Chapter 16
Energy Efficient Content Distribution

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ABSTRACT

In this chapter, the authors investigate the power consumption associated with content distribution networks. They study, through Mixed Integer Linear Programming (MILP) models and simulations, the optimization of data centre locations in a Client/Server (C/S) system over an IP over WDM network so as to minimize the network power consumption. The authors investigate the impact of the IP over WDM routing approach, traffic profile, and number of data centres. They also investigate how to replicate content of different popularity into multiple data centres and develop a novel routing algorithm, Energy-Delay Optimal Routing (EDOR), to minimize the power consumption of the network under replication while maintaining QoS. Furthermore, they investigate the energy efficiency of BitTorrent, the most popular Peer-to-Peer (P2P) content distribution application, and compare it to the C/S system. The authors develop an MILP model to minimize the power consumption of BitTorrent over IP over WDM networks while maintaining its performance. The model results reveal that peers co-location awareness helps reduce BitTorrent cross traffic and consequently reduces the power consumption at the network side. For a real time implementation, they develop a simple heuristic based on the model insights.

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INTRODUCTION

The intrinsic goal behind the creation of the Internet was, and still in most applications is, distributing various kinds of content. Therefore, efficient and cost effective content distribution strategies have played a major role in changing the Internet architecture over the years (Gill, Arlitt, Li, & Mahanti, 2008). Content delivery clouds provide an integrated overlay to utilize cloud computing in delivering content to end-users (Pathan, Broberg, & Buyya, 2009). The increased popularity of the cloud has created large energy consumption burden on the data centers hosting these clouds and the networks connecting the data centres to end users. The optimization of networks connecting data centres and data centres locations is an appealing topic to investigate when designing infrastructure for cloud computing. Optimizing the locations of data centres hosting the clouds plays a vital role in the energy efficiency of clouds at the network side. The presence of data centres in a network can create a hot node scenario where more traffic is destined to or originates from a data centre node, leading to a significant increase in the power consumption of data centre nodes. In this work, we study the power consumption of IP over WDM networks that contain data centres. We determine the optimal location of a data centre or multiple data centres in IP over WDM networks through linear programming and simulations and study how to replicate content that has different popularity to minimize power consumption.

In contrast to the centralized data centres paradigm, Peer-to-Peer (P2P) protocols are emerging as an efficient content distribution approach (Lua, Crowcroft, & Pias, 2005). BitTorrent, the most popular P2P application, has proven to be a near optimal solution that overcomes many issues other P2P protocols suffer from such as scalability, fairness, churn and resource utilization. BitTorrent traffic accounts for 17% to 50% of the total Internet upload traffic in some segments (House, 2011), (Global Internet Phenomena Report, 2011). The current BitTorrent implementation is based on random graphs since such graphs are known to be robust (Cohen, 2003), yet random graphs mean that BitTorrent is location un-aware which represented a burden on ISPs for many years (Bindal, Cao, & Chan, 2006) as traffic might cross their networks unnecessarily causing high fees to be paid to other ISPs. The majority of the research in energy aware BitTorrent has focused on the power consumption at the peers' side neglecting the impact of BitTorrent on the network side. In this work, we also investigate the energy consumption of BitTorrent in IP over WDM networks considering different IP over WDM approaches. We show, by mathematical modelling and simulation, that peers' co-location awareness, known as locality, helps reduce BitTorrent's cross traffic and consequently reduces the power consumption of BitTorrent on the network side. Note that in the IP over WDM network scenario, the peers' locations refer to the IP over WDM nodes rather than ISPs Autonomous System (AS).

ENERGY EFFICIENT CONTENT DISTRIBUTION

Recently, energy efficient content distribution has been attracting increasing research efforts. In (Mandal et al., 2011) the authors studied the savings in power consumption for a content delivery network with a distributed hosting network over an optical network infrastructure. The results in (Jayasundara et al., 2011) provide insight into content placement strategies that improve energy efficiency. The authors in (Li, Liu, and Wu, 2013) have built a model to study energy efficient caching for Content-Centric Networking (CCN) architecture. In (Xu et al., 2010) the authors improved the energy efficiency in video CDN system based on the idea of intelligent coordination among edge video servers. In (Kantarci & *Mouftah, 2012*) the authors proposed an optimized provisioning