Relay Path QoS Estimation Method for Overlay Network

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***Abstract*—In IMS overlay network, real-time media multipath transmission constructed based on application layer relay, is a kind of upgrading method of IMS media transmission technology. In the session establishment process, the merits of path QoS evaluation are needed. The paper presents a suitable path QoS estimation algorithm for this network model, and realizes effective measurement of delay and available bandwidth between relay nodes. And corresponding message interaction process is designed. Finally, the simulation results show that the new mechanism could measure path QoS quickly and accurately through comparison and analysis.**

Keywords-Application Layer Relay; Overlay Network; IMS; QoS

I INTRODUCTION

IP Multimedia Subsystem, IMS for short [2], introduced by 3GPP in Release 5 at first, is a multimedia communication system, which is most likely to become the architecture of next generation telecommunication technology. With TISPAN's advancing fixed IMS network standards, Common IMS is established as the core standards of next generation network. However, bearer network transmission technology lags behind the needs of traffic network development, which has seriously hampered the IMS application development and service innovation. In IMS overlay networks, real-time media multipath transmission constructed based on application layer relay, is a kind of upgrading method of IMS media transmission technology. In the session establishment process, rich application layer relay path selection is needed, which is supported by the merits of path QoS evaluation. Since path selection will be done according to the path Quality of Service (QoS for short), how to measure and estimate the QoS has become a significant issue, which is mostly analyzed in this paper.

Current estimation of path QoS is end-to-end estimation, such as RTCP [1] protocol, which works just in the media transfer process and makes statistics according to the transmission status. There is no real-time measurement and no description of available bandwidth, which could not measure path QoS actively. Currently, active path's available bandwidth measurement is to use PRM and PGM model. PRM model needs to inject a large amount of probe messages into the network and costs long time. In comparison, PGM model algorithm does not require this, but needs to know the bottleneck bandwidth in the path, which often is unable before.

By improving the PGM model algorithm and interacting with the corresponding messages injected into the network, a new solution is proposed, which could be achieved by fewer probe packets and less time cost, at the same time, the round-trip delay of relay path could be measured.

II RELATED KNOWLEDGE

A. The Research Scenario

Fig. 1 shows the overlay network model based on application layer relay [3], which includes three kinds of nodes. They are user node, relay node and relay controller. User node is responsible for sending and receiving media flow, and relay nodes for relay function. Relay controller is the core network elements, which works in two aspects, one hand, responsible for relay node registration and QoS probe between relay nodes, on the other hand, interacts with user node to provide appropriate relay path for relay transmission according to media type and QoS request from user. The paper focuses on study of path QoS estimation.

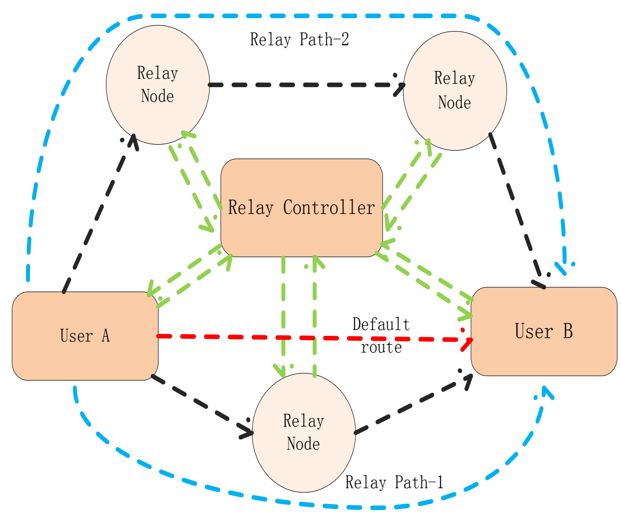

Figure 1. Overlay network scenario

The quality of transmission path could be measured by available bandwidth, delay, jitter, packet loss and so on. The article focuses on delay and bandwidth factors.

B. Delay Measurement

Path delay measurement methods are mainly divided into two ways: one-way and round-trip delay measurement. One-way delay measurement requires that the sender marks his local timestamp. When get the packet, the receiver marks again. Timestamps subtraction could get the result. If clocks of the sender and receiver are not synchronized, one-way delay obtained by two timestamps subtraction is no longer correct. So this method needs the protection of time synchronization mechanism. However precise clock synchronization is difficult, in order to reduce deviation, round-trip delay measurement is selected.

