Introducing Standby Capabilities into Next-generation Network Devices

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SEVENTH FRAMEWORK PROGRAMME

Outline

- Energy saving in the backbone
- Standby, Modularity and Virtualization
- A Traffic Engineering approach
- Performance evaluation
- The Green Router Prototype (ECONET project)

Energy saving in the backbone (1/2)

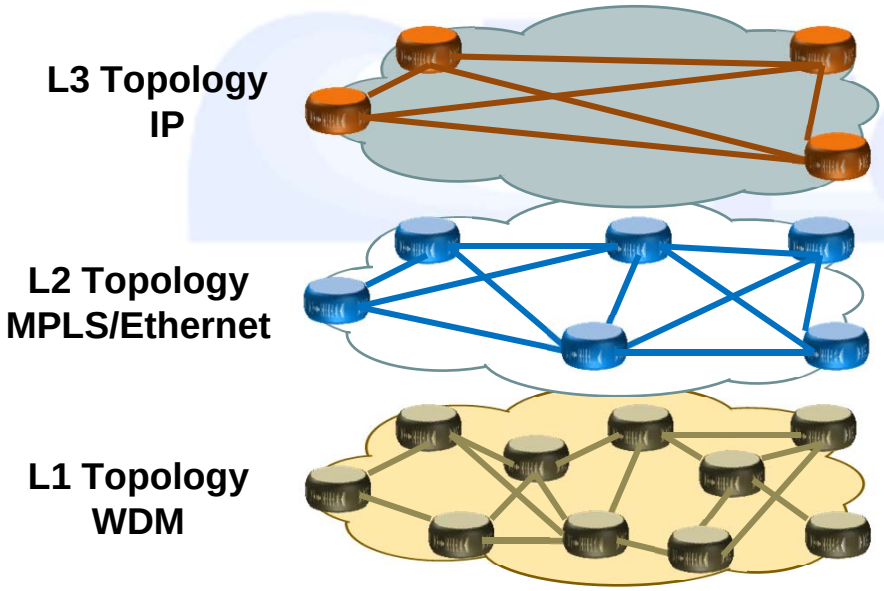
- Emerging research approaches to network control, routing and traffic engineering aim at **dynamically turning off network portions during light utilization periods**.
- Problem: the turned-off elements (e.g., links or nodes) do literally “fall off” the network because they are not able to exchange protocol signaling messages.

Energy saving in the backbone (2/2)

- Consequences:
  - exchange of large amount of control traffic;
  - converge towards new network logical topologies (transitory network instabilities and signaling traffic storms);
  - simultaneous convergences at multiple protocol layers (e.g., MPLS + IP) can cause unexpected routing paths.

The network scenario

- We considered a network scenario similar to the state-of-the-art backbone networks deployed by Telcos, working with a three-layer protocol stack



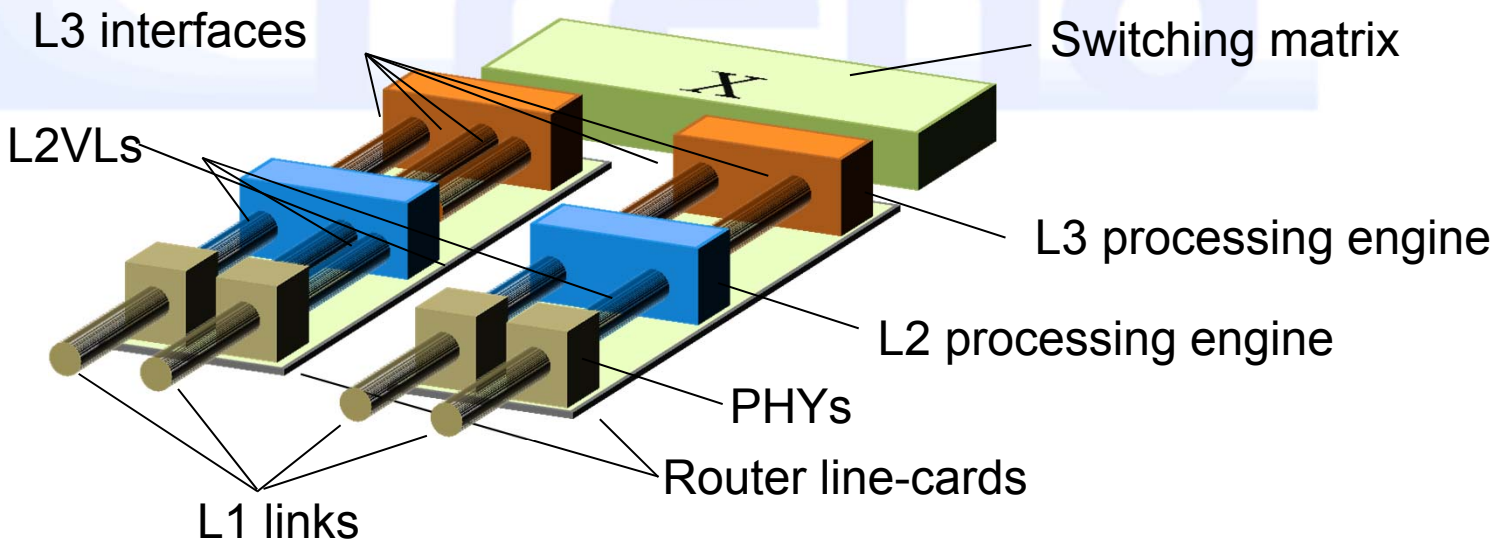
- L2 to optimally map IP traffic on the physical infrastructure (routing, QoS, fast-recovery)
- Each IP link is mapped by means of a L2 link: L2VL (L2 virtual link)
- GMPLS control plane
- IP routing protocol (OSPF or IS-IS) with TE extensions

