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Routing protocols behaviour under bandwidth limitation

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Abstract. Nowadays, network stability is a very important factor in the communications environment. Many companies depend on the fast collaboration between the different departments and a fast reliable network is a must to meet the strict projects deadlines. Any large network uses a routing protocol to route packets between users. In the case of distant offices, a limited bandwidth link is acquired to connect the distant office to the headquarters. By simulating in a commercial environment the routing protocol's behavior under bandwidth limitation, it can be seen that end-to-end connectivity between users can be lost because of the routing protocol's packets that are discarded by the bandwidth limited links.

Keywords: routing, bandwidth, limitation, OSPF, EIGRP

1. Introduction

Classical routing protocols use specific packet types to send routing updates. In an ideal environment, where the speed of a link is determined by the network interface speed, sending routing updates does not pose any problems because, usually, routers use special queues for routing the packets. In practice, many links are bandwidth limited below the network interface speed. The packets that exceed the bandwidth limitation are discarded without looking at the protocol that is encapsulated. So, in the bandwidth limitation process, the routing protocol's packets are treated as any other packet. As I saw, in practice, this can lead to network stability problems because routers can lose adjacency, withdrawing routes in the process without knowing that the link is up. In consequence, the traffic that travels on that link will be redirected to another link or will be dropped.

If the traffic will be redirected, the alternative path can become congested this can lead to packet discarding and network stability problems.

To monitor the network status, many network engineers use routing protocol's adjacency property to monitor the link status. If the routing protocols lose adjacency the link will be reported as down to the monitoring software and network engineers must allocate time to investigate the situation.

2. Routing protocols and bandwidth limitation

Packets travel a link like in an ordered fashion like in Fig. 1. Along with the normal traffic destined to WEB navigation, file transfer, e-mail etc. travels the routing protocol's packets. These packets can be request or responses from different users in a network or can be aggregated.

If the link is bandwidth limited, the packets that exceed the limitation are discarded as in Fig. 2. Among these packets can be, along with HTTP, FTP, SMTP etc., routing protocol information. If too many of these packets are lost, depending on the number of the packets discarded and the type of routing protocol, the routers can lose adjacency.

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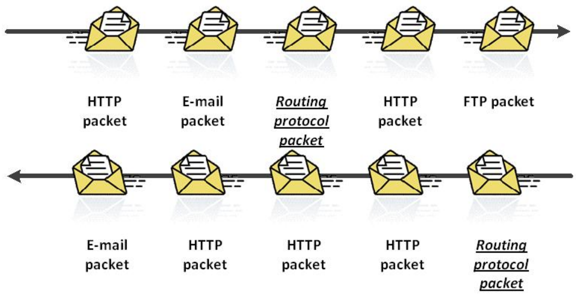

Fig. 1: Packet flow over a link

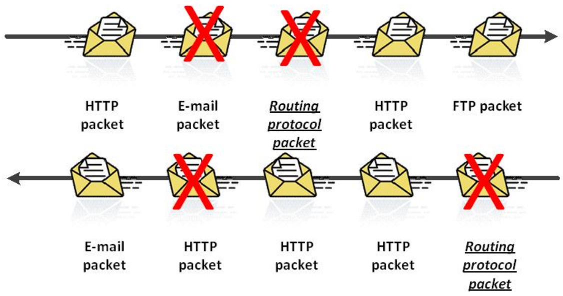

Fig. 2: Packet discarding

3. Single link between routers

To test the effects of bandit limitation on routing protocols I implemented the topology from Fig. 3 in network simulation software. The network is composed of a Traffic generator and receiver, two routers and a limited bandwidth link. The test network operation was simulated for 20 minutes.

Fig. 3: Test platform for routing protocol behaviour – single link between routers

The Traffic generator generates packets at a rate of 40 Mbps using a constant distribution (Fig 4.). The generated traffic is three times the limitation. In practice, 40 Mbps of traffic is specific to a large number of users that access the Internet during the high activity period of the day.

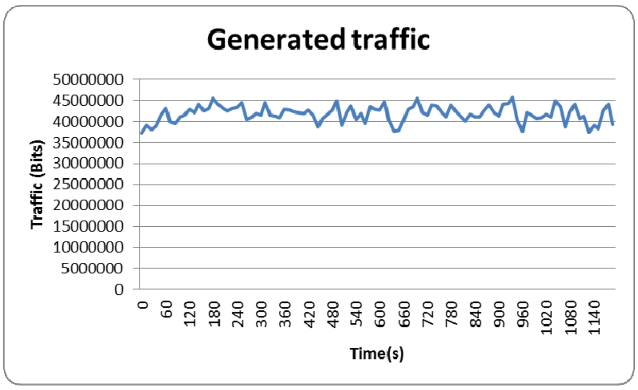

Fig. 4: Generated traffic

First EIGRP proprietary routing protocol was simulated using default parameters (Fig. 5). As it can be observed, a great deal of data is lost because Routers 1 and 2 lost adjacency and withdraw routes. When the routers received traffic the route for the destination could not be found in the routing table and the packets were discarded. The normal operation was restored when routing protocol packets manage to cross the link and the adjacency could be restored.

