Dynamic Link Control with Changing Traffic for Power Saving

Yutaka Fukuda, Takeshi Ikenaga, Hitomi Tamura, Masato Uchida, Kenji Kawahara, and Yuji Oie
Network Design Research Center
Kyushu Institute of Technology
Kawazu 680-4, Iizuka 820-8502 Japan.
{ytk, ike, tamu, m.uchida, kawahara, oie}@ndrc.kyutech.ac.jp

***Abstract*—The scope of this proposal is greening technology in a network area. Our major purpose in this study is to develop a method for achieving power conservation with a network itself. One of the effective ways for power conservation is to have a network switch which can adapt its processing speed to arrival traffic rate just as Intel's Speedstep technology [4], because existing switches fully work regardless of a traffic amount. We first confirm that whether the difference in transmission capacity influences the power consumption at switch, and show that a Giga bit Ethernet port consumes 2 or 3 W with an addition of a link. Therefore, we can conclude that the dynamic control for transmission capacity with traffic volume is one of the important and effective ways to reduce the power consumption in a network. Based on this consideration, we propose a scheme to achieve the dynamic control of the transmission capacity between switches in order to reduce the power consumption, based upon the change in traffic volume. In this context, Link Aggregation is used to dynamically and gradually control the transmission speed. As for the demo system, Ethernet Bonding (trunking) technology is used to form a single logical link. Two PCs, which emulate the network switch, dynamically control the number of links according with the changing arrival traffic. This demo is intended to explicitly show the possibility of power conservation with a network itself by adapting the transmission capacity to arrival traffic.**

***Index Terms*—Power saving, Link aggregation, IEEE 802.3ad, Link Aggregation Control Protocol**

I. Introduction

The scope of this proposal is greening technology in a network area. Previous studies showed that the energy consumption by Internet devices in the U.S. increased more than threefold from 2000 to 2006 [1], [2]. Furthermore, Cisco Systems forecasted that global IP traffic would increase fivefold from 2008 to 2013 [3]. In order to accommodate this growing IP traffic, the increase of power consumption in a network area is expected. Therefore, our major purpose is to develop a method for achieving power conservation with a network itself.

One of the effective ways for power conservation is to have a network switch which can adapt its processing speed to arrival traffic rate just as Intel's Speedstep technology [4], because existing switches fully work regardless of a traffic amount. In this context, we first confirm whether the difference in transmission capacity influences the power consumption at switch. We connect two switches by a UTP cable, add links between switches one by one, and measure the power consumption in each number of links. Experiments show that a Giga bit Ethernet port consumes 2 or 3 W with an addition of a link. The same results are reported in [5], thus, we can conclude that the dynamic control for transmission capacity with traffic volume is one of the important and effective ways to reduce the power consumption in a network.

Here, we examine a scheme for achieving the dynamic control of the transmission capacity between switches in order to reduce the power consumption, based upon the change in traffic volume. In this context, Link Aggregation is used to dynamically and gradually control the transmission speed. As for the demo system, Ethernet Bonding (trunking) technology is used to form a single logical link. Two PCs, which emulate the network switch, dynamically control the number of links according with the changing arrival traffic. This demo is intended to explicitly show the possibility of power conservation with a network itself by adapting the transmission capacity to arrival traffic. The investigation of the proposed scheme regarding both the power saving ability and the effect on communication quality is examined in [6]. As for how much the proposed scheme saves the power consumption in real switches, it is difficult to predict because the power conservation depends on the traffic characteristics. In addition, further discussions with vendors are required to accommodate the proposed scheme with corresponding functions in switches, which we intend to work in near future.

In Section II of this proposal, we explain how our scheme can estimate changes in traffic volume and establish the number of links using Link Aggregation between switches, followed by the explanation of our demo system in Section III.

II. Dynamic Link Control Scheme

Our proposed scheme dynamically controls the transmission capacity between switches depending on the change in traffic volume by using Link Aggregation. Link Aggregation, which is used in many backbone switches to increase the transmission speed, is standardized in IEEE 802.3ad [7], in which LACP (Link Aggregation Control Protocol) is defined as a method to form a single logical link between switches by combining the multiple physical links. The switch implementing LACP can automatically form an aggregated link and follow changes in the condition of link state, such as link failure and physical

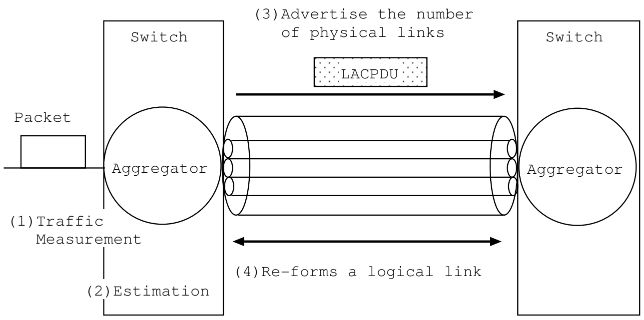

Fig. 1. Modification of LACP.