C. *Available Bandwidth Measurement*

Available bandwidth is defined as the maximum date transfer rate provided by a link with no deliberately reducing background traffic [5-7]. The background traffic is current media flow transmission traffic. Current available bandwidth measurement adopts active measurement method. According to measurement principle, it is divided into two types of models: package rate model(PRM) and packet interval model(PGM). PRM model needs to inject a large number of probe packets, here no longer expatiatory.

PGM model algorithms are generally measuring path QoS by analysis of probe packets relationship when they inject into the network and when they leave, further understanding of end-to-end bottleneck bandwidth and available bandwidth.

In PGM model, shown in Fig. 2, the interval between two probe packets set $\triangle_{in,}$ the receiver measures the receiver interval as $\triangle_{out.}$ And assumes that the link capacity is known, denoted by C. Then get (1) as follows:

$$A = C*(1-\frac{\Delta_{out}-\Delta_{in}}{\Delta_{in}}) \quad (1)$$

Although PGM model algorithm does not need to inject a large number of probe packets, but need to know path bottleneck bandwidth, however, which is often unable to meet. The paper made a little improvement on the PGM model. The improved algorithm could measure available bandwidth of paths without need to know path bottleneck bandwidth C.

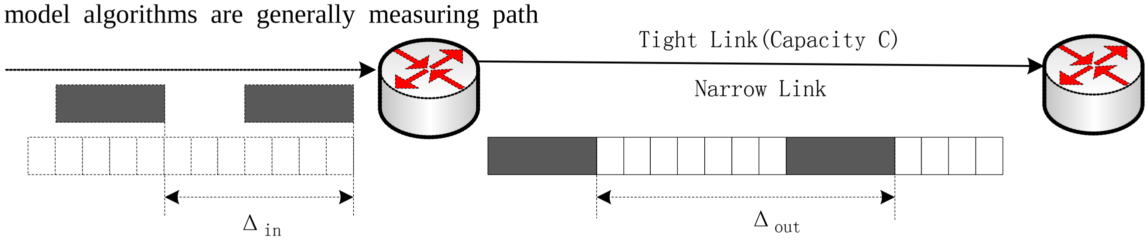

Figure 2. The PGM model

III THE DESIGN OF PATH QOS ESTIMATION MECHANISM

A *The Available Bandwidth Measurement Algorithm*

The schematic diagram of this algorithm also uses Fig. 2. While two prove packets inject into the network as interval time $\triangle_{in}$ and arrives at the tight link at time t_0, the receiver measures the reception interval $\triangle_{out}$. Background flow rate is $R_c(t)$ at the time t, then in the $\triangle_{in}$ interval time, a mount of $\int_{t_0}^{t_0+\Delta_{in}} R_c(t)d(t)$ data is into the bottleneck link, where L is the size of the probe packet. The data transmission time in the bottleneck link is $\triangle_{out}$. Tight link capacity expressed in C and assumes that the background traffic flow rate is unchanged during the measurement, so (2) holds:

$$L + R_c * \Delta_{in} = C * \Delta_{out} \quad (2)$$

Where the size of probe packet L and sender interval time △in are set by the sender, the arrival interval time △out comes from actual measurement. In the equation, only the tight link capacity C and background traffic rate Rc is unknown. Classical algorithm is known that firstly, calculate background traffic rate Rc using the tightly link capacity C which has been known before, then estimate available bandwidth through subtraction between C and Rc.

