



Energy saving mechanisms in metro/ core and their validation on a testbed

TREND Final Workshop
Brussels, 24/10/2013



F. Idzikowski (TUB)



E. Tego, F. Matera, A. Valenti (FUB)



L. Chiaraviglio, A. Cianfrani, A. Coiro (CNIT-UniRoma1)

TREND Final Workshop
Brussels, 24/10/2013



Motivation

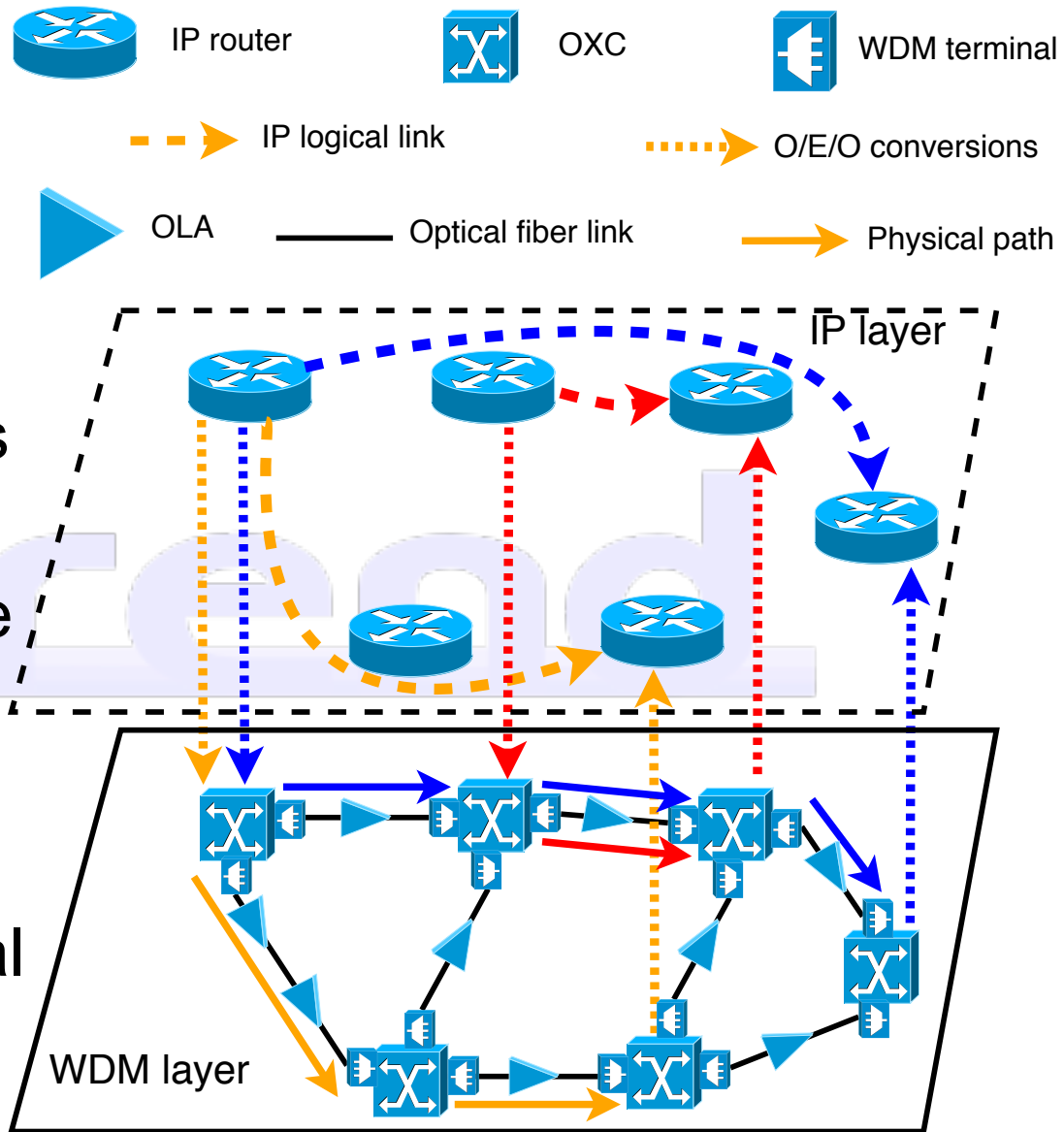
■ Problem

- ❑ Core networks consume non-negligible amount of power and their share in the overall ICT consumption is expected to increase [Lange11jstqe]
- ❑ Several Energy-Aware Adaptive Routing Solutions (EA-ARSs) proposed in the literature (including IRA3.1) to switch off devices in low demand hours
- ❑ Is it feasible to implement the theoretical approaches in reality (WP4)?

