A Comparative Study on broadcasting video quality by Routing Protocols in IPTV Network

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Summary
As multimedia contents rapidly spread and high-speed broadband IP network technologies develop, development of wire and wireless technologies, multimedia and image process technologies through IP network enables various types of service such as IPTV and VoIP. Individual service of communication companies and broadcasters coexist and evolve into a convergence service. Typical broadcast/communication convergence service, IPTV is the strongest application model in this service. As IPTV-like services increase, high-definition data processing through Internet protocol emerges as the main issue of the communication industries that should implement various Internet services.
This paper provides network build-up methods for the effective IPTV services by implementing the standard routing protocol RIP used in small-sized area and the link state routing protocol OSPF used in large autonomic network, implementing the present network IPv4 and next generation internet protocol IPv6 in each routing protocol, measuring the PSNR of real-time broadcasting picture quality and measuring and evaluating the performance of IPv4 and IPv6 based on the values.

Key words:
IPTV, Routing Protocol, Next-generation Internet Protocol, IPv6, IP Network, PSNR, RIP, OSPF

1. Introduction

As today Internet communication is widely used in home and companies, various types of service are being developed based on the IP network. The best-effort method of existing IP network is limited to provide VoIP, VPN and other various multimedia services that require the service quality. So, in order to overcome this limitation, the future communication network is expected to evolve from circuit-based PSTN into IP-based NGN (Next Generation Network). [1, 2]
Especially, the most typical application of broadcasting/communication convergence service, IPTV (Internet Protocol Television) is on the rise as a new paradigm to lead the future broadband convergence services. As IPTV-like services increase, the high-definition data processing through the internet protocol becomes the main issue in communication industries in order to process the increased data and implement various internet services.
This research used the dynamic routing protocol which improves the network performance by using the most suitable routing path of assigned protocols. On the most typical dynamic routing RIP and OSPF, we investigated the traffic effect by routing protocol. We will find the most suitable routing protocol for network bandwidth by measuring and analyzing the broadcasting images with PSNR.
This paper is organized as follows; Chapter 2 explains IPTV, Routing Protocol and PSNR. Chapter 3 explains that implementing network environment and measuring, analyzing and assessing its performances. Finally, Chapter 4 is for the results.

2. Related Research

2.1 IP Network

Information communication technology is preparing a big and innovative change. Core of the change is to unite various elements of communication including communication and distributed computing, voice and data, electrical communication and data communication and control and management. And also, it is to attain the convergence of various networks and services to provide multi services by adding various media such as voice, data and image to a single network with sophisticated performance and capability. That is materialized by NGN of open architecture.
NGN is packet-based network, which unites telephone system, ATM, frame relay, network for personal use and wireless network. ITU (International Telecommunication Union) defines that NGN is packet-based network and IP-based network. ETSI (European Telecommunications Standardization Institute) defines that NGN is packet-based network which can provide the new services in phases using open interface. [1, 2]
The main characteristic of NGN is convergence and packet-based. It can provide various additional services such as internet telephone and multimedia messaging efficiently while receiving voices, data and images

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simultaneously. In addition, because it can simultaneously process several traffics by packet unit on single communication network, the circuit efficiency largely improves and voice telecom services can be provided at much lower cost than existing method. In Korea, BcN (Broadband convergence Network) is being developed. It is the next-generation convergence network, which makes quality-guaranteed broadband multimedia services that combine communication, broadcasting and internet available wherever, whenever and with no interrupt. [3]

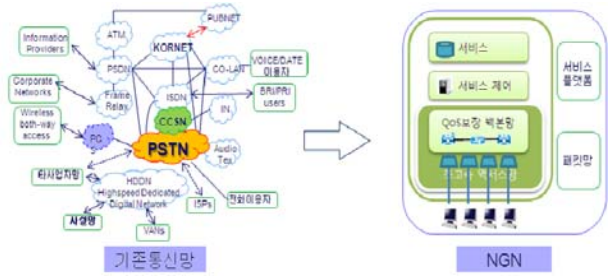

Figure. 1 existing a communication system & NGN

2.2 IPTV

The notion of IPTV [4] is varied based on the service types and users. The IPTV standardization organization, ITU-T Focus Group defines that “it is multimedia services like television, video, audio, documents, graphics and data services through quality-guaranteed, secure and reliable IP network.”

