A Novel Photonic Switch Architecture based on Optical Codes for OBS Networks

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Outline

- Introduction: Optical Burst Switching scenario
- Switching architectures based on TWC
- Optical Codes
  - encoders/decoders
- Proposed photonic switch architecture
  - code based
- Numerical results
  - SPN switch with TWC vs. proposed code based switch
  - Burst blocking probability
  - Complexity/costs
  - Simulation through our C++ M_OBS_Sim tool
- Conclusions

Optical Networks: Evolution

- DWDM technique
  - **Transmission rate in the range of Tbit/s**
- Architectural semplification
  - **From IP over ATM over SONET over WDM to IP over WDM**
- Need to exploit in an effective way the huge transmission bandwidth with IP traffic
  - **Wavelength Routing**
    - ✓ all-optical data network
    - ✓ Low flexibility for IP traffic
  - **Optical Packet Switching**
    - ✓ Ideal transfer mode for IP traffic
    - ✓ Severe technological constraints → not feasible in the short/middle term
      - Optical components immature
      - Optical buffers

Optical Burst Switching

Goal: better sinergy between the mature electronic technologies and the new optical tecnologies (mid-term solutions)

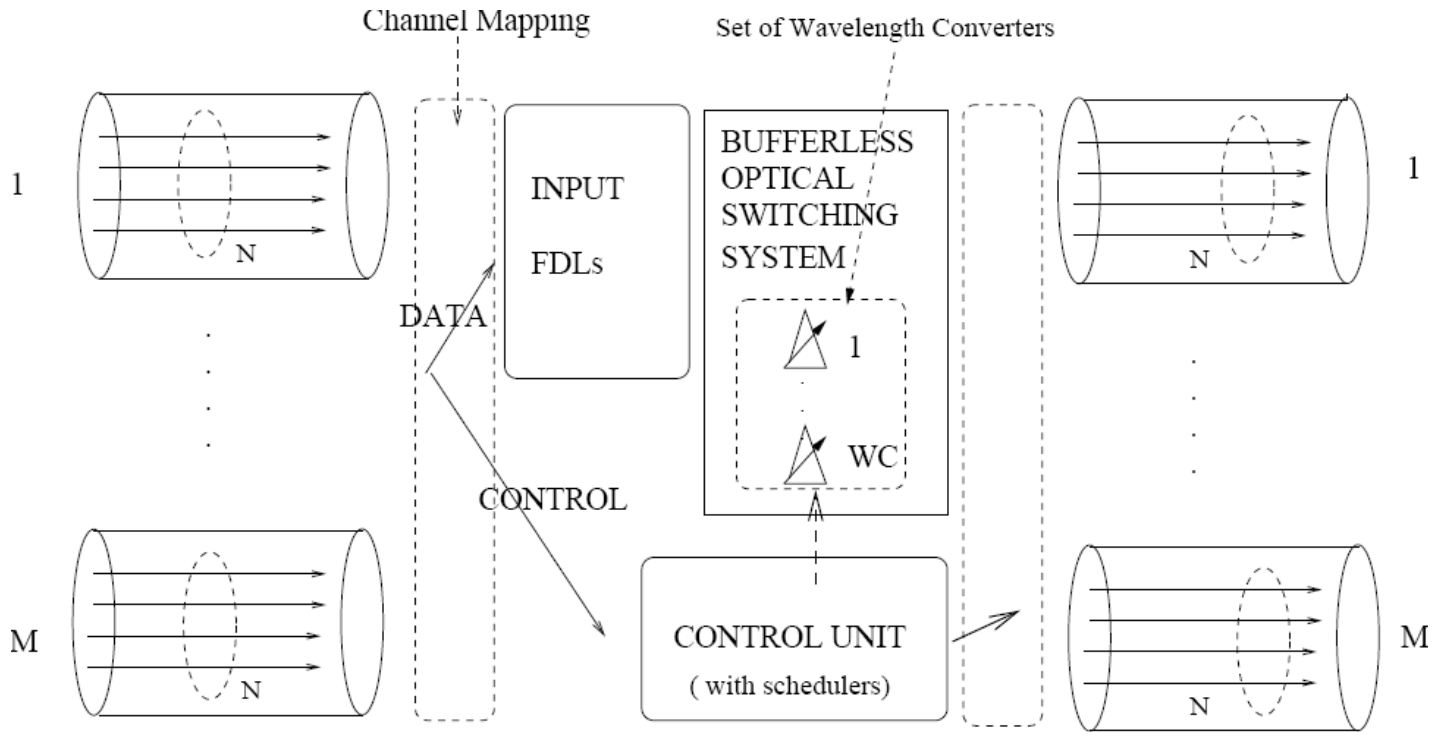
- **Switching granularity between WR and OPS**
  - *Burst concept:* aggregation of IP packets with common features (e.g. destination and QoS), considered as the basic optical unit
- **Time and space separation of data and control (header) fields**
  - Control packet employs dedicated channel and precedes the relative data burst
    - All-optical network, buffer-less and data trasparent
    - Hybrid opto-electronic network for control signals (*out-of-band signaling*)
  - Simplification of the electronic processing of the control packets at intermediate nodes
  - Reduction of the opto-electronic functionalities required to router

