scheduling algorithms are proposed for IPTV services in MMR WiMAX network and the proposed algorithms are implemented using QualNet simulator [8]. The rest of the chapter is organized as follows. Section 5.2 outlines the related work in the literature. Section 5.3 and 5.4 describe overview of IPTV and IPTV in WiMAX respectively. Section 5.5 gives the overview of Scalable
Video Coding (SVC) in WiMAX and Section 5.6 presents the problem statement. The Sections 5.7 and 5.8 describe the proposed relay selection and scheduling algorithms respectively. The discussion of simulation results is given in Section 5.9 followed by conclusion in Section 5.10.

5.2 Related Work

As the wireless multi-hop relay systems play an important role in upcoming broadband wireless networks many researchers are interested in this field. Introduction of relays in IEEE 802.16j network introduced many challenges, among which relay selection is also one of the challenges. In paper [9-10] path selection metrics are proposed. In paper [9] a path selection metric is proposed, named normalized number of mini slots (NNM), which enables a SS to choose a path that satisfies its application rate and delay requirements. Authors in [10] have proposed a path metric, named effective radio resource index (ERRI) to select an effective relay path in the error-prone IEEE 802.16 MMR network. Authors of paper [11] have proposed a cross-layer tree based path construction mechanism to adjust the system deployment when a new SS accesses the network. The work in paper [12] proposed a path selection method for IEEE 802.16j MMR network. The metrics designed for the path selection, such as link available bandwidth, SNR and hop count will be discussed. Authors of [13] have investigated relay selection algorithm based on QoS. The algorithm is compared with shortest distance selection algorithm by simulation.

As the IPTV is a booming multimedia service, many researchers are working on it. In paper [14], IPTV streaming over WiMAX is evaluated using WiMAX testbed. In [15] the performance of H.264/SVC video streaming over mobile WiMAX under realistic network conditions is assessed, with the help of metrics like PSNR (Peak Signal to Noise Ratio) or MOS (Mean Opinion Score). Authors of [16] investigated the performance of IPTV (VoD) over WiMAX networks for H.264/AVC and Scalable Video Coding (SVC) codes. Results obtained from simulation indicate that SVC video codec is an appropriate video codec for video streaming over WiMAX. In [17], the authors proposed a standard-based, cost-effective solution to support multicasting broadcasting services (MBS) in WiMAX MMR networks. They defined a BS-oriented source-routing protocol to automatically discover relay network topology in which the mobile RS forms an ad hoc topology. They used the Internet Group Management
Protocol (IGMP) on the BS to automatically track the MBS group membership and service activation. In [18-22], the authors proposed resource allocation mechanisms for IPTV service over IEEE 802.16 WiMAX networks. To address a resource allocation problem, the authors combined multicast, SVC and adaptive modulation of transmissions. The objective was to dynamically adjust the number of each user’s layer according to its channel condition, available bandwidth and scheduling decisions. In paper [23] authors present a new mechanism for MBS for MMR WiMAX with SVC. In [24] IPTV video streaming forwarding scheme is proposed based on a new multicast tree construction and aggregation mechanism.

5.3 Television over Internet Protocol (IPTV)

Television over Internet Protocol (IPTV) is one of the fastest growing services in the last decade. IPTV is a system through which television services are delivered using the internet protocol suite over a packet switched network such as internet, instead of being delivered through traditional terrestrial, satellite signal and cable television formats. IPTV is distinguished from internet television by its on-going standardization process (by European telecommunication standards institute (ETSI) and international telecommunication union (ITU)) and preferential deployment scenarios in subscriber based telecommunication networks with high speed access channels.

In general, IPTV services can be divided into Broadband television or live television, Time shifted television and Video on demand for stored contents. In IPTV, video streams are distributed using IP unicast and multicast toward subscribers. Typically, unicast is used in the case of video on demand and multicast is employed by Broadband TV service for the delivery of live TV channel streams.

The acceptable standards of quality depend on the class of traffic being carried as a part of the IPTV service. ITU has recommended parameters for packet loss and latency in order to deliver satisfactory video and audio.