In IPTV service concept of Figure 2, various visual media are provided to the streaming server and it is delivered to the subscribers through IP network on user requests.

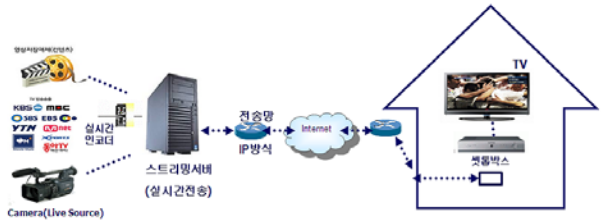

Figure. 2 IPTV service architecture

ITU-T IPTV Focus Group was organized within ITU-T (International Telecommunication Union-Telecommunication Standardization Sector) in July 2006 in order to revitalize the IPTV services, develop the technologies and secure the interrelation. The standardization works for IPTV structure and requirements, QoS, security, network control, middleware terminals and interpretability are on the progress in connection with various standard organizations including IETF (Internet Engineering Task Force), ATIS (Alliance for Telecommunications Industry Solution), DVB (Digital Video Broadcasting) and ATSC(Advanced Television Systems Committee).

2.3 Routing Protocol

2.3.1 RIP (Routing Information Protocol)

RIP [5] is a distance vector protocol to calculate the path by hop count and it is IGP (Interior Gateway Protocol) used for routing within AS (Autonomous System). RIP chooses the path with the smallest number of passing-through router of various paths to receipt point regardless of bandwidth or latency. The number of passing-through router is hop count and RIP is calculated by only hop count. If the hop count is over 16, RIP can’t deliver the packet to the receipt point and it exchanges the routing information by delivering the routing information to adjacent router in every 30 seconds. In exchanging the routing information, the full update method which delivers not only the changed network information but also all network information to the adjacent router periodically is used.

Hop count is not suitable for large network though it can be simply built and operated. And, because only hop count can be used to choose the path, it is not possible to choose the optimal path. It is slow to change the link status because of distance vector algorithm and it can’t process the subnet information.

2.3.2 OSPF (Open Shortest Path First)

OSPF [6, 7] is a routing protocol with typical link state algorithm that is used in large autonomic network. Each router organizes whole network topology and calculates routing tables by exchanging the topology and state of local link to other routers. The most suitable path is set with link state algorithm. The cost to calculate the path is based on the bandwidth.

Because OSPF transmits not the state information periodically but the only changed state information, the collecting time is faster than RIP. Also, it prevents router performance lowering due to exchange of much routing information and saves the band by organizing the layered structure of network by area. It supports VLSM (Variable Length Subnet Mask) and Route Summarization to allocate IP addresses efficiently and supports various network subnet masks in order to subdivide the network.

2.4 PSNR

Loss compression algorithm is generally used in the multimedia application area that requires the high compression rate. It can recognize the similarity visually though the compressed image is not equal to the original one. In order to quantify the proximity to the original data, it needs some types of distortion measurement.