How to save energy?

- We propose a centralized solution able to reconfigure L2 topology (when traffic decreases) maintaining the same L3 topology.
- Our solution exploits three features:
  - **Node modularity**;
  - **Standby state**;
  - **Virtualization of logical functionalities**.

Node modularity

- IP nodes have highly modular architectures:
  - a line-card can host one or more physical links (PHYs)
  - a PHY carries one or more L2VLs
  - a L2VL is terminated on a L3 interface



Standby state

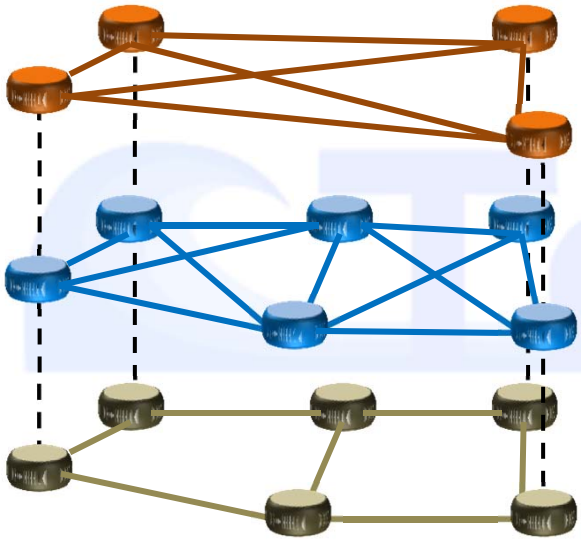
- Standby capabilities are key features of general purpose hardware:
  - hardware modules freezing their operations, while maintaining their “context” information;
  - standby state has very low energy requirements (refresh memory, optionally leave some hardware sub-modules powered on).
- We believe that standby primitives will be available for next-generation network devices.
- Our idea consists in putting in standby state some **line-cards**.

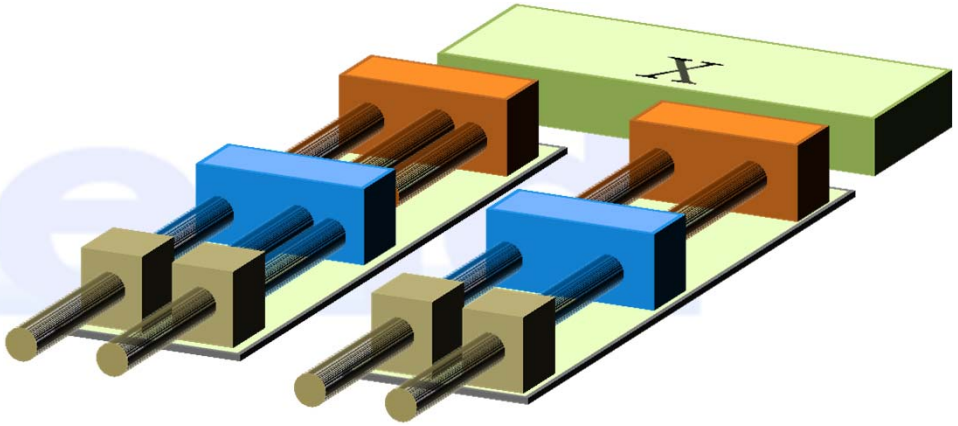
Our proposal (1/3)