The ITU-T recommendations for these parameters are as follows

**Voice traffic:**
- Recommended one way delay: 150 ms, unacceptable 250 ms
- Audio Packet Loss (G.729) 2 percent

**Video traffic:**
- Delay jitter 40 ms
- Maximum Video packet loss: 5 percent
5.3.1 IPTV Network Architecture and Services

A generalized architecture of IPTV is given in figure 5.1. Video and audio services are delivered as “streams” between a media-streaming server and an appropriate receiver device such as an IP set-top box to convert the streaming video to “normal” video, which can be displayed on a TV. An end-to-end QoS controlled network is used to deliver both live TV and streamed “on-demand media” via an IP network.

![Figure 5.1 A generalized IPTV architecture](image)

5.4 IPTV in WiMAX

WiMAX now presents a new window of opportunity to deliver video to fixed, nomadic or mobile devices by virtue of its QoS and service flow-based connections. WiMAX networks present an attractive alternative to wireline-based IPTV offering the following advantages [25]:

- Metro wide or rural connectivity
- High resilience to multipath propagation through OFDM
- Guaranteed QoS and a service class for video
- Universal availability of interoperable client devices
- Mobility upto 125 Kmph with IEEE 802.16e
- High bit rates achievable
- Minimum or no maintenance on access links
Compatibility with IP-based protocols and IPv6

Capability of WiMAX to connect WiFi hotspots

Two-way interactive communications

Compatibility and roaming with 3G mobile networks

Compared to wireless networks such as WLAN, WiMAX has clear advantages for supporting video traffic or IPTV because it provides a service class, which can be associated with the connection. For variable bit rate (VBR) streams like video, the WiMAX defines real time polling services (rtPS) service class, which guarantees a minimum reserved traffic rate. In addition, the mobile WiMAX (IEEE 802.16e) has a support for multicast broadcast service (MBS) and VoIP. The IEEE 802.16e mobile WiMAX provides service flow-based assignment for each connection and this can guarantee base level IPTV video even in a mobile environment.

The IPTV services in general also include video gaming, media downloads, web browsing (HTTP) and VoIP as a part of triple play services. WiMAX has quality of service classes to accommodate various types of services associated with IPTV portfolio.

<table>
<thead>
<tr>
<th>Application</th>
<th>QoS Requirement</th>
<th>WiMAX Scheduling Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>VoIP, Video Conferencing</td>
<td>Real time low latency service (latency &lt; 150ms), low jitter (jitter &lt; 50ms), low bandwidth (32-64Kbps)</td>
<td>Extended real time polling service (ertPS) for voice and real time polling service (rtPS) for video</td>
</tr>
<tr>
<td>Media download (audio, video)</td>
<td>Non-real time high bandwidth (2-10Mbps)</td>
<td>Non-real time polling service (nrtPS) or best effort (BE)</td>
</tr>
<tr>
<td>IPTV or media streaming</td>
<td>Real time with minimum reserved rate, low jitter (jitter &lt; 50ms), medium bandwidth (0.5-3Mbps)</td>
<td>real time polling service (rtPS)</td>
</tr>
<tr>
<td>Interactive gaming</td>
<td>Low latency service (latency &lt; 100ms), low bandwidth (50-100Kbps)</td>
<td>Extended real time polling service (ertPS)</td>
</tr>
</tbody>
</table>
5.4.1 IEEE 802.16j (MMR)

The IEEE 802.16j mobile multi-hop relay (MMR) standard is proposed to provide a suitable solution for both throughput enhancement and coverage extension of IEEE 802.16e networks. The BS needs to be modified to support relay operations and it is called multi-hop relay BS (MR-BS) to reflect this capability. The subscribers which are near enough to MR-BS can communicate with it directly. Using relay stations (RS), SSs in the border of the coverage cell, can receive the signal with higher data rate.

Two types of relay operation modes are included in the IEEE 802.16j standard, transparent mode and non-transparent mode. A relay in transparent mode, does not broadcast control signaling. In this mode, an SS associated to an RS is located within the coverage of the MR-BS; but it can achieve higher throughput by using two hops instead of direct communication with MR-BS. The control signaling from the MR-BS is always transmitted with the most robust modulation scheme and can directly reach the SSs. The data traffic is relayed via a relay station. Transparent relay only supports centralized scheduling. MR-BS coordinates and allocates the radio resources to SSs and RSs within the cell by distributing control information and arbitrating access requests. In addition to throughput enhancement, transparent relays can solve the problem of coverage holes [26]. Conversely in non-transparent relay mode, all data and control signaling transmissions between MR-BS and SS are relayed and therefore, a non-transparent relay can increase coverage area.

