Performance Evaluation of Channel Scheduling Algorithms with different QoS classes

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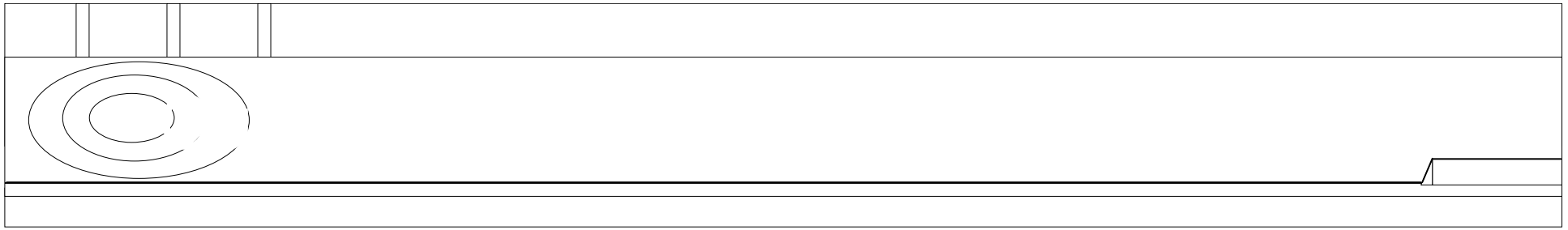
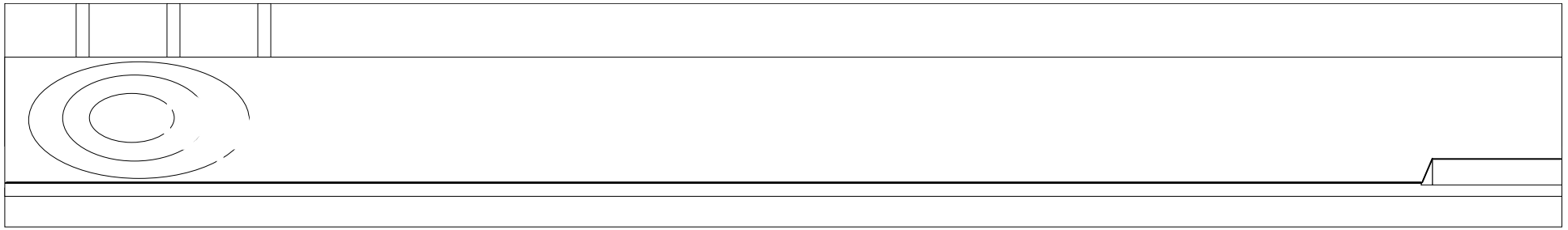
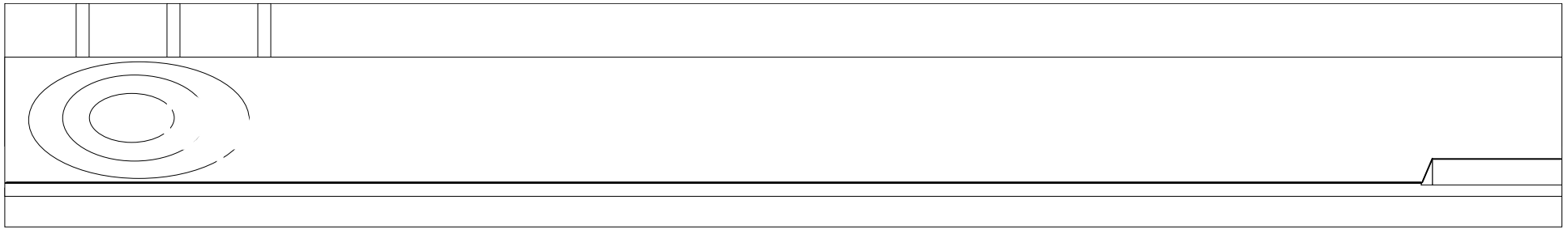