■ Solution

- ❑ Approaches proposed in [Idzi11osn], particularly the simple one FUFL (Fixed Upper Fixed Lower)
- ❑ Testbed at ISCOM (Ministero dello Sviluppo Economico) in cooperation with FUB [Valenti12networks]

Network Model



- Routing of traffic demands in the IP layer
- Routing of lightpaths in the WDM layer
- GbE optical links are used instead of lightpaths on the testbed
- Routing in the optical layer fixed

Energy saving approaches [Idzi11osn]

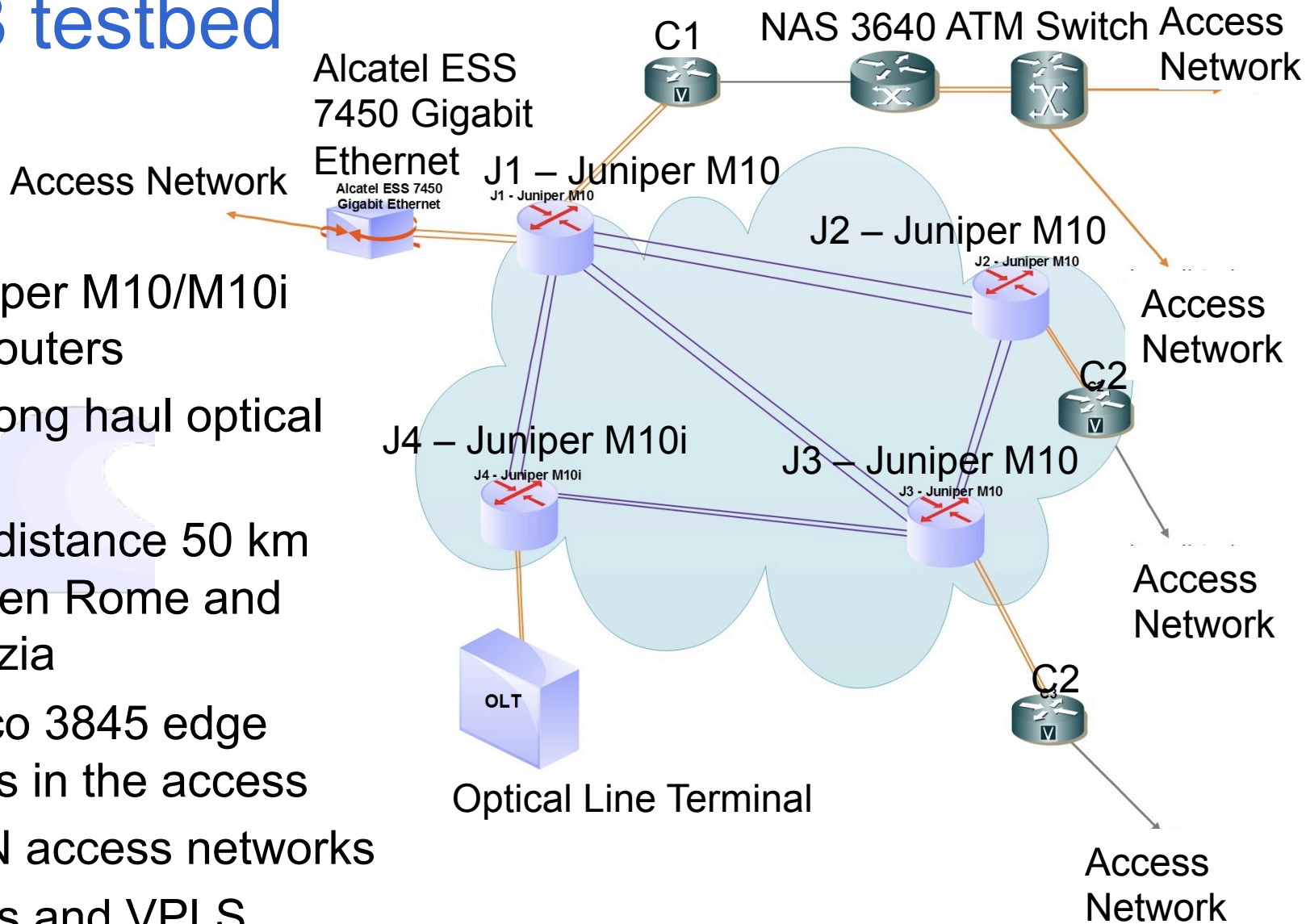
- Fixed Upper/Fixed Lower (FUFL)
 - No possibility to change the IP routing
 - No possibility to change the logical topology
 - Network line cards can be switched off if a decrease of traffic on a logical link consisting of multiple lightpaths allows it
- Dynamic Upper/Fixed Lower (DUFL)
 - Possibility to change the IP routing
 - No possibility to change the logical topology
 - IP rerouting and decrease of traffic determine power saving
- Dynamic Upper/Dynamic Lower (DUDL)
 - Possibility to change the IP routing
 - Possibility to change the logical topology
 - Network line cards can be switched off if logical topology reconfiguration, IP rerouting and decrease of traffic allow it