The introduction of relay station has introduced the path selection challenge that is associate a SS to either the BS or a RS. The path selection algorithm has a significant impact on the achievable throughput of the network. As there is a cost in terms of overhead associated with the selection of a relay, the design of an intelligent path selection algorithm is necessary to ensure good performance of the system in terms of throughput and delay.

5.5 Scalable Video Coding (SVC) for IPTV

IPTV provides different types of services like HDTV, SDTV, Web TV and mobile TV for the same video information. As these services differ in their data rate, the providers are sending each service separately even though all the services contain the same information by maintaining different servers for different types as shown in figure 5.2. Sending the same information for different services can increase the network
consumption of the providers. Hence a new encoding technique called Scalable Video Coding (SVC) technique is used to send only one copy of IPTV video stream. The SVC is an extension of the H.264/AVC video codec standard, it allows desirable scalability at a bit stream level, at the cost of an increase in decoder complexity compared to single-layer H.264/AVC. The many functions supported by SVC improve transmission and storage applications. The video codec standards developed prior to SVC are not capable of providing the coding efficiency and scalability that SVC provides. The implementation of SVC has proven highly beneficial for various video applications [27].

![Diagram of IPTV transmission]

Figure 5.2 Basic Way of IPTV transmission

However if the SVC technique is used for encoding, then an intelligent entity should be present in between the server and the end users in order to decode the IPTV contents from SVC encoded data and forward it to the end users. Hence the authors of [23] used RSs as the intermediate entities to receive the SVC encoded IPTV data as shown in figure 5.3. In [23] the SVC decoding functionalities are integrated for all network RSs to extract IPTV video streams to different formats (HDTV, SDTV, Web
TV and mobile TV), as shown in figure 5.4. The MR-BS sends the SVC encoded IPTV data to the RSs, further the RSs decodes thee data and forwards the decoded data to the connected SSs. However in IEEE 802.16j network, the SS may connect to the MR-BS directly or through RS, the MR-BS decodes and sends the IPTV data to the SSs which are connected to it directly. In this chapter the relay selection and scheduling algorithms are proposed for the work in [23].

![Figure 5.3 IPTV transmission using SVC encoding](image1)

![Figure 5.4 Principle for SVC decoding [23](image2)
5.6 Problem Statement

The architecture of SVC encoded IPTV delivery over WiMAX network is shown in figure 5.5. MR-BS receives SVC encoded video stream from media server. Both MR-BS and RS decode SVC in order to support different IPTV services of their connected SSs. In WiMAX the SS may connected to MR-BS directly or through RS. If the SS accessing IPTV service is directly connected to MR-BS, then MR-BS schedules bandwidth to both RSs and SSs. When the number of directly connected SSs accessing IPTV service increases, bandwidth required for IPTV transmission also increases. This leads to deterioration of QoS of IPTV services due to scarcity of bandwidth. In order to overcome this problem, a novel algorithm has been proposed in this chapter which transfers IPTV load from the MR-BS to RSs, in order to improve the QoS by reducing the bandwidth required for IPTV transmission. In addition when a SS is in vicinity of multiple RSs with same modulation and coding scheme (MCS), relay selection becomes crucial which is considered in this work.

![Figure 5.5 Architecture of SVC encoded IPTV delivery over WiMAX network](image)

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5.7 Proposed Relay Selection Algorithm for IPTV

In the proposed algorithm, in order to reduce the bandwidth required by MR-BS for IPTV transmission, MR-BS sends the encoded IPTV content to the subordinate RSs only. So in order to have an IPTV access the SS must connected to MR-BS through RS only.

