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Relay Selection Algorithm for IPTV based Services

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***Abstract*—** Television over Internet Protocol (IPTV) is an emerging multimedia service which provides ubiquitous TV access. Transmitting IPTV over Broadband Wireless Access networks is a challenging issue, because of its stringent Quality of Service (QoS) requirements. 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. Concept of Relay networking is a powerful means for the service providers, in order to offer IPTV services to the users. In this paper, in order to cope up with the scarce bandwidth resource along with QoS provision, a relay selection algorithm is proposed for IPTV services in relay based networks. The performance of proposed algorithm is evaluated through simulation by considering bandwidth used, delay and throughput as performance metrics.

***Keywords*—** Relay Station, IPTV, Quality of Service, SVC

I. INTRODUCTION

Broadband Wireless Access technologies are playing important role in providing ubiquitous access to network services and applications for the users with good quality of experience. With these access technologies, the multimedia applications are emerging in new dimensions day by day. Television over Internet Protocol (IPTV) is one such application which is attracting the internet users.

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 [1]. IPTV enables users to receive TV program data through IP-based wired and wireless networks [2]. 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 [3]. To provide ubiquitous delivery, IPTV service providers have to pay special attention to wireless broadband technologies as their access networks.

Relay networking is a powerful means for the service providers, in order to offer IPTV services to the users. In this paper, in order to cope up with the scarce bandwidth resource along with QoS provision, a relay selection algorithm is proposed. In proposed algorithm, 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. The rest of the paper is organized as follows. Section II outlines the related work in the literature. Section III and IV describe the overview of IPTV and Scalable Video Coding (SVC) respectively. Section V presents the problem statement and VI describes the proposed relay selection algorithm. The discussion of simulation results is given in Section VII followed by conclusion in Section VIII.

II. RELATED WORK

As the IPTV is a booming multimedia service, many researchers are working on it. In paper [4], IPTV streaming over WiMAX is evaluated using WiMAX testbed. In [5] 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 [6] 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 [7], the authors proposed a standard-based, cost-effective solution to support Multicasting Broadcasting Services (MBS) in relay WiMAX networks. They defined a Base station (BS) - oriented source-routing protocol to automatically discover relay network topology in which the mobile Relay Station (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 [8-12], 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 [13] authors present a new mechanism for MBS for relay WiMAX network with SVC. In [14] IPTV video streaming forwarding scheme is proposed based on a new multicast tree construction and aggregation mechanism.

III. 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 ETSI and 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.

IV. 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 1. 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 [15].

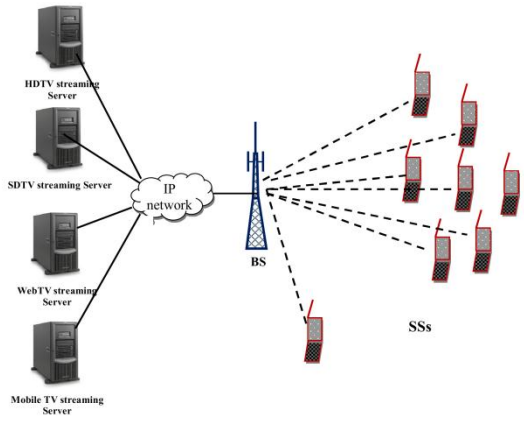

Figure 1. Basic Way of IPTV transmission

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. The authors of [13] used Relay Stations as the intermediate entities to receive the SVC encoded IPTV data as shown in figure 2.

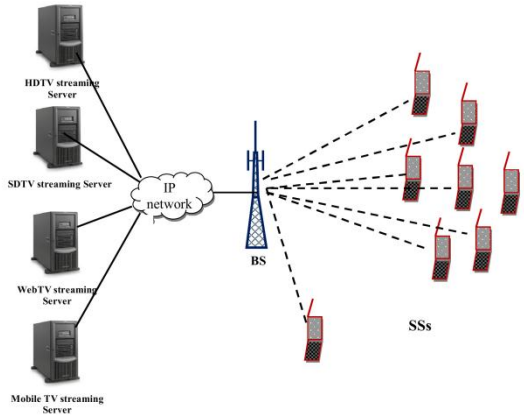

Figure 2. IPTV transmission using SVC encoding

Relay networking technology is an appropriate choice to provide IPTV 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. Relaying is one of the features in the 4G LTE Advanced system and WiMAX. The aim of relay networking technology is to enhance both coverage and capacity.

In [13] the SVC decoding functionalities are integrated for all network RSs to extract IPTV video streams to different formats as in figure 3.