Switching Architectures with WC

Contention resolution through:

- Wavelength conversion: optoelectronic devices
  - Tunable Optical Wavelength Converters (TOWC)
    - ✓ From any input wavelength to any output wavelength (any-to-any)
    - ✓ Tunable lasers
  - Fixed Output Wavelength Converters (FOWC)
    - ✓ From any input wavelength to one output wavelength (any-to-one)
    - ✓ Fixed wavelength laser
- Share-per-Node
  - Shared bank of TOWC employed by any incoming burst on any wavelength
- Share-per-Input-Link
  - Shared bank of TOWC employed by bursts on the same fiber
- Share-per-Output-Link
  - Shared bank of TOWC employed by bursts addressed to same output

Shared-per-Node Switch Architecture



- **Limited pool of shared full range TOWC**
- **No fiber delay lines**
- **Widely investigated in the past: it can be considered a reference**

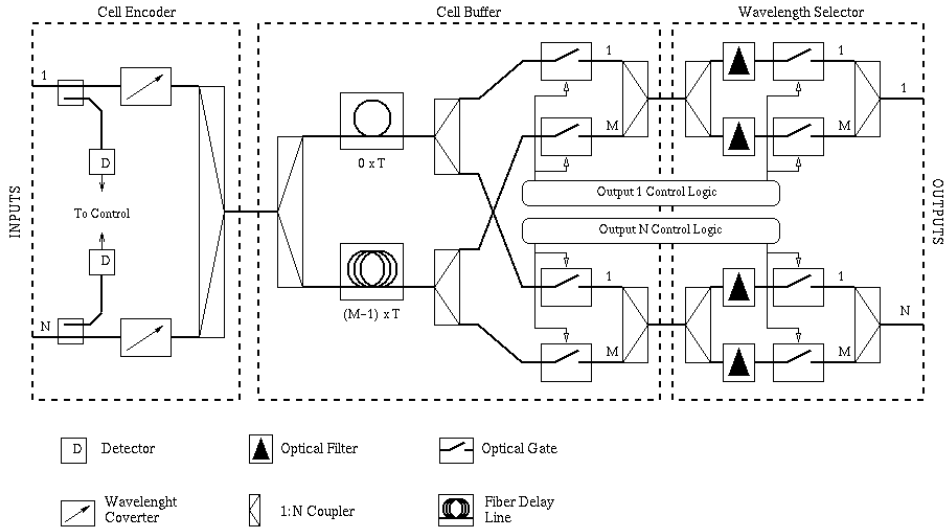
Optical Codes in Switches

- **Issue**: minimize the processing time of the burst control packet
- Possible approach: use of optical codes combined with MPLS/GMPLS
- Optical codes associated to labels
- To this end some optical devices have been proposed and evaluated: multiple plane encoders/decoders
- With such devices a packet processing rate of 13 gigapackets/s can be reached

Switching methods

- **OASIS switch (1995-96)**
  - **Incoming packets converted to wavelengths associated to the addressed output**
  - **Fiber delay lines for contention resolution**