Second OSPF routing protocol was simulated, the most wide spread link state routing protocol, using the network in Fig. 3 and the default OSPF parameters.

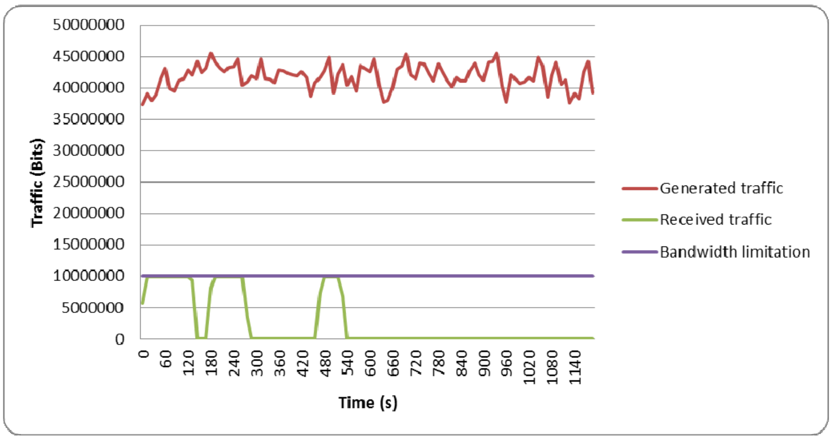

Fig. 5: EIGRP protocol behaviour under bandwidth limitation

For EIGRP the adjacency is maintained in the following time intervals:

- 108÷192
- 264÷492
- 528÷1200

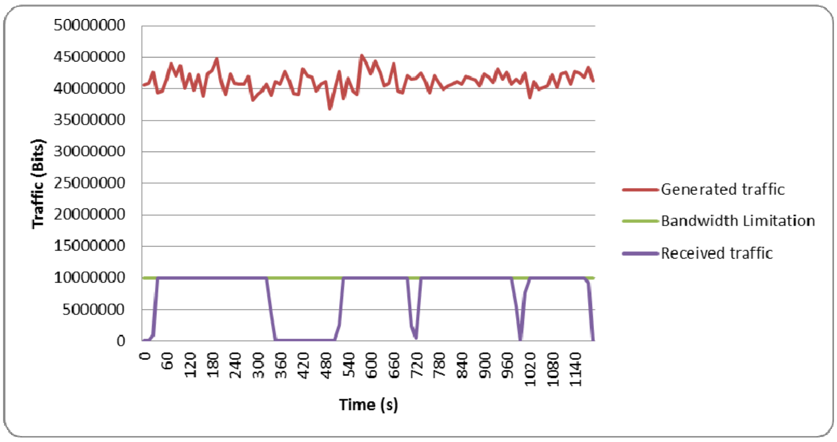

Fig. 6: OSPF protocol behaviour under bandwidth limitation

For OSPF the adjacency is maintained in the following time intervals:

- 324÷528
- 696÷732
- 972÷1020

4. Two links between routers

OSPF routing protocol uses load balancing and distributes the traffic between the two links that connect Router 1 and Router 2(Fig. 7). If we have 40 Mbps of generated traffic, each link will have to carry 20 Mbps of data. Because these links are limited at 10Mbps, only 20 Mbps of traffic will reach Router 2. When a router will be unreachable over one link, OSPF will withdraw the corresponding route from the routing table and redirect all the traffic to the remaining link. In this situation the adjacency will not be lost. Although from Router 1 is another path to reach Router 2, there are situations in which the adjacency is lost on the second link resulting in loss of traffic like in Fig. 8 time index 360 seconds. If the adjacency is lost over one link only 10Mbps of traffic will reach Router 1 and the Traffic receiver station.

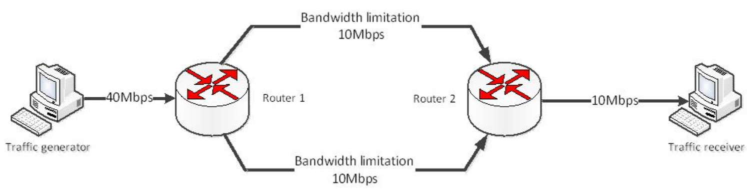

Fig. 7: Test platform for routing protocol behaviour – two links between routers

The adjacency is lost for one or both links in the following time intervals:

- 84÷132 seconds
- 372÷432 seconds
- 624÷828 seconds
- 876÷888 seconds
- 1020÷1104 seconds