- Introducing **standby** capabilities for line-cards of network devices
- **Virtualizing** IP network functionalities:
  - standby line-cards transfer their network functionalities to active line-cards of the same device
- Our proposal:

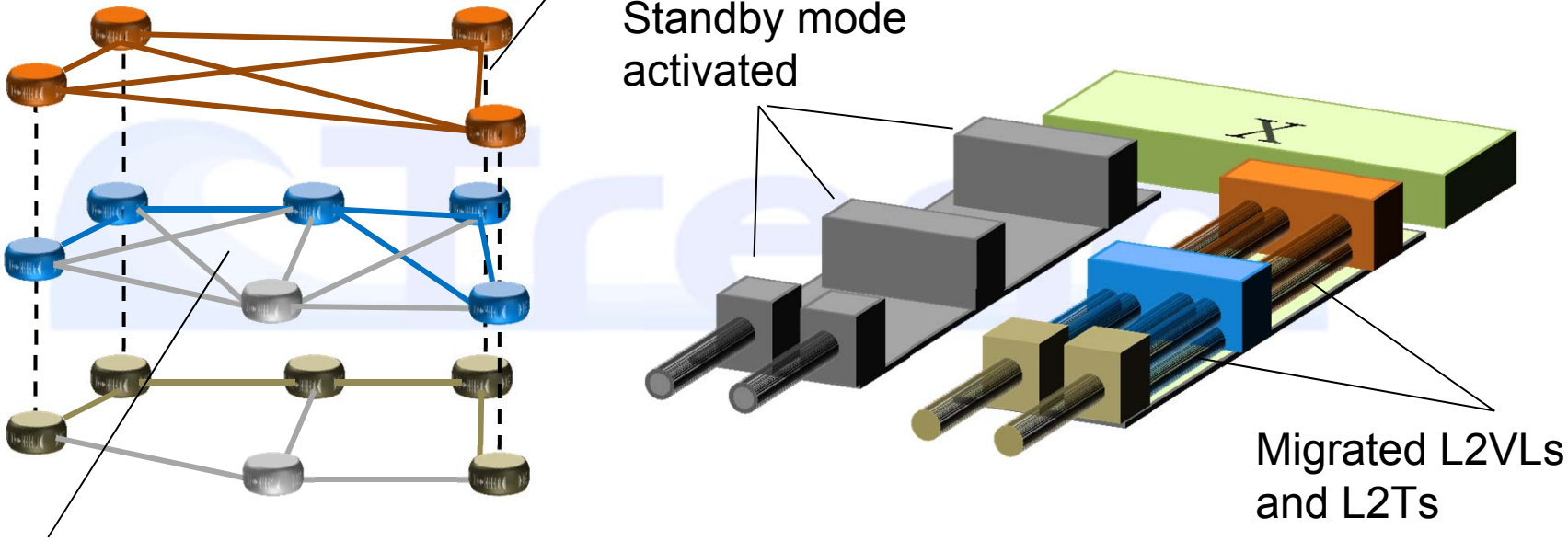
  decoupling physical elements (line-cards), which may be put in standby, from their (virtual) functionalities, so that the latter can be migrated towards other active physical elements of the same device.

Our proposal (2/3)





Our proposal (3/3)



The advantages of an L2 solution

- Our solution is completely transparent to L3:
  - IP routing protocols are unaware of network changes and so control message exchange and IP convergence (really slow) is avoided.
  - A double re-convergence (L2+L3) is avoided.
- We exploit L2 protocols since:
  - they are specifically designed to manage virtualization;
  - they already include efficient mechanisms for rapidly moving/migrating L2VLs across the network (e.g., the fault recovery procedures).

The Traffic Engineering strategy (1/2)

- A TE strategy is needed:
  - to detect the line-cards to put to sleep
  - to computes new L2VL paths (QoS)
- We propose a really simple mechanism to prove the energy saving capability of our proposal.
- The TE strategy
  - is centralized;
  - is based on fixed traffic thresholds;
  - takes into account QoS requirements (i.e. maximum link utilization).