The BS sends the SVC encoded IPTV data to the RSs, further the RSs decodes the data and forwards the decoded data to the connected SSs. However, the SS may connect to the BS directly or through RS, if the IPTV user is connected

to BS directly, then the BS has to decode and send the IPTV data to the SSs which are connected to it directly. In this paper, a relay selection algorithm is proposed for the work in [13] to reduce the bandwidth required for IPTV transmission.

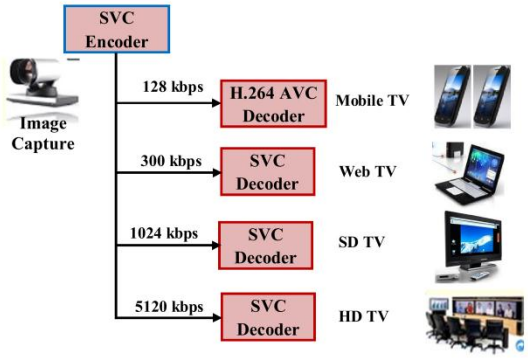

Figure 3. Principle for SVC decoding [13]

V. PROBLEM STATEMENT

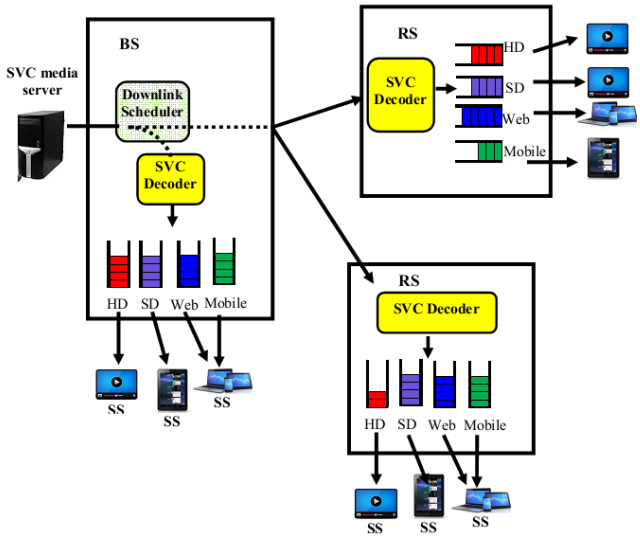

Figure 4. Architecture of SVC encoded IPTV delivery over Relay-based network

The architecture of SVC encoded IPTV delivery over Relay-based network is shown in figure 4. BS receives SVC encoded video stream from media server. Both BS and RS decode SVC in order to support different IPTV services of their connected SSs. In relay-based networks, the SS may connect to BS directly or through RS. If the SS accessing IPTV service is directly connected to BS, then 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 paper which transfers IPTV load form the 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.

VI. PROPOSED RELAY SELECTION ALGORITHM FOR IPTV

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

In a relay network, the basic path selection algorithm determines the path between a BS and SS in following manner; 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 BS-SS and the selected RS-BS. The sum of the link qualities between the BS-RS and RS-SS link is compared with the BS-SS link quality. If BS-SS link quality is better, then SS will be connected to BS directly otherwise the SS will be connected to BS through RS.