- Introduction: Optical Burst Switching scenario
- Scheduling algorithms
  - FFUC, LAUC, FFUC-VF, LAUC-VF
- Proposed scheduling algorithm
  - LA-FFVF
- Numerical results
  - Simulation through M_OBS_Sim tool
- Conclusions



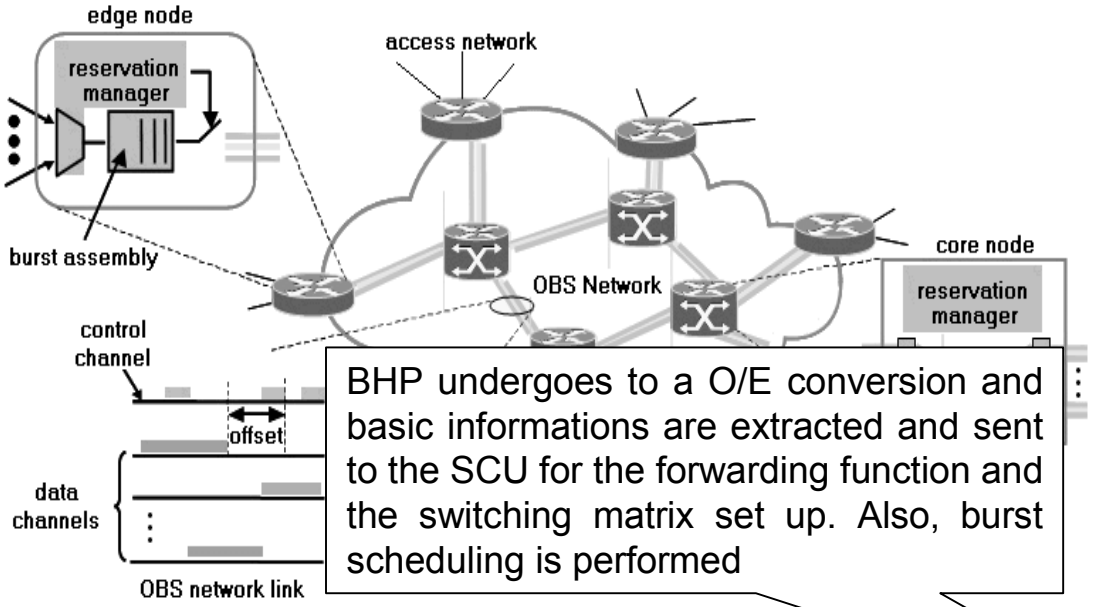
- DWDM technique
  - **Transmissionrate in the range of Tbits**
- Architectural semplification
  - **From IP over ATM over SONET over WDM to IP over WDM**
- Need to exploit in an effective way the huge transmission bandwidth with IP traffic
  - **Wavelength Routing**
    - ✓ all-optical data network
    - ✓ 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



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

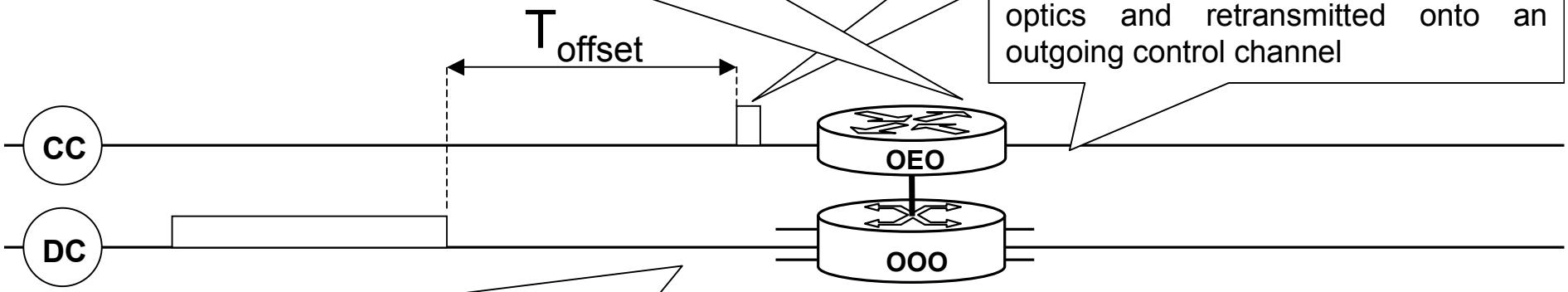


- **Two types of nodes:**
  - **Edge node**
    - **Interface between legacy network and optical domain**
    - **Assembly / Disassembly**
  - **Core node**
    - **BHP processing**