The basic relay selection algorithm implemented in IEEE 802.16j contributed module for QualNet, determines the path between a SS and MR-BS based on the modulation and coding scheme (MCS) used. The basic algorithm calculates the link quality between SS under consideration and RSs which are in the vicinity of SS and RS with higher link quality is selected for path decision process. Also the basic algorithm calculates the link quality between MR-BS–SS (under consideration) and the selected RS–MR-BS. The sum of the link qualities between the MR-BS–RS and RS-SS link is compared with the MR-BS–SS link quality. If MR-BS–SS link quality is better, then SS will be connected to MR-BS directly otherwise the SS will be connected to MR-BS through RS.

The proposed algorithm follows similar relay selection procedure as that of basic algorithm during network entry of SS and for the SSs which are not accessing the IPTV services. When a SS request IPTV service, then the MR-BS employs proposed relay selection procedure. In the proposed relay selection procedure, the SS is compelled by MR-BS to select one of the RSs in order to access IPTV services. After receiving the scanning and synchronization information from the MR-BS, SS calculates the link quality with RSs which are in the vicinity and feeds back the link quality information to MR-BS. If the SS is in the vicinity of single RS, then MR-BS selects that RS as the access path to the SS. If the SS is in the vicinity of multiple RSs, then MR-BS selects the RS for which higher MCS can be achieved. However, when SS is in the same MCS region of multiple RSs, then in the proposed algorithm MR-BS selects the RS based on the IPTV metric (ITM). The ITM provides the information regarding the IPTV load of the RS and is calculated using the equation 5.1.

\[
ITM_{RS} = \sum_{1}^{n} \text{Datarate of each IPTV connection} \quad (5.1)
\]

Where \( n \) is the total number of IPTV connections in the considered RS.
The RS with lesser ITM values is selected by the MR-BS as the access path for that SS. Figure 5.6 demonstrates the flowchart of proposed algorithm. Part of the flowchart embedded in dotted line is basic algorithm and with solid line covers the proposed improvement to the basic algorithm.

Figure 5.6 Flowchart of proposed RS selection algorithm
5.8 Proposed Scheduling Algorithm for IPTV

The proposed scheduling algorithm considers only the rtPS scheduling part of the MR-BS downlink scheduler. The proposed algorithm uses weighted round robin (WRR) scheduling algorithms for IPTV connections and weighted fair queuing (WFQ) scheduling algorithms for the other rtPS connections.

In basic scheduling algorithm, the connections are served on the basis of service type priority. That is, UGS connections are served first, then ertPS connections, later rtPS, nrtPS and BE connections. Within a service type, the selection of connections to be served is based on the WFQ scheduling algorithm. Since IPTV services are mapped on to rtPS connections, all the IPTV streams along with other rtPS services are also served based on WFQ scheduling algorithm. Since IPTV services require stringent QoS and MR-BS does not serve SSs with IPTV services in the proposed algorithm, IPTV services need to be differentiated from other rtPS services. The rtPS services except IPTV services are scheduled using WFQ algorithm as same as that of basic algorithm and the IPTV services are scheduled using WRR scheduling instead of WFQ. The figure 5.7 depicts the categorization of rtPS connections and scheduling scheme adopted by the proposed algorithm.

![Figure 5.7 Proposed Scheduling algorithm for rtPS services](image-url)
In the proposed algorithm the IPTV connections are considered as higher priority services than other rtPS services since the general IPTV services are used for Live TV access. WRR scheduler is based on static weights. According to the weight for each RS, the MR-BS determines the RS to be served and schedules the bandwidth to the RSs. The WRR scheduler calculates the weights to determine RS to be served by considering the number of channels subscribed by the individual RSs as per the equation 5.2.

\[
\text{Weight}_{\text{RS}} = \frac{\text{Number of IPTV channels subscribed by the RS}}{\text{Total number of IPTV channels by all RSs}} \quad (5.2)
\]

### 5.9 Simulation and Results

QualNet simulator is used to implement the proposed relay selection and scheduling algorithms. The QualNet simulator has the contributed model for IEEE 802.16j, in which basic relay capabilities are implemented [8] and SVC decoding scheme is not implemented. Hence modification has been implemented in 802.16j contributed model to support SVC decoding schemes at the RS. The modification is implemented to the RSs in order to receive the SVC encoded IPTV content, decode it to HDTV, SDTV, Web TV and Mobile TV contents and further forward it to the connected SSs.