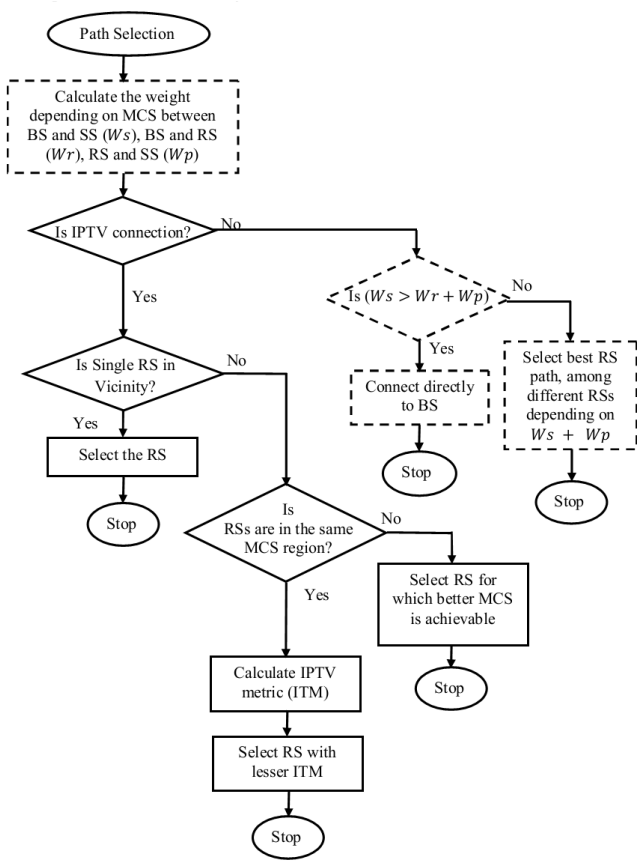

Figure 5. Flowchart of proposed RS selection algorithm

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 BS employs proposed relay selection procedure. In the proposed relay selection procedure, the SS is compelled by BS to select one of the RSs in order to access IPTV services. After receiving the scanning and synchronization information from the BS, SS calculates the link quality with RSs which are in the vicinity and feeds back the link quality information to BS. If the SS is in the vicinity of single RS, then BS selects that RS as the access path to the SS. If the SS is in the vicinity of multiple RSs, then BS selects the RS for which higher link quality can be achieved. However, when SS is in the same MCS region of multiple RSs, then in the proposed algorithm 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 1.

$$ITM_{RS} = \sum_{1}^{n} Datarate\ of\ each\ IPTV\ connection \quad (1)$$

Where ***n*** is the total number of IPTV connections in the considered RS.

The RS with lesser ITM values is selected by the BS as the access path for that SS. Figure 5 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.

VII. Simulation and Results

QualNet simulator is used to implement the proposed relay selection algorithm. The QualNet simulator has the contributed model for IEEE 802.16j, in which basic relay capabilities are implemented [16] 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 algorithm. 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 relay WiMAX cell consisting of BS, RSs and SSs is considered for simulation study 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.

A. Scenario 1

This scenario is designed to study the effect of proposed relay selection algorithm on the bandwidth consumption of the network. A single relay WiMAX network with a 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 6 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.

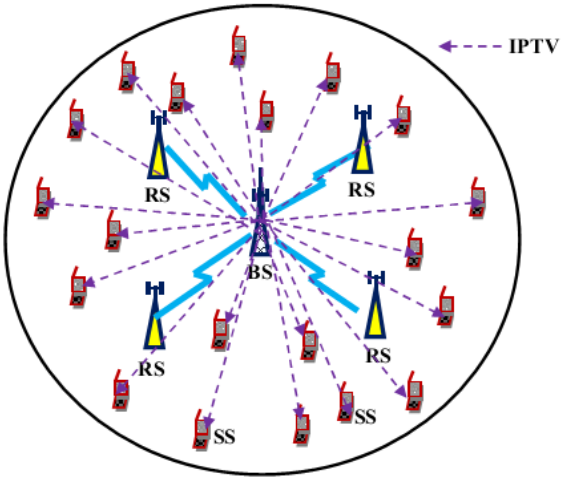

Figure 6. Representative diagram of scenario 1

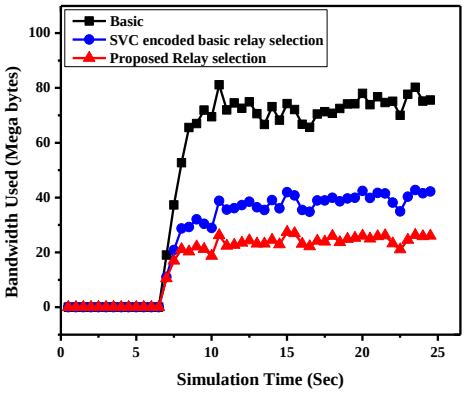

Figure 7. Bandwidth used with respect to simulation time

Figure 7 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 7 that the bandwidth used by basic way of IPTV transmission is more since the 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 BS transmits SVC encoded IPTV data to the RSs and decoded IPTV data to the SSs which are connected to the BS directly. It is also observed from the figure 7 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 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.

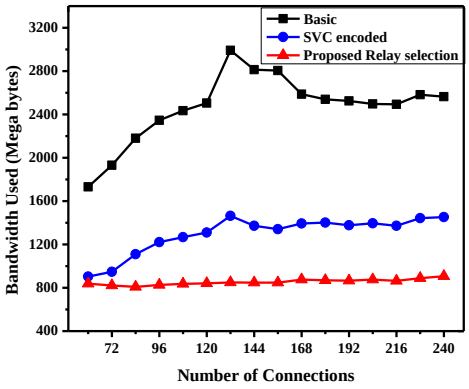

Figure 8. Bandwidth used for varying number of IPTV connections

Figure 8 gives the bandwidth used for varying number of IPTV connections. It is observed from the figure 8 that, 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 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 BS transmits SVC encoded IPTV data to the RSs and decoded IPTV data to the SSs which are connected to the BS directly. It is also noted that as the number of connections increases, the 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 8 that the bandwidth used in proposed algorithm is less compared to other two algorithms since in the proposed algorithm, 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.