Distortion measurement is to measure the proximity to the original copy with some distortion standard and it is divided into cognitive distortion and mathematical distortion. The cognitive distortion regards the visual system and visibility about the image distortion

characteristic, whereas the mathematical distortion considers the quantity difference and use mainly MSE, SNR and PSNR.
Though you may think that the image quality assessment is subjective, there is an objective standard. That is the value PSNR (Peak Signal To Noise Rate) [8] also used in the international standard organizations. It is technological term to represent the rate between peek signal and noise that interrupts it. With this, the quality of compressed images are compared and measured to the original images.

$$PSNR = 10 \cdot \log_{10}\left(\frac{(2^n-1)^2}{MSE}\right) = 20 \cdot \log_{10}\left(\frac{2^n-1}{\sqrt{MSE}}\right)$$

Literally, PSNR is the maximum value (peak signal) to noise rate. It is measured by log unit, and it is determined by (Square of the number of maximum samples in image. Here, 'n' denotes the number of bit of image sample.), the rate between original image and lost image or by MSE (Mean Squared Error) between video frames.

$$MSE = \frac{1}{mn}\sum_{i=0,j=0}^{m-1n-1} \| I(i,j) - K(i,j) \|^2$$

MSE (Mean Squared Error) is the mean squared error between two images with same size. The less MSE is, the more equal the image size is. That is, if the decibel is high, the noise is low and the image quality is high. And, the higher PSNR is, the higher the image quality is and vice versa.

3. Implementation of Network Environment and Performance Measurement

3.1 Implementation of Network Environment

The implementation of RIP and OSPF network environment is like Figure 3 and the Area is organized by Area0 and Area1 to present the large network system of OSPF.

Switches and routers of Cisco are used for investigation of real-time broadcasting image quality. Because present ISPs use Catalyst 6500 series of switch in connection to servers, router 3700 series in middle network and Catalyst 4500 series of switch in connection to the subscribers, we organized like these. Fluke is a traffic generator to make network environment by forecasting the data increase on network by users increase. We measured PSNR of real-time broadcasting image quality by increasing the packet generating rate by 0%, 20%, 40%, 60%, 80%, 91%, 93%, 96% and 98% of bandwidth.

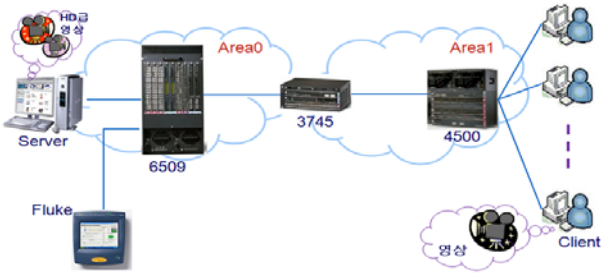

Figure. 3 Network environment of Routing Protocol

Cisco Catalyst 6509 is suitable for the application that requires large bandwidth and provides multi-layered switching. Cisco 3745 is Multiservice Access Router and provides various capabilities such as network restoration, scalability, QoS and security. Cisco Catalyst 4500 is Multilayer Switch and provides the optimized business services and user accessibility. IOS environment of each switch is ver. 12.2 and IOS environment of router is ver. 12.4. Fluke OptiviewTM Series Ⅲ provides communication path check, real-time usage check, error analysis, protocol analysis and present traffic check with Trace Switch Route.

3.2 Performance Measurement of RIP and OSPF

As mentioned in Implementation of Network Environment, we measured performance of RIP and OSPF by transmitting the HD images by streaming service from server and comparing PSNR of images that clients received to original images of server.
Figure 4 shows the server monitor of RIP and OSPF in IPv4 network, and x-axis is time and y-axis is datagram per second. The transmission stream is more running in OSPF than RIP.

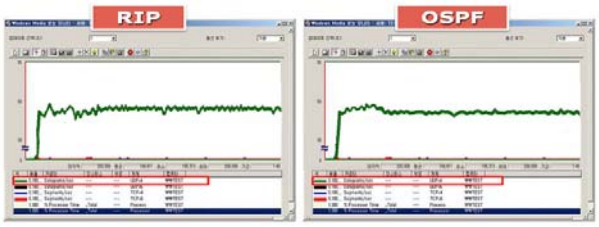

Figure. 4 Server monitor of RIP/OSPF in IPv4 Network

In Figure 5, the transmission run in IPv6 network shows smoother running in OSPF than RIP.

