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Performance Evaluation of Power Saving Scheme with Dynamic Transmission Capacity Control

Network Design Research Center,
Kyushu Institute of Technology
Yutaka Fukuda, Takeshi Ikenaga, Hitomi Tamura, Masato Uchida, Kenji Kawahara, and Yuji Oie

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Outline

- Power Consumption of the Internet
 - network itself should have some functions for achieving or enhancing the power saving in a network
- Preliminary Survey
 - What function is effective for achieving power saving with a network itself?
- Objective
 - develop a scheme to achieve the dynamic control of the transmission capacity based upon the change in traffic volume
- Proposed scheme
 - estimate the transmission capacity based on the peak value of throughput
- Simulation Results
 - examine the effectiveness from viewpoints of both power conservation and communication quality
- Demonstration System of the Proposed Scheme
- Conclusion

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Power Consumption of the Internet is growing

- Energy Consumption of networking device in the U.S. in 2000
 - Kurt W. Roth et al, "Energy Consumption by Office and Telecommunications Equipment in Commercial Buildings Volume I: Energy Consumption Baseline"

Device	Device Number	Total Electricity Consumption
Hubs	93.5 Million	1.6 TW-h
LAN Switch	95,000	3.2 TW-h
WAN Switch		0.15 TW-h
Router	3,231	1.1 TW-h
Total		6.05 TW-h

requires one nuclear reactor unit

- It was 20 TW-h in 2006
 - B. Nordman, "Networks, Energy, and Energy Efficiency," presentation at Cisco Green Research Symposium, March 2008.

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Internet Traffic

- The provided bandwidth in the Internet

Global Internet Geography Executive Summary, TeleGeography Research

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Forecast of the global IP traffic

- Global IP traffic would increase fivefold from 2008 to 2013
 - Cisco Visual Networking Index: Forecast and Methodology, 2008–2013
- This growing IP traffic causes the increase of power consumption in a network area
- "Green of ICT"
 - network itself should have some functions for achieving or enhancing the power saving in a network

develop a method for achieving power conservation with a network itself

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Preliminary Survey

- What function is effective for achieving power saving with a network itself?
- How power consumption of switch does change with a network utilization?
- measure the power consumption of a switch at each number of PCs

power consumption rises with the increase of number of PCs

dynamic control of link up/down is one of the important and effective ways to reduce the power consumption in a network

Objective

- Transmission method using multiple links
 - Link Aggregation (IEEE 802.3ad) is used in many backbone switches to increase the transmission speed
 - assume the switches connected by the LACP (Link Aggregation Control Protocol)

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propose the scheme for achieving the power saving by dynamically control the transmission capacity between switches based upon the change in traffic volume

Processes of Modified LACP

- The switch implementing LACP
 - automatically form an aggregated link and follow changes in the condition of link state by sending LACP DU (Data Unit) packet to the peer
- The LACP does not have a function to form a logical link based on both measurement and estimation of arrival traffic

- Switch measures the arrival traffic.
- Switch estimates the number of links in order to satisfy the traffic demand.
- Switch sends LACP DU packet to the peer to notify the number of links to form a new logical link.
- Peer responds with the required transmission capacity based on the measurement of arrival traffic?

Abstract of the Proposed Scheme

- determine the transmission capacity based on the peak value of throughput

Proposed Scheme (1)

- the arriving throughput is measured in a very short term, e.g. 1 msec.
- Peak throughput values is recorded in each τ period
- At the end of each control interval
 - a distribution is made from peak throughput

Proposed Scheme (2)

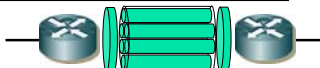
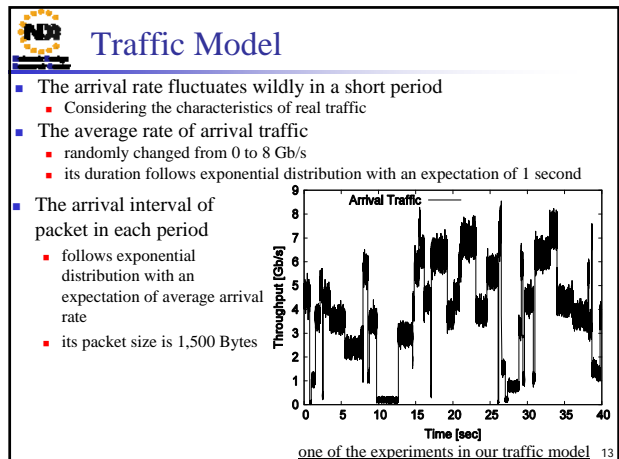
- Next transmission capacity is determined as it satisfies a predetermined percentile in the distribution
 - As the percentile becomes larger, the margin to accommodate any unexpected increase in traffic volume grows

Proposed Scheme (3)

