MFMP Vs ECMP Under RED Queue Management

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Abstract

In this paper we compare the performance of a Maximum Flow Multi Path routing (MFMP) and Equal Cost Multi Path routing (ECMP) under a congestion avoidance scheme: Random Early Detection (RED). We show through simulation that MFMP performs well than ECMP in terms of mean end to end delay, packet loss percentage and packet delivery percentage.

Keywords: Computer Network Routing, Maximum Flow, Shortest Path, Multi Paths, RED.

1. INTRODUCTION

The current Internet protocols such as RIP [11], OSPF [13] and BGP [19] use a single shortest path to forward traffic from any source to any destination in the network.
Even that some protocols such as OSPF and EIGRP support a multipath routing, however it is not used until configured manually. The use of solely of shortest path can lead to unbalanced traffic distribution due to congestion of the frequently used shortest path. To overcome this problem, a multipath routing is proposed as an alternative to single shortest path to take advantage of network redundancy, distribute load [15], improve packet delivery reliability [8], ease congestion on a network [1],[7], improve robustness [16], increase network security [3] and address QoS issues [4].
In literature we find several multipath schemes both in wired and wireless routing [17], [2], [20], [24–30] however the most used multipath routing in today's router is the Equal Cost Multi Path [13], [31], [32].
In our previous work [9] we have proposed a multipath algorithm that is based on a Maximum Flow algorithm and we have shown [10] that our proposed algorithm (MFMP) is better than Equal Cost Multi Path (ECMP) when using First In First Out (FIFO) queuing discipline in terms of packets delivery and delay.
In this paper we use a congestion avoidance scheme, Random Early detection (RED) to look deeper at the performance of MFMP over ECMP.
The remaining of the paper is organized as follows. In Section 2, we give a short description of RED, MFMP and ECMP. In Section 3, we give the parameters of the simulation. In Section 4, we present the results of the simulation and analyze them. And finally we conclude in Section 5.

2. RED, MFMP and ECMP

RED [5] was designed with the objectives to minimize packet loss and queuing delay, avoid global synchronization of sources, maintain high link utilization, and remove biases against bursty sources. The basic idea behind RED queue management is to detect incipient congestion early and to convey congestion notification to the end-hosts, allowing them to reduce their transmission rates before queues in the network overflow and packets are dropped. To do this, RED maintains an exponentially-weighted moving average (EWMA) of the queue length which it uses to detect congestion. When the average queue length exceeds a minimum threshold (minth), packets are randomly dropped or marked with an explicit congestion notification (ECN) bit [6]. When the average queue length exceeds a maximum threshold (maxth), all packets are dropped or marked. MFMP sends packets over multiple paths obtained by a maximum flow algorithm, while ECMP uses multiple shortest paths. Both algorithms in this simulation use RED to control congestion in the network nodes.

3. SIMULATION ENVIRONMENT

Using OMNET++ 3.3, the performance of MFMP is compared to ECMP in the topology shown in Figure 1, which represents the optical core of the infrastructure in the COST-239 project [14]. This core network can be represented as a graph G = (N, L), where N represents a set of nodes interconnected by a set of links L as shown in Figure 2. It consists of 11 nodes (routers), of which, one bursty source (node 1) and one sink (destination) (node 9) and 25 bidirectional links of different weight as shown in Figure 2.

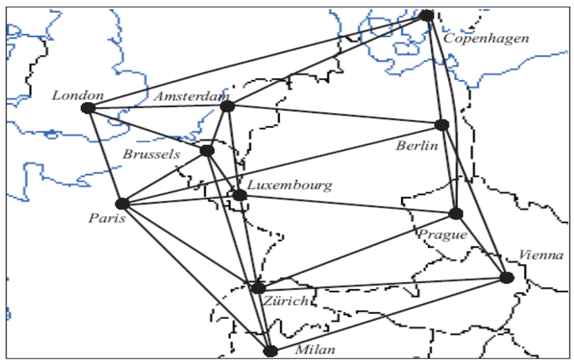


FIGURE 1: The COST-239 core network

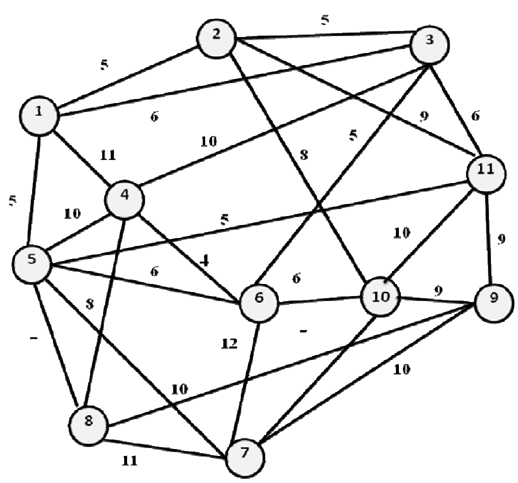


FIGURE 2: Graph representation of COST-239 core network

The TCP packets used in our simulation are of size equal to 1500 bytes. We used the same packets size for MFMP and ECMP to ensure that, packets are treated fairly by the routers for each protocol with regards to the size of the packets.

We used only unidirectional traffic. That is the source sends the data packets to the sink and the receiver sends nothing except ACK packets back on the reverse path. This approach has been followed by many researchers in their simulation work in order to avoid what is known ACK compression [12], [22] and [23].

