Performance Evaluation of the PBR and QoS Control Routing for Multi-Channel Adaptive Streaming (PQMAS) Model

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Summary
In this paper, we experimentally present our simulation analysis and results as a complement to our previous method which is the PBR and QoS Control Routing for Multi-Channel Adaptive Streaming (PQMAS) approach model. The evaluation results of this approach model are based into two major attributes which are; the Throughput and the Time Computation Performance. More specifically, the Time Computation Performance attribute will be classified into three calculation categories which are; the Prime-Time performance, the Non-Prime-Time performance and the Average-Time performance. These categories are defined to show the usage and exploitation of the customers for the bandwidths at the range of the categories time as will be discussed in this paper. As a result, the throughput indicated to be high in the bandwidth routing operation which is 98.027% which means that scalability and fairness of the simulation was improved. The time performance indicated to an increase since the number of nodes are increasing, but, not drastically.

Key words:
IPv4, IPv6, Quality of Service (QoS), nodes (subscribers), Policy-Based Routing (PBR), Internet Protocol Television (IPTV), Broadcasters.

1. Introduction

As known, the IPv6 is the improvement of the IPv4 [1], [2]. This improvement was in terms of a number of significant features upgraded by the Internet Engineering Task Force (IETF). For example, Mobility, Quality of Service (QoS), the increase in the address (from 32 bits to 128 bits) and many other features. In [1], we have focused in such certain feature of the IPv6 features which is the QoS that was considered to be highly related to our domain scope (PBR domain in the IPTV).

In the recent technology, the internet provider, companies, subscribers and the researchers will be benefited by depending on the multimedia applications [3]. The Internet Protocol (IP) is considered to be as a best effort, but still it is not alone by itself guaranteed for continuous use of serving and covering the customer's needs. So, in the future, the TV broadcasters will use the IP network. In other words, there will be a convergence of the broadcast network with the IP to form the Internet Protocol Television (IPTV) under the recent technology. Since, the IPTV lacks of the fairness of supporting the packets bandwidth regulation distribution, there must be such policy routing management when sending packets (channels) to the nodes (subscribers). For example, a broadcaster can afford full QoS bandwidths from the network manager, but, still the network manager must achieve fairness in distributing packets to other remaining broadcasters, therefore, there will be such policies regulations in sending limited number of bandwidth equivalently. All this forms a strong need that motivated us to perform this research. One more important thing that also interested us to perform this research is that IPv6 not only overcomes the shortcoming problems in the IPv4, but also overcomes and benefits the Quality of service (QoS) in the IPv6. More specifically, the main reason of using the IPv6 in this research is that it supports the Quality of Service (QoS) which is considered to be as a main scope IPv6 feature our research.

Previously, the TV system can view just one channel at a time for the viewer, where, at the same time the Internet Protocol (IP) was considered to be as a best effort, but, today's development, when the Internet Protocol (IP) was combined with the broadcast network to form the Internet Protocol (IPTV), the viewers can have more freedom in their TV viewing experience. For example, the viewer can watch multiple channels at the same time instead of just one channel. In other words, they can broadcast multi-channels based on the internet tool. More clearly, the broadcaster may request and pay for more QoS of packets bandwidth from the network management, but, still there is no fairness of providing other broadcasters with an equivalent amount of these packets bandwidths. According to this, [4] have addressed their problem on the weakness of performing bandwidth management among channels, since the IPTV allows one viewer to receive multiple channels; therefore, they have proposed an approach model called the Multi-Channel Adaptive Streaming (MCAS) approach model. Our problem in [1] has addressed the same problem of [4] which is the weakness of bandwidth management among channels (packets), in other words, the weakness of the QoS

Manuscript received April 5, 2008
Manuscript revised April 20, 2008

fairness in distributing bandwidths among all broadcasters equivalently. According to this, packets traffic should be more regulated and organized under a certain number of policy rules for the broadcast network. So, the support of both Quality of Service (QoS) and Policy-Based Routing (PBR) are needed to handle the amount of packets traffic flow in the IPv6.

