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Bandwidth-aware energy efficient flow scheduling with SDN in data center networks

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HIGHLIGHTS

- We describe and model the energy efficiency problem for deadline specified flows.
- We propose a bandwidth-aware energy efficient routing algorithm with SDN.
- We evaluate the energy efficiency and flow completion time in OMNeT++ simulations.

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ABSTRACT

Nowadays the energy consumption has become one of the most urgent issues for Data center networks. For general network devices, the power is constant and independent from the actual transfer rate. Therefore the network devices are energy efficient when they are in full workload. The flow scheduling methods based on the exclusive routing can reduce the network energy consumption, as the exclusive routing paths can fully utilize all their links. However, these methods will no longer guarantee the energy efficiency of switches, as they handle flows in priority order by greedily choosing the path of available links instantaneously. In a previous work we proposed an extreme case of flow scheduling based on both link and switch utilization. Herein we consider general scenarios in data center networks and propose a novel energy efficient flow scheduling and routing algorithm in SDN. This method minimizes the overall energy for data center traffic in time dimension, and increases the utilization of switches and meet the flow requirements such as deadline. We did a series of simulation studies in the INET framework of OMNet++. The experiment results show that our algorithm can reduce the overall energy with respect to the traffic volume and reduce the flow completion time on average.

1. Introduction

Cloud is a "hot" research topic at the moment, with interests in security [1–6], privacy [6,7], forensics [8–15], and achieving efficiency [16] in Data Center Networks(DCNs). For DCNs, the increasing energy consumption has been restricting the sustainable growth of cloud services and raises economic and environmental crisis. The Power Usage Effectiveness (PUE) of typical DCNs ranges from 1.3 to 3.0, as reported from the Green Grid in 2012 [17]. Among data center energy consumptions, the increasingly salient network energy contributes 20% of the whole power consumption typically [18] and even 50% when we use the server power management techniques [19,20]. Basically, the DCN architectures built with rich connections can achieve high network performance by multi-party routings, however, the architectures waste energy for two reasons. Firstly, the network devices are in low utilization as the DCN traffic is typically smaller than the peak, especially in the traffic valley time [21]. On the other hand, the power of network devices is nearly constant when the traffic speed changes [22].

Traffic aggregation and scheduling techniques are widely adopted in the existing work of energy efficient DCN networking. The former can shape the traffic distributions while the latter can manage the traffic admissions. The traffic aggregation methods [23–26] can aggregate traffic into fewer switches/ports and turn more switches/ports into sleep to obtain a minimum power for a given traffic matrix. The traffic scheduling methods can suspend the delay-insensitive traffic until energy efficient paths are available, achieving more energy savings with acceptable completion time. As an extreme case of the traffic scheduling, the exclusive routings [27,28] keep the rule that each link serve a flow at

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