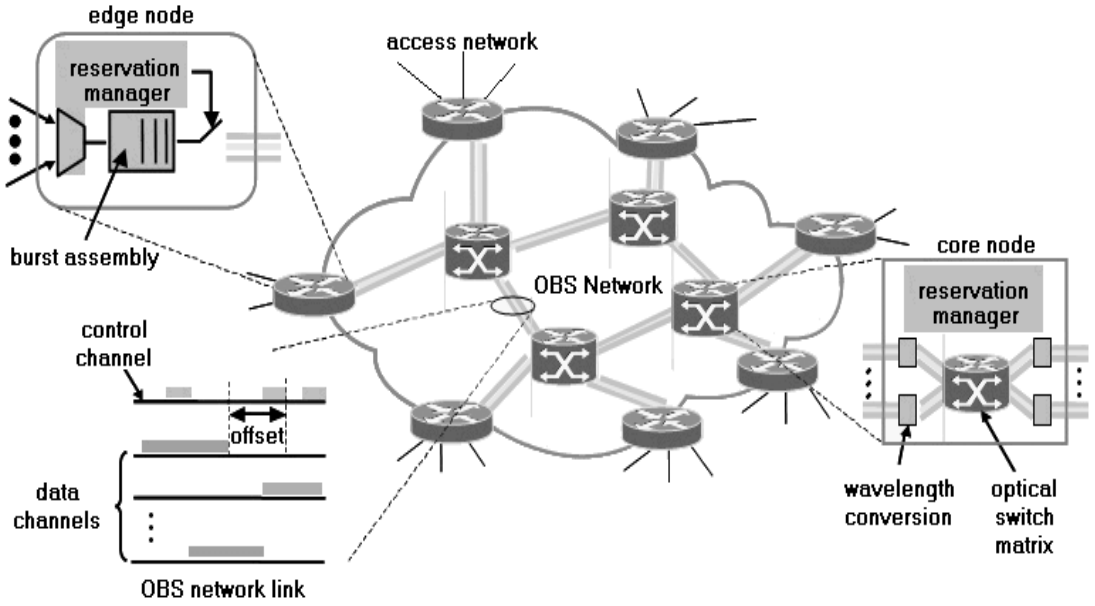
BHP undergoes to a O/E conversion and basic informations are extracted and sent to the SCU for the forwarding function and the switching matrix set up. Also, burst scheduling is performed

Control packet (BHP) arrival at the interface of a core node

BHP is updated, reconverted into optics and retransmitted onto an outgoing control channel



When the data burst arrives at the core node, the optical matrix is already set up and all internal devices configured. Data burst does not experience any delay and remain in the optical domain