The Traffic Engineering strategy (2/2)

- The TE strategy is based on physical interfaces (PHYs) load.
  a) A list containing all the line-cards of the network is created.
  b) The list is ranked on the basis of line-cards load.
  c) The least loaded line-card is selected.
  d) For each L2VL crossing the line-card a new path (maintaining QoS requirements) is searched:
  e) if for every L2VL a path is found, L3 interfaces are moved and the line-card is put in standby mode;
  f) the next line-card is evaluated.

Performance evaluation

- We considered two different physical networks.
- The IP overlay has a fully meshed topology; each IP link has been realized by means of a L2VL.
  - L2VLs have been allocated on the physical topology by using a simple shortest path routing strategy.
- A reference maximum-load traffic matrix has been considered, and, after L2VLs' allocation, the physical network has been dimensioned by considering two conditions:
  - a maximum traffic load on physical links equal to 50%;
  - the availability of physical interfaces with capacity multiple of 2.5 Gbit/s.

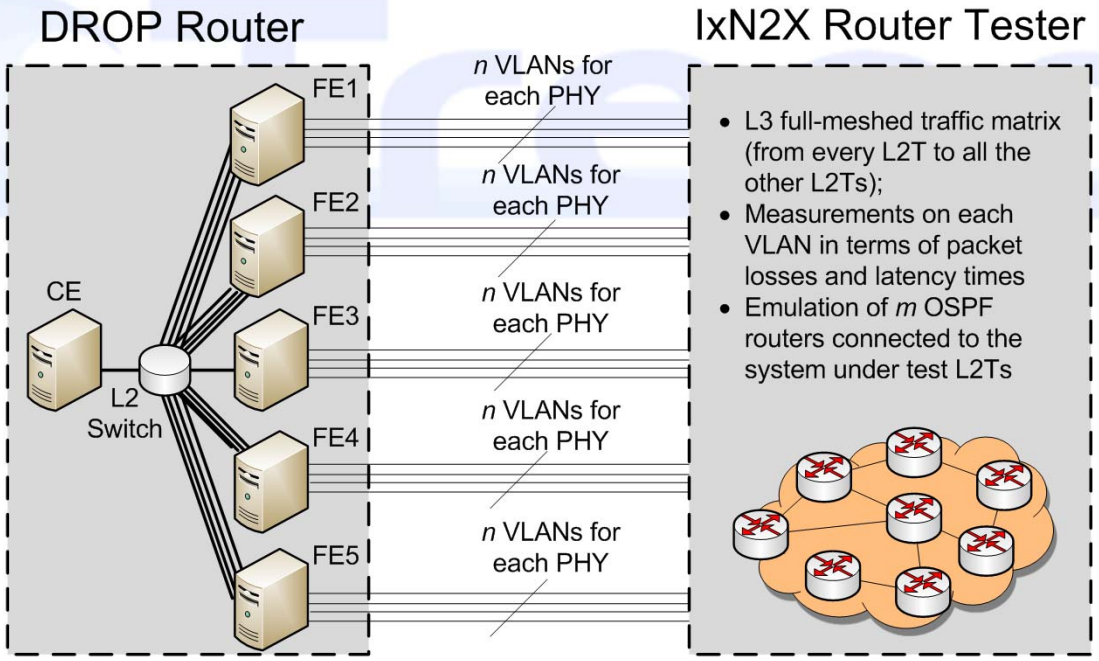
Results

- We computed the number of standby line-cards when traffic decreases under fixed thresholds (η = % of the maximum-load traffic matrix).

η	**Network topology 1 (159 nodes, 614 links)**	**Network topology 2 (244 nodes, 1080 links)**
	Standby line-cards [#]	Standby line-cards [#]
75 %	42%	45.7%
50 %	48%	51%
25 %	51.6%	55.4%

The Green Router Prototype

- An open-source SW router prototype (DROP) has been realized in ECONET project.
  - Multiple SW routers work as a single modular IP router.
  - The L2VLs are realized by means of IEEE 802.1q VLANs.



Conclusions

- A comprehensive approach to smartly support the use of standby primitives in backbone network devices is proposed.
- Node modularity and logical functionalities virtualization features are exploited.
- A simple TE solution allowing to dynamically manage standby primitives according to the traffic is defined.
- Ongoing work: constraints due to optical layer devices (ROADM)

THANKS