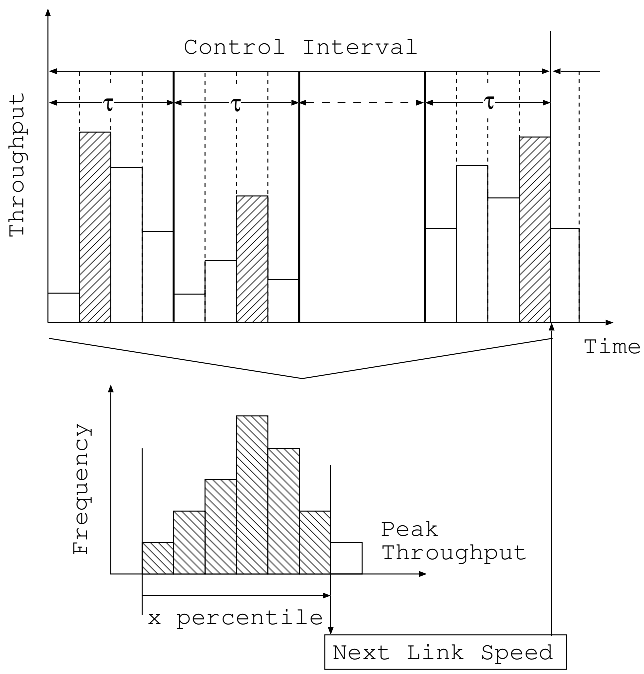

Fig. 2. Estimation Scheme.

link addition by sending LACP DU (Data Unit) packet to the peer.

Since LACP does not have a function to form a logical link based on both measurement and estimation of arrival traffic, we slightly modify LACP as illustrated in Fig. 1 where modified processes are described as follows:

1) Switch measures the arrival traffic.
2) Switch estimates the number of links in order to satisfy the traffic demand.
3) Switch sends LACP DU packet to the peer to notify the number of links to form a new logical link.
4) Peer re-forms a logical link with the notified number of links.

The important key in our scheme is the estimation of the required transmission capacity, based on the measurement of arrival traffic. We propose a scheme to determine the transmission capacity (i.e., the number of links to form a logical link) based on the peak value of throughput. More specifically, we estimate the necessary transmission capacity, using the empirical distribution of peak throughput. Although we could use the distribution of peak throughput provided with a precise statistical analysis method, such as Extreme Value Theory, a theoretical foundation for the analyzing rare events, we use empirical distribution as a first step for realizing our idea.

Fig. 2 shows the measurement and estimation process in our scheme. First, the arriving throughput is measured in a very short term, e.g. 1 millisecond, and peak throughput values is recorded in each τ period. At the end of each control interval, an empirical distribution is made from peak throughput, and next transmission capacity is determined as it satisfies a predetermined percentile in the distribution. As the percentile becomes larger, the margin to accommodate any unexpected increase in traffic volume grows. Finally, the determined value of transmission capacity is mapped to the number of links, and the switch forms a new logical link by sending LACP DU to the peer.

III. Demo System

Our demo is implemented with two PCs which emulate the network switch. In order to provide multiple links between PCs corresponding with switch's ports, each PC has 2 NICs which have quad ports. As shown in Fig. 3, each PC is directly connected to the other by eight UTP cables.

As mentioned in Sec. II, our proposed scheme uses LACP to dynamically control the transmission capacity between switches. In order to achieve the same control in the demo system, Ethernet Bonding (trunking) technology is used to form a single logical link.

Traffic is generated and communicated by two note PCs, via the two PCs, which emulate network switch with our proposed scheme. Two PCs dynamically control the number of links according with the arrival traffic, which is randomly varied by traffic generator on note PCs.

Our demo system and GUI are shown in Fig. 4 and Fig. 5. The left side of Fig. 5 visualizes the active number of links which is estimated by our proposed scheme based upon the change in traffic volume. On the right side, presented are the received traffic ratio, number of link change, drop packet, and delay of link. Required space is 180 $\times$ 90 cm, in which the two PCs and two note PCs are deployed. Setup time is approximately one hour. Our demo system, consisted of two PCs, two note PCs, and a display, requires approximately 15 ampere of power. Wired internet access is needed for PC's maintenance. The equipments used in our demo are summarized in Table I.

TABLE I
The equipment in demo system.

PCs	2
Note PCs	2
Display	1
UTP Cables	10

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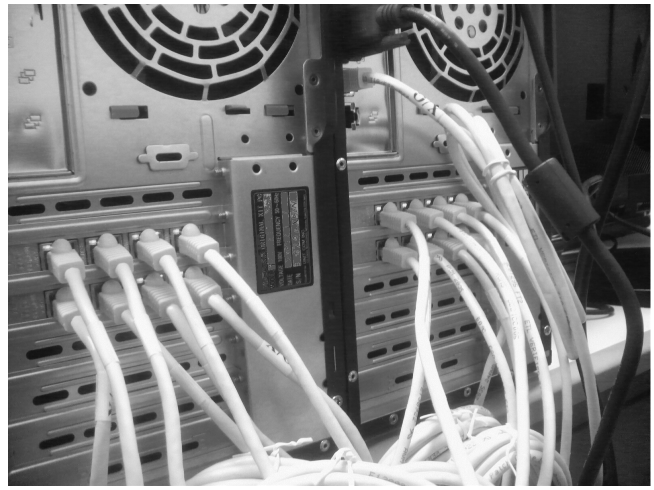

Fig. 3. Two PCs are connected by eight cables with each other.

Fig. 4. Demo System.

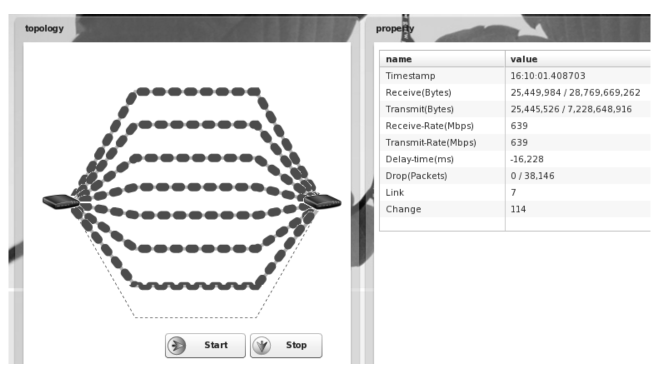

Fig. 5. GUI.