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A QoS-aware routing in SDN hybrid networks

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Abstract

Changing the whole network into a software defined network (SDN) is impractical due to high replacement cost. Therefore, there exist SDN hybrid networks, where SDN switches and legacy switches coexist at the same time. In this paper, we propose an SDN hybrid network architecture which can discover existence of legacy switches by using the Spanning Tree Protocol and thus have a global view of the SDN hybrid network. We also enable OpenFlow switches to cooperate with legacy switches by using the Learning Bridge Protocol without requiring any modification on legacy switches. By utilizing the characteristics of SDN, SDN applications can dynamically find routing paths according to pre-defined QoS requirements and current network status. We also propose a *simulated annealing based QoS-aware routing* (SAQR) algorithm which can adaptively adjust weights of delay, loss rate and bandwidth requirements in a cost function to find the best fit path according to QoS requirements. We evaluate the proposed SAQR in a simulated SDN hybrid network which runs applications with different QoS requirements. Simulation results show that the SAQR performs better than related work MINA in terms of the fitness ratios of delay, loss rate and bandwidth, with 88%, 90.8% and 86.5% of flows meeting their respective QoS requirements, in contrast to MINA, with only 63%, 82.4% and 87.5% of flows meeting their respective QoS requirements.

Keywords: *Data center; hybrid network; QoS-aware; routing; SDN*

1. Introduction

The software defined network (SDN)[1] is a novel network architecture which separates the control plane and the data plane, and the network is managed by a logically centralized controller. This architecture has two benefits:

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1) *Centralization*: A logically centralized controller can maintain a global view of the whole network, and this enables the controller to make a better decision than that in the traditional network. 2) *Abstraction*: It enables network managers to write applications deployed on the controller to control OpenFlow[2] switches and to prevent vendor lock-in. Although SDN has the benefits mentioned above, changing the whole network into an SDN network is impractical due to high replacement cost. So evolutionary deployment is a feasible way for data center networks to benefit from SDN. This is so called "hybrid networks" or "transition networks" [3, 4]. In an SDN hybrid network, we will encounter two main problems: 1) how to let the SDN controller have knowledge about the SDN hybrid network, 2) how to let OpenFlow switches and legacy switches cooperate with each other.

Related studies designed some SDN applications for SDN hybrid networks, such as link failure recovery and rerouting applications[5, 6]. However, their controllers need pre-built network topologies that include legacy switches. This is inflexible since the controller cannot grasp an SDN hybrid network topology automatically. In this paper, we use characteristics of STP (Spanning Tree Protocol) and LBP (Learning Bridge Protocol), which run on L2 legacy switches to solve the above two problems. Our proposed architecture can build an SDN hybrid network topology by discovering existence of legacy switches. We indirectly control legacy switches without modifying them for elastic routing, and this enables the proposed architecture to have better network utilization than Panopticon[4].

In addition to big data applications, more and more applications run in data centers have their own QoS requirements. Related studies proposed solutions on how to dynamically route flows by QoS requirements, but they considered only one constraint[7, 8]. We deal with this problem by proposing a simulated annealing (SA) based QoS-aware routing (SAQR) algorithm that runs on SDN hybrid networks and addresses multiple constraints. The proposed SAQR can fit the current network status and will not get stuck in a local optimum.

Our research makes two main contributions: 1) An SDN hybrid network architecture is proposed that can deploy partial SDN switches for data centers transiting from traditional networks to SDN networks and let applications do elastic routing by applying network topology discovering and controlling mechanisms to legacy switches. 2) The proposed SAQR can adaptively adjust weights of delay, loss rate and bandwidth deviations in a cost function to find the best fit routing path that meets *multiple* QoS requirements (or constraints). Simulation results show that the proposed SAQR is better than MINA[9], in terms of meeting delay, loss rate and bandwidth requirements.

2. Related work

2.1. SDN hybrid networks

The SDN hybrid network is a widely discussed problem recently because evolutionary deployment of SDN is practical for enterprises. The first thing we need to consider when deploying partial SDN switches into the network is that which and how many legacy switches should be replaced. In Panopticon[4], it simulated an enterprise network using a traffic matrix and VLAN (Virtual LAN) IDs to analyze an SDN deployment plan. In Chu et al.[5], authors used a heuristic algorithm to deploy as few SDN switches as possible, but can do recovery when detect any single link failure in the network. In Das et al.[10], authors used a greedy algorithm to decide which switches should be replaced to increase as many alternative paths as possible. After we decide where to place SDN switches, we need to let SDN switches and legacy switches cooperate with each other. In Panopticon[4], an entire network is separated into several SCTs (Solitary Confinement Trees) that each of them includes a host, a spanning tree built by legacy switches, and at least one SDN switch as a frontier for inter-domain routing. This will separate the whole network into several domains, and SDN switches will act as routers to do routing decisions. In Chu et al.[5], authors proposed an SDN hybrid network link failure recovery strategy. When a link failure occurs, it will use an IP-tunnel to construct a new path under the hybrid network. In the following, we address the issues of pre-built topology or network discovery in SDN hybrid networks. In Vissicchio et al.[3], authors classified hybrid networks into four classes: topology-based, service-based, class-based and integrated SDN hybrid networks, and analyze features and implementation challenges of each class. In Telekinesis[6], authors used SDN switches to indirectly control legacy switches by characteristic of LBP, in order to reroute packets to a new path. The related works mentioned above need a pre-built network topology for the SDN controller to have a global view of the hybrid network. In contrast, in our research, we intend to design a network topology discovery method that allows the SDN controller to build a hybrid network topology automatically, and to indirectly control legacy switches without modifying them for elastic routing.