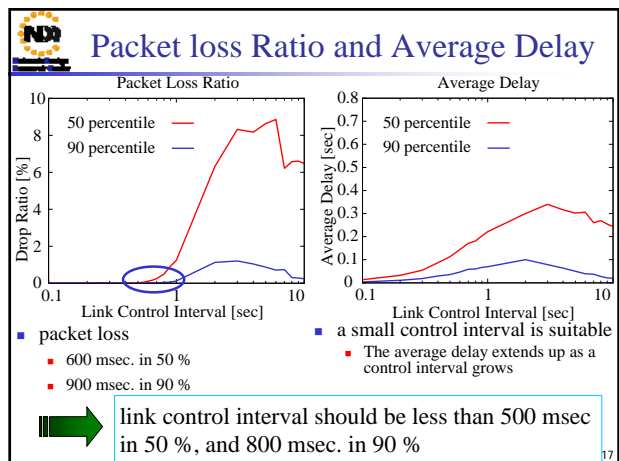
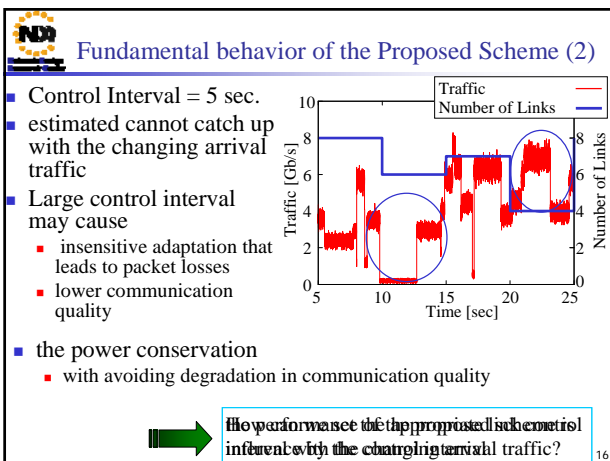
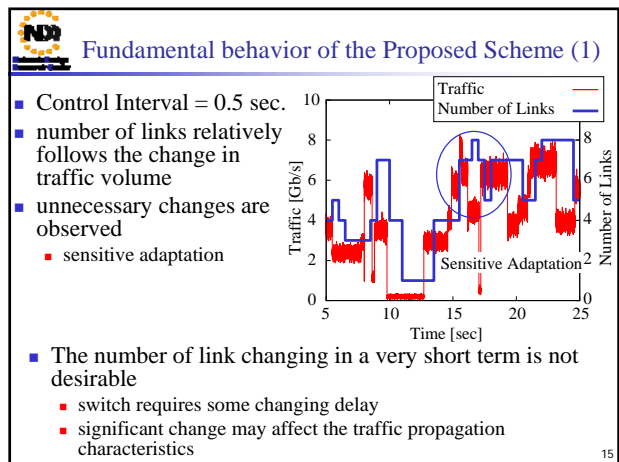
- a distribution is made from peak throughput
 - next transmission capacity is determined by the threshold
 - mapped to the number of links