It assumes that the background traffic rate is still unchanged if in a very short time after the interval time △in detection. Then change probe interval and send probe packets into the path again, you can get a new equation. Through the two equations, you could calculate out C and Rc, finally the path available bandwidth, expressed in ABW, could get (3) as follows:

$$ABW = C - R_c \quad (3)$$

In order to reduce deviation and network load as possible as we can at the same time, the paper suggests to set eight pairs of probe packets. Among them, odder number of probe packet pairs are sended in Δ_{in}^1 time interval, and even number of probe packet pairs are sended in Δ_{in}^2 time interval. The receiver measures odd packages receiving time interval Δ_{out}^1 in average and even packages receiving time interval Δ_{out}^2 in average. Then get (4) (5):

$$L + R_c * \Delta_{in}^1 = C * \Delta_{out}^1 \quad (4)$$

$$L + R_c * \Delta_{in}^2 = C * \Delta_{out}^2 \quad (5)$$

Finally available bandwidth, expressed in ABW could get (6) from solving the equations.

$$ABW = L * \frac{\Delta_{in}^{2} - \Delta_{in}^{1} - (\Delta_{out}^{2} - \Delta_{out}^{1})}{\Delta_{in}^{2} * \Delta_{out}^{1} - \Delta_{in}^{1} * \Delta_{out}^{2}} \quad (6)$$

Through reasonable assumptions, we found that bandwidth is only related to probe packet size L, send interval and receiving interval, which all can be relatively easy to get.

B Interactive Process Design of Path Qos Measurement

Fig. 3 shows the interaction process of path QoS measurement. When relay node A sends registration request to relay controller, the controller will send relay node A path detection request message called Probe message. The Probe request message carries which relay node list that relay node A needs to probe and measure. It is relay node B in this example.

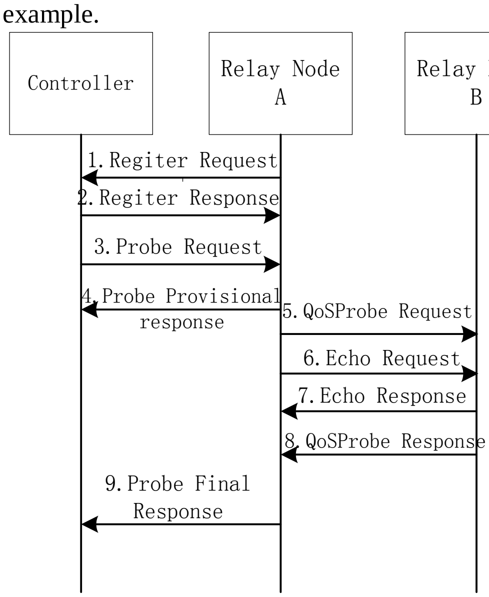

Figure 3. The process of path QoS measurement

1) relay node A sends a provisional response to controller when receiving a Probe request message. It indicates that the request has received and probe process is ongoing.

2) relay node A sends a QoSProbe request to relay node B which indicates that A wants QoS measurement between A and B.

3) relay node A sends Echo request message to relay node B four times and waits for response.

4) relay node B sends Echo response message if received request. Then relay node B calculates available bandwidth between A and B using Echo request and response and sends final QoSProbe response which carries available bandwidth to relay node A.

5) relay node A calculates round-trip delay in average and sends a final Probe response carrying measurement result.

In order to save space, Fig. 3 shows Echo request and response only one time in brief.

The paper no longer shows the specific format of messages, only states mechanism. Echo request message carries NTP timestamp, whose value sets the Echo request sending time. There are two timestamps designed in the Echo response message. One is called REcho whose value sets the same as Echo request sending time, the other is called DREcho whose value sets interval time from the time receiving the message to the time sending back response message. The sender records the time of receiving Echo response message, expressed in T, so round-trip delay calculation formula (7) between two relay nodes, RTT for short, is as follows:

$$RTT = T - REcho - DREcho \quad (7)$$

Available bandwidth could get as follows: firstly, the timestamp of second time Echo request message minus the timestamp of first time Echo request message gets sending interval time Δ_{in}^{1}, in the same way to using the third time Echo request and the fourth Echo request, we get sending interval time Δ_{in}^{2}.At the receiver, we could get the arrival interval time Δ_{out}^{1} and Δ_{out}^{2}.

Probe packet length usually sets 1500 bytes. Using these variables into the ABWprobe calculation formula, we could get the available bandwidth of relay path.

IV THE SIMULATION AND VALIDATION

A. Simulation Scenario

OMNeT++ is an object-oriented discrete event network simulator, which allows users to simulate practical system logical structure in the simulation environment. Simulation diagram is shown in Fig. 4, relay1 and relay2 represents two relay nodes and controller represents relay controller.