B. Scenario 2

This scenario is designed to study the effect of proposed algorithm on the performance of other services. 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 real time connection and one non real time connection each (total four real time connections and four non real time connections) 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 increasing the number of SSs transmitting real time and non real time services in steps of 4 (i.e., each SS transmits one real time connection and one non real time connection with data rate of 2 Mbps) till 20.

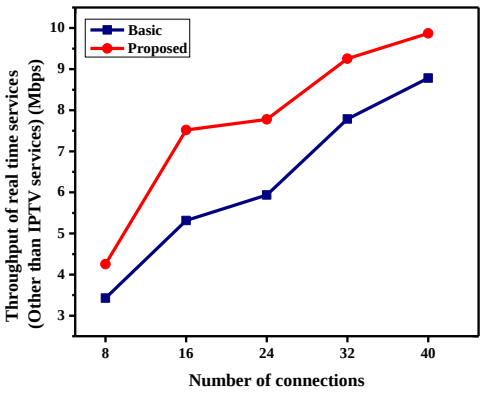

Figure 9. Throughput performance of real time services (other than IPTV connections) for varying number of connections

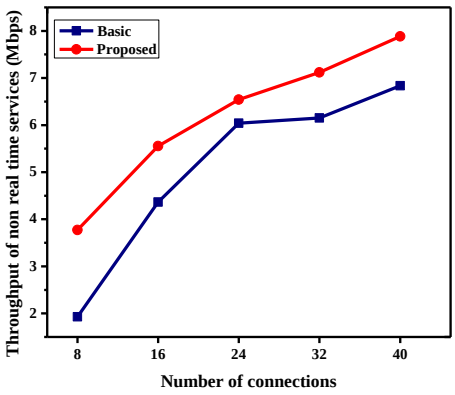

Figure 10. Throughput performance of non real time services for varying number of connections

Figures 9 and 10 give the throughput performance of real time services (other than IPTV services) and non real time services respectively for varying number of connections. It is observed from the figures 9 and 10 that the throughput performances of real time services (other than IPTV services) and non real time 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 real time and non real time services.

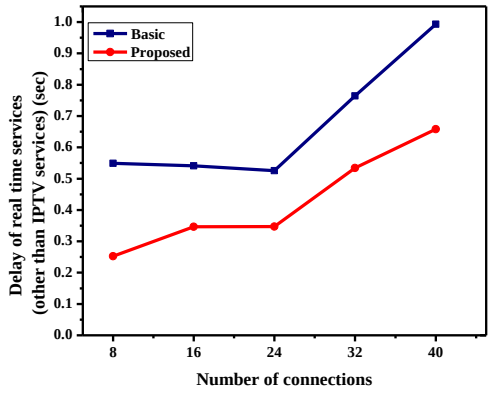

Figure 11. Delay performance of real time services (other than IPTV connections) for varying number of connections

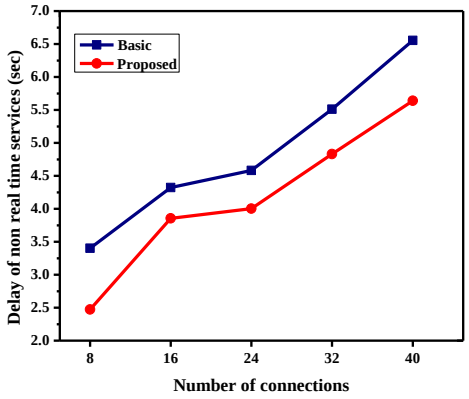

Figure 12. Delay performance of non real time services for varying number of connections

Figures 11 and 12 give the delay performance of real time services (other than IPTV services) and non real time services respectively for varying number of connections. It is observed from the figures 11 and 12 that the delay performances of real time services (other than IPTV services) and non real time services for proposed algorithm are better compared to basic algorithm, since in the proposed algorithm more bandwidth is available for these connections.

VIII. CONCLUSION

The quick evolution in communication technologies has allowed IPTV video stream delivery over IP networks. The relay based networks are suitable for SVC encoded IPTV transmission. In this paper, a relay selection algorithm is proposed for SVC encoded IPTV services to reduce the bandwidth required for IPTV services. The proposed algorithm is 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 algorithm reduces the BS bandwidth required for IPTV transmission, without deteriorating the QoS of IPTV services and improves the overall performance of the network.

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