LTCI — GTO team

Optical Telecommunications

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- **GTO in general: optical communications, devices, networks**
  - Team leader: Yves Jaouën

- **Cédric Ware: cross-layer optical networks, optical functionalities**
  - Reach for global optimum (performance and energy) rather than layer by layer
  - Leverage optics' low energy consumption for higher-layer processing
  - Special functions: quantum key distribution, chaos-based security...

- **Elie Awwad: optical fiber sensing and monitoring**
  - Retrieve QoT information from optical propagation & signal processing
  - Employ deployed telecom fibers as distributed sensors

- **Challenge: handle these optical functionalities at network level**
  - Feedback to network $\rightarrow$ automation, dynamic reconfiguration & optimization
  - Feedback to user $\rightarrow$ influence energy consumption, digital sobriety
  - Need network abstractions, paradigm beyond layered network

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- Optical packet switching?
  - ▶ Works in the lab but heavy packet loss (contention)
  - ▶ Packet loss handled → protocol layer
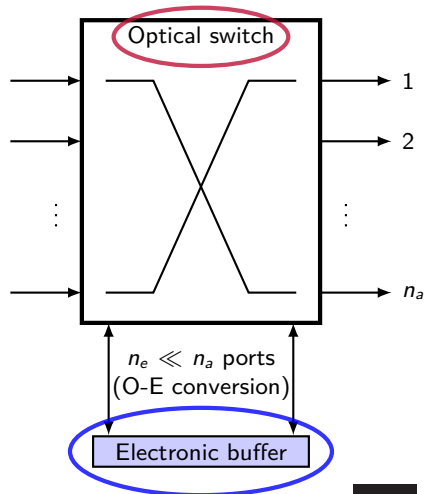 - ▶ Currently not adapted ⇒ poor performance

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$1 \rightarrow$ Dispatch roles between
optics & **electronics** ⇒ **hybrid switch**

Optical switch

→ 1

→ 2

⋮ ⋮

→ n_a

$n_e \ll n_a$ ports
(O-E conversion)
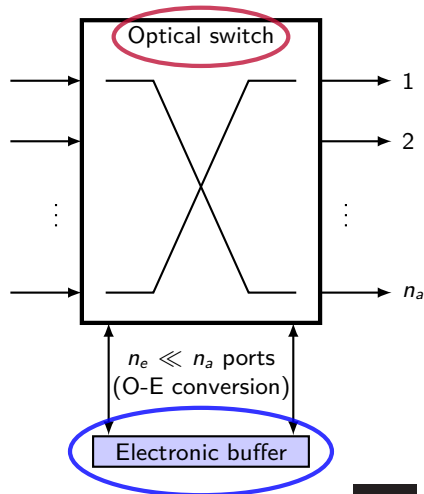
Electronic buffer

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2 → **Rework TCP's congestion control algorithms**

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→ 2

⋮   ⋮

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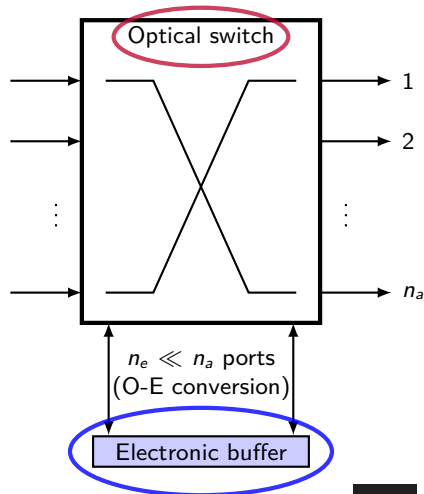 - Currently not adapted ⇒ poor performance

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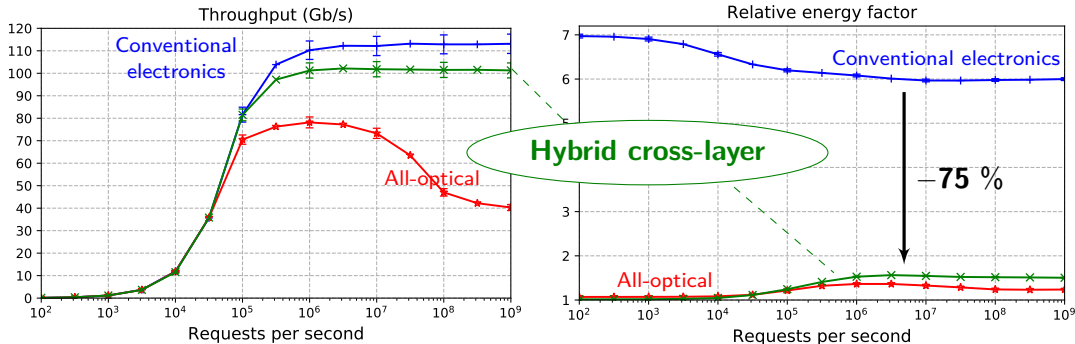**optics** & **electronics** ⇒ **hybrid switch**

$2 →$ **Rework TCP's congestion control algorithms**

- Study target: data centers
  - High consumption, 60 % from commutation
  - Short distances
  - Specialized network ⇒ possible to customize

Optical switch

→ 1

→ 2

⋮ ⋮

→ n_a

$n_e ≪ n_a$ ports
(O-E conversion)

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Throughput (Gb/s)

Relative energy factor
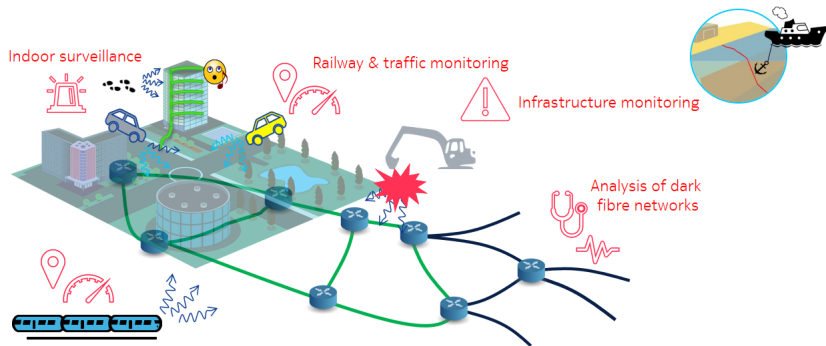
- **75 % savings for only 10 % capacity loss**
- −45 % consumption for data centers alone
- −250 TWh/year ($\simeq$ ½ France's electricity production)

A. Minakhmetov, L. Iannone and C. Ware. *IEEE Photonics Technology Letters* 31.8 (Apr. 2019).
A. Minakhmetov, C. Ware and L. Iannone. *Photonic Network Communications* (June 2020).

Example: Applications of distributed sensing over telecom infrastructure

Indoor surveillance

Railway & traffic monitoring

Infrastructure monitoring

Analysis of dark fibre networks

- Standard telecom applications
  - Characterization of the environment of deployed dark fibers in metro networks
  - Monitoring of first submarine cable span

- Smart City applications
  - Indoor surveillance
  - Surveillance of sensitive sites
  - Road/Train traffic monitoring
  - Safety applications

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Optical Phase vs Time response for selected sensors
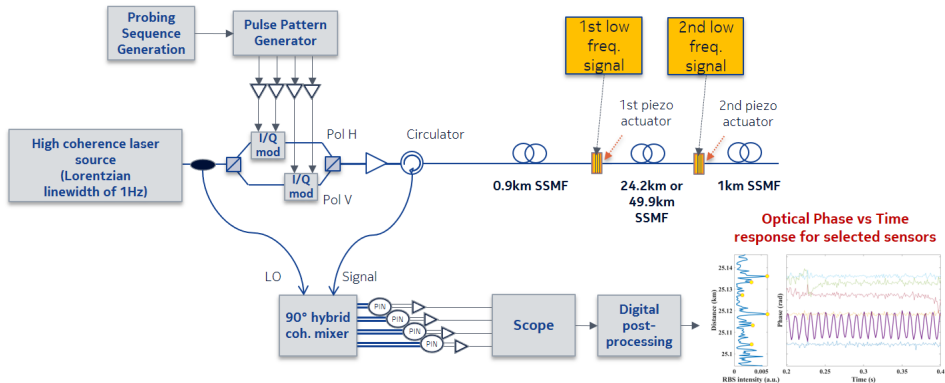
- 50MBaud PDM-BPSK codes, length: approx. 1ms yielding a bandwidth of 475Hz, acquisition window: 1s
- 2 applied perturbations at 0.9 km and 25.1 km (resp. 50.8 km) from interrogator

E. Awwad, C. Dorize and S. Guerrier, *IEEE Journal of Lightwave Technology* 38.12 (2020).

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