Particularly interesting
for network operators
[Idzi13icc]

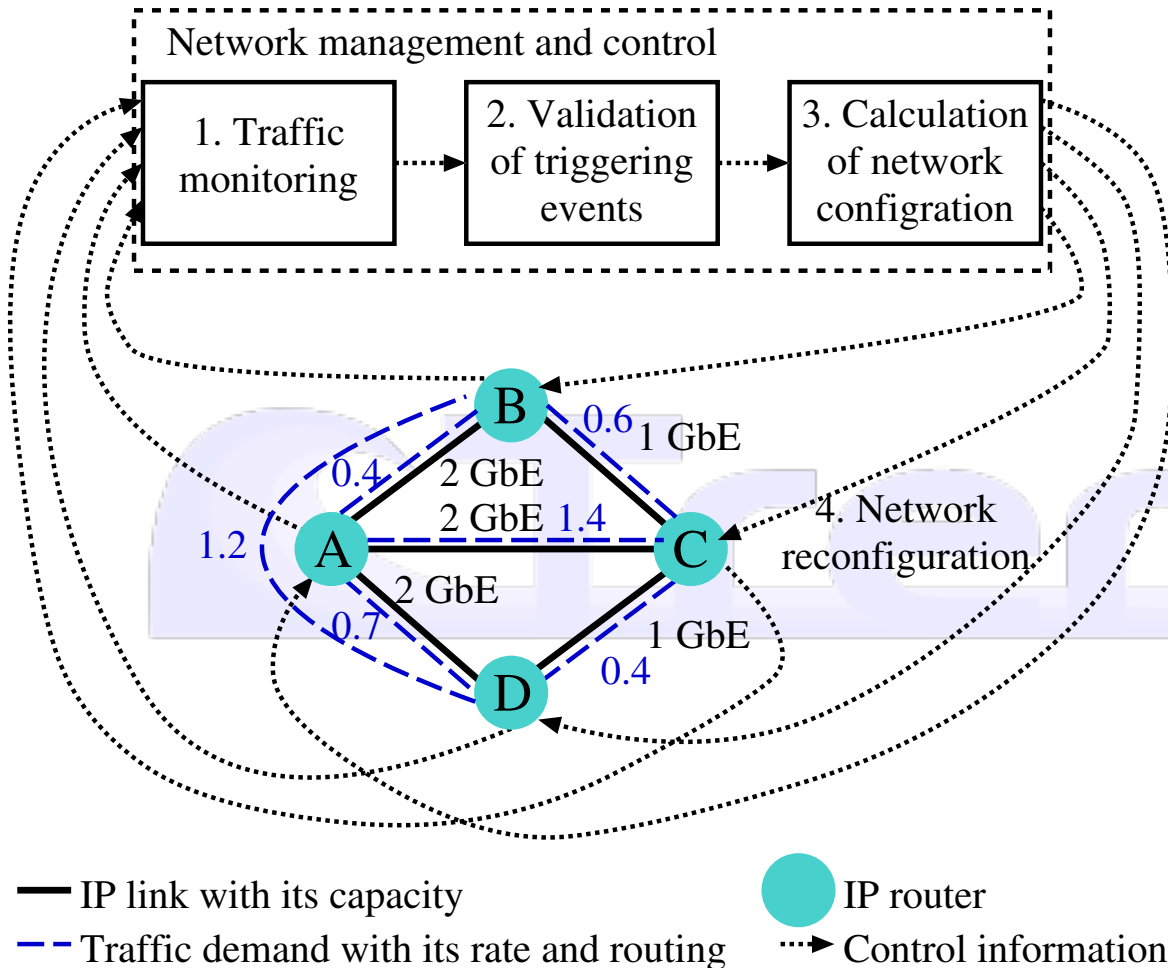
Dynamic Upper
contributes the most
to energy savings

FUB testbed

- 4 Juniper M10/M10i core routers
- GbE long haul optical links
- Total distance 50 km between Rome and Pomezia
- 3 Cisco 3845 edge routers in the access
- GPON access networks
- VLANs and VPLS