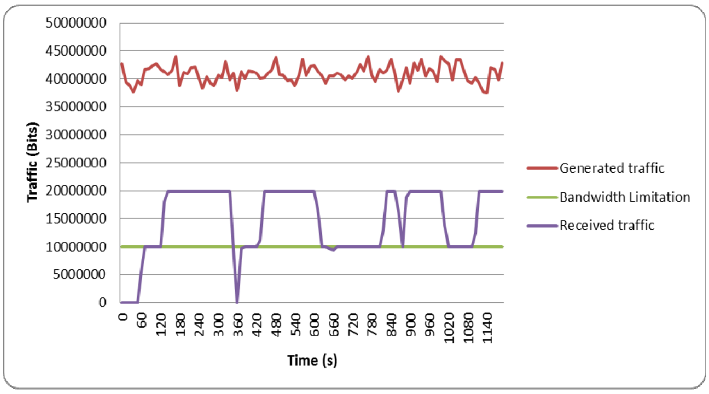

Fig. 8: Behaviour of OSPF routing protocol under bandwidth limitation

In the case of EIGRP routing protocol we can observe that it reacts more quickly to the packet loss. This behaviour is useful if the links are limited to the network interface speed because it can switch rapidly to an alternative path reducing the amount of lost traffic.

If the links are bandwidth limited bellow the network interface speed and the generated traffic is at least three times higher than the bandwidth limitation, the adjacency will be lost.

Like OSPF, EIGRP uses load balancing to distribute traffic over multiple paths. As we can see in Fig. 9, after the initial convergence activity, at time index 588 seconds and 672 seconds the convergence is lost for a short period of time. More, between time index 1044 and 1200 seconds the convergence is lost resulting in a large amount of lost data.

The adjacency is lost for one or both links in the following time intervals:

- 264÷288
- 336÷348
- 384÷468
- 528÷804
- 876÷1044

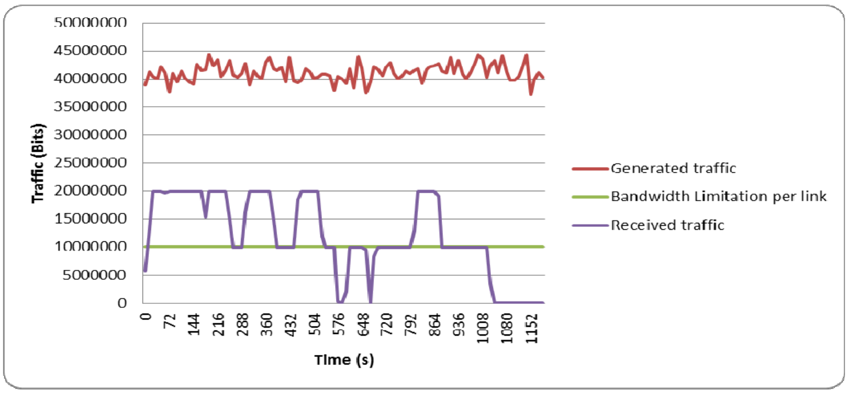

Fig. 9: Behaviour of EIGRP routing protocol under bandwidth limitation

5. Conclusions

Routing protocols are very important part of an IP network. They are the key element in routing packets between different subnets. In a small network, routing can be done using static routes, but in a large dynamic network, a routing protocol must be implemented. If the network relies on links that can carry data at network interface card speeds, the analysed routing protocols perform as they were designed. As we saw, if we introduce bandwidth limitation, the typical scenario for leased lines, the routing protocols start to introduce instability in a network.

Usually, the bandwidth limitation process is done by discarding packets or Ethernet frames in a blind manner without analysing the type of data that is carried by the packet or Ethernet frame. Inevitably, if the traffic is high enough, the routing protocol's hello packets are lost. If enough hello packets are discarded in a row, the adjacency is lost between the routers on both ends of a link resulting in loss of data. Even if there is an alternative bandwidth limited path between the routers, the adjacency will also be lost resulting in loss of data. Possible solutions can be to increase the link bandwidth, to limit the ingress traffic rate to the router or to fine tune the routing protocol parameters. In these cases there will be enough hello packets that reach the router at the other end and the adjacency will not be lost.

Routing protocol	Number of links	Total time of lost traffic	Percent of lost traffic time
OSPF	1	288 seconds	24%
	2	408 seconds	34%
EIGRP	1	984 seconds	82%
	2	564 seconds	47%

If there is a single link between routers, the percent of lost traffic time is 24% for OSPF and 82% for EIGRP. So, EIGRP is more sensitive to bandwidth limitation than OSPF.

In the case of two links between routers, the percent of lost traffic time is 34% for OSPF and 47% for EIGRP. Again, EIGRP is more sensitive to bandwidth limitation. Compared to the previous case, for EIGRP the percent of lost traffic time is reduced dramatically because EIGRP reacts more quickly to link down events than OSPF and switches more rapidly to an alternative path.

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