There are two main objectives of this paper to be discussed. These are:

1. To analytically compare our approach model with [4]'s approach model. This comparison is in terms of qualitative comparisons.
2. To highlight our simulation results in terms of two attributes which are; the Throughput and Time Computation Performance.

The rest of the paper is organized as follows. Section 2 discusses various works that have been done by many researchers. Section 3 briefly discusses the qualitative analysis comparisons between our approach model and [4]'s model. Section 4 presents the experimental analysis and results of our method proposed in [1]. Finally, in Section 5, we conclude the paper.

2. Related Works

Various methods have been proposed to address specific problems in the Internet Protocol (IP). These problems can be classified into three major method categories; IPv6, QoS and PBR methods. Each category was supported by different various methods to handle such problems, as an example of these problems, the traffic handling problem.

2.1 IPv6 methods

A technique for IPv6 called the In-line Measurements technique was proposed by [5]. This technique efficiently evaluates the performance of the network flows in the IPv6 domain. The main idea was to obtain the extension headers of the IPv6 in order to that the same packets of the payload data can be able to carry both; the indications of the instantaneous and the triggers measurements. This will take into consideration the behavior of the real user traffic flows. Over the network layer, an application of these measurements is performed in the purpose of measuring the different types of the traffic using the measurements technique. As a result, a transport of services was efficient and reliable after being tested in the dynamic implementation. A measurement was performed in the delay of the real time variation, in one-way delay and in the end-to-end. Another method in the IPv6 was proposed and developed by [6]. This method is called Opengate method. It was developed at the Saga University to use a system for user authentication in the network. This system depends in using both; the user authentication and the access control, where, these both depend on the use of the authentication and the logging. In [7], a framework contribution was proposed to include high quality service to the applications of the internet in the future. This framework used a measurement for the loss and delay of the evolution in the network of the IPv6. A method for IPv6-based networks called the Bandwidth Determination was presented by [8]. This method was applied in the IPv6 by specifying the bandwidth of the network in an efficient, reliable and accurate way. This way was achieved over the extension header for the IPv6 hop-by-hop by determining and presenting the proposed timestamp option. Another new approach was proposed by [2] in the IPv6 domain version for the purpose of providing a support and efficient integration for the environments of multicast networking for the Asynchronous Transfer Mode (ATM). This approach was called the MEDIA approach that depends on other approach called MARS approach. The MEDIA approach provides a mapping for the addresses of the IPv6 multicast through the addresses of the ATM with support of the QoS-aware. Then, this approach very simply performs both; QoS re-negotiation and load sharing. In addition, there is a high exploitation for the addresses of the ATM multicast, and, also in the membership management to the multicast set over the PNNI.

In order to study how the packets are routed as a request routing through the hosts of the mobile and also how this routing operation is based on the tasks of the CDNs wide area routing request, [9] presented a method in the IPv6 in order to do so. As a next step, these researchers developed an intelligent scheme to provide an efficient support to the mobility in the IPv6. In [10], a method to improve the quality and services in the IPv6 networks was proposed. This method was based on the Dual-Stack nodes that have the ability of covering the faced problems over the world networks of the IPv6. The main idea of this method was to make the work with both protocols; IPv4 and IPv6 at the same time. This operation is efficiently performed by the Dual-Stacked nodes. As a result, the features delay in the addresses of the IPv4 was less than on that on the IPv6's addresses, despite that, when the IPv6 contains a high delay, only a few numbers of paths are gotten. Hence, problems must be studied in its worst case to enhance the quality and efficiency over the IPv6 Internet

2.2 QoS methods

In order to rapidly satisfy the customer's requirements, [3] proposed the Assurance QoS method. Its main idea was to perform an efficient support that will be based on the assurance of the provisioning QoS over the internet. The QoS Management API framework was proposed in [11]. This framework configures the underlying routers. Their implementation was performed in their prototype for a proprietary configuration interface. This implementation was achieved in their operating system which is the Linux-based DiffServ router implementation. In other words, their prepared implementation and proposal was based on an object oriented Quality of Service Management System, where, this system doesn't depend on the router hardware and its software. Another QoS framework was presented by [12]. This framework supports and serves the IPv6 by reducing the packets being lost and resulting with less delay and less jitter.