In this work simulation studies are carried out to evaluate the performance of proposed relay selection and scheduling algorithms. Also simulation studies are carried out for basic relay selection algorithm for SVC encoded data and for basic IPTV transmission without SVC encoding to illustrate the performance of proposed algorithm. A single MMR WiMAX cell consisting of MR-BS, RSs and SSs is considered in the simulation area of 2Km X 2Km working at a frequency 2.4 GHz. The path loss model selected is two-ray with constant shadowing model of shadowing mean 4dB. The simulation parameters settings are mentioned in table 5.2.
### Table 5.2 Simulation Parameters

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel bandwidth</td>
<td>20 MHz</td>
</tr>
<tr>
<td>FFT size</td>
<td>2048</td>
</tr>
<tr>
<td>Antenna model</td>
<td>Omni directional</td>
</tr>
<tr>
<td>BS antenna gain</td>
<td>10 dB</td>
</tr>
<tr>
<td>RS antenna gain</td>
<td>0 dB</td>
</tr>
<tr>
<td>SS antenna gain</td>
<td>0 dB</td>
</tr>
<tr>
<td>BS antenna height</td>
<td>12 m</td>
</tr>
<tr>
<td>RS antenna height</td>
<td>5 m</td>
</tr>
<tr>
<td>SS antenna height</td>
<td>1.5 m</td>
</tr>
</tbody>
</table>

### 5.9.1 Scenario 1

This scenario is designed to study the effect of proposed relay selection algorithm on the bandwidth consumption of the network. A single MMR WiMAX network with single MR-BS, four RSs and 120 SSs is considered for the performance evaluation. The SSs are deployed randomly in the simulation area 2Km x 2Km. In this scenario ten IPTV channels are considered and each SS is made to access one of the IPTV channels, hence the number of IPTV connections considered is 120. The simulation studies are carried out with proposed relay selection algorithm, basic relay selection algorithm for SVC encoded data and for basic way of IPTV transmission without SVC encoding by considering bandwidth used as the performance metric. Figure 5.8 shows the representative diagram of scenario 1 with 20 SSs.

Further the simulation studies are carried out by varying the number of connections from 60 to 240 insteps of 12. Initially simulation studies are carried out by considering 60 SSs, each accessing one IPTV services. Further the simulation studies are repeated by increasing the number of SSs accessing IPTV services in steps of 12 till 240 connections.
Figure 5.8 Representative diagram of scenario 1

Figure 5.9 Bandwidth used with respect to simulation time

Figure 5.9 gives the bandwidth used with respect to simulation time for proposed relay selection algorithm, SVC encoded basic relay selection algorithm and for basic way of IPTV transmission. It is observed from the figure 5.9 that the bandwidth used by basic way of IPTV transmission is more since the MR-BS transmits the IPTV data to individual SSs. The performance of SVC encoded basic relay selection algorithm is better compared to basic way of IPTV transmission, since MR-BS transmits SVC encoded IPTV data to the RSs and decoded IPTV data to the SSs which are connected.
to the MR-BS directly. It is also observed from the figure 5.9 that the bandwidth used in proposed algorithm is less compared to other two algorithms. Since in the proposed algorithm, the SSs are accessing IPTV data only through RS and also the MR-BS transmits IPTV encoded data only to the RSs avoiding transmission of IPTV decoded data directly to SS in contrast to SVC encoded basic relay selection algorithm.

![Bandwidth Graph](image)

**Figure 5.10 Bandwidth used for varying number of IPTV connections**

Figure 5.10 gives the bandwidth used for varying number of IPTV connections. It is observed from the figure 5.10 that, MR-BS bandwidth used for basic way of IPTV transmission is more compared to other two algorithms, also as the number of connections increases the bandwidth used increases since the MR-BS transmits the IPTV data to individual SSs. The bandwidth performance of SVC encoded basic relay selection algorithm is better compared to basic way of IPTV transmission since MR-BS transmits SVC encoded IPTV data to the RSs and decoded IPTV data to the SSs which are connected to the MR-BS directly. It is also noted that as the number of connections increases, the MR-BS bandwidth used for SVC encoded basic relay selection algorithm increases may be due to increase in number of directly connected SSs. It is also observed from the figure 5.10 that the bandwidth used in proposed algorithm is less compared to other two algorithms since in the proposed algorithm, MR-BS transmits IPTV encoded data only to the RSs avoiding transmission of IPTV decoded data directly to SS and the SSs are accessing IPTV data only through RS.
5.9.2 Scenario 2