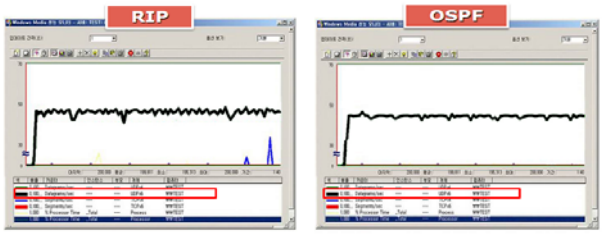

Figure. 5 Server monitor of RIP/OSPF in IPv6 Network

When we measured PSNR of server images and client images by transmitting real-time images, we found that the image quality would be different based on PSNR. When PSNR is over 40dB, it is same as original images by naked eyes. When PSNR is 30dB and less, it shows thermal images and frame distortion.

Figure. 6 Video comparison by PSNR value

We measured the values by varying the packet generating rates by OSPF and RIP protocol in IPv4 network and IPv6 network and summarized in Table 1 and 2. ('%' in the table is packet generating rate.) When the packet generating rate is between 0% and 91%, there is no image quality difference. From 93%, OSPF shows better quality than RIP. In Table 2, when the packet generating rate is between 0% and 93%, there is no image quality difference. From 96%, OSPF shows better quality than RIP.

IPv4	0%	20%	40%	60%	80%	91%	93%	96%	98%
OSPF	49.8	49.9	49.8	48.2	49.9	48.1	42.3	45.5	9.6
RIP	49.3	44.1	47	46.9	43	44.1	19.9	14.4	8.2

Table. 1 PSNR value of OSPF/RIP in IPv4 Network

IPv6	0%	20%	40%	60%	80%	91%	93%	96%	98%
OSPF	49.2	49.6	50.2	49.7	47.9	46.4	43.4	41.1	13.3
RIP	44.2	48.5	45.5	42.9	43.6	45.3	42.2	30.9	13.1

Table. 2 PSNR value of OSPF/RIP in IPv6 Network

3.3 Performance analysis

In Figure 7, when the packet generating rate is between 0% and 91%, there is no image quality difference between RIP and OSPF in IPv4 network. From 93%, OSPF shows better quality than RIP. There is no image quality difference in 0~93% of packet generating rate in IPv6 network. From 96%, OSPF shows better quality than RIP. Therefore, when 0~93% of packet generating rate in IPv4 and IPv6 network, RIP routing protocol is more efficient than OSPF routing protocol with complex network design.In order to confirm the validity of the proposed method, it has been first applied to the simulation experiment. In this simulation experiment, the random noise is generated by use of Gaussian random numbers. The generated

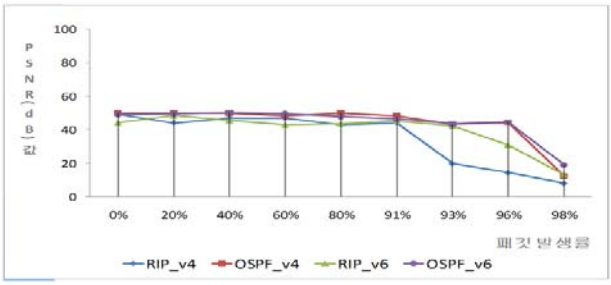

Fig. 7 video comparison by PSNR value graph

4. Conclusion

This research investigated the real-time image quality based on the routing protocols in IPTV network with mathematical distortion measurement. Of two protocols, the performance of OSPF routing protocol is more stable and better than RIP. But in 0~91% of packet generating rate in IPv4 network and 0~93% in IPv6 network, the RIP routing protocol performance is also good. That's why small-sized ISP should use the RIP routing protocol not OSPF routing protocol with complex network design. The method to use and manage the network performance efficiently satisfying the QoS requirements at the same time is needed.

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