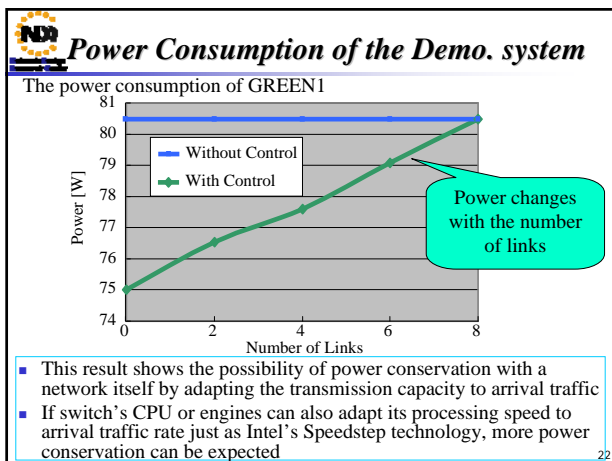
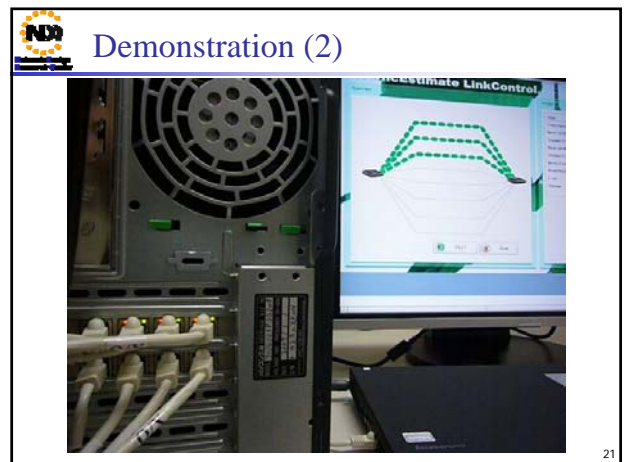
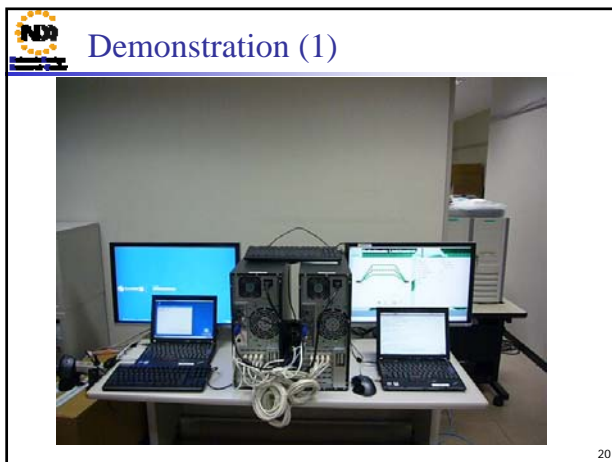
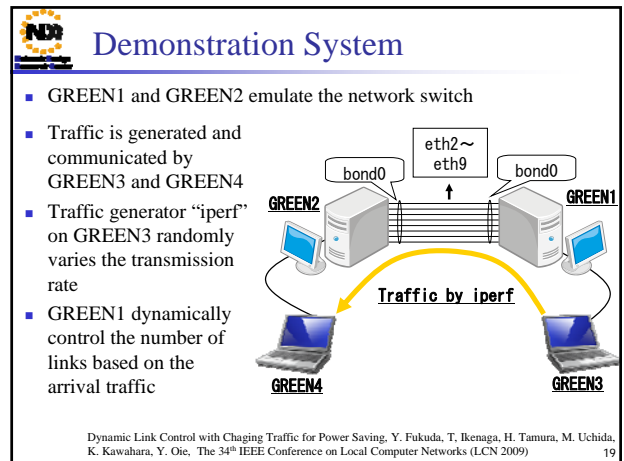
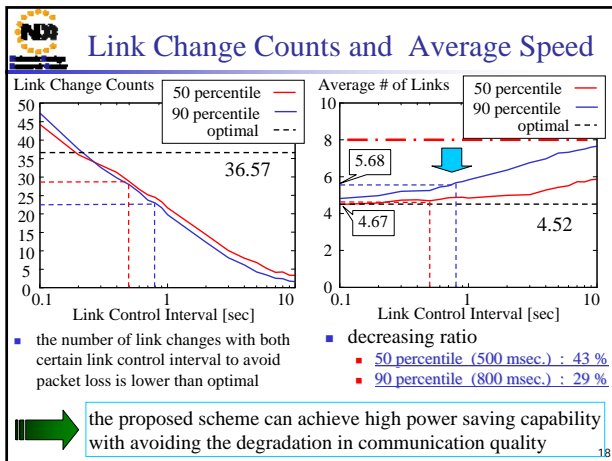
Simulation Model

Number of Links	8
Link Speed	1 Gb/s
Buffer Size	512 MByte
Packet Size	1,500 Byte
Link Control Interval, T	0.1 sec. ~ 10 sec.
Sampling, τ	T/100
Throughput Measurement Period	1 msec.
Threshold (%)	50, 90
Class Intervals in histogram	100 Mb/s
Simulation Time	40 second

- ### Performance Metrics and Requirement
- Link Change Counts** (Power Conservation)
 - The number of link changes in a simulation
 - Small value is suitable for stable communication
 - Average Speed**
 - Average number of physical links in a simulation
 - Power saving effect improves as an average speed shortens
 - Packet loss Ratio** (Communication Quality)
 - Average Delay** (Communication Quality)
- Requirement : avoid the degradation in communication quality by employing the proposed scheme
- Packet drop should be avoided
 - Small number of link change counts
 - Minimize the average number of links





- ### Conclusion (1)
- Growing energy consumption of the Internet
 - power saving technology in the Internet has become a vital issue
 - network itself should have some functions for achieving or enhancing the power saving in a network
 - Preliminary survey
 - What function is effective for achieving power saving with a network itself?
 - dynamic control of link up/down is one of the important and effective ways to reduce the power consumption in a network
 - Objective
 - achieving the power saving by dynamically control the number of links between switches based upon the change in traffic volume



Conclusion (2)

- Proposed Scheme
 - determine the transmission capacity based on the peak value of throughput
- Simulation Evaluation
 - [the proposed scheme can achieve high power saving capability without the degradation in communication quality](#)
- Demonstration System
 - shows the possibility of power conservation with a network itself by adapting the transmission capacity to arrival traffic
 - [Just as Intel's SpeedStep technology, If switch's CPU or engines can also adapt its processing speed to arrival traffic rate, more power conservation can be expected](#)

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