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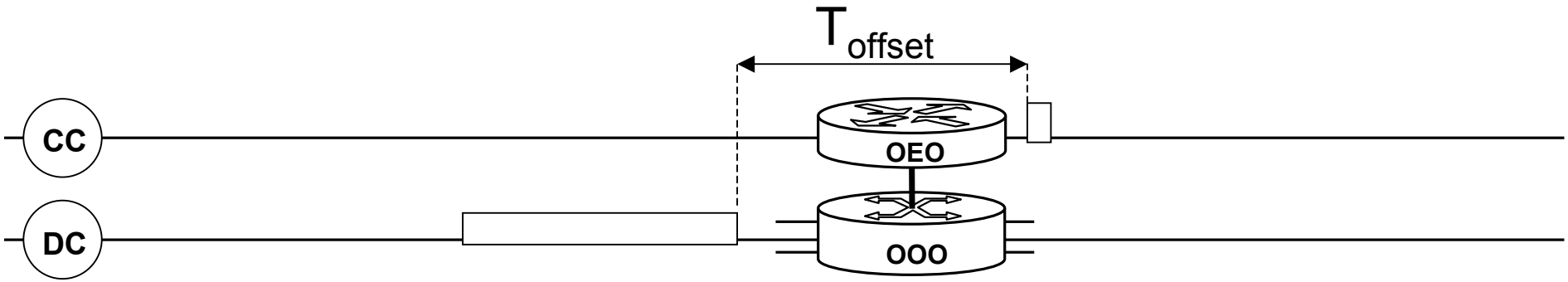
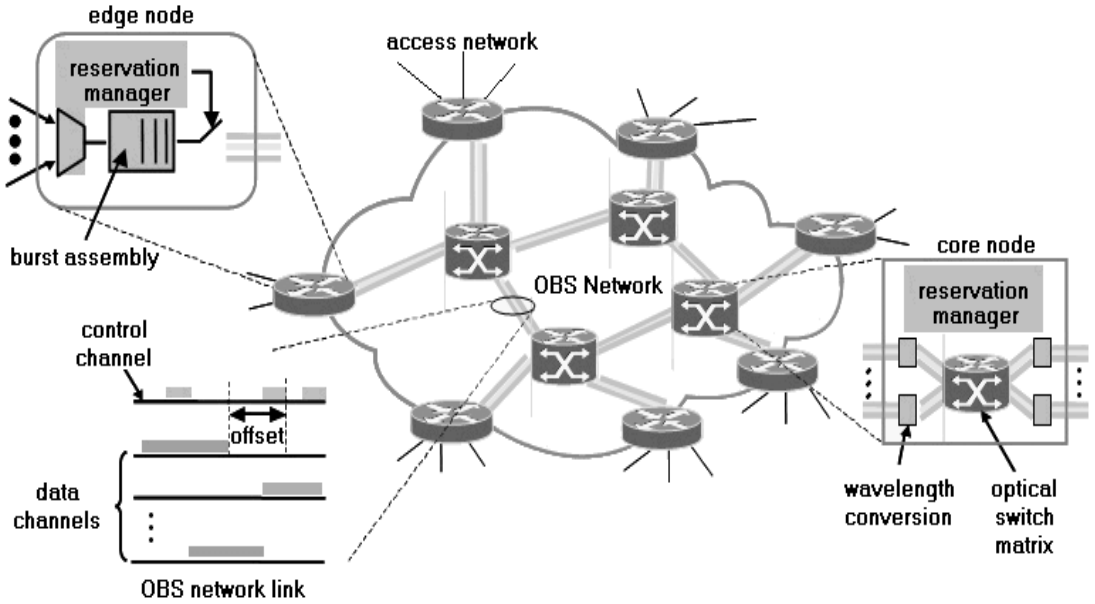
    - **Routing table look-up**
    - **Scheduling**





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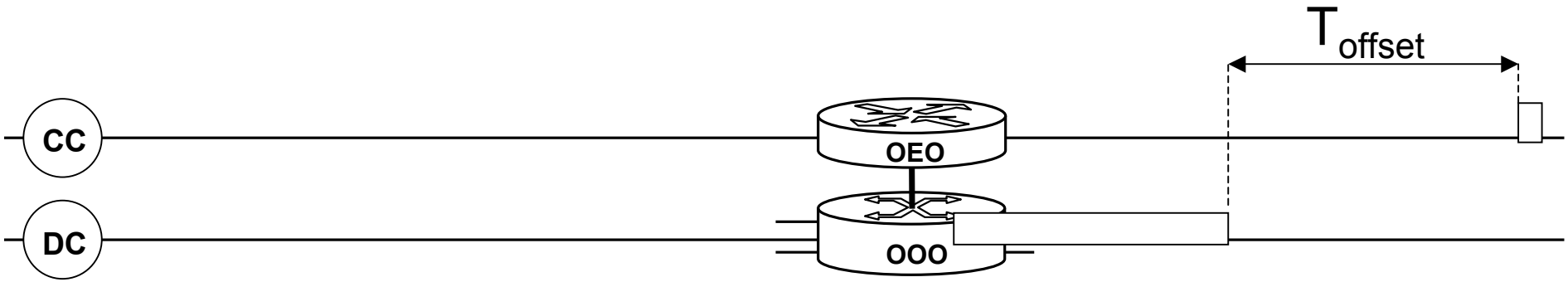
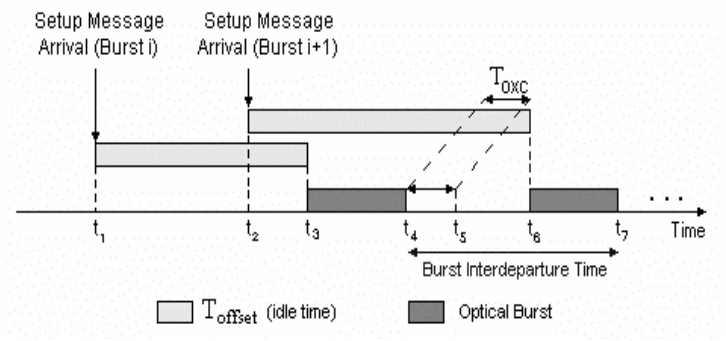
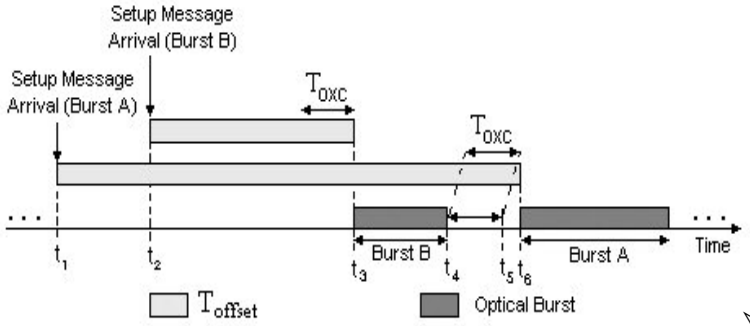
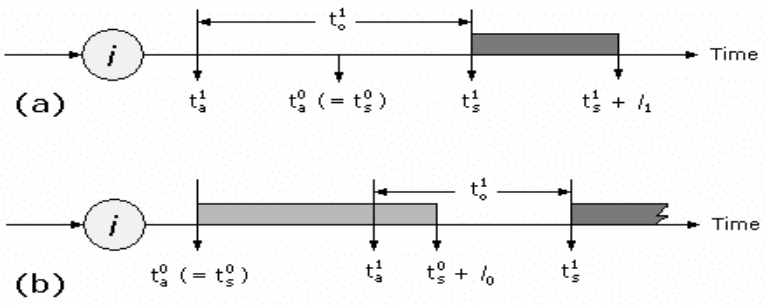


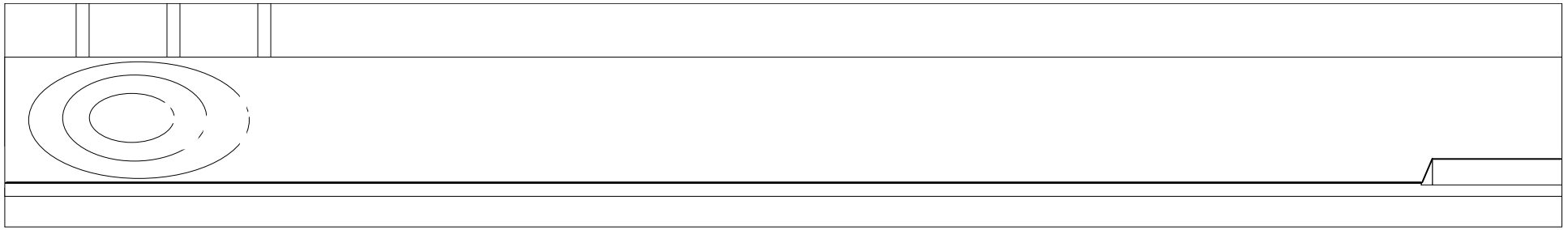




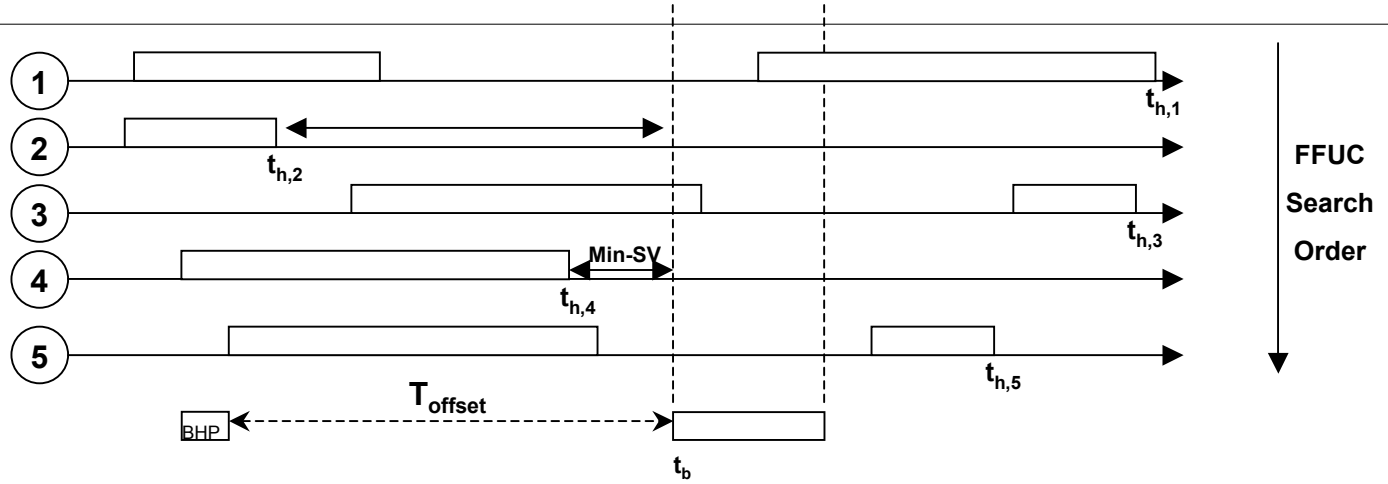


- Delayed reservation (Just Enough Time)
  - **BHP contains informations about the start and the duration of the correspondent data burst**
  - **Output wavelength is reserved only for the dat a burst length**
    - Efficient resource utilization
  - **Possibility to exploit empty spaces between 2 previously scheduled bursts (Void Filling)**