- **KEOPS project (1998)**
  - **Incoming packets converted to wavelengths associated to the input link**
  - **Fiber delay lines for contention resolution**

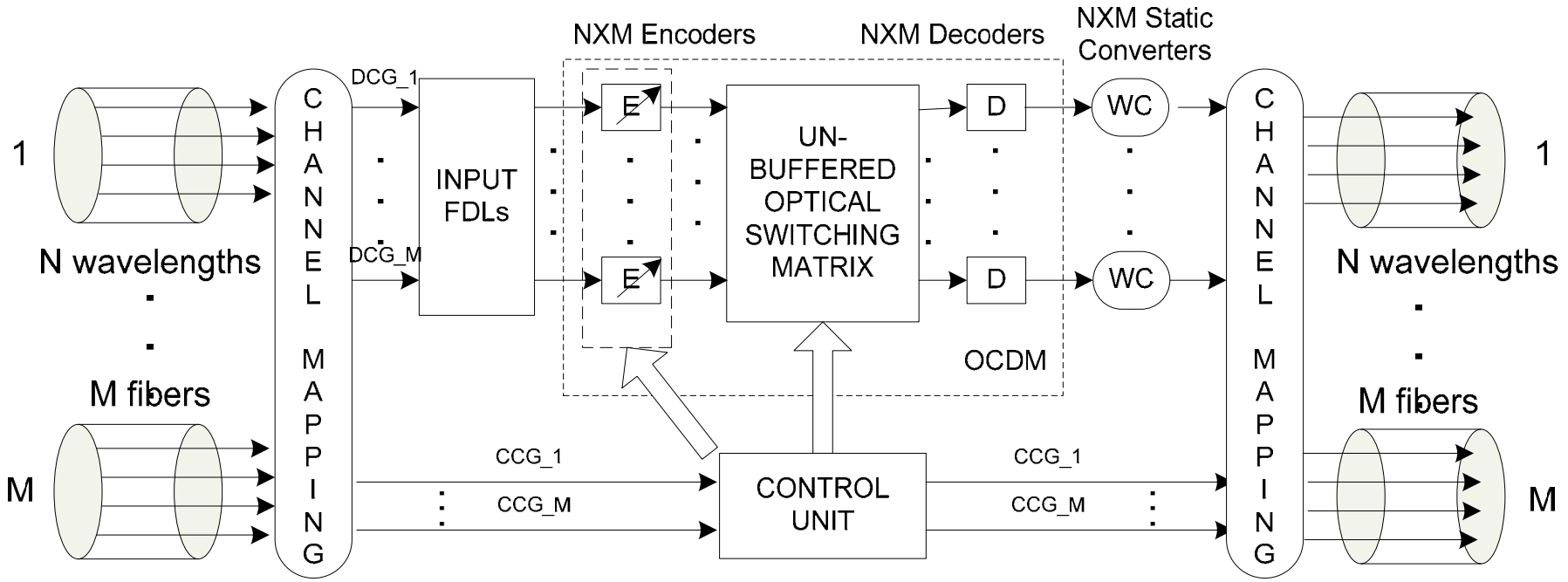


Proposal:

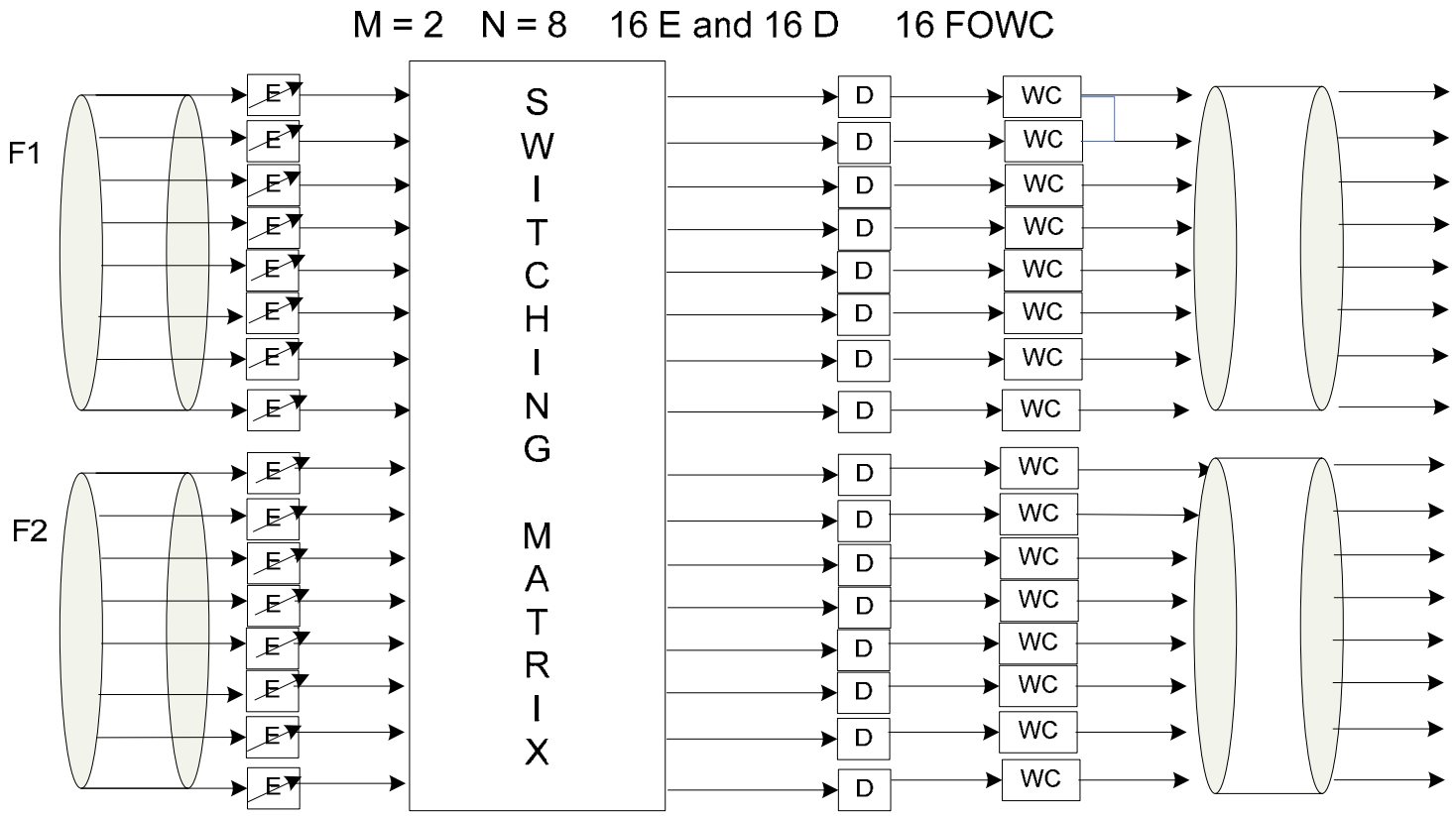
Switching bursts by encoding them as a function of the requested output, i.e., to associate a code to each output wavelength

Novel Code based OBS core router

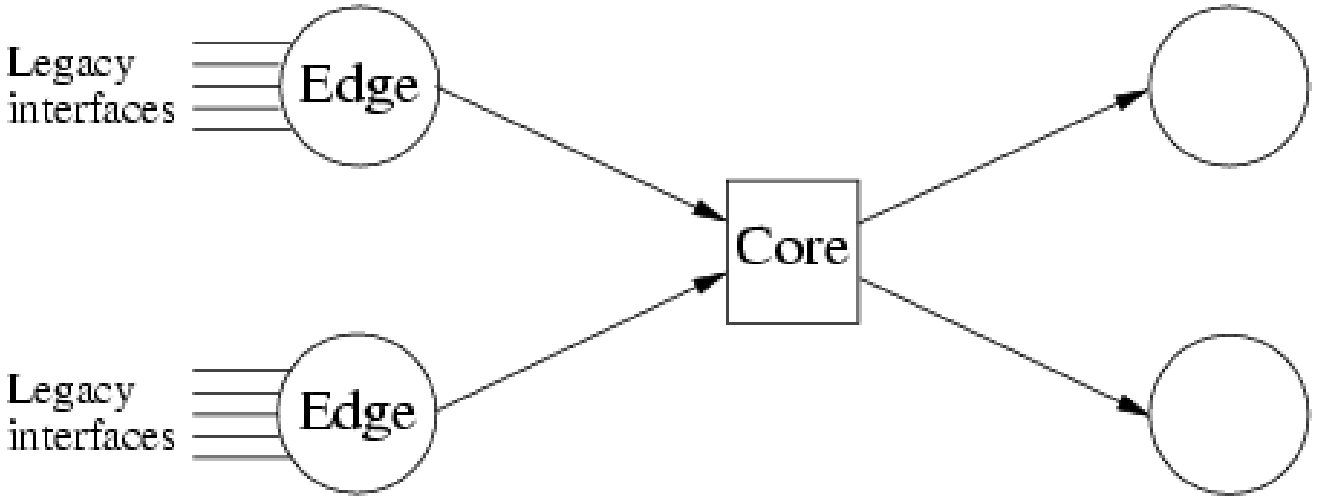
- **Encoders (variable) and decoders (fixed)**
- **Fixed Output Wavelength Converters (any-to-one)**



Example: 2x2 switch with 8 wavelengths

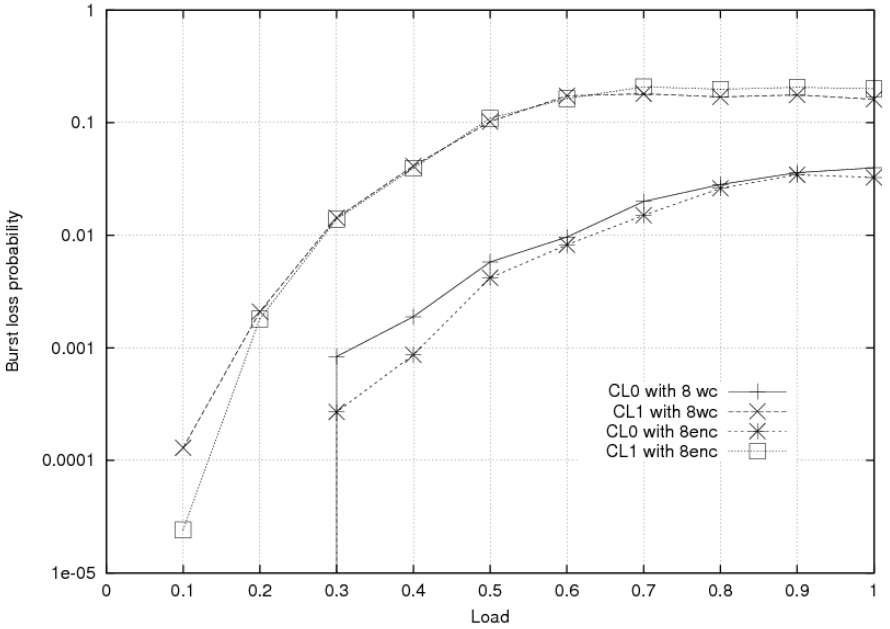


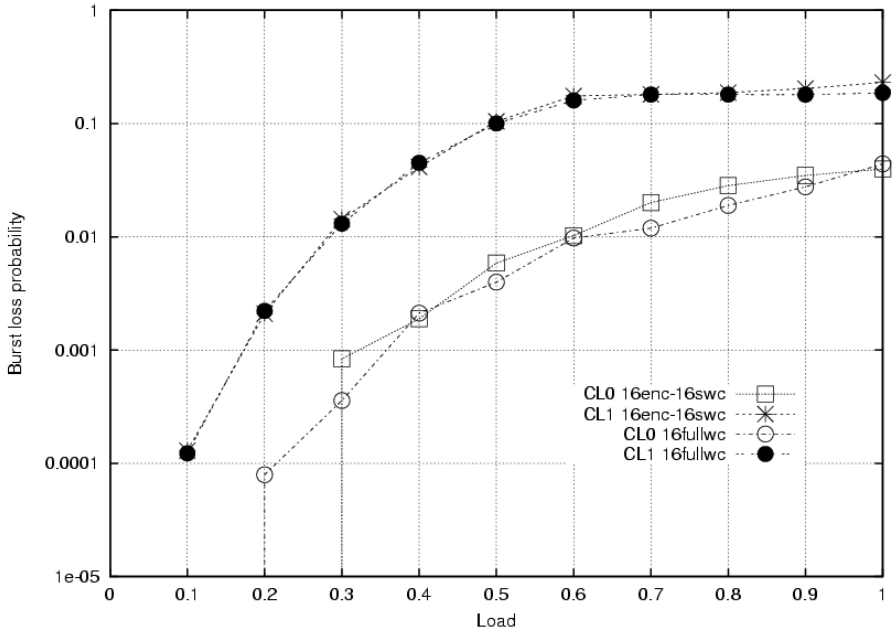
The Reference Network



- **Link rate (each wavelength) = 10 Gbit/s**
- **Incoming traffic: two classes of service (p_0 and p_1), M/Pareto**
  - **ON = 512 bytes**
  - **α = 1.2**
- **JET reservation mechanism: extra-offset for class 0 = 18 μs**
- **Edge nodes: time assembly algorithm with T_{max} = 2 μs**
- **LA-FFVF scheduling algorithm**
- **Control packet size = 16 bytes**

Code based vs. SPN with TOWC architecture

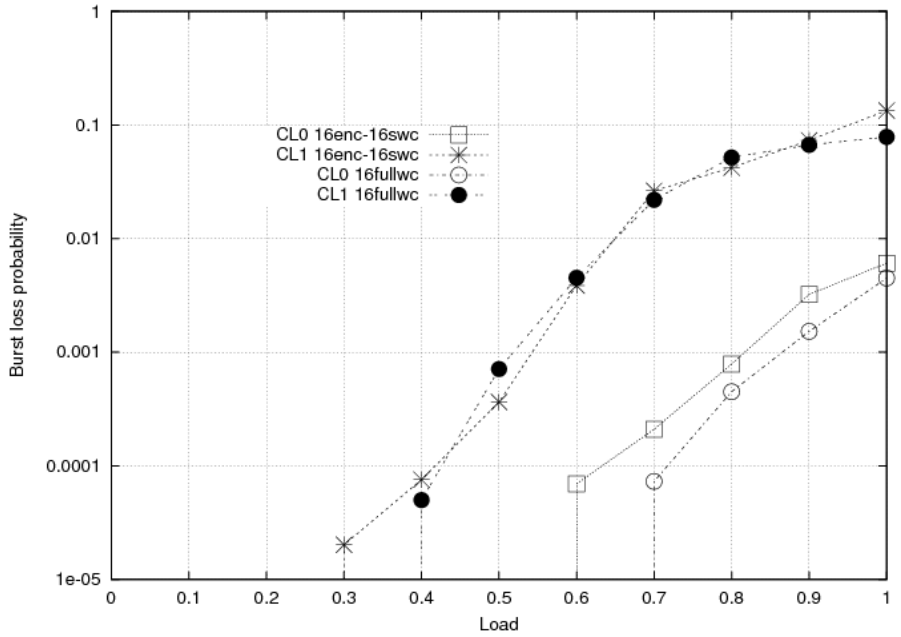


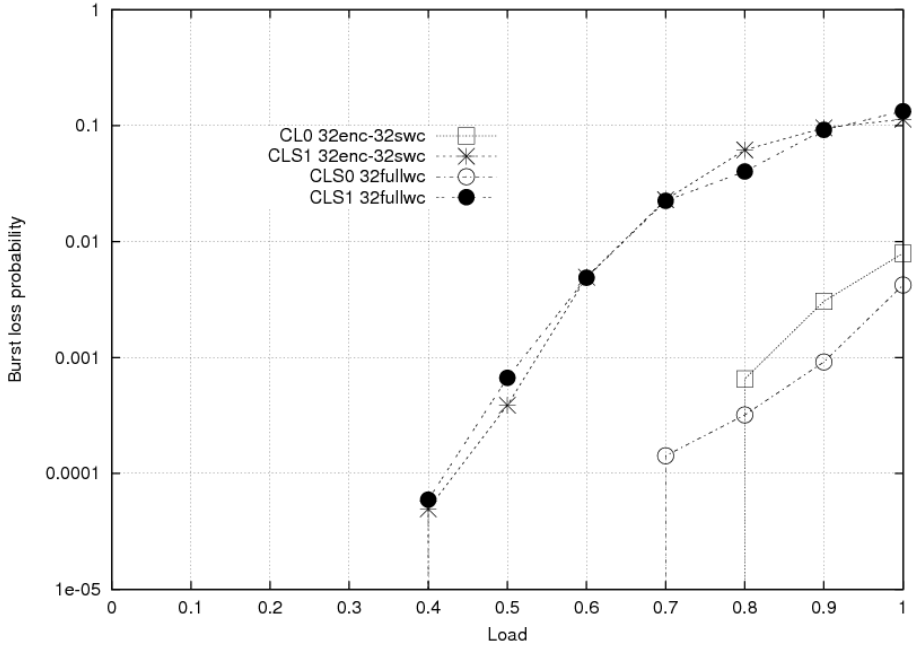


Two traffic classes: p_0=0.2 and p_1=0.8

- 2x2 switch with 4 wavelengths
- 4x4 switch with 4 wavelengths

Code based vs. SPN with TOWC architecture

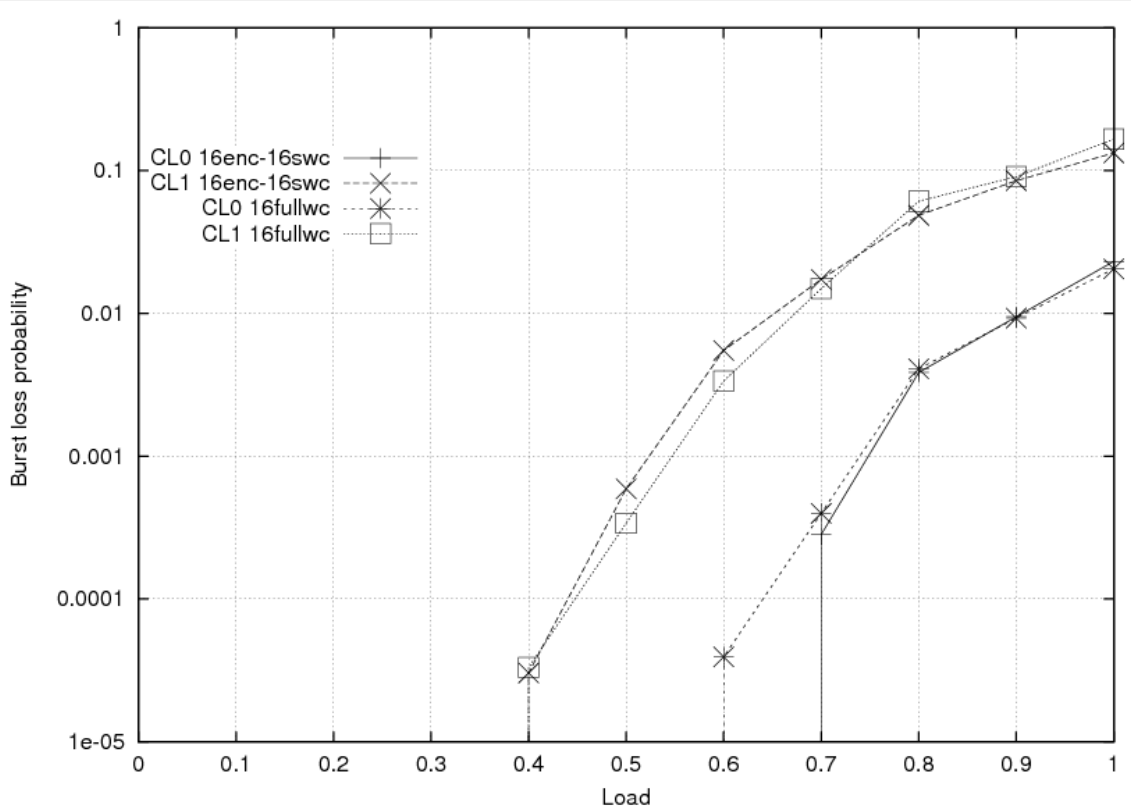




Two traffic classes: p_0=0.2 and p_1=0.8

- 2x2 switch with 8 wavelengths
- 4x4 switch with 8 wavelengths

Code based vs. SPN with TOWC architecture



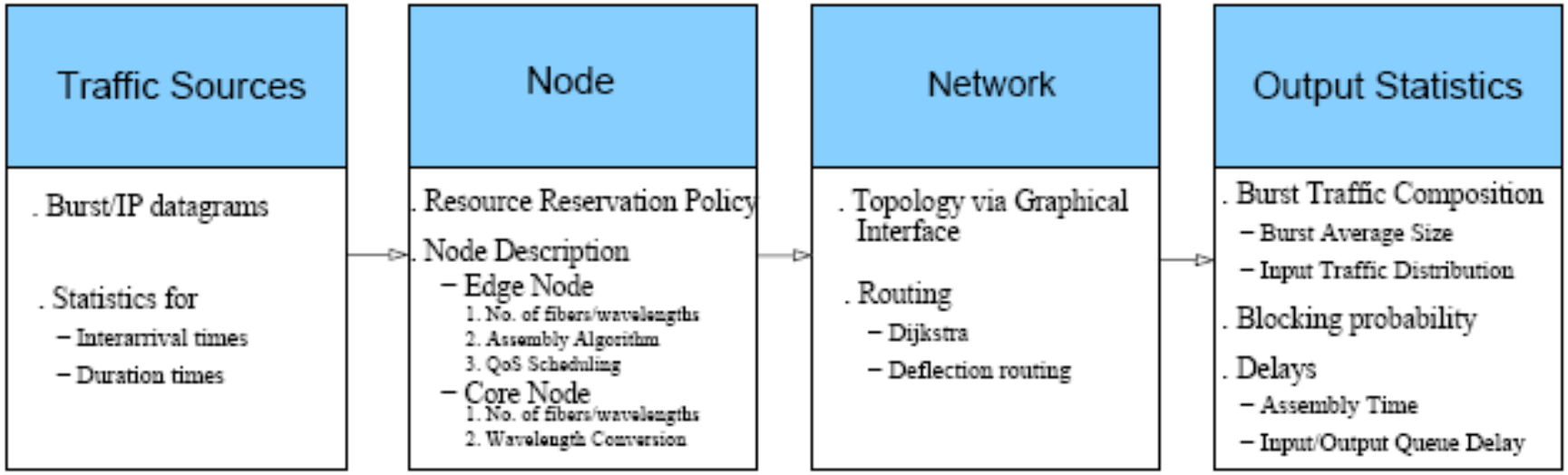
2x2 switch with 8 wavelengths

Two traffic classes: $p_0=p_1=0.5$

Main results:

- **Performance in terms of BLP are very similar in all investigated scenarios**
- **the proposed code-based switch architecture can be used in place of switches based on expensive TOWC**

M_OBS_Sim: LOGICAL SCHEME



(demo available at **http://www.dii.unimore.it/~mcasoni**)

M.Casoni, E.Luppi. U.Manzoli, M.L. Merani,
"M_OBS_SIM: a Powerful Modular Optical Burst Switched (OBS) network SIMulator",
Simulation Modelling Practice and Theory, vol. 14 (2006), pp. 874–883, *Elsevier Journal*.

Conclusions

- A novel switching architecture based on optical codes has been proposed and evaluated for core nodes in OBS networks
- Optical codes have been used for coding incoming bursts as a function of the selected output wavelength to perform the switching function
- Encoders and decoders are used
- Output contentions solved in the wavelength domain through variable-input fixed-output wavelength converters
- The proposed architecture has been compared with a SPN switch based on tunable output wavelength converters
- Performance evaluation in terms of burst blocking probability

Main results:

- **Performance in terms of BLP are the same in all investigated scenarios**
- **the proposed code-based switch can be used in place of switches based on expensive TOWC, leading to remarkable savings and to a lower complexity**

THANK YOU FOR YOUR ATTENTION

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… suggestions are very very welcome