Study on Multicast Network Optimization Based on SDN

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論　文　内　容　の　要　旨

Today's networking infrastructure system has been maintained almost in the same form for decades, while a lot of new services have been introduced and almost these services came with new control requirements, which in turn led to increasing network complexity that facing significant networking issues, such as Quality of Service (QoS), security, mobility and management. The network research community, have proposed many new ideas for solving these networking issues. However, these ideas often include nonstandard aspects that required change in current networks. It is difficult to incorporate these changes into current network technology since, the current technology and devices are installed at a large scale, with numerous devices and protocols, and that they are mostly based on enclosed proprietary network devices, meaning that only equipment vendors can configure and create protocols. Moreover, most current network devices have an integrated control and data plane, forcing service providers to use a repetitive process to configure each device or group of devices of the same brand in an independent way. These reasons does not help the implementation of new ideas that may arise by the research community or by new requirements of network operators. It is becoming increasingly difficult for the traditional networking infrastructure, designed decades ago, to satisfy the requirements of modern application. A solution that is able to meet the future requirements as they arise is needed. This is where the philosophy of Software Defined Networking (SDN) may play an important role. The concept of SDN emerged as a proposal to overcome these limitations. SDN is the next generation of networking architecture that is dynamic, manageable, cost-effective, and adaptable, making it ideal for the high-bandwidth, dynamic nature of today's applications.

Recently, there are several large scale companies interested in using and transiting to SDN technology. However for an efficient transition from current network technology to SDN various issues need to be addressed. This study focuses on optimization approaches for concurrent multicast applications namely, multimedia streams in software defined networks. Thereby, the challenges with multimedia traffic routing should be highlighted, this study address the following three important challenges in this regards.

1) IP network uses multicast as an effective method to maximize network resources utilization. However, widespread support of IP multicast is unavailable due to technical and economical reasons, leaving the floor to application layer multicast which increased traffic load for the

network, because of the responsibility for management of multicast groups is distributed among network routers, routing rules calculated based on local view and difficulties to obtain on-time network traffic. SDN provides new opportunities for re-engineering multicast protocols that can address current limitations with IP multicast.

To address this problem, the features of SDN is used and a load balance approach for multicast traffic through real-time link cost and switch load modification is presented. In this approach, the OpenFlow controller is used for network load-aware by monitoring on-time network traffic then a new concept *"available link bandwidth"* and *"available switch capacity"* is presented to be used as link and switch weights respectively. The idea is that overall performance of the network could be improved and both link and switch congestion could be avoided by considering the different capacity of each link and switch by using the concept of *"available capacity"* as weights rather than using the concept of *"current utilization"* as weight. The multicast tree was calculated using the extend Dijkstra shortest path algorithm and based on real-time measuring network traffic. The proposed approach evaluated using Mininet network emulation with POX controller. The evaluation prove that the proposed method can improve traffic distribution in network.

2) The previous proposed load balance approach for multicast traffic in SDN can shows that this method can optimize and improve traffic distribution in network and can avoid network congestion. However, using Shortest Path Tree (SPT) algorithm represented by Dijkstra algorithm for calculating multicast tree often can optimize each path in the tree but can't optimize overall multicast tree. To optimize overall multicast tree the Minimum Steiner Tree (MST) algorithm is needed. MST is NP Hard problem and always there is a negotiation between SPT that can calculate multicast tree faster than MST and the MST that can generate solutions optimum than SPT.

To that end, a novel approach for constructing the multicast tree by combines both of Dijkstra shortest path algorithm and heuristic Tabu Search (TS) algorithm is presented. In the proposed method Dijkstra algorithm and TS work respectively for fast start-up multicast session and minimizing the size of the routing tree solution with increasing in the number of multicast group size. Proposed algorithm take the advantages of both algorithms such as fast convergence time of Dijkstra algorithm and optimum solution of TS and avoid the shortages of both algorithms. The results prove that the proposed approach can improve start-up time for initialization multicast session. Also, can minimize the constructed multicast tree.

3) Latency in a network is an important parameter that can be utilized by a variety of applications which required unicast or multicast QoS policies. Several methods for monitoring latency have been introduced. However, most of these methods monitor end-to-end path delay (delay per path) by sending probes requests along the path. These methods led to redundant work and network overhead, which resulting from monitoring multiple paths between each pair of nodes. Moreover, end-to-end probes cannot monitor the delay on path segments (delay per

link) between arbitrary network devices. Monitoring delay per link is more efficient than per path delay for a lot of applications. However, measuring per link delay is challenging.

To address this challenge, the link-based delay monitoring method using OpenFlow in real-time is proposed, this method does not require any complementary support from the switching hardware and can avoid redundant work and network overhead. The key idea is to build a tree that includes all the possible paths that cover all network links from the monitoring point and eliminate redundant measurement paths to reduce the number of packets for measurement. The advantage of the proposed method is the reduction of the number of OpenFlow rules and probing costs that required for monitoring. The results prove that the proposed method can avoid redundant work and network overhead.