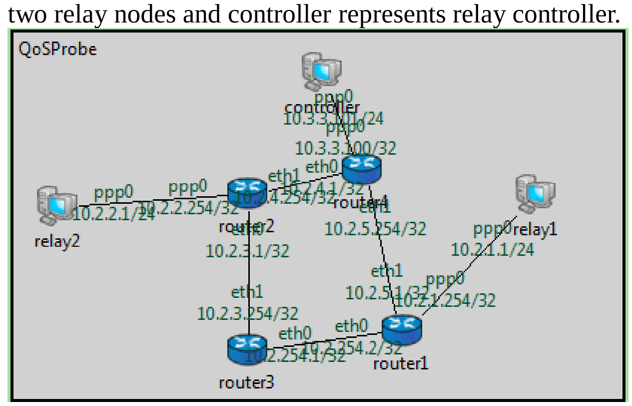

Figure 4. Simulation scenario

B. Simulation Result

The simulation sets bottleneck bandwidth which appears between route1 and route3, 20Mbps. And the rest links of the bottleneck bandwidth set 100Mbps. Each link channel subjects to normal distribution of 1.5ms delay in average, 0.5ms in standard deviation. Time delay measurement result shows in Fig. 5.

There are four section links between relay1 and relay2, which should be around 6 ms delay. Considering the process delay of routers, time delay we measures is between 6ms to 8ms as result, which has rationality.

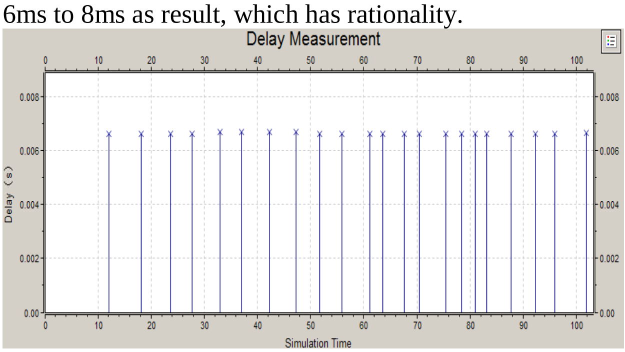

Figure 5. Delay measurement result

The simulation sets background traffic flow change between 10Mbps to 15Mbps. Due to the bottleneck bandwidth is 20Mbps, the theoretical calculation value of available bandwidth should be changed between 5Mbps to 10Mbps. The result shows according to ABWprobe algorithm, in Fig. 6.

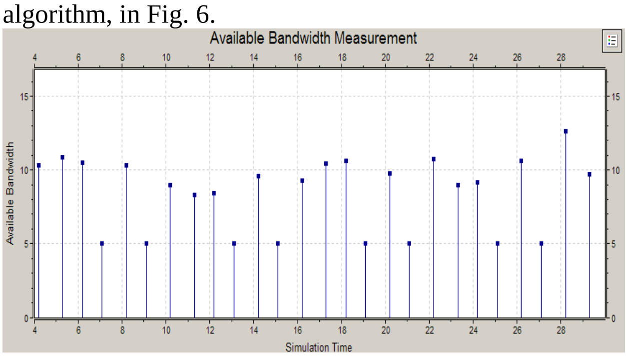

Figure 6. Available bandwidth measurement result

The actual measurement result changes between 5Mbps to 13Mbps, which is coincidence with the theoretical value. Measurement do not need to know any link of bottleneck bandwidth, and costs approximately only 30ms a time, which has better real-time performance.

V CONCLUSION

Path selection process is supported by QoS measurement between relay nodes. A relay path QoS probe mechanism is presented in this paper, and design the interaction process of estimation according to the scenario, finally verify its rationality and feasibility through comparison and analysis.

There is also some shortcoming in this paper, path probe process exists in the session establishment process, unavoidably causing delay in the session establishment process, etc. How to reduce interval time of signaling interaction process, more effective to establish session will be a key research point.

Believe that IMS traffic network will get further development with improvement of related IMS media transmission theory based on application layer relay overlay network.

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