VoIP ネットワークにおける迂回を考慮した
エンドポイントアドミッションコントロール

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あらまし 本稿では、メッシュネットワークにおけるダイナミックルーティングとアドミッションコントロール方式について検討する。このアドミッションコントロールについての基本的な考えは、各 VoIP 呼の直通ルートと 2-リンクルートのひとつに対して、2つのプローブフローを同時に送信する事により QoS 測定を行う。プローブフローの QoS の評価に基づいて、発信ノードがルートを決定する。シミュレーションにより、メッシュネットワークにおけるダイナミックルーティングおよびダイレクトルーティングの性能評価を行う。本稿では、呼損率およびパケット損失率に基づき迂回経路学習型のダイナミックルーティングの優位性を示す。

キーワード VoIP アドミッションコントロール QoS ルーティング プローブ 測定

Endpoint Admission Control for VoIP Networks with Dynamic Routing

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Abstract In this paper, we propose an endpoint measurement based admission control (EMBAC) with dynamic routing, with which is executed in mesh networks. The basic idea of this admission control is, to use probe flows to measure two routes, which are direct route and one of the two-link routes between each VoIP call's originating-terminating node pair at the same time. Based on the probe flow's QoS evaluation, the node decides a route for call. We compare performance of direct routing, basic dynamic routing and advanced dynamic routing by using simulation. It is shown that an advanced dynamic routing with EMBAC works better to minimizing call blocking probability and packet loss rate than direct routing in the network.

Keyword VoIP Admission Control QoS Routing Probe Measurement

1. Introduction

Although the Internet now runs faster and faster, but it is still based on best-effort service. Each packet's delivery is not guaranteed. Delivering packets face to be dropped or delay because of network congestion. These characteristics are not suit for VoIP (voice over IP), which is sensitive with delay jitter or loss of data in transmission.

To overcome these problems, some Quality of Service (QoS) technologies have been developed. The MPLS (Multi Protocol Label Switching) is one of them. MPLS some times is viewed as a switching architecture.
That is, the main idea of MPLS is to attach a label onto a packet, the content of the label tell the LSRs (Label Switching Router) where is the labeled packet comes from and where it should be forwarded next hop. By this approach, a packet can be forced to take a particular route through the network.

In this paper, our works are based on such MPLS technology. Currently, one of the most popular routing protocols in IP network is OSPF (Open Shortest Path First). Because of OSPF's algorithm, congestion often occurs on the shortest route between flow source and flow destination. Recently, some works on EMBAC (endpoint measurement based admission control) have been developed to avoid congestion on a certain route [2],[3]. In these researches, probe flow is the tool, which measures the link resource utilization of VoIP network. Based on probe flow's QoS (quality of service) evaluations, the VoIP flow source node determines whether to inject new calls into networks or not. Most of these researches focus on executing admission control test on a single route, which is found by routing protocols such as OSPF. However, we believe that in a network, the traffic load is under unbalance status in most case. Some of routes in the network are busy and overload, while others are idle. Assume that, there are more than one route between each call's Originating-Terminating (O-T) node pair, if we always use a fixed route to hold the VoIP traffic load, it may cause congestion in this route, but at the same time, rest routes between the O-T node pair may be idle, so the resource on idle routes are wasted. This paper proposes dynamic routing with EMBAC to optimize the link utilization between each O-T node pair.

The rest of this paper are arranged as follows: The basic operation of EMBAC will be presented in 2.1. Then we introduce dynamic routing with EMBAC. There are two modes in it, one is called Basic mode, which is introduced in section 3.2, and the other one is called Advance mode, which is introduced in section 3.3. In section 4, we explain our simulation model and discuss results, and the section 5 is conclusion of the paper.

2. Basic operation of EMBAC

We first introduce the basic operation of EMBAC. As shown in Fig.1, there is an O-T node pair, which is node1 and node2. Assume that a VoIP call (call1) originates at node1, and terminates at node2. Before call1 is established, an AC will be executed at both directions by using a pair of probe flows. The procedure of AC can be described as follows: after receiving Call Setup Request, the node1 and the node2 send probe packet flow to each other independently. This pair of probe flows are flow1 which sent by node1, and flow1' which sent by node2.

