High Speed 100GE Adaptive Link Rate Switching for Energy Consumption Reduction

Takahiro Miyazaki
KEIO University, JAPAN
Talk Plan

- Background
- Overview 100Gigabit Ethernet (100GE)
- Energy Reduction Technologies
- Proposed method
- Simulation Analysis
- Conclusion
To handle with traffic demands, 100GE was specified in 2010.

Demand for 100GE is growing more and more.

- Energy consumption is growing more and more.

Fig 1. Market Forecasting in each link speed (Ovum on Forecast, April 2014)
100GE Architecture

MAC: media access control
MII: media-independent interface
PCS: physical-coding sublayer
PMA: physical-medium-attachment sublayer
PMD: physical-medium-dependent sublayer
PHY: physical-layer

Fig2. Generalized 100GE module architecture

MAC Frame

Encoding from 64B to 66B

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To realize high link rate a multi-lane technology is used in 100GE

Fig3. Detailed structure of the transmitter side of a 100GE module
Energy Reduction Technologies

Two approaches to reduce energy consumption
- LPI (Low-Power-Idle) technology
- ALR (Adaptive Link Rate) technology

LPI and ALR are the technologies which can save power by preventing transmit ability.

Fig4. Weekly traffic trace in CAIDA data

- Link utilization is changing every time
- Average link utilization is 30%-40% in core network
- LPI and ALR are effective in actual network
Energy Reduction Technologies

- **LPI (Low-Power-Idle)**
  - Power use is saved during the sleeping time
  - Figure 5: Low-power-idle

- **ALR (Adaptive-Link-Rate)**
  - Changing both the link rate and the power consumption
  - Figure 6: Adaptive-Link-Rate
Selectively activating each lanes, ALR is realized in 100GE

Fig7. Adaptive-Link-Rate in 100GE

Electrical lanes, optical lanes, and TOSA can be turned off
Conventional Scheme

- Drawback of the conventional scheme
  - It takes many time to change a link-rate
    ▶ Turn off TOSA takes time.
    ▶ Sender and receiver negotiation in needed and it takes time.
  - Long rate-changing time worsen ALR performance
    ▶ Because network traffic has spiky traffic

- We propose 100GE-ALR with coherent light wave transmission
  - 2 Key ideas
    ▶ Coherent light wave technology in 100GE
    ▶ Dummy packet inspection
Coherent light wave technology in 100GE

- DP-QPSK coding method are used
  - Not turn off an optical module
    - but electrical and optical lane can be turned off.
  - Sender and receiver negotiation is not needed to change a link rate.
    - Dummy signal insertion are proposed
Proposed Scheme

- Dummy signal insertion

- Dummy signal are inserted in a DSP
  - Optical signals are sent stays unchanged so that negotiation is avoided
  - Amplifier tuning can be avoided

High-speed rate switching can be realized
Simulation Analysis

Simulation parameters

► Power consumption in each link speed

<table>
<thead>
<tr>
<th>Link speed</th>
<th>Conventional</th>
<th>Proposal</th>
</tr>
</thead>
<tbody>
<tr>
<td>25Gb/s</td>
<td>12.1W</td>
<td>29.1W</td>
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<tr>
<td>50Gb/s</td>
<td>24.0W</td>
<td>38W</td>
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<td>75Gb/s</td>
<td>35.9W</td>
<td>46.9W</td>
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<tr>
<td>100Gb/s</td>
<td>47.8W</td>
<td>55.8W</td>
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</tbody>
</table>

► Traffic Pattern
- CAIDA trace

Purpose of the simulation analysis

► To Verify the proposed scheme get better power consumption and packet delay
► How switching time affect to a power consumption
Simulation Analysis

- Power use in conventional scheme and 100GE-ALR-CLT

![Graph showing power consumption comparison between conventional and proposed schemes](image)

- 100GE-ALR-CLT consumes less power than 100GE-ALR
  - 100GE-ALR consumes extra power during rate switching time
  - Long rate switching time worse ALR performance
Simulation Analysis

- Power use in conventional scheme and 100GE-ALR-CLT

In 100GE-ALR-CLT, packet delay is less than 100GE-ALR
  ▶ Long rate switching time worse the packet delay

Fig. Average packet delay in conventional and prop scheme

- In 100GE-ALR-CLT, packet delay is less than 100GE-ALR
  ▶ Long rate switching time worse the packet delay
Conclusion

**Background**
- Due to the traffic demand, high-speed link speed is needed
- The more a link speed, the power use is also increasing

**Conventional Scheme**
- Conventional scheme takes long time to change a link rate

**Proposed Scheme**
- High speed rate switching can be realized using coherent light wave transmission

**Simulation Analysis**
- The proposed scheme can get better performance in low link utilization
Thanks!