The traffic is generated by one ON-OFF source that sends bursts with random duration distributed by Pareto distribution to model self-similar arrival and to model a broadband traffic [18]. To consider the effect of variation of load, we run our simulation under different traffic intensity scenarios varied from heavy traffic load corresponding to short inter arrival time (2000 packets/s for λ= 0.0005 and 1000 pkts/s for λ= 0.0010) to light traffic load corresponding to long inter arrival time (667 pkts/s for λ= 0.0015, 500 pkts/s for λ= 0.0020, and 400 pkts/s for λ= 0.0025). The ON period follows Pareto distribution (1, 0.5) and OFF period follows an exponential distribution (0.5 s).
The metrics of interest used to evaluate the performance of MFMP Vs ECMP are: packet delivery ratio percentage, mean end to end delay, and packet loss ratio percentage.
We run our simulation under two RED scenarios one for a short queue size (Minth=15, Maxth=33) and another for a medium queue size (Minth=20, Maxth=66).

4. SIMULATION RESULTS AND ANALYSIS

The following graphs summarize the results of the simulation.

Figure 3 - Packets delivery percentage - short queue size scenario

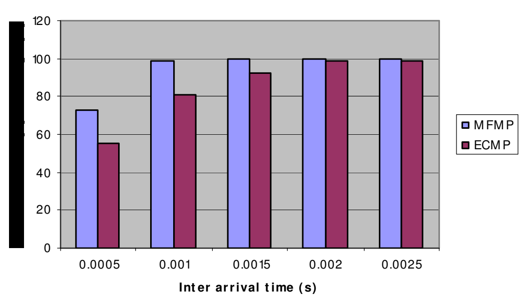


Figure 4 - Packets loss percenatge - short queue size scenario

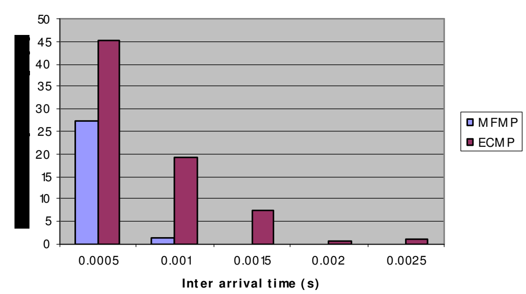


Figure 5 - Packets delivery percentage - meduim queue size scenario

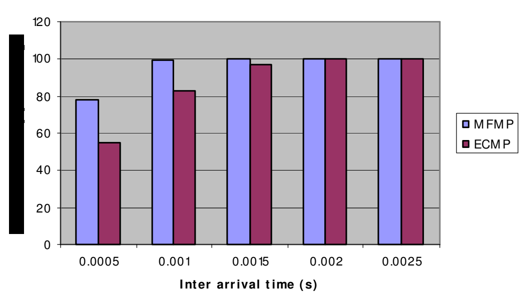


Figure 6 - Packets loss percentage - meduim queue size scenario

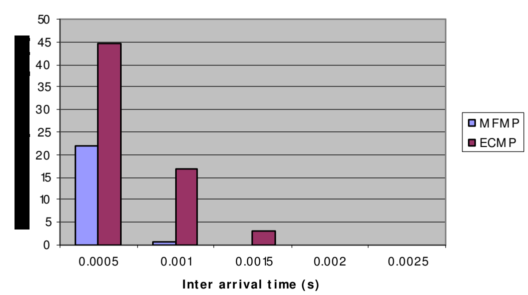


Figure 7 - Mean end to end delay - short queue size scenario

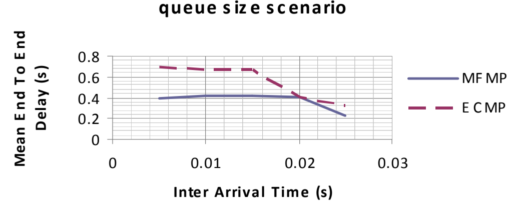
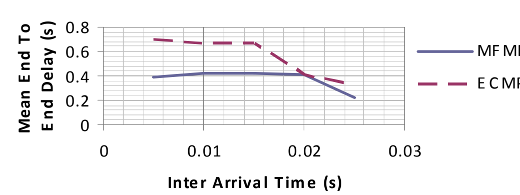


Figure 8 - Mean end to end delay - meduim queue size scenario



The performance of MFMP is clearly better than ECMP (in terms of packets delivery and packets loss percentages and mean end to end delay) for heavy traffic loads (λ = 0.0005, 0.0010, 0.0015)

both in short and medium queue size scenarios. But for light loads (λ = 0.0020, 0.0025), MFMP and ECMP give approximately the same performance because there is no congestion and RED is without effects. The long queue size scenario has not been considered for the same reason.
This performance is due to that when some paths in a multipath are congested, the max flow uses other alternative paths, that can be with same length as paths in ECMP or longer, that maximize the flow. So MFMP is able to benefit from the number of alternative paths. However the topology of the considered network influences theses results: if we have a network where MFMP uses long paths and ECMP short paths, then the performance of our algorithm can be worst than ECMP, at least for some cases of heavy traffic loads. Fortunately, this is not the case in practice. In most of the real networks, the paths of MFMP are the paths of ECMP plus some extra paths. So in the worst case, MFMP and ECMP have the same performance.

5. CONCLUSION

In this paper, we have shown through simulations that MFMP is better than ECMP under RED queue management in terms of packets delivery and loss percentage, and mean end to end delay. This is to confirm our previous results obtained in the case of FIFO queue management scheme.
Future investigations can be done in other queue management schemes.

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