This scenario is designed to study the performance of proposed scheduling algorithm. In this scenario, the design of scenario 1 is retained with 120 SSs each accessing one IPTV service. The number of IPTV channels transmitted by the SVC encoded IPTV servers is increased from 10 to 60 insteps of 10. The 120 SSs are made to access these transmitted IPTV channels randomly. The simulation studies are carried out by considering the proposed relay selection algorithm for both proposed scheduling algorithm and basic scheduling algorithm. Throughput and delay are considered as performance metrics.

![Figure 5.11 Throughput performance of IPTV services for varying number of channels](image)

Figures 5.11 and 5.12 give the throughput and delay performance of IPTV services for varying number of channels for both basic and proposed scheduling algorithm. It is observed from the figures 5.11 and 5.12 that for lesser number of channels the throughput and delay performance of both basic and proposed scheduling algorithm are same. As the number of channels increases, the throughput and delay performances of proposed scheduling algorithm are better compared to basic scheduling algorithm. Since in the proposed scheduling algorithm, WRR scheduling is employed for IPTV services and the weight is calculated based on the number of channels.
This scenario is designed to study the effect of proposed algorithms on the performance of other service types. In this scenario, the design of scenario 2 is retained with 40 SVC encoded IPTV channels and 120 SSs which are accessing one of the IPTV channels. Initially among 120 SSs, 4 SSs are made to transmit one rtPS connection and one nrtPS connection each (total 4 rtPS and 4 nrtPS) of 2Mbps data rate along with accessing IPTV service. Simulation studies are carried out for both proposed relay selection algorithm and SVC encoded basic relay selection algorithm. Throughput and delay are considered as performance metrics. The simulation studies are repeated by considering the number of SSs transmitting rtPS and nrtPS connections in steps of 4 (i.e., each SS transmits one rtPS and one nrtPS with data rate of 2 Mbps) till 20.

Figures 5.13 and 5.14 give the throughput performance of rtPS services (other than IPTV services) and nrtPS services respectively for varying number of connections. It is observed from the figures 5.13 and 5.14 that the throughput performances of rtPS services (other than IPTV services) and nrtPS services for proposed algorithm are better compared to basic algorithm. Since in proposed algorithm the bandwidth requirement by higher priority IPTV connections is reduced through relay selection algorithm, this bandwidth is used to serve the other rtPS and nrtPS services.
Figure 5.13 Throughput performance of rtPS connections (other than IPTV connections) for varying number of connections

Figure 5.14 Throughput performance of nrtPS connections for varying number of connections
Figure 5.15 Delay performance of rtPS connections (other than IPTV connections) for varying number of connections

Figure 5.16 Delay performance of nrtPS connections for varying number of connections

Figures 5.15 and 5.16 give the delay performance of rtPS services (other than IPTV services) and nrtPS services respectively for varying number of connections. It is observed from the figures 5.15 and 5.16 that the delay performances of rtPS services (other than IPTV services) and nrtPS services for proposed algorithm are better
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compared to basic algorithm. Since in proposed algorithm more bandwidth is available for these connections with the aid of proposed relay selection algorithm.

5.10 Conclusion

The quick evolution in communication technologies has allowed IPTV video stream delivery over IP networks. WiMAX technology is one of the access technologies that enable transmission of IPTV services, since it offers higher data rates along with QoS provisioning. The IEEE 802.16j mobile multi-hop relay (MMR) WiMAX is an amendment to mobile WiMAX standard which are suitable for SVC encoded IPTV transmission. In this chapter, a relay selection algorithm and scheduling algorithms are proposed for SVC encoded IPTV services in MMR WiMAX network to reduce the bandwidth consumption and average delay. The proposed algorithms are implemented using QualNet simulator and the performance is evaluated through simulation by considering bandwidth used, delay and throughput as metrics. It is evident from the simulation results that the proposed algorithms reduces the BS bandwidth used and improves the performance of the network.

References


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