There are many protocols [13], [14], [15], [16], [17] that are based on the idea of [18] which was to provide a secure system for protocol forming that develops the on-demand QoS-Guided Route Discovery. This idea formed a method called the Securing Quality of Service (SQoS) method. Moreover, [19] and [20] addressed the same subject in different methods. This subject was the Differentiated Services for QoS. But, what differs is that [19] proposed a new approach model for the same subject over the Internet to avoid having congestion, while, [20] tested the QoS in both domains; IPv6 and IPv4 for making an evaluation for the same subject, but, over the software of the Dual Stack Network. Finally, their performance was to improve both; the efficiency and the strength performance of their method when performing all the routing operations for such packets over the whole network.

One more framework that depends on the QoS is the Multi-Channel Adaptive Streaming (MCAS) framework proposed by [4]. Their problem is close to our problem which is the weakness in bandwidth management among channels. The main idea was to provide the user with multi-channels to be viewed at the same time instead of single channel.

2.3 PBR methods

The Directed Flood-Routing Framework (DFRF) was introduced by [21] for the purpose of supporting the wireless sensor networks by enhancing a model for routing protocols by developing a number of determined applications, where, these applications are under the control of the directed flooding. For the purpose of making a routing design plan for the content-based network, [22] proposed a method to achieve this plan. This network is considered to be a design of communication network that contains unobvious addresses of messages and loop-free, the network of a content-based will provide routing that results with an efficient and significant topological information, and also results with predicates that have propagation. The same idea of [22] was addressed in [23] which is to introduce approaches of the constraint-based routing through the internet. More interestingly, two types of routing approaches of the constraint-based routing where studied and taken into consideration, these types were classified as both; the policy routing and the QoS routing as mentioned in [1]. Then, the both approaches were presented and formulated into different frameworks. In [24], a mechanism to design the source of a routing to support the forwarding policy in the network capabilities was studied and proposed, where, this concept clarifies the preliminaries and the principles of the authorization and resource. Moreover, these researchers also presented the Platypus which is considered to be as "A loose source routing mechanism that uses network capabilities to enable local policymaking while giving both end hosts and ISPs the freedom to specify arbitrary routes" [24].

A method that improves a differential probabilistic and constrained retransmission policy delay mechanism that referred to as the learning kernel mechanism was being highlighted by [25]. The main idea of their method is to perform a routing for the wireless sensor networks for constraint flooding protocols. The main advantage of this mechanism is its strength that is based on the flooding. By depending in the control of the constraining retransmissions, the result of this control is to support an efficiency of high energy in performing tasks. As a final step, these researchers have performed an analysis in the application of the real-world using an efficient simulation in the sensor networks. In addition, [26] proposed a framework that merges both the routing and grooming policies in the WDM networks. This framework plan was proposed to provide full integration to support the combination (routing and grooming) of these policies over the mentioned network. Taking into consideration, the traffic lifetime is also being exploited in this combination. The results showed that in combining the both policies, there tasks are of the same and as so they are integrated to provide high performance to their system. In addition, there was improvement in exploiting the use of the light paths resource. Moreover, the method performed more efficient exploitation of the wavelength and less blocking probability.

