Energy Consumption Optimization for Software Defined Networks Considering Dynamic Traffic

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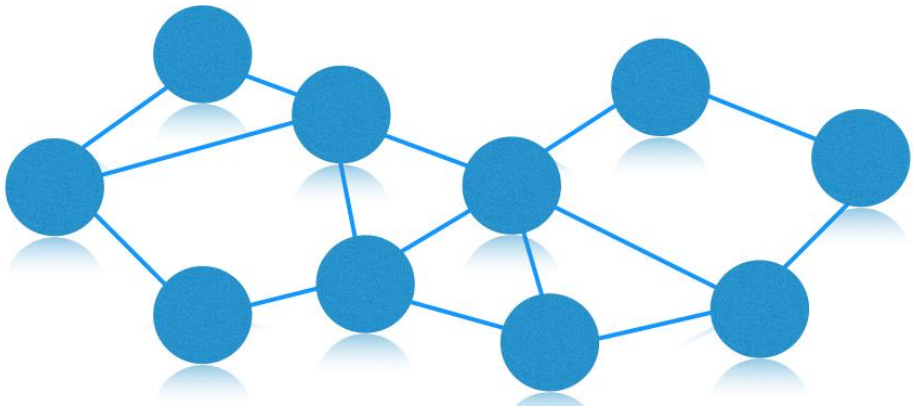
Agenda

- Software Defined Networking
- Energy consumption management
- Proposed approach
- Performance Evaluation
- Conclusion

Current communication Network

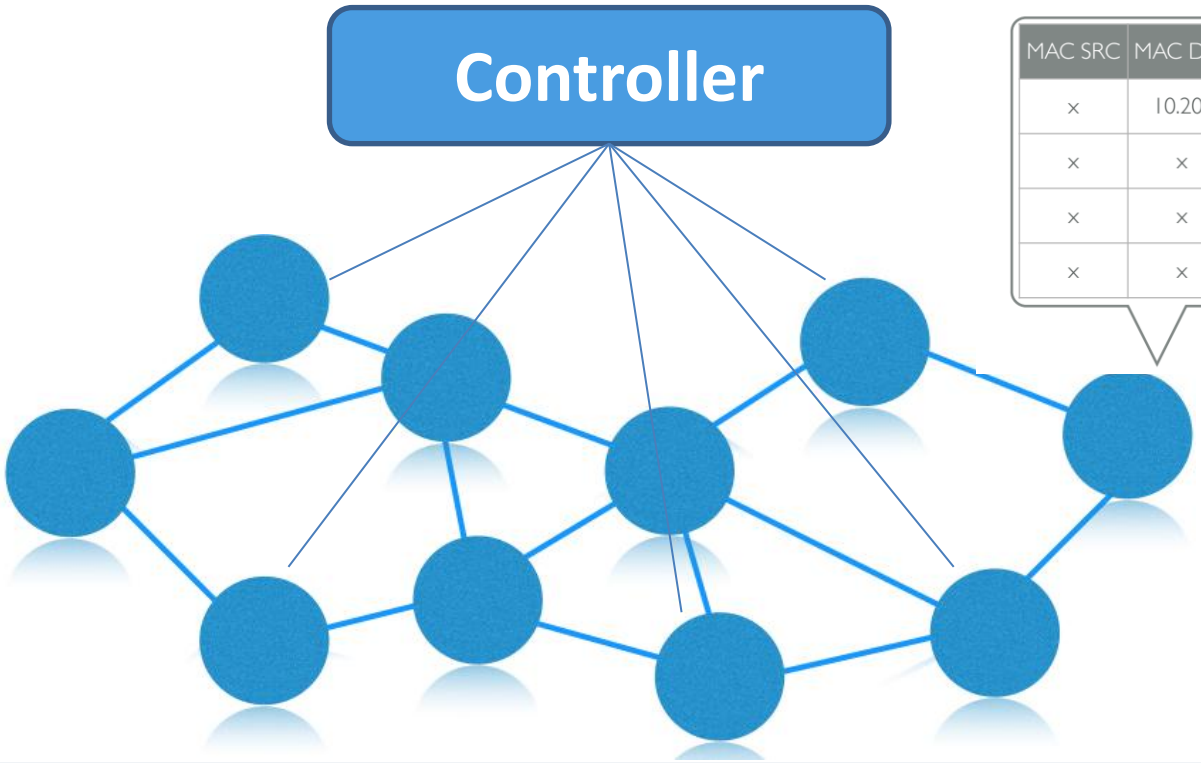
- Distributed state: Control and forwarding in same device



- Mass of protocols
- OSI model: elegant abstraction for the data plane - however no foundation for control protocols

Software Defined Networking

- Global network state view
- Controlled by a centrallized software

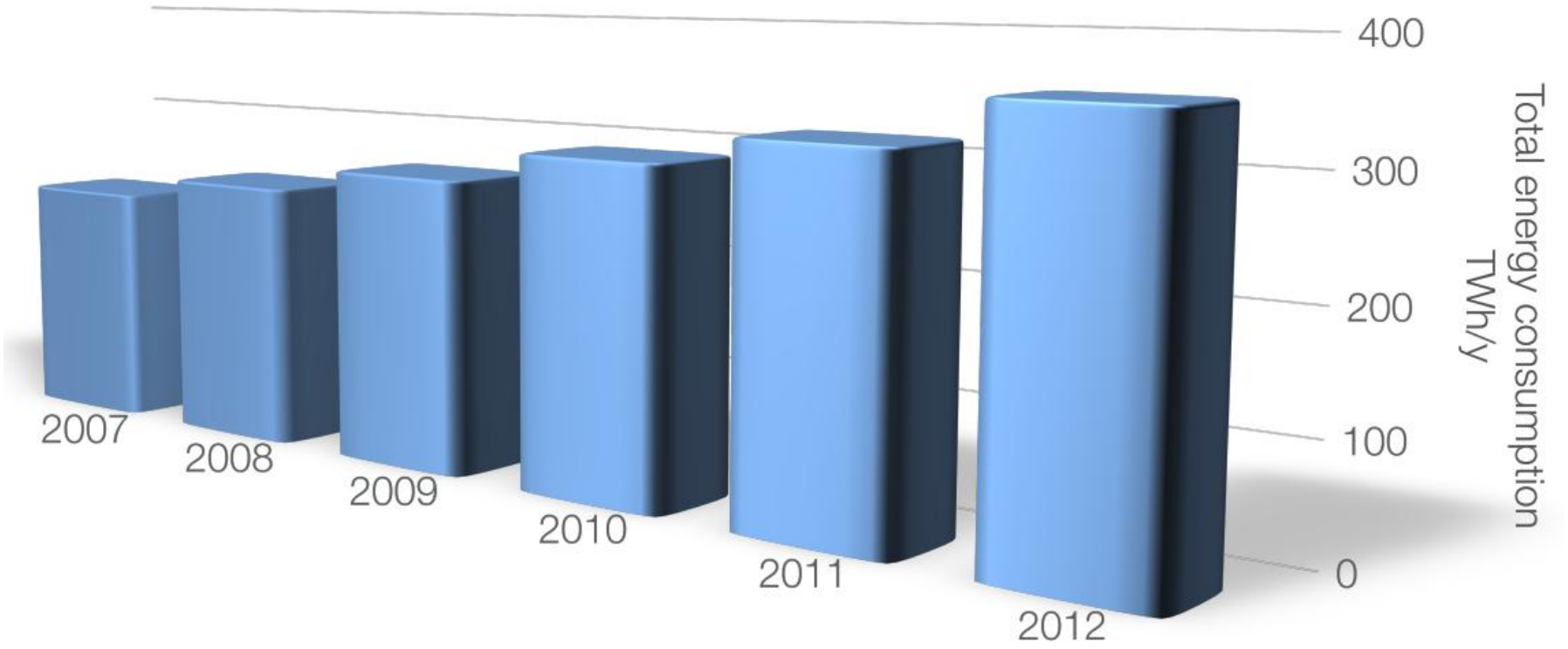


MAC SRC	MAC DST	IP DST	TCP DST	…	Action	Count
×	10.20:.	×	×	×	port1	387
×	×	5.6.7.8	×	×	port 2	272
×	×	×	25	×	drop	783
×	×	×	372	×	controller	480

Advantage of SDN

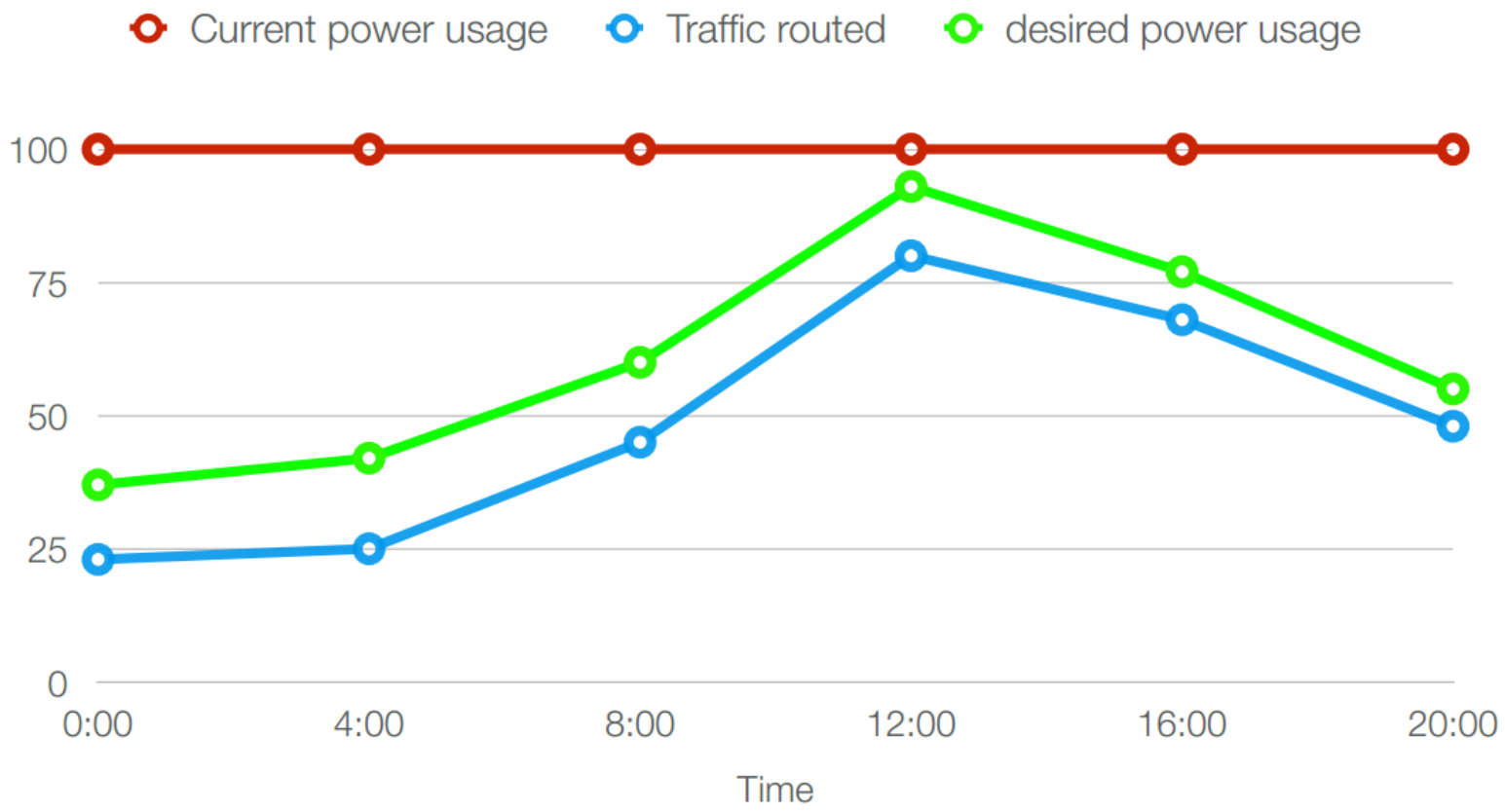
- Easy QoS improvement
- Less error-prone maintenance
- Enhanced innovation and research
- Easy testing and verification
- …

Energy consumption in ICT



- Global network power usage grows 10% each year
- 1,8 % of the worlds total energy consumption

Energy consumption



How to switch off SDN switches to save energy,
while still serving all traffic demands?

Mathematical formulation

Objective function

$$min \left\{ \sum_{l=1}^{L} a_l c_{1,l} + \sum_{n=1}^{N} b_n c_{2,n} \right\}$$

Link capacity constraint

$$\sum_{p=1}^{P} \sum_{r=1}^{R} \delta_{p,r}^{l} t_{p,r} \leq a_l \beta_l \quad , \quad \forall l$$

Traffic demand

$$\sum_{r=1}^{R} t_{p,r} = d_p \quad , \quad \forall p$$

Node-link relationship

$$w_n a \leq b_n \quad , \quad \forall n$$

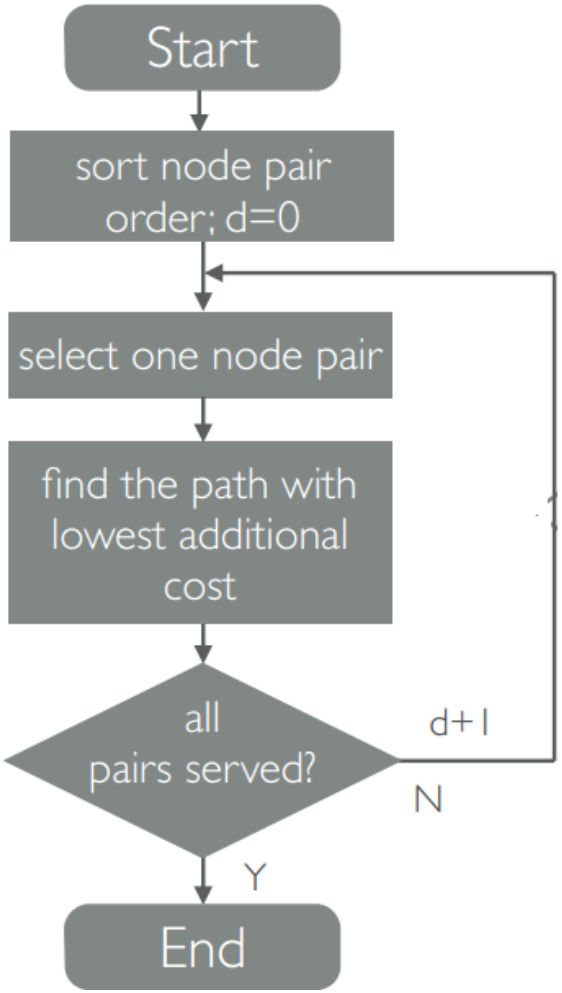
Variables:

a_l	denoting if link **l** is on
b_n	denoting if node **n** is on
$t_{p,r}$	traffic of node pair **p** routed through route **r**

Parameters:

$c_{1,l}$	power usage of link **l**
$c_{2,n}$	power usage of switch **n**
$\delta_{r,p}^{l}$	1 if link **l** belongs to **r** of **p**
β_l	bandwidth of link **l**
d_p	demand of node pair **p**
w_n	links belonging to node **n**

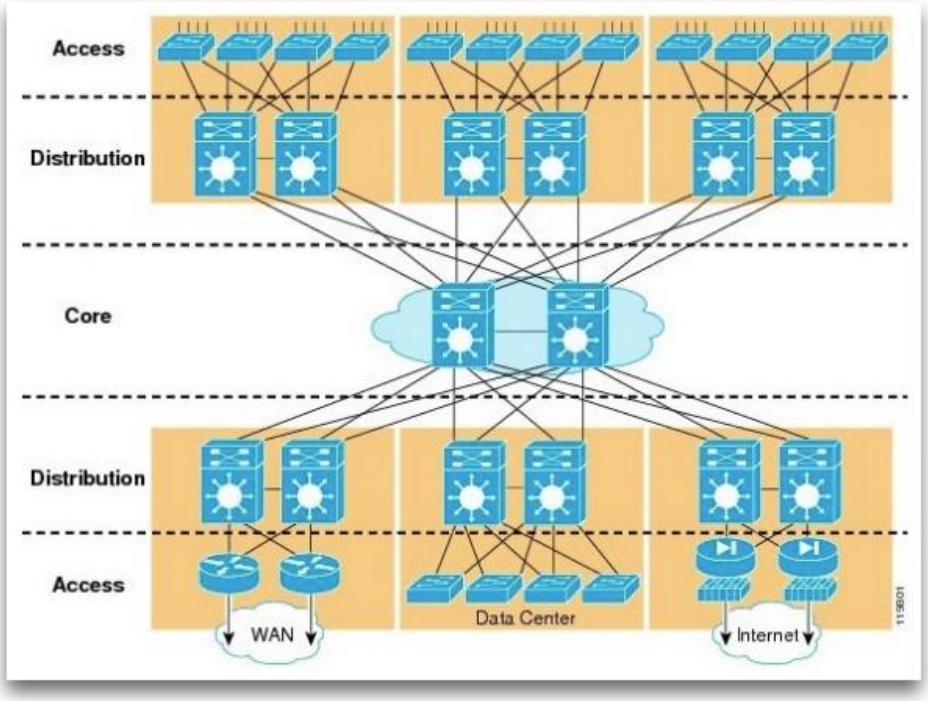
Heuristic algorithm



Shortest **P**ath **F**irst
Longest **P**ath **F**irst
Smallest **D**emand **F**irst
Highest **D**emand **F**irst

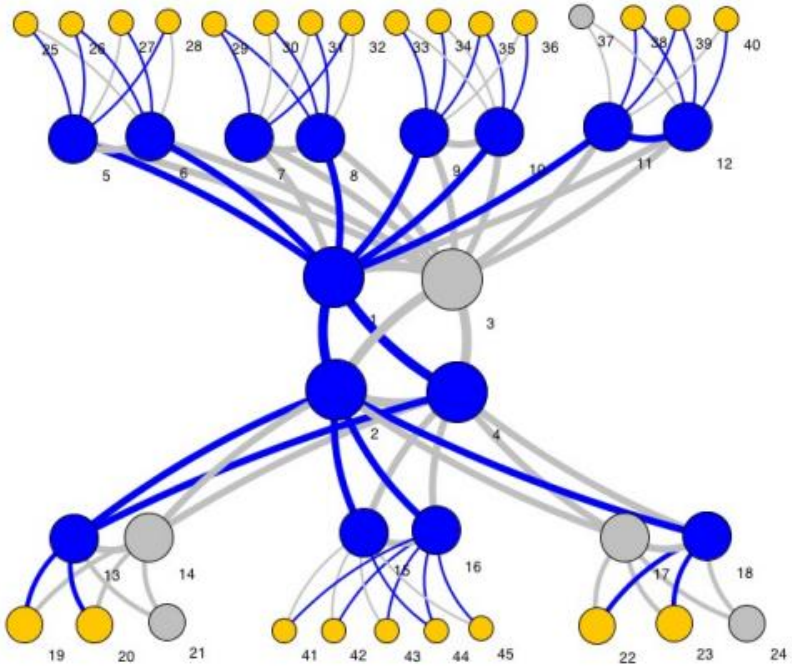
Performance Evaluation
Campus Network Scenario

Type	Switch e.c (W)	Line Card e.c. (W)	Bandwidth (Gbit/s)
Core	2000	150	400
Distriubution	1000	80	150
WAN	700	50	100
Access	200	-/- 5W Port	50

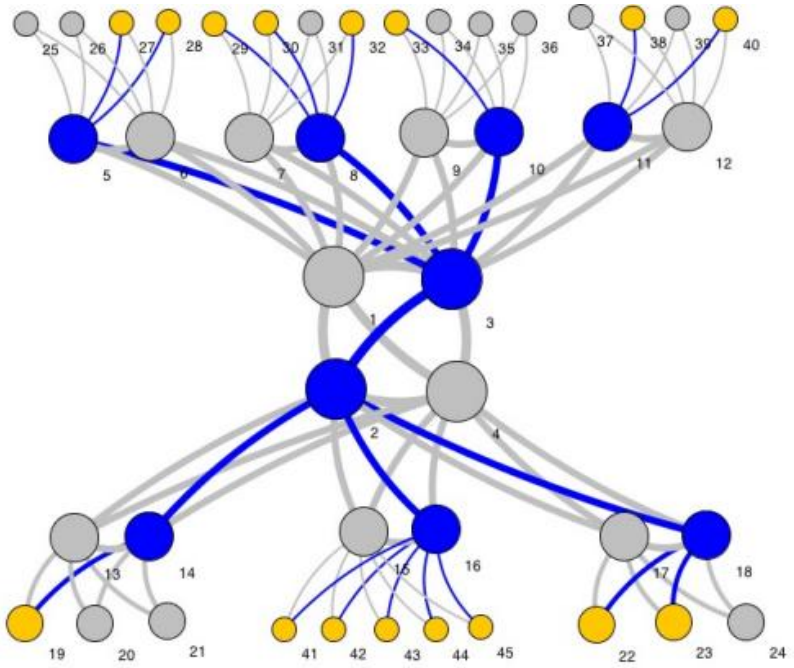


- Traffic demands are randomly generated at low, medium and high level

Results: optimal solution



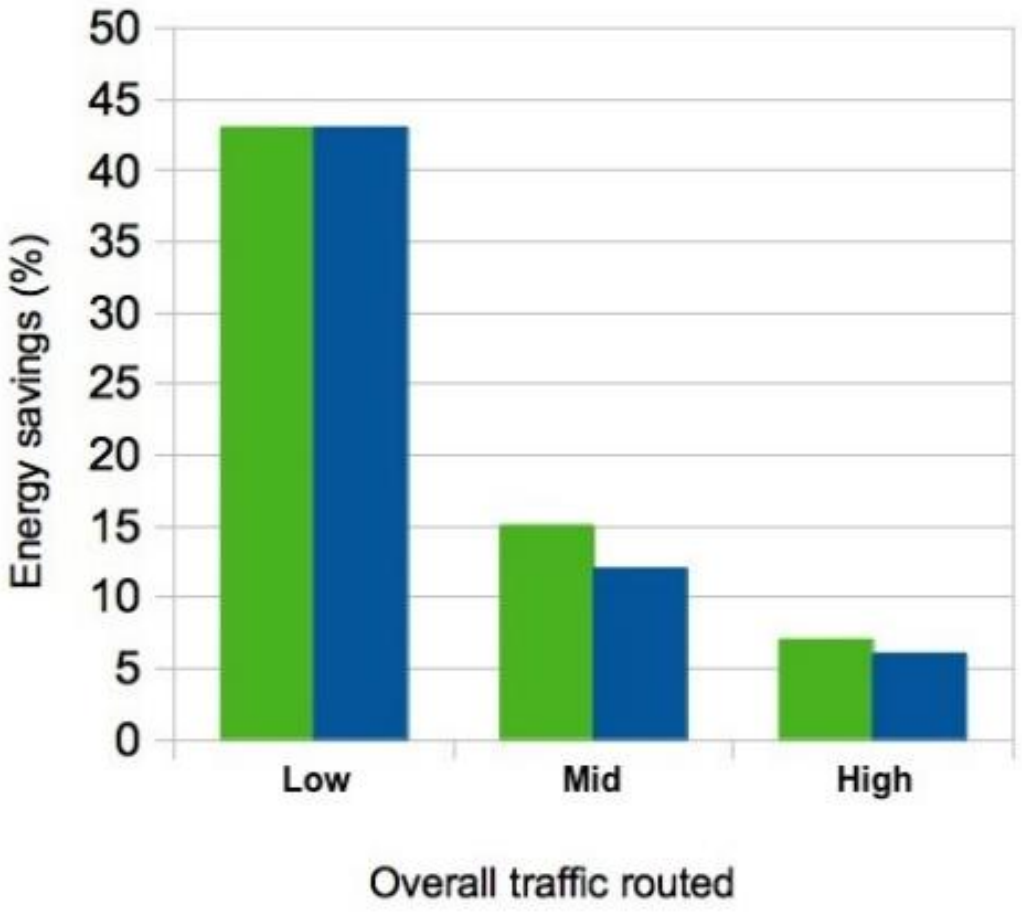
Medium traffic load



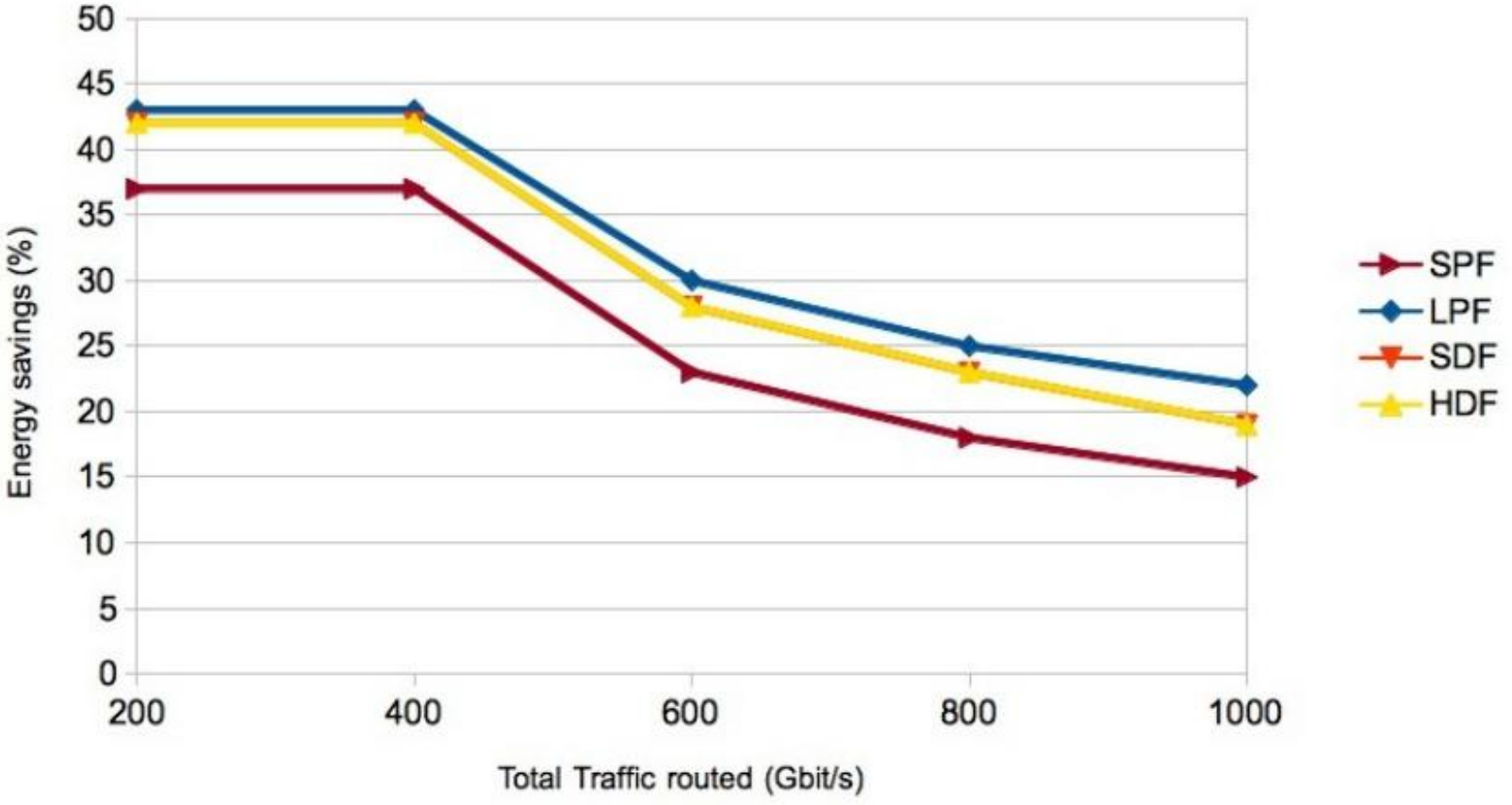
Low traffic load

- At low traffic load, energy consumption can be saved up to 45% compared to „always on“ networks

Optimal vs. heuristic solution

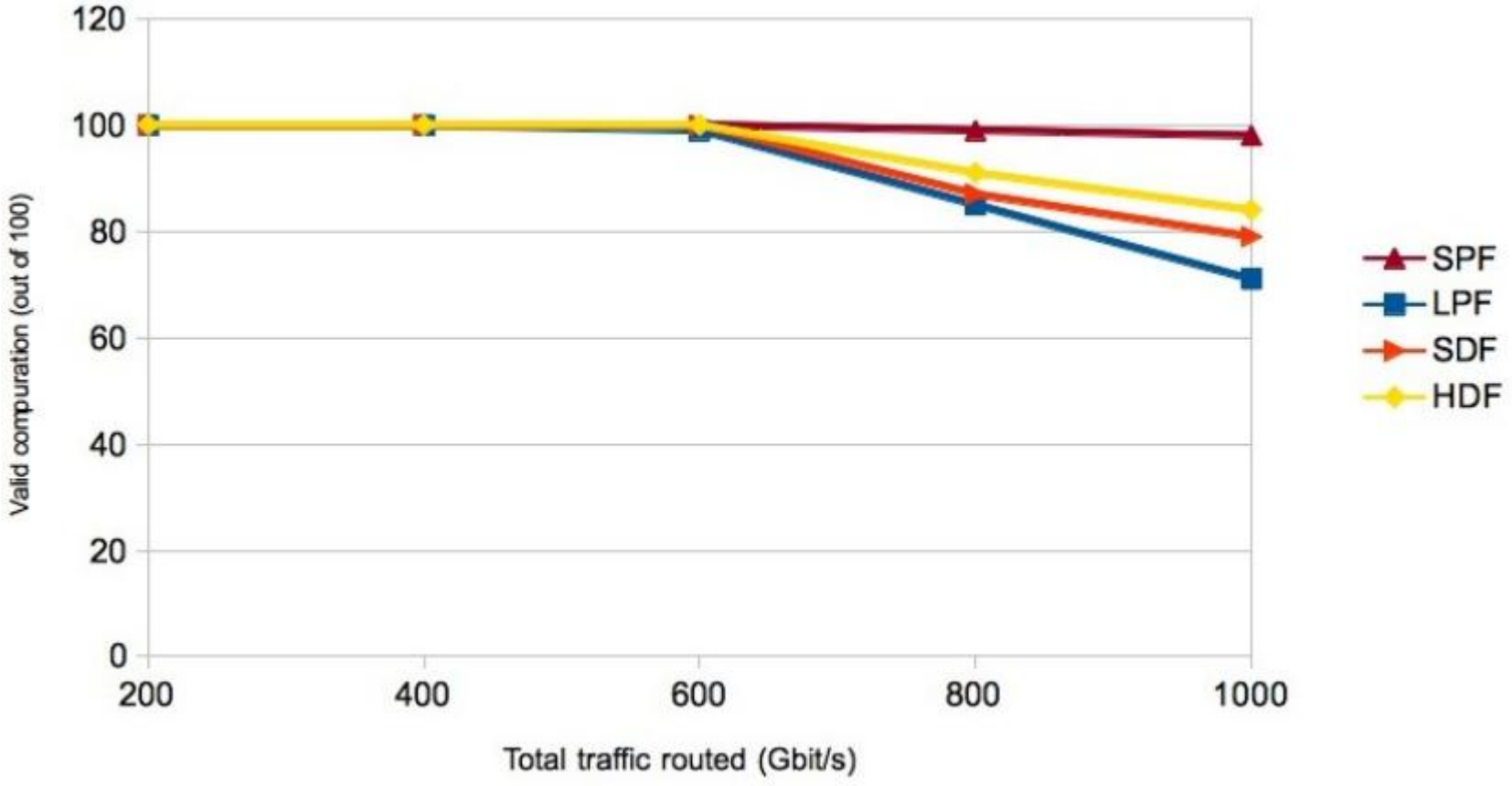


Comparison of heuristics



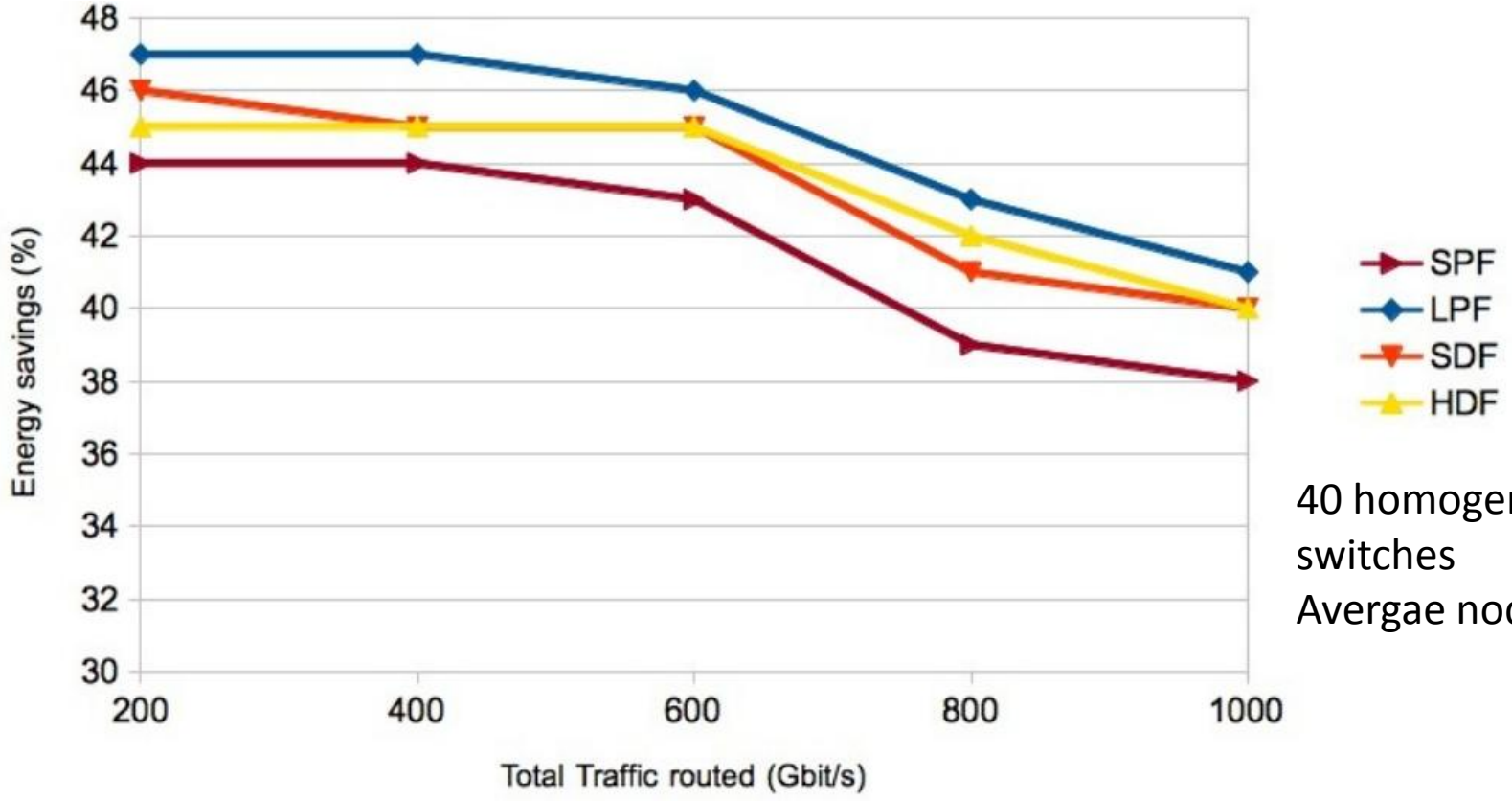
Longest Path First (LPF) is the best heuristic strategy!

Robustness of heuristic algorithm



Campus network scenario

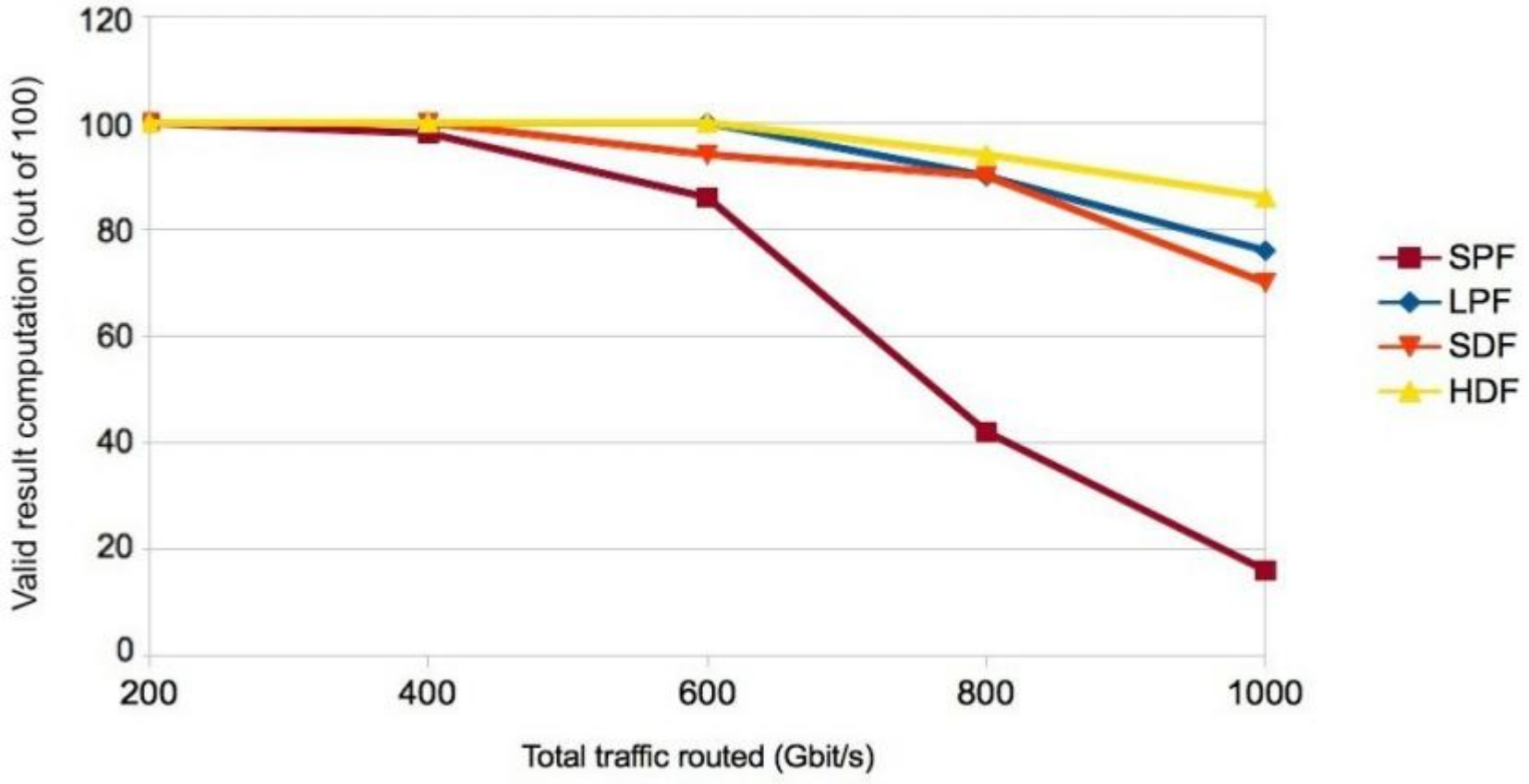
Heuristic solution for Random Mesh Network Scenario



40 homogeneous switches
Avergae node degree: 4

Longest Path First (LPF) is the best heuristic strategy!

Robustness of heuristic algorithm (2)



Random mesh network scenario

Conclusion

- Energy saving potential in SDN was investigated.
  - Up to more than 40% energy saving at low traffic load
- Four heuristic algorithms to dynamically switch on and off SDN switches to reduce energy consumption was proposed.
- LPF is the best heuristic in terms of energy saving

Thank you for your attention!

Questions?