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On Dependability Traffic Load and Energy Consumption Tradeoff in Data Center Networks

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Mega data centers (DCs) are considered as efficient and promising infrastructures for supporting numerous cloud computing services such as online office, online social networking, Web search and IT infrastructure out-sourcing. The scalability of these services is influenced by the performance and dependability characteristics of the DCs. Consequently, the DC networks are constructed with a large number of network devices and links in order to achieve high performance and reliability. As a result, these requirements increase the energy consumption in DCs. In fact, in 2010, the total energy consumed by DCs was estimated to be about 120 billion Kilowatts of electricity in 2012, which is about 2.8% of the total electricity bill in the USA. According to industry estimates, the USA data center market achieved almost US 39 billion in 2009, growing from US 16.2 billion in 2005. One of the primary reasons behind this issue is that all the links and devices are always powered on regardless of the traffic status. The statistics showed that the traffic drastically alternates, especially between mornings and nights, and also between working days and weekends. Thus, the network utilization depends on the actual period, and generally, the peak capacity of the network is reached only in rush times. This non-proportionality between traffic load and energy consumption is caused by the fact that -most of the time- only a subset of the network devices and links can be enough to forward the data packets to their destinations while the remaining idle nodes are just wasting energy. Such observations inspired us to propose a new approach that powers off the unused links by deactivating the end-ports of each one of them to save energy. The deactivation of ports is proposed in many researches. However, these solutions have high computational complexity, network

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delay and reduced network reliability. In this paper, we propose a new approach to reduce the power consumption in DC. By exploiting the correlation in time of the network traffic, the proposed approach uses the traffic matrix of the current network state, and manages the state of switch ports (on/off) at the beginning of each period, while making sure to keep the data center fully connected. During the rest of each time period, the network must be able to forward its traffic through the active ports. The decision to close or open depends on a predefined threshold value; the port is closed only if the sum of the traffic generated by its connected node is less than the threshold. We also investigate the minimum period of time during which a port should not change its status. This minimum period is necessary given that it takes time and energy to switch a port on and off. Also, one of the major challenges in this work is powering off the idle devices for more energy saving while guaranteeing the connectivity of each server. So, we propose a new traffic aware algorithm that presents a tradeoff between energy saving and reliability satisfaction. For instance , in HyperFlatNet, simulation results show that the proposed approach reduces the energy consumption by 1.8*104 WU (Watt per unit of time) for a correlated network with1000-server (38 % of energy saving). In addition, and thanks to the proposed traffic aware algorithm, the new approach shows a good performance even in case of high failure rate (up to 30%) which means when one third of the links failed, the connection failure rate is only 0.7%. Both theoretical analysis and simulation experiments are conducted to evaluate and verify the performance of the proposed approach compared to the state-of-the-art techniques.