Flow1 and flow1' are carried at the same route in the network. The probe flow is CBR traffic. After a fixed probe time, each node calculates probe packet loss rate for the received probe flow. If the packet loss rate for each flow is less than a predetermined admission control threshold (AT) value, it means that this route passed the AC test, and is available to be used to hold call1, otherwise, it means that this route can not pass the AC test and is in busy status, which are not qualified to hold call1 temporarily and call1 will be blocked.

3 EMBAC for a mesh network

3.1 Direct routing

We assume that the network is a mesh network. In this kind of network, each O-T node pair has one direct route (DR), and N-2 two-link routes (TR) to connect them, where N is number of nodes in the network. In our work, N is 5, so the network model looks like that in Fig.2 (a). Each node in the network can acts as both call origination and call termination points.

For easier to illustrate, we focus on only one O-T node pair, and separate it from the whole network. So after separation, the network can be expressed as shown in Fig.2 (b), one DR and three TRs connect node1 and node2. Three TRs of connecting node1 and node2 are TR1 (node1→node3→node2), TR2 (node1→node4→node2), and TR3 (node1→node5→node2).

Suppose that, a call originates at node1 and
terminates at node2. As we introduced before, before the call’s establishing, the AC test should be carried out in both directions between node1 and node2. In direct routing, the AC test is conducted only for the DR. The AC procedure is same as that mentioned in 2. Direct routing has a parameter of AT, which is admission threshold of the DR.

3.2 Dynamic routing-Basic mode

In dynamic routing, the AC test contains two actions. One is carrying AC on DR and the other one is carrying AC on a TR. Here, this TR was randomly selected from the three TRs. In this example, we suppose it is TR1. Node1 sends two probe flows, which are probe flow1 and probe flow2 at the same time. Probe flow1 goes along the DR, which reaches to node2 directly. Probe flow2 goes from node1 to node2 along TR1 via node3. While the node1 sends probe flows, the node2 also sends two probe flows which are flow1’ and flow2’ to node1 independently. Flow1’ was transmitted from node2 to node1 along DR, and flow2’ was transmitted from node2 to node1 along TR1 via node3. Here, we define this kind of TR, which is selected to hold probe flow as current-TR. Notice that, when a node serves as a termination, it has not right to select current-TR. In this example, the selection of current-TR (TR1) is decided by originating node (node1). As we illustrated before, after receiving probe packets, each node, which received flow begins to calculate the probe flow’s packets loss rate. The O-T node pair can realize that if each route, which has been probed are busy or not. If both of these two routes cannot pass the AC test, the call will be blocked. If both of them passed the AC test, the DR will be selected to hold VoIP call. If DR failed and current-TR passed the AC test, the current-TR will be selected to hold VoIP call. In another word, the current-TR will be selected only when the AC test on DR is failed and it passed on TR at the same time.

By using MPLS technology, it is easy to achieve transmitting packet flow along different route from flow source to flow destination. So, it is possible to carry the dynamic routing AC in a network.

3.3 Dynamic routing-Advanced mode

The dynamic routing advanced mode is similar to the dynamic routing-basic mode, except the selection of current-TR.

In the basic mode, the current-TR is chosen from a set of TRs randomly. In the advanced mode, the node selects the current-TR by means of “learning” information of the last call. If AC test was failed in one current-TR for the last call, this TR is forbidden to be selected as current-TR for next call. For example, a call (call1) originated at node1 and terminated at node2. We assume that, the current-TR is TR1 for call1. If AC test, which was executed on TR1, passed, next call (call2), which originated at node1, and terminated at node2 will still use TR1 as current-TR. On the other hand, if the AC test of TR1 was failed for call1, the node1 “learned” it, and for call2, TR1 will not be selected and the current-TR will be randomly selected from the rest of TRs.

Dynamic routing-basic mode can be expressed as Basic (AT1, AT2), and dynamic routing-advance mode have a set of parameter (AT1, AT2), Where AT1 is admission control threshold of DR, and AT2 is admission control threshold of current-TR.

