Final Project—
The Energy Optimization in Data Center Network

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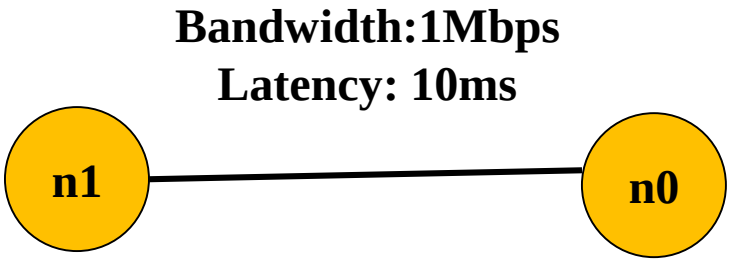
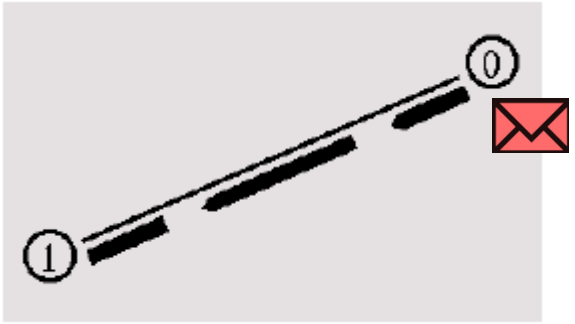
Outline

- NAM
- Introduction to GreenCloud
- The Energy Optimization in Data Center Network
- Conclusion
- Reference

NAM

- NAM
  - Network animator
  - Visualization tool
  - Tcl Script
    - Create network topology
    - Create transport connections
    - Generate traffic
  - Trace files





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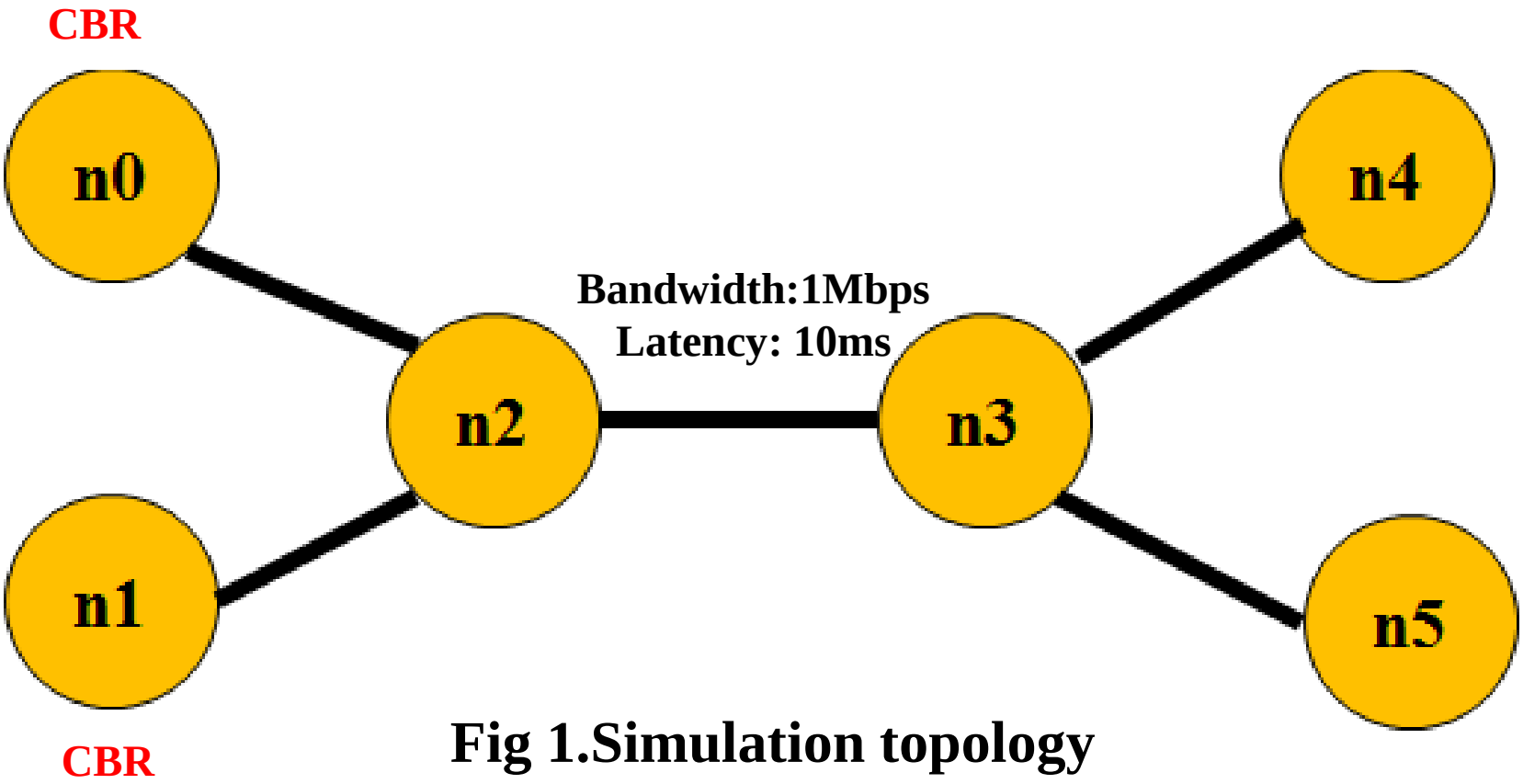


Fig 1.Simulation topology

Demo

NAM

Link type	Duplex-link
Queue type	Drop tail
Queue size	10
Packet size	1500bytes

Fig 2.Parameter setting

```
+ 2.12 2 3 cbr 1500 ------- 0 0.0 4.0 92 101
d 2.12 2 3 cbr 1500 ------- 0 0.0 4.0 92 101
- 2.12 2 3 cbr 1500 ------- 0 1.0 5.0 4 92
r 2.124 1 2 cbr 1500 ------- 0 1.0 5.0 9 102
+ 2.124 2 3 cbr 1500 ------- 0 1.0 5.0 9 102
r 2.128 2 3 cbr 1500 ------- 0 1.0 5.0 3 90
                    :
- 2.132 1 2 cbr 1500 ------- 0 1.0 5.0 11 106
r 2.132 3 4 cbr 1500 ------- 0 0.0 4.0 86 89
r 2.132 0 2 cbr 1500 ------- 0 0.0 4.0 93 103
+ 2.132 2 3 cbr 1500 ------- 0 0.0 4.0 93 103
d 2.132 2 3 cbr 1500 ------- 0 0.0 4.0 93 103
- 2.132 2 3 cbr 1500 ------- 0 0.0 4.0 88 93
r 2.136 1 2 cbr 1500 ------- 0 1.0 5.0 10 104
```

Fig 3.Trace file

NAM


代表事件發生的時間
d 2.12 2 3 cbr 1500 ------- 0 0.0 4.0 92 101
1 2 3 4 5
代表
1：代表 connection(flow) 的 id
2 ：代表 source address
3：代表 destinations address
4：代表 packet 的 sequence number (network layer protocol's)
5：代表 packet 的 id

Introduction to GreenCloud

- Motivation
  - The lack of detailed simulators on the market
- GreenCloud
  - University of Luxembourg
  - A simulation environment for advanced energy-aware studies of cloud computing data centers

Introduction to GreenCloud

- Architecture
  - Basic knowledge in C++
  - Terminal command language (TCL)
  - Network Simulator (NS2) is a plus point
- Features
  - ✓ Open Source
  - ✓ Simulation of CPU, memory, storage and networking resources
  - ✓ Complete TCP/IP implementation
  - ✓ Support of virtualization and VM migration

Introduction to GreenCloud

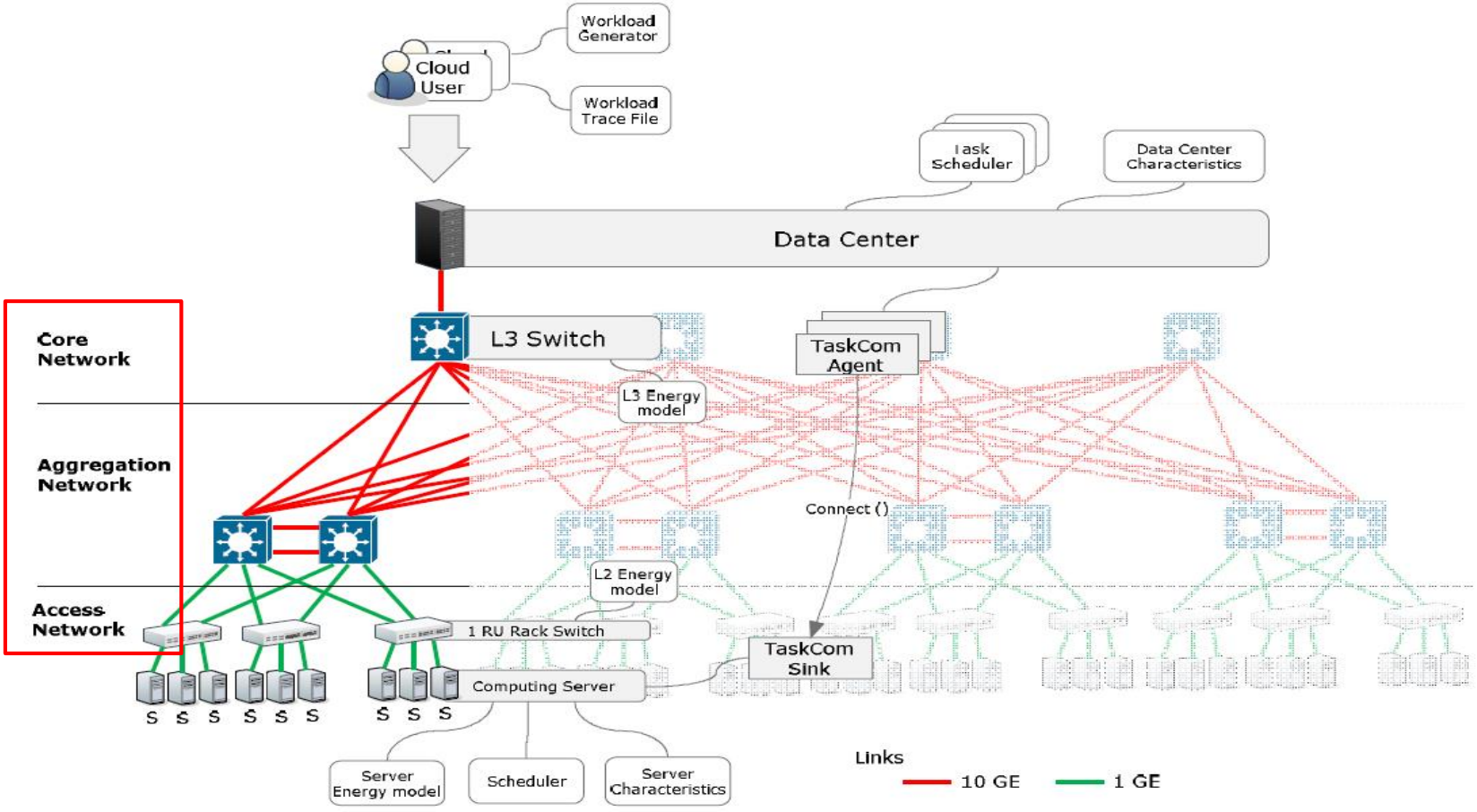
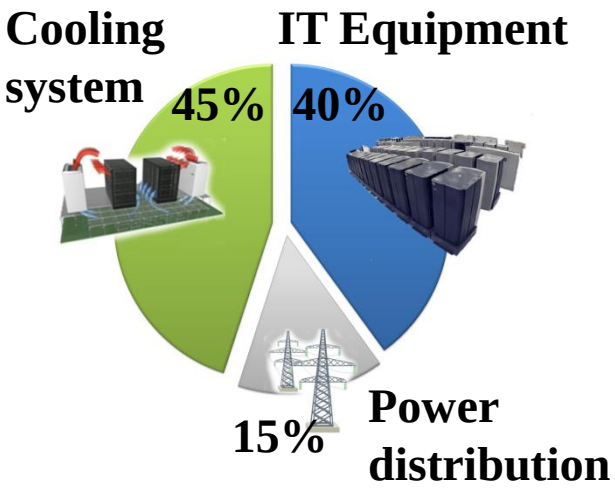


Figure 1. Architecture of the GreenCloud simulation environment.

The Energy Optimization in Data Center Network

- Main idea
  - **Utilize as few switches, switch links and switch link rates as possible**



Link rate↑、Number of links ↑

Power consumption ↑

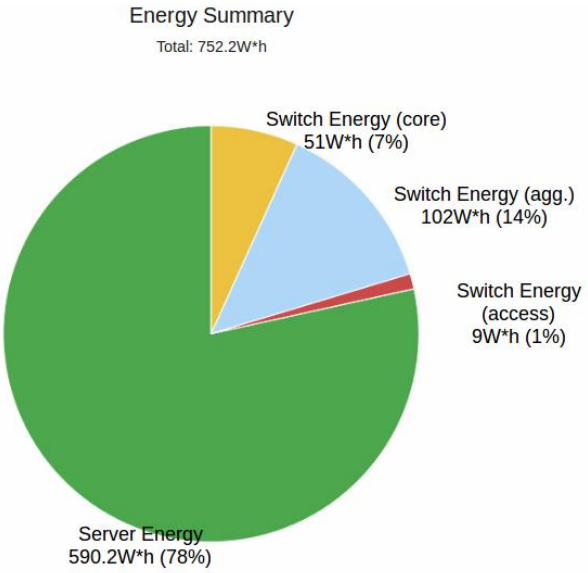
Shuo Fang, Hui Li, Chuan Heng Foh, Yonggang Wen, Khin Mi Aung, "**Energy optimizations for data center network:Formulation and its solution**," IEEE Global Communications Conference (GLOBECOM), 2012

The Energy Optimization in Data Center Network

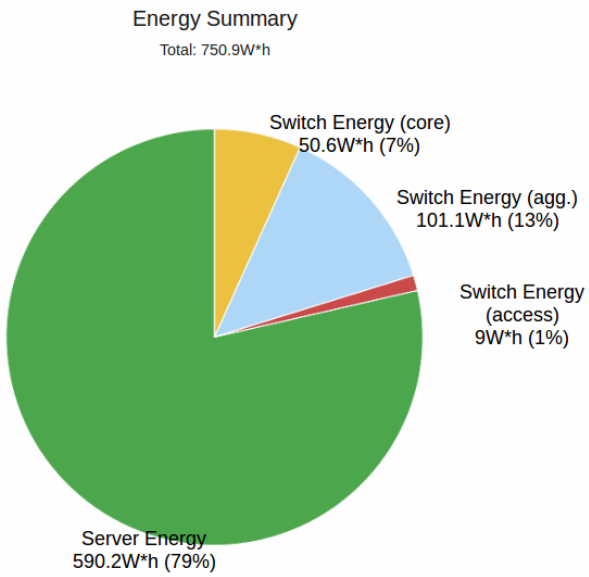
$$P_{switch} = P_{chasis} + n_{linecards} * P_{linecards} + \sum_{i=0}^{R} n_{ports} * P_{r}$$

The Energy Optimization in Data Center Network

Core layer	1
Aggregation layer	2
Access layer	3
CPU load	0.3



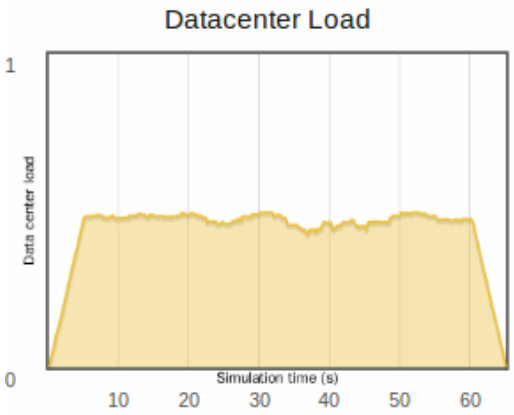
10G/1G

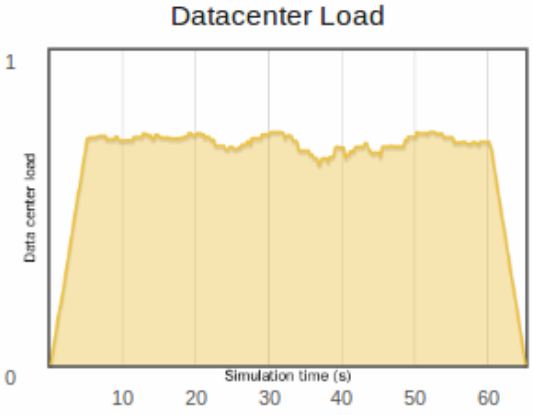


1G/100M

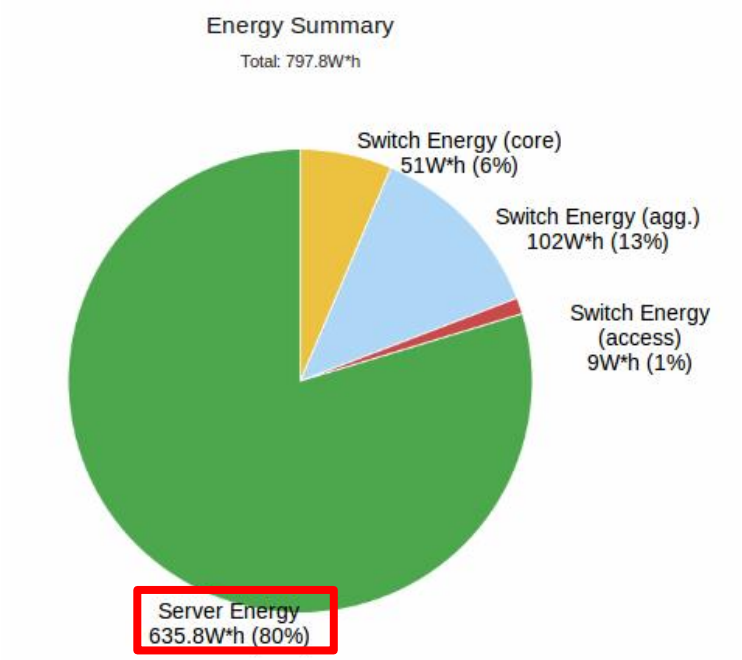
The Energy Optimization in Data Center Network

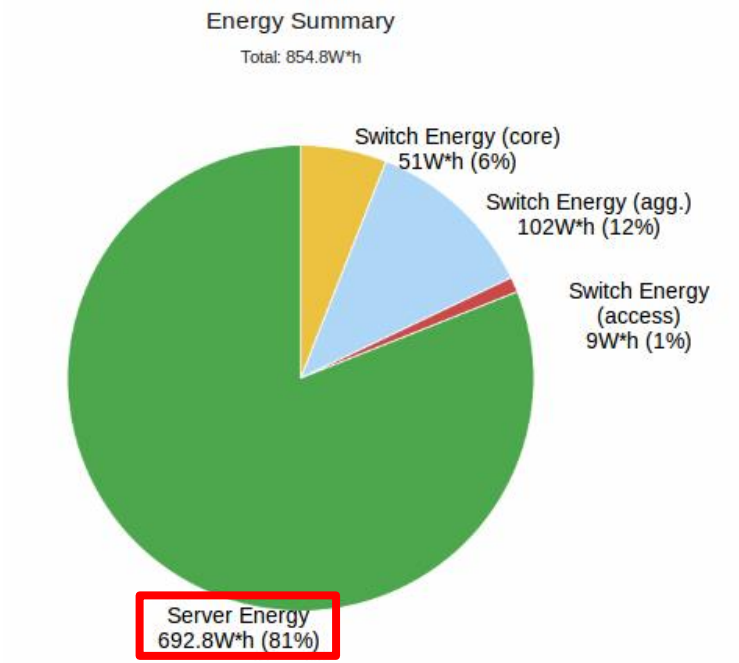
CPU Load=0.5



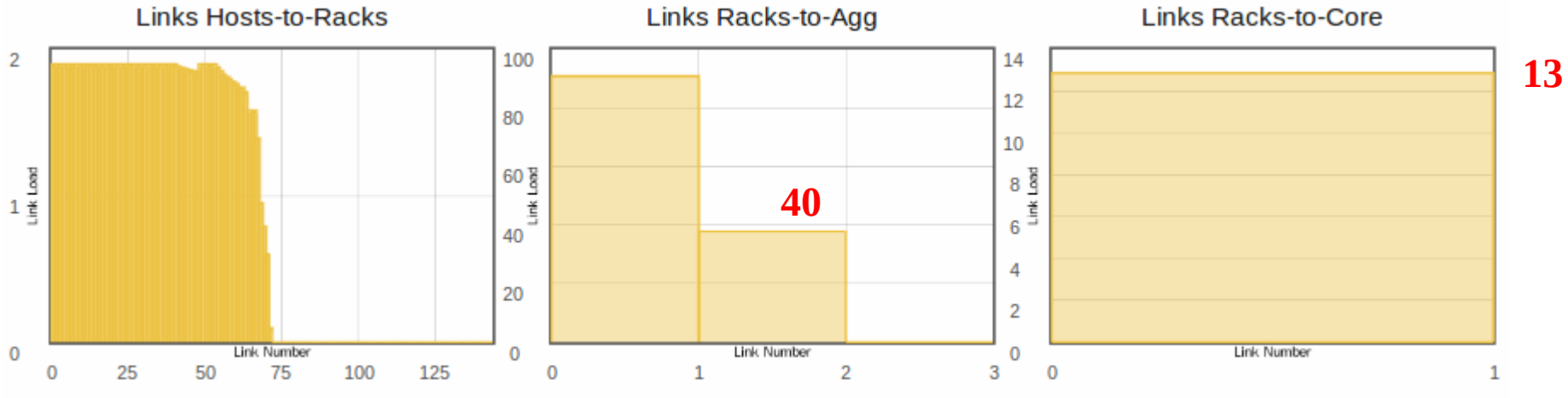


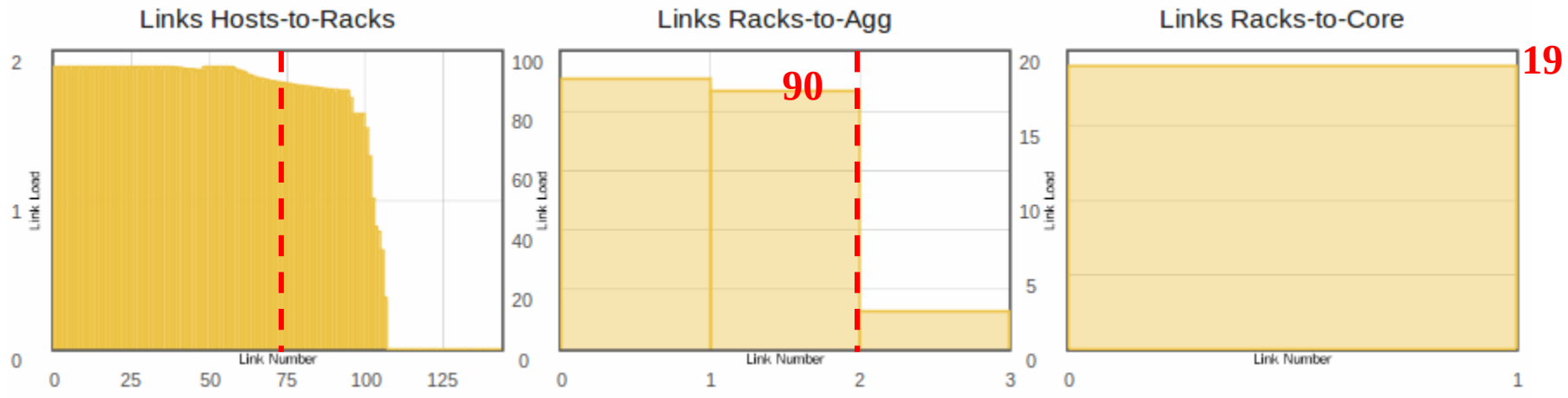
CPU Load=0.75





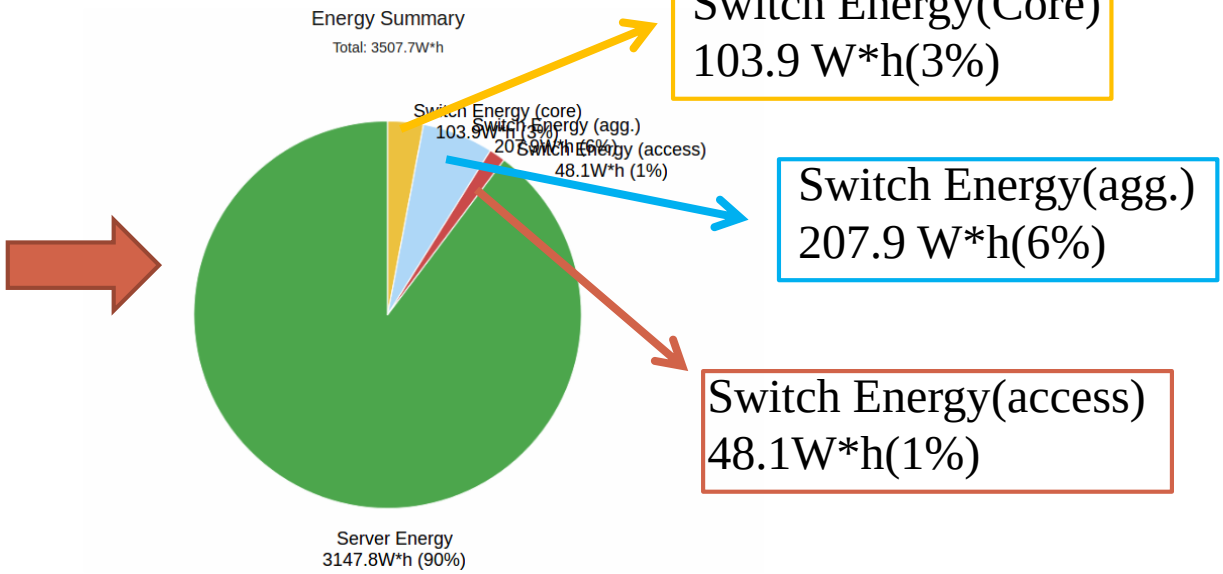
The Energy Optimization in Data Center Network



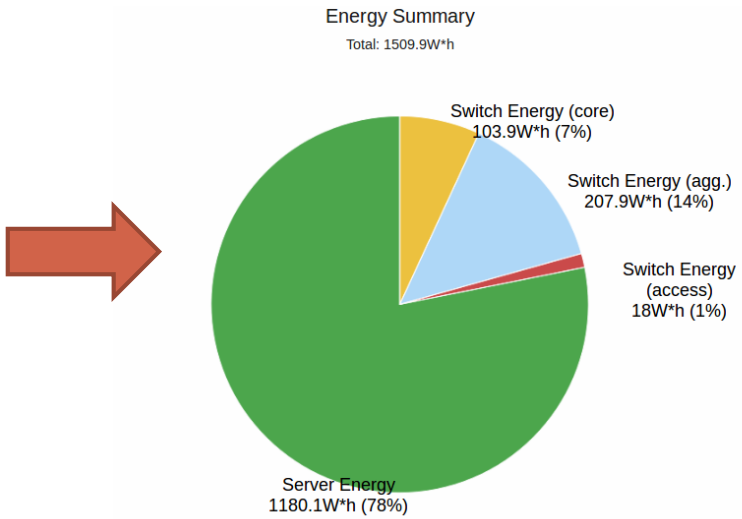


The Energy Optimization in Data Center Network

Core layer	2
Aggregation layer	4
Access layer	8
Server	288
CPU load	0.3



Core layer	2
Aggregation layer	4
Access layer	3
Server	768
CPU load	0.3



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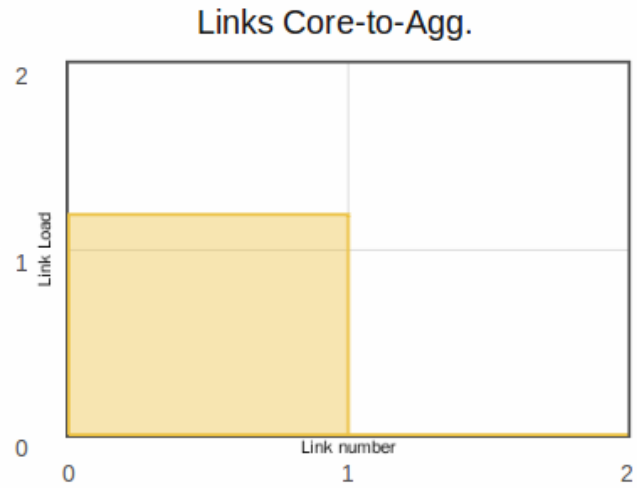

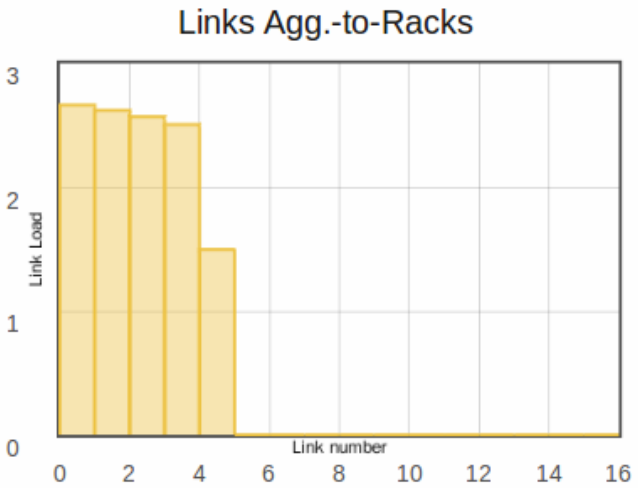

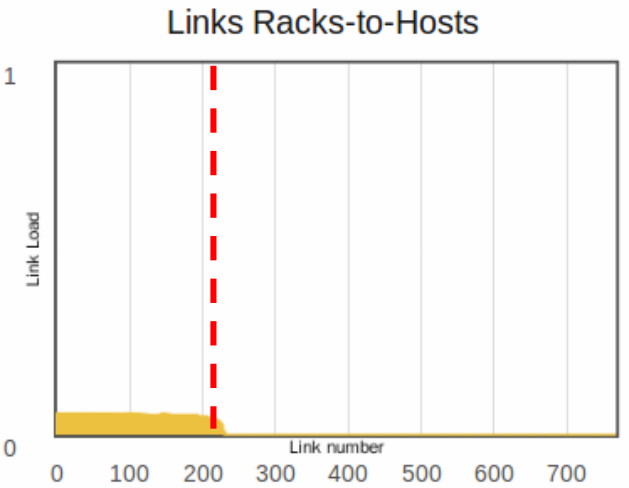

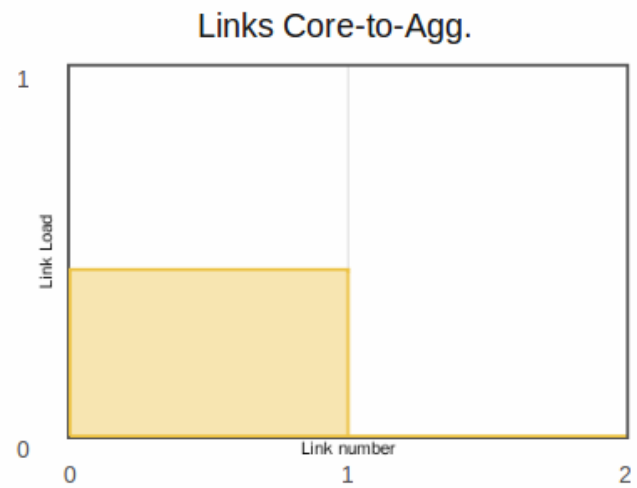

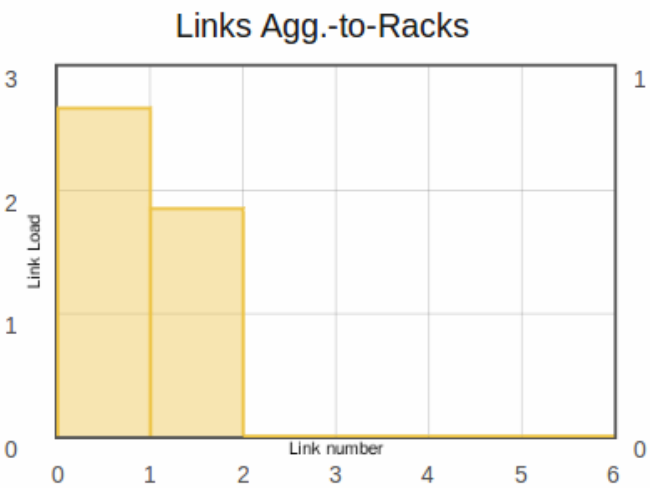

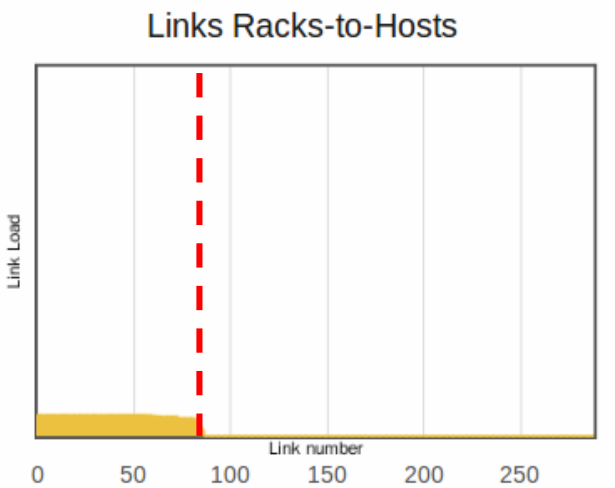

Conclusion

- The other methods of energy optimization in data center network
  - Scheduling
    - Network-aware resource allocation
  - VM migration
  - Network hardware
    - Switches, routers and links
    - Communication systems

Reference

- [1] http://greencloud.gforge.uni.lu/index.html
- [2] Shuo Fang, Hui Li, Chuan Heng Foh, Yonggang Wen, Khin Mi Aung, "Energy optimizations for data center network: Formulation and its solution," IEEE Global Communications Conference (GLOBECOM), 2012