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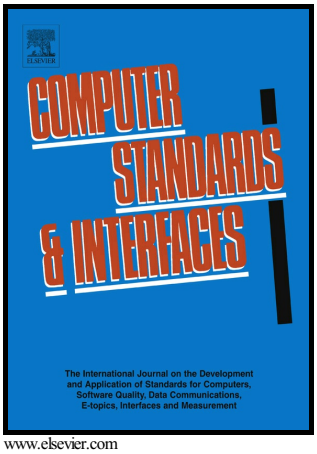

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Energy Saving Carrier-Grade Networks: A Survey

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Abstract

Energy consumption of large-scale networks has become a primary concern in a society increasingly dependent on information technology. Novel solutions that contribute to achieving energy savings in wired networks have been proposed to mitigate ongoing and alarming climate change and global warming. A detailed survey of relevant power-saving approaches in wired networks is presented here. We give a special focus on carrier-grade networks. At first we perform a comprehensive study of communication infrastructures regarding energy saving. Then, we highlight key issues to enable green networks, ranging from network design to network operation. After that, we present the major contributors to power consumption in wireline networks. Afterwards, we survey, classify, and compare the main energy-aware methods and mechanisms that are the most appropriate for improving the energy efficiency of carrier-grade networks.

Keywords—Green networking; wired networks; energy consumption in network devices; energy-aware traffic engineering; carrier grade networks

I. INTRODUCTION

Reducing electricity bills and energy consumption has become a crucial goal for all industries, including the Information and Communication Technology (ICT) sector, as it is rapidly becoming an important play-actor in daily life [1, 2]. The alarming figures reported by worldwide energy consumption have pushed telecom operators to rethink their network policy [3]. Nowadays, the function of the ICT is progressed by addressing energy awareness in all phases of production and service delivery. Energy-aware studies in communication networks, especially with respect to the environmental conditions, are commonly referred to as green networking.

As the traffic demand continues to grow, it requires additional network resources with higher capacity and faster processing speeds. Moreover, the improvements in network infrastructure drive the quest for green networking. In particular, for transport and carrier grade networks, represent permanent and extensive resources of power consumers. For instance, data center operators require a considerable amount of power to operate server stacks, storage equipment, cooling equipment, operation room and so on. Green networking has two main reasons [4]:

1) The enviromental reason: most energy consumption is accompanied by non-negligible GHG (Green House Gas) emission that has harmful consequences on climate. In addition, a decrease in GHG emission volume between 15–30 % is required before 2020 to keep the global temperature increase below 2°C [5].

A large set of telecom operators and Internet Service Providers (ISPs) consider GHG reduction and its ecological impacts. In fact, the volume of carbon dioxide emissions produced by the ICT sector alone is estimated to be over 2% of the total world carbon footprint in 2020 [6]. In 2007, this 2% was equivalent to 830 million metric tonnes of carbon dioxide [7] and it would be about 1100 million tonnes by 2020 [8,9].

Statistical reports provided by certain telecom operators state the overall amount of their power requirements and the related carbon footprint [10–12]. All of these studies show that ICT energy consumption represents an important carbon dioxide emission and will increase rapidly if no green technique is adopted. It might account for more than 35.8 TWh by 2020 [196][197].

2) The economic reason: the rapid increasing of CAPEX (Capital Expenditure) and OPEX (Operational Expenditure) represents a major economical concern. CAPEX is related to network infrastructure establishment cost, whereas OPEX is related to network operation and administration. Energy costs have been investigated by the operators and their financial damage has been put in perspective. Figure 1 shows the constantly rising energy costs. Moreover, [13] anticipates that a one-third reduction of carbon footprint emissions could create an economical benefit greater than the investments required to attain this goal. Table I presents the cost of energy devoted for network devices The estimation of energy consumption is based on the primary/seminal study done by [14], which states the annual electricity consumed by networking devices in the U.S. was 6.06 TWh, which costs USD$1 billion per year and it is equivalent to one nuclear reactor.

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