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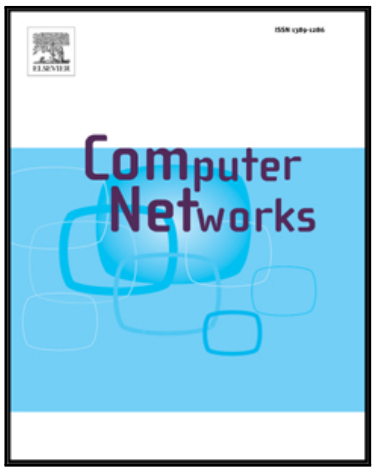

Scalable Orchestration of Software Defined Service Overlay Network for Multipath Transmission

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Abstract

Multipath transmission on overlay network is proved to effectively improve transmission quality for Internet applications requiring stringent QoS guarantees, e.g., real-time conversational applications. The orchestration of overlay nodes is the basis of overlay multipath transmission, which fundamentally impacts the management, control and transmission quality of overlay network. In this paper, we introduce SDN (Software Defined Networking) paradigm to orchestrate overlay nodes for optimal global management and intelligent forwarding control and we name the overlay multipath framework Software Defined Service Overlay Network (SDSON). To achieve efficient and reliable orchestration of nodes in SDSON, we focus on two major challenges, 1) the match between overlay and underlay networks for reducing the transmission quality degradation from the uncertainty of overlay paths, 2) the enhancement of scalability for eliminating control plane bottleneck of SDSON centralized structure. Correspondingly, we propose a scalable overlay orchestration structure. 1) coordinate-based global topology view of overlay nodes is employed to characterize and constrain relationships between overlay nodes. Coordinates are generated by using MDS-MAP to convert measured delays. And a balanced-binary-tree measure method is designed to balance measure loads. 2) The two-level distributed control plane is designed by decoupling control and management functions in control plane and together a novel collaborative control mechanism. The first level focuses on global management and the second concentrates on conducting global control with the collaborative control mechanism among distributed controllers. We use modified ISODATA with density-based initialization improvement to partition global topology view into distributed sub-domains, which are governed by controllers composing the second level control plane. Evaluations on OMNeT++ demonstrate that coordinate-based view matches well with practical underlay networks, sub-domains partition quality outperforms classical algorithms, and the scalable control planes with collaborative control mechanism alleviate control pressure and improve control performance efficiently.

Keywords: collaborative control; multipath transmission; overlay orchestration; scalability; software-defined networking; topology match

1. Introduction

At present, wide varieties of Internet applications and network transmission capability promote and motivate each other mutually. Though the link capacity and node connectivity of network infrastructures deployed by internet service provider are increasing in various stages [1], existing and emerging Internet applications impose higher demands and new challenges on current transport networks. Applications belonging to conversational class [2, 3], e.g., instant video conversation or instant virtual reality, require the most strict quality of service (QoS) guarantee including high bandwidth consumption, low latency tolerance and smooth procedure. Experiences of these applications are impacted significantly by random congestion or bandwidth bottleneck occurring on certain links. End-to-end (E2E) QoS is difficult to guarantee mainly due to best effort and traditional single path routing policies of IP layer [4, 5, 6]. A reformative but effective solution on current networks is multipath transmission, and representative works based on application layer include [7, 8, 9, 10, 11, 12, 13]. In our previous work MPTS-AR (Multipath Transmission System based on Application-level Relay), an application-level relay-based multipath transmission framework is designed [14, 15, 16, 17]. In order to achieve global efficient orchestration, intelligent multipath routing and optimal transmission quality, SDN (software-defined networking) paradigm is introduced into MPTS-AR, so comes up the Software-Defined Service Overlay Network (SDSON). SDSON possesses advantages of SDN, separation of forward and control, centralized control and programmable interface [18, 19], moreover, thanks to its overlay features, SDSON is capable to provide Internet-wide multipath transmission service with E2E QoS guarantee yet brings no modification to existing underlay bearing networks [14, 16]. Orchestration structure of overlay nodes is a primary and crucial challenge not only in SDSON but also in universal overlay networks. It is the basis of routing and management for overlay networks, so that it should be convenient for efficient routing and be robust. So in this paper, we consider the orchestration structure of SDSON from two perspectives 1) the structure should commendably serve generating efficient multiple overlay paths (routing), and 2) the scalability of the centralized control plane of SDSON should be enhanced.

1) Orchestration structure has significant impacts on overlay routing. One important aspect is the match between topologies of overlay and underlay networks[20, 21, 22, 23]. Many classical solutions for overlay orchestration have been proposed and widely used, e.g., Chord [24], CAN [25],Pastry [26], and

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