Another type of routing method was done by [27] whom proposed the optimal routing policies in the Ad Hoc Wireless in order to test the sensitivity of these policies based on the channel's quality that estimates the errors. In [28], an algorithm that operates an efficient routing in the broadcast networks was proposed. The main goal of this algorithm is to provide a minimum cost in the structured DHT-based peer-to-peer networks. In a determined node that locates the broadcast message over a system of *N* nodes, this broadcast message has the ability to be distributed over the rest of the nodes after an exact number of messages which is equal to $N - 1$ message. After that, these researchers studied the system of the DHT class in the distributed k-ary search model. This system has a benefit to be exploited in building the spanning tree as a main goal to support the exploitation of the broadcast routing in an efficient way. Then, the broadcast was assumed to provide the capability to explore known available DHTs. This exploration depends on the support of random queries, such as, the disseminate/collect global information. As a result of this performed algorithm, it is expected to perform a good performance results in the DHT system by depending on the use of the dynamic network. In addition, this algorithm provided an efficient broadcast routing algorithm.

3. Qualitative Analysis Comparison between MCAS and PQMAS

In order to enhance the MCAS approach model and achieve more fairness, more scalability and more efficiency, we have theoretically applied the PBR in [1] to their method and come up with our method which is the PQMAS approach model. More significantly, the reason of our enhancement (PBR application) flows into 4 reasons. These are as follows:

1. PBR provides flexible, high speed, fairness and efficient means when routing packets by allowing a defined policy to be configured by the manager for traffic flows, which lessens reliance on routes derived from routing protocols.
2. Another reason is that PBR gives you more control over routing by extending and complementing the existing mechanisms provided by routing protocols (such as, QoS and Controlling Network Traffic (CNT)).
3. In addition, PBR allows you to set the IPv6 precedence, since the PBR will be based on the IPv6 for routing packets.
4. Another last reason is that the PBR efficiently allows you to specify a path for certain traffic, such as, priority traffic over a high-cost link.

There are certain qualitative analysis differences between MCAS model and PQMAS model. These are:

1. The MCAS model concerns more in enabling users to discover and select channels based on their program content, where, users can compose multiple channels and view them in a customized way. The PQMAS model concerns more in enabling more fairness for QoS by limiting the number of bandwidths to be sent to each broadcaster according to such criteria being set by the network manager, such as, the number of nodes (subscribers), the prime-time, the non-prime-time and the average-time.
2. The MCAS model applied 3 applications to satisfy the first difference as mentioned previously. These applications are; the use of user-level semantic information, the QoS sensitive membership management and the state-of-art single-channel adaptive streaming techniques. The aim of [4] was to make the MCAS design more flexible by achieving the first qualitative objective as mentioned above. The PQMAS model applied the same as the MCAS which is the QoS management, but, 2 additional applications were applied to achieve more fairness and high efficiency task when distributing bandwidths. In other words, MCAS concerns more in simplifying their service through their model, but, PQMAS concerns more in achieving fairness in routing bandwidths to a determined broadcasters, in addition, to speeding the service for the subscribers.
3. MCAS achieved also high scalability and high efficiency by building locality aware DAG overlays for P2P bandwidth adaption. PQMAS achieved also high scalability and high efficiency by setting up a number of PBR rules over MCAS to achieve fairness and high performance in the routing operation.

4. Experimental Analysis Design and Results

In this section, we experimentally show our simulation analysis and results for the presented approach model which is the PBR and QoS Control Routing for Multi-Channel Adaptive Streaming (PQMAS). In Section 4.1, the experimental analysis will be presented along with the data parameters were used. In Section 4.2, our evaluation results will be presented.

4.1 Experimental Analysis

The PQMAS approach model has tested 1000 nodes for 9 broadcasters using 512 MB main memory, 160 GB hard disk. The PC machine runs windows XP professional operating system. We virtually simulated 9 broadcasters. The number 9 was chosen due to the maximum number of broadcasters being used at Malaysia is 9 collectively. Our model used the C++ programming language on a 1.66 GHz Pentium 4 PC machine. We have used this programming language since it is considered to be powerful, efficient and flexible programming language that practically supports many practical methods to be simulated. The 1000 nodes were tested sequentially starting from 100 nodes, 200 nodes, 300 nodes, … , 1000 nodes, respectively. In each stage of the tested nodes, we calculated the throughput of the amount of bandwidths to be sent from a determined broadcaster to its nodes (subscribers). Then we compared the throughput of the 1000 nodes into the remaining broadcasters with also 1000 nodes sequentially. As a next step, we have performed the time performance speed of the sent bandwidths for each broadcaster to its nodes. In other words, the speed depends on three time phases. These time faces are:

1. Prime-Time: The behavior of the customers when they request bandwidths (channels) at this time which is from (12 pm – 9 pm). At this time, the amount of bandwidths is mostly exploited; because, Adults, Children are used to be awake during this period.
2. Average-Time: The behavior of the customers when they request bandwidths (channels) at two times which are from (9 pm – 1 am). At this time, the amount of bandwidths is lesser exploited; because, few of the Adults may be sleeping and most of the children are to be sleeping at this time.
3. Non-Prime-Time: The behavior of the customers when they request bandwidths (channels) at this time which is from (1 am – 10 am). At this time, the amount of bandwidths is at most not used; because, most of the Adults and all of the children are sleeping during this time.

The throughput for a determined broadcaster and the number of nodes is calculated as in the following equation:

$$\text{Throughput} = \frac{\text{Num. (SBW)} - \text{Num. (RBW)}}{\text{Num. (SBW)}} \times 100\% \quad \ldots (1)$$

Where:

Throughput: is the ratio number or amount of the non-lost received bandwidth.

Num. (SBW): is the number or amount of the bandwidth provided by the network manager and to be sent to all the nodes of the determined broadcaster.

Num. (RBW): is the number or amount of the bandwidth that is received from the determined broadcaster. This amount may differ from when it was to be sent; due to simple loss of bandwidth during routing operation.

4.2 Simulation Results

In order to evaluate our method, two main attributes are being taken into account; *Throughput* and *Time* performance between the nodes and their broadcasters. We compared the throughput behavior of each broadcaster with their nodes starting from 100 nodes and increasing to reach 1000 nodes. The experiment results indicate that the total average throughput for the 9 broadcasters was resulted with 98.027% which means a very small ratio of the bandwidths was lost when the broadcasters have routed the bandwidths to their nodes. Moreover, the flow label was used, since it has priority to produce fairness in routing (sending) the bandwidths from the broadcasters to their nodes (subscribers). The main aim is to protect dropping the packets. This is done by having lower priority in the IPv6 flow label. By this protection, the delay time will be decreased.

Table 1 below, illustrates the throughput results between each of the 9 broadcasters and a defined number of nodes.

Table 1: Throughput between the 9 broadcasters and the number of nodes.

Num. of nodes	Throughput for the 9 broadcasters
100	98.115
200	98.102
300	98.083
400	98.061
500	98.039
600	98.012
700	97.993
800	97.977
900	97.956
1000	97.934
Total Average throughput for the 9 broadcasters	**98.027**

So, now, the total throughput average for all of the 9 broadcasters collectively will be (98.027%) which means (1.973%) of packets are lost (very small amount).

Figure 1 below, graphically illustrates the throughput results between each of the 9 broadcasters and a defined number of nodes.

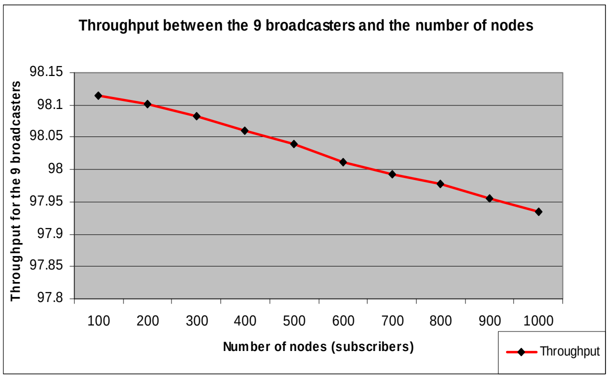

Fig. 1: Throughput results between the 9 Broadcasters and the number of nodes.

