Bits'–Carrying Capacities of Switched Local Area Networks

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INTRODUCTION

All switched Local Area Networks (switched LANs) have a common parameter, known as 'bits-carrying capacity', which is one of the parameters that network managers and administrators use in managing the performances of the networks. In fact, every network has a limited bits'-carrying capacity; and, an increase in a network's response time, which is a measure of the time between when a user requests a service and the time when the service is granted, is an indication that a network is operating above its bits'-carrying capacity (Forouzan, 2008, p. 876). Knowing the bits'-carrying capacity of any network is therefore, very important with respect to operating/managing the network optimally; that is, the ability to operate the network at all times, at, or near, its bits'-carrying capacity. This is because, if a network is operated above its bits'-carrying capacity, its response time increases, leading to a fall in throughput: on the other hand, it is a waste of resources, to operate a network below its bits'-carrying capacity. However, it appears that there is no available, formal method, or formula in literature for determining this parameter. For example, in Chapter 1 of CISCO CCNA Exploration Companion Guide (2018, p. 15), the following advice was offered to LAN Designers/Installers: When selecting switch hardware for a switched LAN, it is necessary to determine which switches are needed in the core, distribution, and access layers - the three-layer hierarchical network design model enunciated by CISCO CCNA Exploration Companion Guide (2018, p. 2) to accommodate the bandwidth requirement of the LAN. The pertinent question that was not answered in this CISCO documentation, and, has not been answered elsewhere is: How should the bandwidth requirement of a LAN be determined? In this Chapter, the derivation of a formula which can be used to obtain the bits'- carrying capacity (usually referred to as bandwidth by some professionals) of any switched LAN is reported. Also reported, is a formula that can be used to obtain the capacity (that is, bits' capacity, in units, such as, Megabits; Gigabits) to subscribe for, whenever a switched LAN needed to be connected to the network of a service provider, such as connecting the LAN to the Internet via an ISP (Internet Service Provider). Illustrative examples applying both formulas are also given.

BACKGROUND

A common networks' management metric that should always be monitored by the application programs which are used to manage the operations of computer networks is the bits'-carrying capacities. Every

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network has a limited bits'-carrying capacity, and one of the functions, according to Forouzan (2008, p. 876), of a network management system (software) is ensuring that a network is not operated above its bits'-carrying capacity (see also, Rathi, N. Malik, Chahal, & S. Malik, 2014; Zubair, Ahmad, Faraz Ahmad, & Ali, 2014).

Bandwidth-Delay Product (BDP) is the term given to the bits'-carrying capacity of a single link (or bits' pipe) in a network; and, is a quantity obtained by multiplying the bandwidth of the link in bits/second, with the round-trip time (RTT) in seconds (that is, the propagation-delay of the link multiplied by 2). The BDP of a link is a very useful quantity to keep in mind when analyzing the performance of computer-communication networks; because, the BDP as defined by Forouzan (2008, p. 93), is the capacity of the bit-pipe from a transmitter to a receiver, and back to the transmitter (see also, Szymanski, 2016; Rangaswamy & Krishnareddy, 2015; Tanenbaum, 2006, p.559). As an example, if the BDP of a bit-pipe is 60 million bits, a transmitter at one end of the pipe would need to transmit a 60 million bits burst to be able to keep transmitting at maximum rate, until it receives the first acknowledgement: in order words, this is the number of bits it takes to fill the pipe. (Tanenbaum, 2006, p.559) In the words of Kai et al. (2004), BDP-UB (Bandwidth Delay Product – Upper Bound) is a path's upper-bound BDP, and this according to the paper, can be considered as a path's maximum packets (bits) carrying capacity. Attempting to operate a network above its BDP-UB does not lead to the achievement of additional throughput; instead, a fall in throughput occurs when more bits than the BDP-UB are injected into the network. (Kai et al. 2004; Gerd, 1989, p.203) Therefore, it is apparent that, knowing the bits'-carrying capacity of any network is very important for the optimal operation of the network. Comer (2004, p.247) in this context, has averred that network administrators and managers are generally agreed on the position that, networks should not be operated above 90% of their bits'-carrying capacities.

FOCUS OF THE ARTICLE

Deriving from the points-of-views that were highlighted in the previous sections, the following main question becomes pertinent: How therefore, should the bits'-carrying capacities of switched LANs be determined? Switched LANs to the best of the knowledge of the research team involved in this work are just arbitrarily installed, without the capacities being known, and, various ad-hoc approaches are usually used for the network management, using network management application programs as the main aids. The research team involved in this work has also not seen it reported in literature, or documented elsewhere of an approach, or, approaches for the determination of the bits'-carrying capacities of switched LANs. Information and Communication Technology (ICT) Managers/Administrators of the Networks of organizations, and, switched LANs Designers/Installers, also appear not to have formal basis for the determination of the bits' capacities (which some erroneously refer to as bandwidths – erroneous because, the unit of interest in this context, is bits, and not, bits/second), which they should advise the management of the organizations they are working for to purchase from Service Providers like ISPs, for Internet access purposes. The capacity (in bits) requirement of any organization for the purpose of Internet access is unarguably, a function of the capacity of the installed base of its LAN – that is, how large the LAN is in terms of the number of its connected end users, which in turn, determines the number of switches that would be installed in the LAN. These ideas are illustrated in Figure 1. From experience subscriptions for bits' capacities has largely been done arbitrarily, using, rule-of-thumb approaches in most cases. The need to provide solutions to these problems was the motivation for the work reported in this article.