Main idea

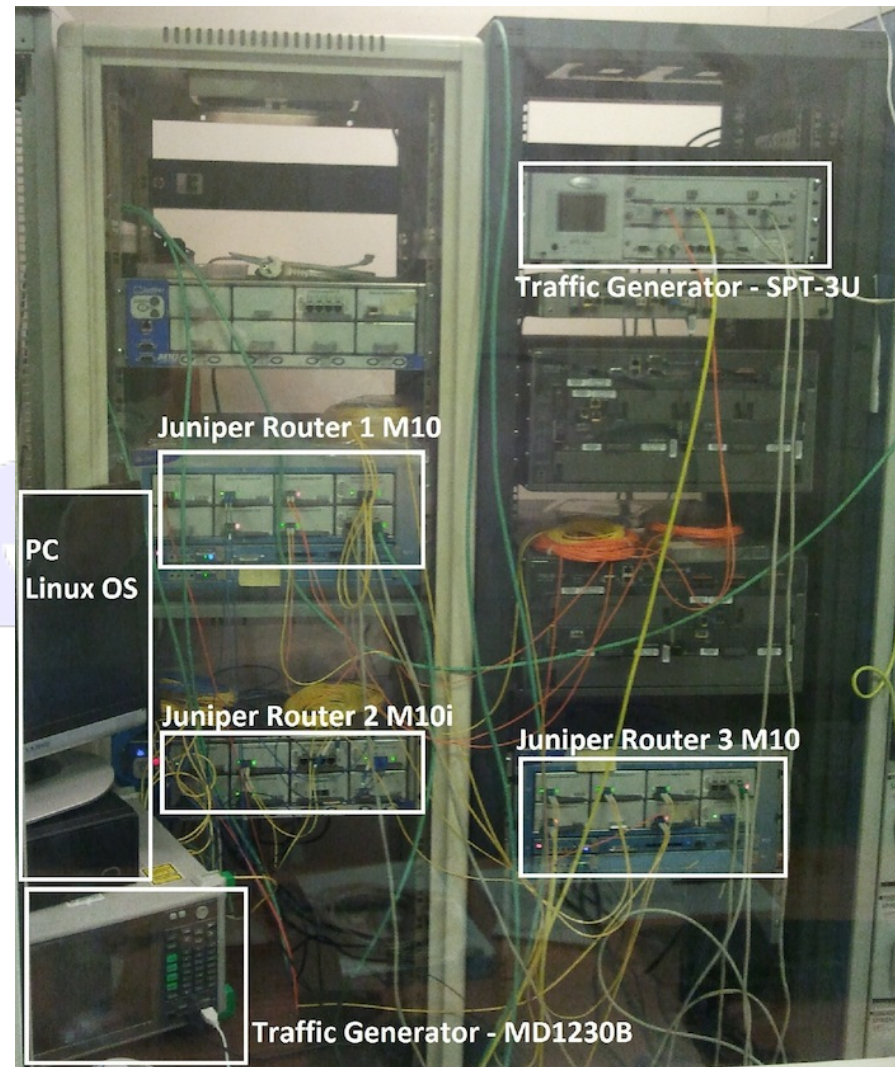


- T_M – averaging period of monitored traffic

- T_L – validation of events triggering calculation of network configuration

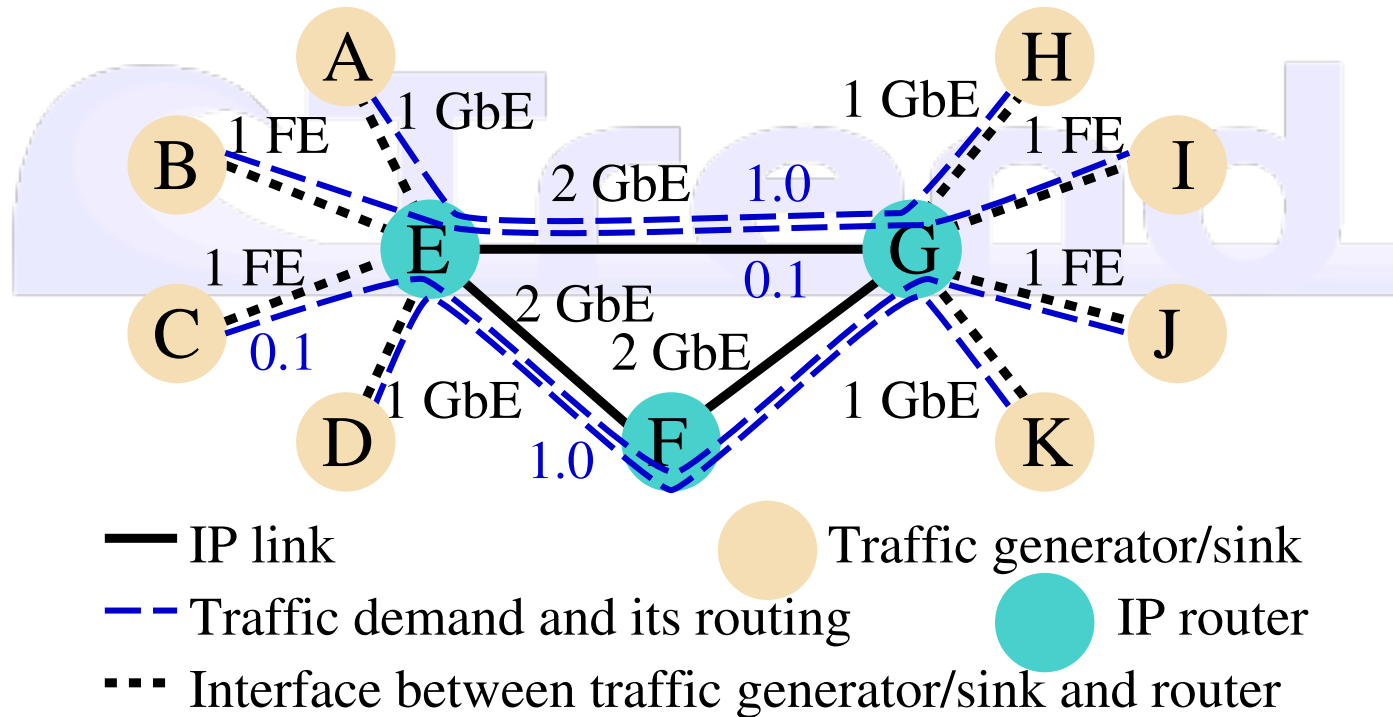
Testbed configuration

- 3 Juniper routers used
 - 2 x Juniper M10
 - 1 x Juniper M10i
- Traffic generated with:
 - SPT 3U Traffic Generator
 - MD1230B Traffic Generator
 - Linux PC
- Network Management and Control implemented on a Linux PC



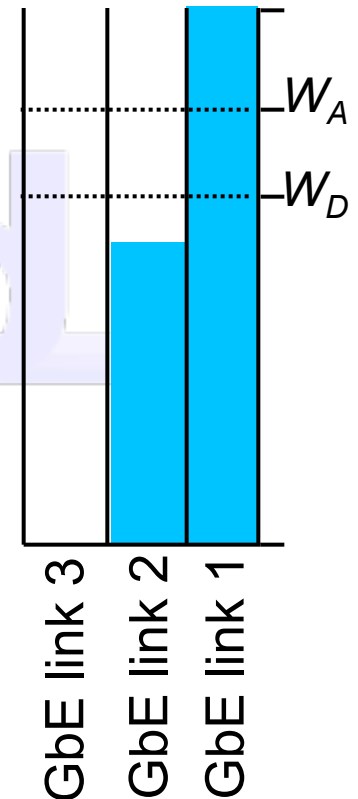
(Simple) scenario

- A logical ring with 3 routers
- Capacity of each logical link: 2 GbE
- $T_M = 10$ s
- $T_L = 10$ s



Fixed Upper Fixed Lower (FUFL)

- FUFL – use day-night variation of aggregated traffic to deactivate unnecessary resources from Static Base Network (SBN) [Idzi11osn]
- Two thresholds triggering activation/deactivation [Idzi13icc]:
 - W_D - if a GbE link is empty, and the utilization on the previous parallel GbE link becomes less than the threshold W_D , Deactivate the GbE link with the corresponding interfaces
 - W_A - if the utilization of the previous GbE link exceeds the threshold W_A , Activate the GbE link with the corresponding interfaces



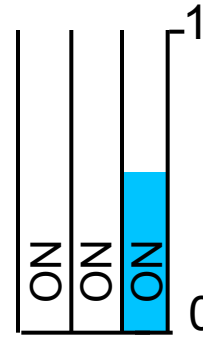
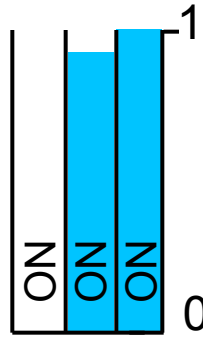
FUFL – illustrative example

