6
Conclusion

This thesis presents the problem of heavy computing requirements in the IT industries in these days, particularly because dependency of people on web services has been increasing day by day. How to provide a better service for them is the overwhelming question. Data centers may be helpful for these industries, only if they are designed and optimized in a proper manner. In this thesis we addressed the challenges of web applications, different topology structures and newly introduced clues (solutions) in data centers. Finally we deemed that for high performance data center the existing Internet approaches do not suffice. The design of high bandwidth topology structure and befitting utilization of its resources are the need of the time. The proposals and deliberations in this thesis make an effort to utilize topology structure of a data center to accomplish the requirements of the applications. The topology structures in data centers are well structured, symmetric, have fewer hops and are under the control of single management. This motivates us to capitalize these advantages for the performance improvement of data center.

6.1 SUMMARY

This thesis makes an effort to utilize the topology capabilities of data center. In this thesis, the attributes of data center topology like the number of hops between sender and receiver, the oversubscribed structure and multiple paths between source and destination; are used for improving the performance of data center. The thesis utilizes multiple paths of topology for traffic distribution, in a better way, by increasing fault tolerance. The number of hops between sender and receiver and the oversubscribed structure of topology are used for reducing the latency of flow.

For the sake of reducing the flow completion time of delay sensitive traffic generated by small (mice) flows, this thesis presents TAP, an improved priority scheduling over pFabric. The priority scheme of TAP incorporates the distance (in terms of hop length) between the sender and receiver of a flow with the remaining flow size. The idea of TAP utilizes topology structure by assigning high priority to long distance flows compared to short distance ones. This prioritization ensures that majority of flows get benefited in any structure.

The next work in this thesis JFEPM, utilizes the oversubscribed topology structure of data center. This proposal uses jumbo frames (of size 9000 byte), supported by high speed Ethernet switches, at a high layer of topology in data center networks. JFEPM allows in-network data aggregation by merging the packets of the same flows into a jumbo frame at the sender's ToR switch. These jumbo frames are split into original size packets at the receiver's ToR switch before reaching the destination. The idea of JFEPM is to reduce the frequent switching at higher layer switches through jumbo size frames.

As a last part of this thesis an adaptive, distributed, end host driven and flow-level load-balancing scheme, FlowFurl is presented. Since the topology in data center is well structured, the FlowFurl takes advantage of this property with Fat-Tree topology. FlowFurl is a dynamic flow-to-path assignment approach, in which connectivity information of topology is utilized with congestion information for switching a flow to a new path. In FlowFurl, a source receives less number of ECNbit enabled packets, when a flow has less number of paths. Hence, re-routing of flows with less number of paths to the destination can be reduced. Further, this proposal uses link level local information for deciding new path of a congested flow. In order to reduce the number of re-routing events, this scheme applies the analytic hierarchy process on link level local information.

For validating the ideas proposed in this thesis, extensive simulation studies are performed with various scenarios in different configurations. The simulation results are compared with existing proposals from the same class. These results show the performance improvement in terms of reduction in number of out of order segments, reduction in average flow completion time and tail flow completion time, and number of packets dropped.

6.2 FUTURE WORK

Most of multipath load-balancing schemes in data center network are at flow-level. The flow-level approaches cope up against packet re-ordering problem in case of asymmetry in network. This merit of dealing with asymmetry of flow-level load-balancing attracts the interest of researchers. Load-balancing at packet-level is more efficient compared to flow-level. However, these packet-level schemes suffer from out of order packets problem. For reducing the out of order packet problem in packet-level schemes like MPTCP, we also try to propose an RTT based algorithm which is presented in Annexure A. In future, design of a load aware, packet-level approach will be helpful for data center networks. Further, only the receiver is responsible for the packet reassembling in current scenario. In order to reduce the reassembling at receiver, an on-path reassembling in packet-level scheme can balance traffic more efficiently with less re-ordering.

Rate reservation-based approaches for reducing the latency have been defined in literature. In such schemes, a flow will be accepted only if all switches along the path accept the request. Although it is also possible that, intermediate switches, which are not directly connected with either the sender or the receiver, can also pause the flow due to low availability of bandwidth. In order to avoid flow pausing by intermediate switches, a multipath rate reservation-based scheme can be helpful. With this approach all subflows of a flow can request some friction of its desired rate, and if any of the subflows is accepted on any of the path, then the subflow can start transmission. This accepted subflow will lower down the desire rate of flow in future. The rate reservation-based scheme can also be implemented over MPTCP.

...