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Research Article

Sorted-GFF: An efficient large flows placing mechanism in software defined network datacenter

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Abstract

The emerged SDN innovation moves the intelligent routing functions out of forwarding devices into the centralized controller to provide the centralization and flexibility. It detaches the two planes (control and data) via its new architecture and programming solutions. Data centers benefit from SDN capabilities in the modern scalable network environments and tends to be managed by a central entity basing on its global view and intelligent dynamic decisions. Researches showed that elephant flows carried the largest amount of data in such data centers. These Large flows need to be detected and managed to enhance the resources utilization of the recent multi-path topologies.

In this work, we developed the requirements for an efficient TE mechanism basing on an intelligent elephant flows management, and proposed the Sorted-GFF flow scheduler. Mininet simulation is used to calibrate the performance of the Sorted-GFF as compared to the GFF and the ECMP routing via examining them on a scalable low cost fat tree data center for various generated traffic patterns.

Keywords: SDN; Load balancing; Elephant flow; Flow scheduling; Data center

1. Introduction

1.1. SDN in data centers

Software Defined Networking (SDN) is an emerging paradigm that detaches the control plane from the data forwarding plane with a promise of improving the infrastructure utilization, simplifying the management with a reduced cost, promoting innovation and easier evolution. It provides the flexibility through the centralization and presents the programmability in networking. The network controller became the best candidate to make the rerouting decisions and tolerate the possible faults. New competitive traffic engineering flavors became possible through this separation. A centralized controller and the effective load balancing of SDN mechanisms enhanced the performance of the recent huge size network and *Data Center* (a site where multiple servers are co-located).

The variety of SDN applications in the data centers generates two main types of flows generally; latency and throughput sensitive. The up to a few kilobytes size flows that are generated by network protocols

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(such as ARP and DNS) and interactive applications are usually considered as latency-sensitive flows. On other hand, the flows that are created by an applications or events like MapReduce, scientific computing, and virtual machine migration are transferring up to gigabytes and considered as throughput-sensitive flows. Thus, the recent datacenter networks need to present an efficient data delivery for both types by accommodating the high bisection bandwidth demands of the throughput-sensitive flows with an accepted setup delay that can adapt the latency-sensitive flows transfer in the same time. The fast computing, the minimum delay, the high storage capacities, the failure tolerance and the fast networking are some associated challenges of any recent large data center to satisfy the QoS-demands of the application requirements. Resources utilization, resiliency and the heterogeneity also left some open research areas in the data center context researches. SDN promised to face the challenges through its centralization and flexibility. Many researches showed that data center networking can benefit from SDN largely, especially with the huge size of live network migration [1], with the management and failure tolerance [2], with the network utilization enhancement [3–5]. Low cost control and minimum flow setup delay of SDN are also concluded by Krishnamurthy [6] in (2014). Fast reaction and efficient VM placement solutions are summarized by Benson [7] in (2011). Real-time monitoring and failure detection are enhanced by the SDN according to recent articles [5]. Detecting abnormal behaviors is reported by Arefin [2] in (2013) to avoid the infrastructure failure. In conclusion, researches showed that it is easier to develop and deploy data center applications with the global view of the SDN, in addition to enforcing the consistency of the scalable data center network policies. Taking into account the exploded size growth of the exchanged data through the nodes of data center is still needed too, to integrate the scalability of these huge data centers.

1.2. An exploded growth in the user demands

Today's large complex data needs specific management tools and methods to be controlled and managed. The generated traffic of different sources, such as the normal web pages, social networks, Internet of Things (IoT), video conferences, media streaming… etc. is increasing exponentially. Global data volume will increase with a factor of 300, from 130 EB in 2005 to 40,000 EB in 2020, representing double growth every two years according to what reported by the (IDC) [8]. An all-to-all transfer of up to petabytes of files during the shuffle phase of a MapReduce [9], the timely migration of large size virtual machines between sites is done in today's high throughput networks. Real-time or near-real-time big data applications will be difficult to be implemented without the underlying support of networking due to their extremely large volume and computing complexity [10]. Today's datacenter switching fabrics need to face the impact of this exploding growth of exchanged information through thousands nodes in the network.

SDN greatly facilitates the big data transmission and processing via its dynamic resources allocation. SDN helps data centers to meet their service level agreements (SLAs). The global central abstraction of the control plane enables obtaining the required monitoring information of different network layers. However, the SDN facilitates designing datacenter networks using some redundant topologies such as HyperX [11], Fat-tree [12], and Flattened Butterfly [13] to solve the high-bandwidth requirement challenge, traffic engineering (TE) is still needed to obtain the best bisection bandwidth utilization and to manage the flow more efficiently. To be applicable and more efficient, recent resources utilization enhancement approaches need to focus on the SDN scalability challenges to face the fast continuous user demands growth.

1.3. SDN implementation and scalability challenges

A primary design level challenge of the SDN networks is the controller functionality. Thus, many researchers studied the SDN controllers' performance, architectures and workloads. NOX-MT [14] micro benchmarks demonstrated that the controller responsiveness is the primary factor among the other performance metrics. He [15] in (2014) presented three measurement-driven techniques that addressed scalability performance regarding path installation time and link utilization depending on their target problem. A series of performance tests using various SDN experimental platforms is presented by Isaia [16] in (2016). The author concluded that the setup time is highly affected by the number of existed switches, the number of failed ping packets increases as the number of links on the path increases. Hu [17] proposed a mathematical metric to quantify the scalability and a similar approach by Karakus [18] in (2016) also proposes a metric to quantify control plane scalability according to the workload ratio. In general, SDN controller proactively or reactively handles or tears

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