Time

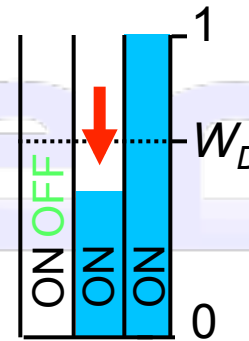
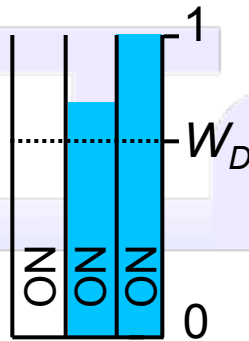
t

t+1

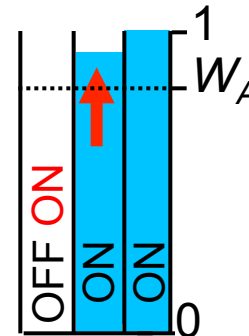
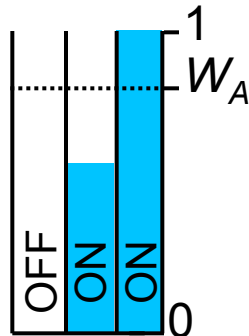
SBN
(independent
from traffic)



FUFL
(traffic
decrease)



FUFL
(traffic
increase)

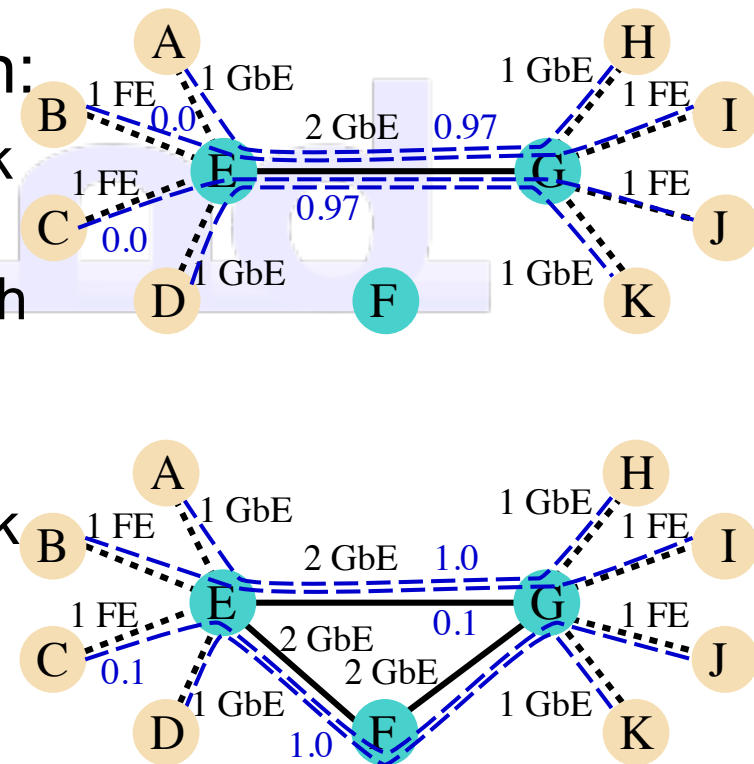


- Fully distributed
- Requires only local knowledge
- Low computation time
- No control mechanism necessary

Dynamic Upper Fixed Lower (DUFL)

- DUFL – IP rerouting allowed
- The simple scenario led to the following implementation of DUFL with two thresholds triggering activation/deactivation:

- W_L - if the utilization of a logical link becomes less than the threshold W_L , an attempt to reroute traffic with the aim of deactivation logical links E-F, and F-G is made
- W_H - if the utilization of a logical link becomes more than the threshold W_H , the previously deactivated logical links are activated