4. Performance evaluation

4.1 Simulation model and assumptions

In our experiment, we use the network model that is shown in Fig.2 (a). We first introduce the traffic conditions in our simulation. Traffic matrix is generated as follows: for each O-T node pair, the amount of traffic is randomly selected from the range $[40(1-0), 40(1+0)]$, using the parameter $\theta$ ($0 \leq \theta \leq 0.4$), which is termed traffic deviation. Thus, a traffic matrix with $\theta=0$ has 40erl for all elements (uniform traffic matrix). With larger $\theta$, elements have larger deviation with average of 40erl. The distribution of the average call holding time is base on exponential distribution with the average 180 sec. The
call activity, which is a ratio of voice signal in a call, is supposed as 30%. The VoIP packets have higher priority than probe packets to avoid VoIP packet's loss, which is affected by probe packet traffic. Other parameters in the simulation are described as below:

- Each link has the same bandwidth, which is 0.5 Mbps.
- The probe time is 1 sec.
- Both probe traffic and VoIP traffic is CBR traffic, the interval between two consecutive packets is 20 ms, so there are 50 packets in each probe flow. One packet loss means 2% packet loss rate.
- Both VoIP packet size and probe packet size is 60 bytes.
- The buffer size for VoIP traffic is 8 packets and for probe traffic is 4 packets.
- Average packet loss rate and call blocking probability are used as QoS evaluation parameter.
- Simulation time is 9600 sec.

4.2 Results and discussions

The performance of three routing schemes, direct routing, dynamic routing-basic mode and dynamic routing-advanced mode are compared in Fig.3 to Fig.6.

In Fig.3, the value of AT1 is 2%, which means on DR, only a probe flow in which number of lost packets are equal or less than 1 can pass the AC test. The value of AT2 is 0%, which means at the TR, there is even only one packet loss in a probe flow, it means that TR can not pass the AC test. As a result, the performances of direct routing and dynamic routing have not much different. Because dynamic routing, which has the strict AC test on current-TR, forces most calls to be held by DR. Thus, in this kind of case, the performance of dynamic routing is close to the performance of single probe flow AC. In Fig.4, We increase the value of AT2 to 2% and still keep on fixing the value of AT1 at 2%, it means that the AC test on TR becomes easier to be passed. As the results, both average loss rate and blocking probability of dynamic routing-advance mode is lower than they are in direct routing. The reason of dynamic routing's blocking probability decreasing is, AT2's increasing permit more calls injected into network. The reason of dynamic routing's average loss rate decreasing is, the traffic in the network is distributed into each route reasonably, and the link utilization is improved at this time. In Fig.5, we keep on increasing the value of AT2 to 4%, which means that it is easier for a call to pass the AC test on TR than AC test on DR. As the results, the blocking probability of dynamic routing keeps on decreasing, and the average packet loss rate is also increasing as the cost. When a call is held by current-TP, it costs more network resource than the call, which is held by DR, because current-TR is a two-link route while DR is a one-link route. If in the network, the numbers of using TR is increasing, the probability of congestion in the network becomes higher than it is when the network only uses direct routing. The more current-TRs are used, the faster network resource is cost. It is the reason that in Fig.6(a) the average loss rate of EMBAC with dynamic routing increase fast since the value of AT2 is more when the value of AT1. Fig.6 (b) shows that the EMBAC with dynamic routing-advance mode, works much better than with direct routing on controlling the blocking probability.

5. Conclusion

This paper proposes three routing schemes with EMBAC for VoIP network, one is direct routing, the other two are dynamic routing, one is dynamic routing-basic mode, the other one is dynamic routing-advance mode. Dynamic routing can be achieved by using MPLS technology. Our simulation was executed under non-uniform traffic. It is shown that, under this kind of traffic condition, the dynamic routing with EMBAC, especially in advance mode works better than with direct routing to achieve higher performance.

![Average loss rate](image1)

![Blocking probability](image2)

Fig.3 performance of each AC with AT1=2%, AT2=0%
Fig. 4 performance of each AC with $AT1=2\%$, $AT2=2\%$

Fig. 5 performance of each AC with $AT1=2\%$, $AT2=4\%$

Fig. 6 performance of each AC with $AT1=2\%$ and traffic deviation $=0.4$

References: