IP Traffic Engineering over OMP technique

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These days we live through significant changes with regard to using of Internet that is equipped with very constrained traffic management solutions. The demand on using eligible and efficient traffic management and engineering methods is increasing. This kind of efforts hallmarks the protocols/methods being under research/standardisation phase, such as OSPF-OMP, MPLS-OMP, MPLS-Traffic Engineering, etc. This paper discusses application of OMP (Optimised MultiPath) technique for Traffic Engineering purposes in IP networks and reviews OMP simulation results.

1 Introduction

IP traffic on the Internet and private enterprise networks has been growing exponentially for some time. Today the use of efficient traffic management solutions in IP networks is more and more inevitable. In this paper we first briefly review OSPF routing protocol, Multi-Protocol Label Switching (MPLS) to provide a background for Traffic Engineering, and OPNET simulation tool which was used to examine the behaviours of OMP technique. Then we discuss the general issues of OSPF-OMP and MPLS-OMP. Finally we present the simulation results in case of a basic network topology using OSPF, OSPF-ECMP, OSPF-OMP, MPLS and MPLS-OMP techniques and in the last section we summarise the results and future plans.

1.1 OSPF

OSPF (Open Shortest Path First) is an internet routing protocol [1]. It is classified as an Interior Gateway Protocol (IGP). This means that it distributes routing information between routers belonging to a single Autonomous System (AS). The OSPF protocol is based on link-state and SPF technology. In a link-state routing protocol, each router maintains a database describing the AS's topology. Each participating router has an identical database. Each individual piece of this database is a particular router's local state (e.g., the router's usable interfaces and reachable neighbours). The router distributes its local state throughout the AS by flooding. The possible routes to reach a destination node are computed by using of SPF algorithm.

1.2 MPLS

MPLS (Multi-Protocol Label Switching) [2] integrates a label-swapping framework with network layer routing. The basic idea involves assigning short fixed length labels to packets at the ingress to an MPLS cloud. The forwarding function of a conventional router involves a capacity-demanding procedure that is executed per packet in each router in the network. MPLS simplifies the forwarding function in the routers by introducing a connection-oriented mechanism inside the connectionless IP networks so label switched paths (LSP) are set up for each route or path through the network in advance using an IGP (e.g. OSPF). Throughout the interior of the MPLS domain, the labels attached to packets are used to make forwarding decisions (usually without recourse to the original packet headers).

1.3 OPNET

OPNET (OPtimised Network Engineering Tools) [3] is a simulation tool, which provides a comprehensive development environment supporting the modelling of communication networks and distributed systems. OPNET allows large numbers of closely spaced events in a sizeable network to be represented accurately. It uses a modelling approach where networks are built of nodes interconnected by links. Each node's behaviour is characterised by the constituent components. The components are modelled as a state-transition diagram. We used OPNET as our simulation environment.

2 OMP Technique

We proposed to study Traffic Engineering [4] issues in IP networks. TE is a vast research area and we focused our efforts to study OMP (Optimised MultiPath) technique with OSPF and MPLS.

2.1 OSPF-OMP

OSPF may form multiple equal cost paths between source-destination pairs. In the absence of any explicit support to take advantage of this, a path may be chosen arbitrarily. ECMP (Equal Cost Multi-Path) technique have been utilised to divide traffic somewhat evenly among the available paths. However an unequal division of traffic among the available paths is generally preferable. Routers generally have no knowledge of traffic loading on distant links and therefore have no basis to optimise the allocation of traffic. OSPF-OMP [5] utilises the OSPF Opaque LSA option to distribute loading information, proposes a means to adjust forwarding and provides an algorithm to make the adjustments gradually enough to insure stability yet provides reasonably fast adjustment when needed.

2.2 MPLS-OMP

In an MPLS network MPLS ingress routers may establish one or more paths to a given egress to the MPLS domain. Load can be balanced across a complex topology using MPLS. It requires that the ingress router is capable of computing a hash with a sufficiently fine level of granularity based on the IP source and destination and selecting a forwarding entry based on the outcome of the hash. MPLS-OMP [6] is an extension to MPLS. It does require that the IGP be capable of flooding loading information. At the MPLS ingress an algorithm is applied to select alternate paths where needed and adjust forwarding. Forwarding is adjusted gradually enough to insure stability yet fast enough to track long term changes in loading.

3 Simulation Results

Our main goal concerning TE was to implement and examine load-balancing policy using OSPF-OMP and MPLS-OMP technique in OPNET simulation environment.

3.1 Test Network Topology

Our basic test network is depicted on Figure 1. The router nodes represent IP-based gateways in case of OSPF simulations and ATM-based gateways in case of MPLS simulations. The terminals and the server are connected to the nearest router node by Ethernet connections. The link costs are the same on each link, the capacity of the links is 64 Kbps. The test network models an almost ideal IP network in which the possibility of packet loss is zero using infinite queues at the router nodes. The terminals made connections to the server node and offered the traffic. The amount of the offered traffic by Terminal_2, Terminal_1 and Terminal_3 was 35 Kbps, 23 Kbps and 12 Kbps, respectively. The duration of every simulation was 3 hours. Terminal_1 and Terminal_2 started to transmit the traffic towards the server at the beginning of the simulations while Terminal_3 started the transmission 2 hours later.

3.2 OMP Simulation Results

We have run five different tests on our test network. In these tests we used OSPF, OSPF with ECMP, OSPF with OMP, MPLS and MPLS with OMP techniques, respectively. In each case we monitored the throughput on the critical links of the network (Link_3 and Link_4). In the first and fourth tests (when we used pure OSPF and MPLS) we got the result which was expectable if the routing is based on shortest path calculation. If the shortest paths between different source and destination pairs contain the same critical link then link overloading can occur. (In our case the shortest paths between Terminal_1 server and Terminal_2 server contain the same low capacity link (Link_3) which got overloaded.) The throughput of critical links is depicted on Figure 2, Figure 3. In case of OSPF-ECMP test the traffic generated by Terminal_2 was shared evenly between the equal cost paths so the network could avoid overloading on the critical links (see Figure 4). However this sharing solution is static so the aggregate traffic can reach such amount that could cause overloading on the critical links. In OSPF-OMP simulation the throughput on the Link_3 and Link_4 was controlled by the OMP algorithm (see Figure 5). When the system sensed high load on the critical link, OMP was activated and it directed load from the most heavily loaded link toward less loaded links to achieve a steady state when the most heavily loaded links of the network are about equally utilised. The convergence time of the algorithm depends on the degree of the load on the network and the setting of the OMP's parameters. In case of MPLS-OMP test the throughput of the links was higher due to the relatively big amount of ATM header traffic. Comparing the resulted graph (see Figure 6) with the graph of OSPF-OMP we can see that its structure is similar to the other

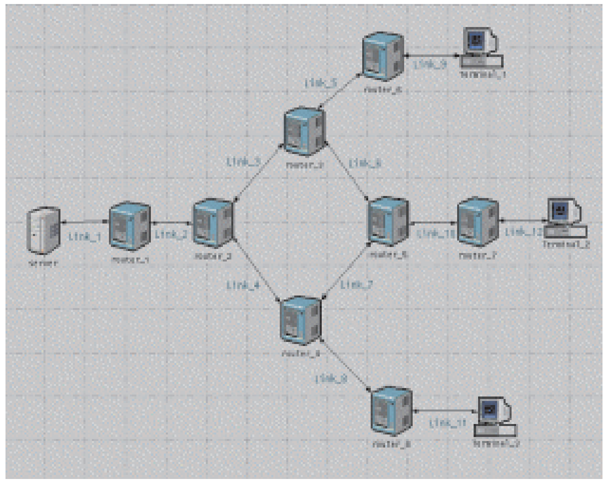

Figure 1: Test Network Topology

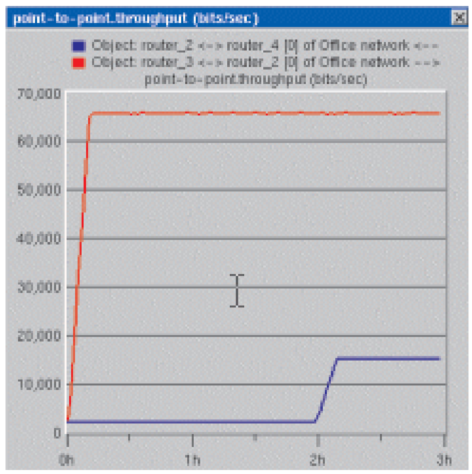

Figure 2: Throughput in case of MPLS

one due to the simple topology of the test network. The curves follow the changes of loading and converge to a state where the loading on the most heavily loaded links are equally distributed.

4 Conclusions and Future Plans

Today the importance of use of efficient traffic management solutions in IP networks is more and more increasing. If the offered traffic toward a destination is too high link overloading can be caused in the network using only pure OSPF, MPLS. OMP technique solves this problem by flooding loading information across the network and balancing load between the alternative paths. In this paper we examined some basic features of OSPF-OMP and MPLS-OMP techniques by implementing them in OPNET simulation environment. The simulation results back up our expectations that OMP decreases the load of the most loaded links and increases the utilisation of the network. Our future plans are to examine OMP in case of more different network topology by simulation moreover we would like to implement and measure OMP on a real MPLS network.

References

[1] OSPF Version 2 , IETF RFC 2328, www.ietf.org/RFC/RFC2328

[2] Multiprotocol Label Switching Architecture, Internet Draft, www.ietf.org/internet-drafts/draft-ietf-mpls-arch-06.txt

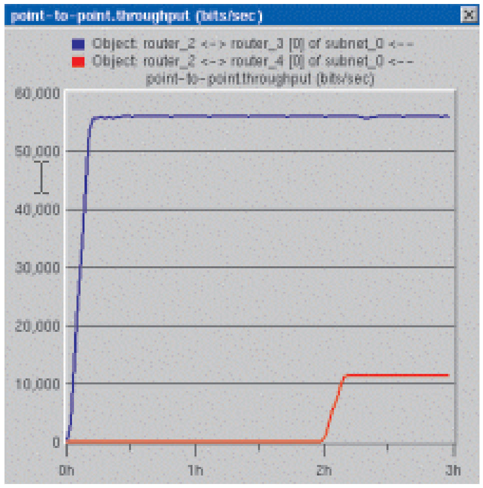

Figure 3: Throughput in case of OSPF

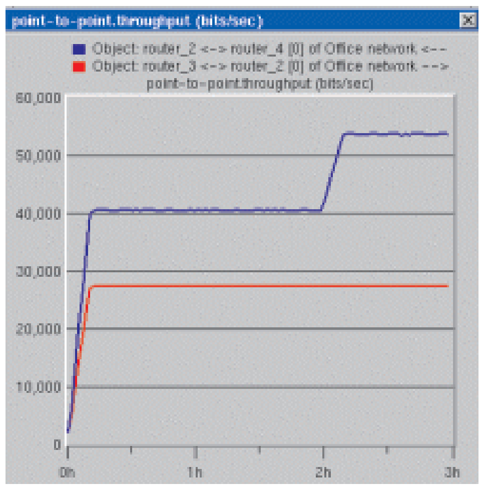

Figure 4: Throughput in case of OSPF

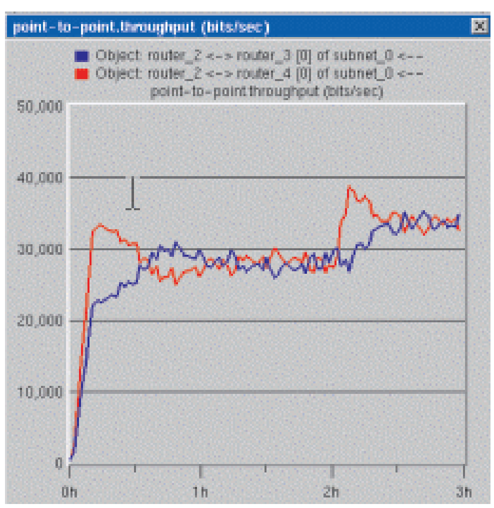

Figure 5: Throughput in case of OSPF-OMP

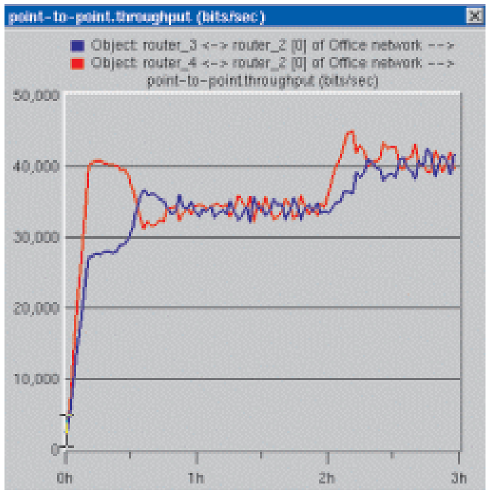

Figure 6: Throughput in case of MPLS-OMP

[3] OPNET Online Manual

[4] Requirements for Traffic Engineering over MPLS, IETF RFC 2702, www.ietf.org/RFC/RFC2702

[5] OSPF Optimised Multipath (OSPF-OMP), Internet Draft, www.ietf.org/internet-drafts/draft-ietf-ospf-omp-02.txt

[6] MPLS Optimised Multipath (MPLS-OMP), Internet Draft, www.ietf.org/internet-drafts/draft-ietf-mpls-omp-01.txt