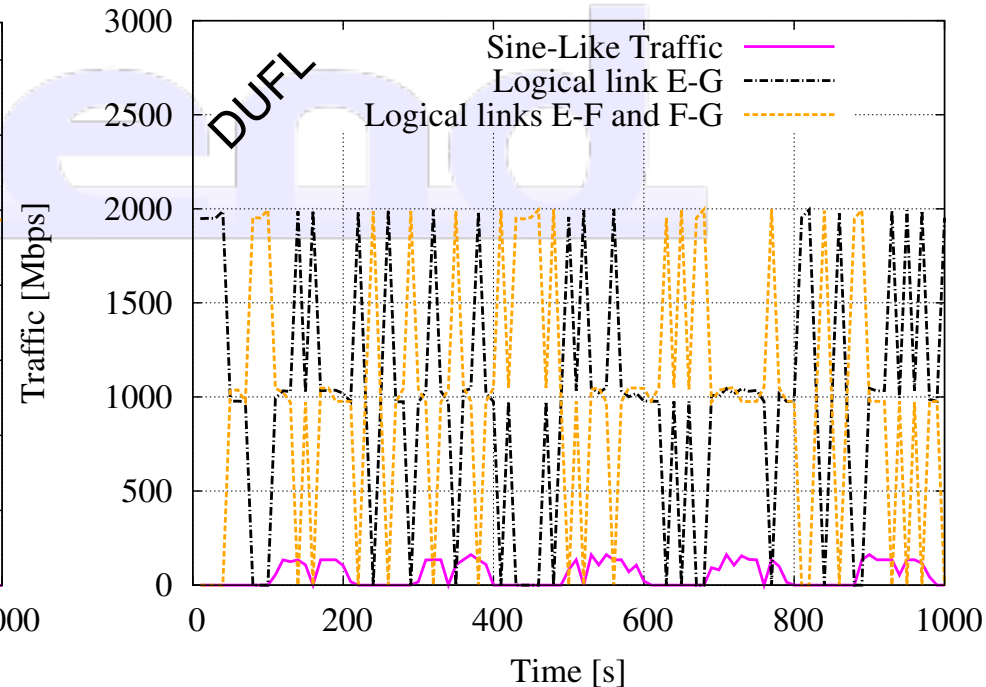
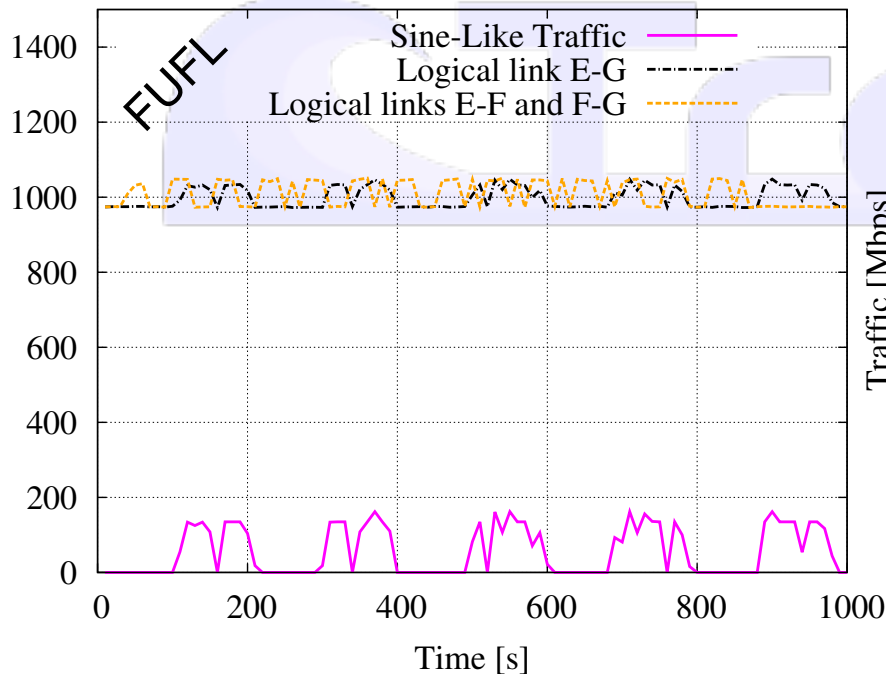
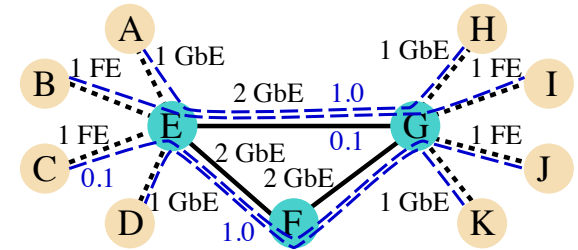