Notice that with the increase in number of nodes for the broadcasters, the bandwidth throughput will be decreased while routing packets from the broadcasters to their nodes. This decrement is due to the packet loss. The relation here is an inverse relation. More clearly, although our throughput results are decreasing, it is still not drastically being decreased. This **decrement** is acceptable; therefore, it shows the scalability and fairness of the routing operation.

Now, Table 2 below illustrates the computation time performance in second's results between each of the 9 broadcasters and a defined number of nodes.

Table 2: Time performance computation in seconds for prime-time, average-time and non-prime-time between the 9 broadcasters and the number of nodes.

Num. of nodes	Prime-Time in seconds for the 9 broadcasters	Average-Time in seconds for the 9 broadcasters	Non-Prime-Time in seconds for the 9 broadcasters
100	122.356	64.178	13.212
200	123.412	65.238	14.324
300	125.986	65.982	15.536
400	126.777	66.484	16.102
500	127.348	67.717	16.780
600	128.673	69.545	17.929
700	129.394	70.872	19.300
800	130.711	73.109	20.459
900	132.492	75.411	22.674
1000	133.211	76.922	23.899
Total Average for each type of time in seconds	**128.036**	**69.546**	**18.021**

So, now, the total average for all types of time (prime-time, average-time and non-prime-time) computation average for all the broadcasters collectively will be:

$$\frac{128.036 + 69.546 + 18.021}{3} = 71.867 \text{ seconds}$$

Figure 2, below, graphically illustrates the throughput results between each of the 9 broadcasters and a defined number of nodes.

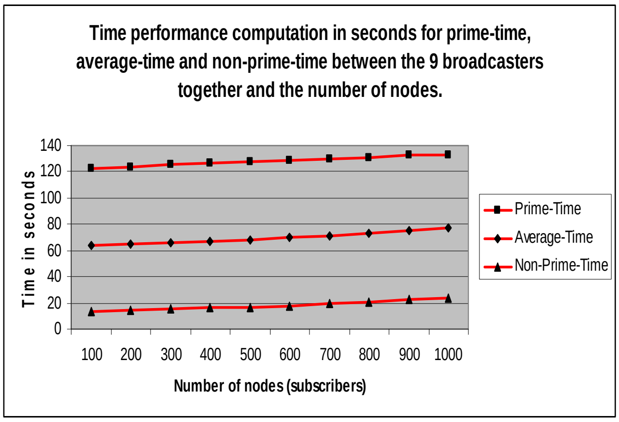

Fig. 2: Time performance computation in seconds for prime-time, average-time and non-prime-time between the 9 broadcasters and the number of nodes.

Note that, that, when the number of nodes increases the time also increases. That means there are many traffic bandwidths for packets to be sent to the nodes (subscribers), as the number of these nodes increases. One important point, although the three types of time performance (prime-time, average-time and non-prime-time) are increasing, it is still not drastically being increased. This **increment** is acceptable; therefore, the increase of time also it shows the scalability, high performance and fairness of the routing operation at these types of time performance.

4. Conclusion

In this paper, we presented our simulation analysis and experimental results for the PBR and QoS Control Routing for Multi-Channel Adaptive Streaming (PQMAS) Approach Model. This method was theoretically being compared with the MCAS Approach Model into a qualitative analysis. Our evaluation was based into two attributes; Throughput and Time performance. The Throughput resulted to (98.027%) which means totally (1.973%) of the packets were lost (very small ratio). The Time performance consists of three types of categories to be measured; Prime-Time, Average-Time and Non-Prime-Time. It was noticed that the Time was increasing, but, not drastically, as so, the Throughput was decreasing but not drastically also.

In the future work, our method will combine the ECN (Explicit Congestion Notification) since it protects the packets from being lost.

Acknowledgments

The authors would like to thank the Universiti Sains Malaysia (USM) for the research grant.

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