Traffic

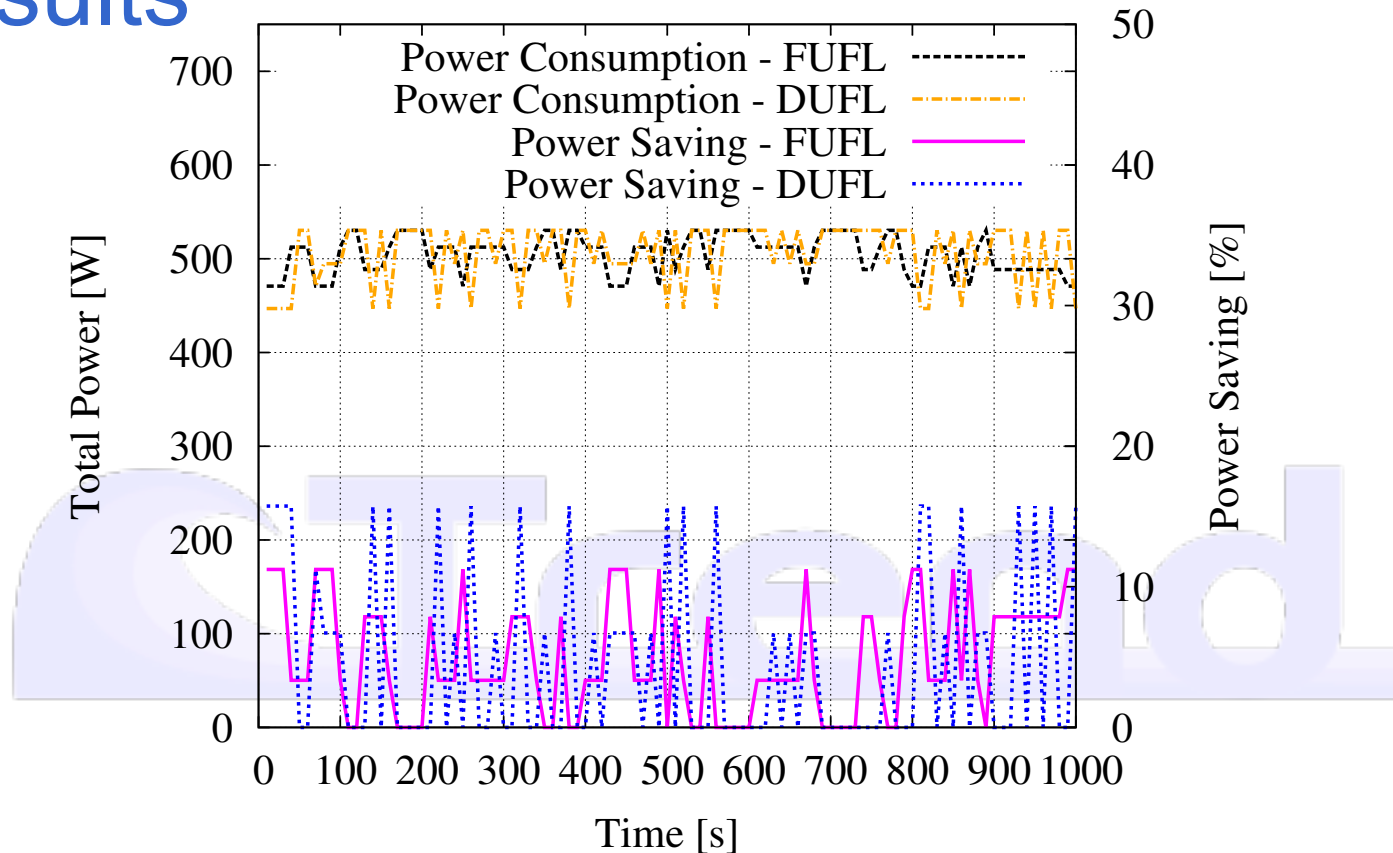
■ Two traffic types

- Sinelike (0-100 Mbps per flow) – flows B-I and C-J, period 200 s
- Random (970-1000 Mbps per flow) – flows A-H and D-K

■ Not realistic but sufficient for demonstration



Results



- GbE interfaces dynamically powered on and off using off the shelf equipment
- Power savings: low abs. values (<83.5 W), and moderate rel. values (<17%)
- Packet loss avoided with the make-before-break mechanism
- Reconfiguration takes ~22-24 s in total

Conclusions

- It is feasible to save energy using off-the-shelf equipment
- No packet loss
- Power savings
 - Small absolute values
 - Moderate relative values
 - Not the focus of this work
- Dedicated control mechanisms are required to speed up the reconfiguration

References

- [Lange11jstq] C. Lange, D. Kosiankowski, R. Weidmann, and A. Gladisch, “Energy Consumption of Telecommunication Networks and Related Improvement Options,” *Journal of Selected Topics in Quantum Electronics*, vol. 17, no. 2, pp. 285–295, March–April 2011.
- [Idzi11osn] F. Idzikowski, S. Orłowski, C. Raack, H. Woesner, and A. Wolisz, “Dynamic routing at different layers in IP-over-WDM networks – maximizing energy savings,” *Optical Switching and Networking, Special Issue on Green Communications*, vol. 8, no. 3, pp. 181–200, July 2011.
- [Valenti12networks] A. Valenti, A. Rufini, S. Pompei, F. Matera, S. Di Bartolo, C. Da Ponte, D. Del Buono, and G. Beleffi, “QoE and QoS comparison in an anycast digital television platform operating on passive optical network,” in *Proc. of the Networks*, Rome Italy, October 2012.
- [Idzi13icc] F. Idzikowski, L. Chiaraviglio, R. Duque, F. Jiménez, and E. Le Rouzic, “Green Horizon: Looking at Backbone Networks in 2020 from the Perspective of Network Operators,” in *Proc. of the ICC*, Budapest, Hungary, June 2013.



Thank you!

Merci ! Dank u!

Questions?

I. Haratcherev et al., "The TREND Experimental Activities on "green" Communication Networks,"
Proc. of the Tyrrhenian International Workshop on Digital Communications, Genoa, Italy,
September 2013.