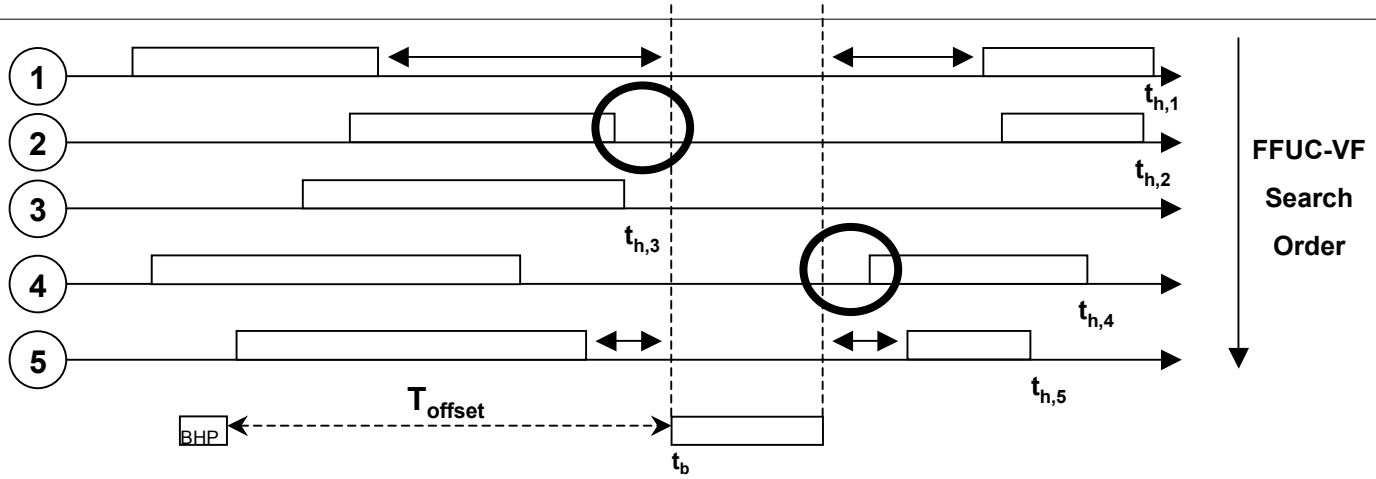
- QoS
  - **Additional extra offset allows to BHP to reserve the output channel in advance**
    - Lower blocking probability
    - Implementation of different QoS classes



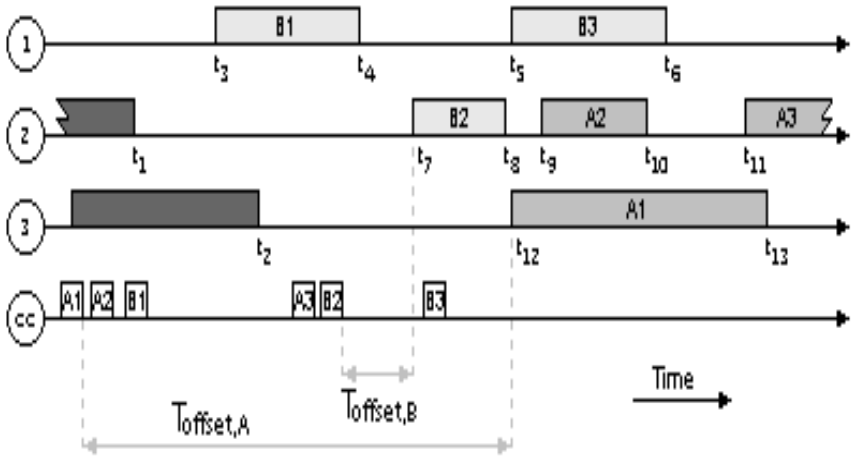
- Outputchannel contention
  - **Contention in a buffer-less node increases the burst loss probability.**
- Contention Resolution
  - **Core router complexity and cost increases**
- Better to avoid contention rather than resolve it
  - Improve the wavelength exploitation, i.e. improve the scheduling algorithms
    - ✓ Algorithms without Void Filling
    - ✓ Algorithms with Void Filling



- **FFUC (First Fit Unscheduled Channel)**
  - **Following a predefined order (e.g. round robin), it is reserved the first channel whose *Horizon time* is less than the burst starting time**
    - **Very simple and fast**
    - **Low resource utilization (fragmentation for T_{offset})**
- **LAUC (Latest Available Unscheduled Channel)**
  - **The channel made available most recently is reserved (e.g. Min-SV)**
    - **Resource fragmentation is minimized because the inter burst gap is decreased**
    - **More complex because a data structure must be kept and updated with all the Horizon times**



- **FFUC-VF (First Fit Unused Channel with Void Filling)**
  - **A channel is available if it is not already scheduled or it has a void suitable for the current burst**
- **LAUC-VF (Latest Available Unused Channel with Void Filling)**
  - **In addition to LAUC, it is now possible to insert a burst in a suitable void**
    - **Min-SV**
    - **Min-EV**
    - **Best-Fit**



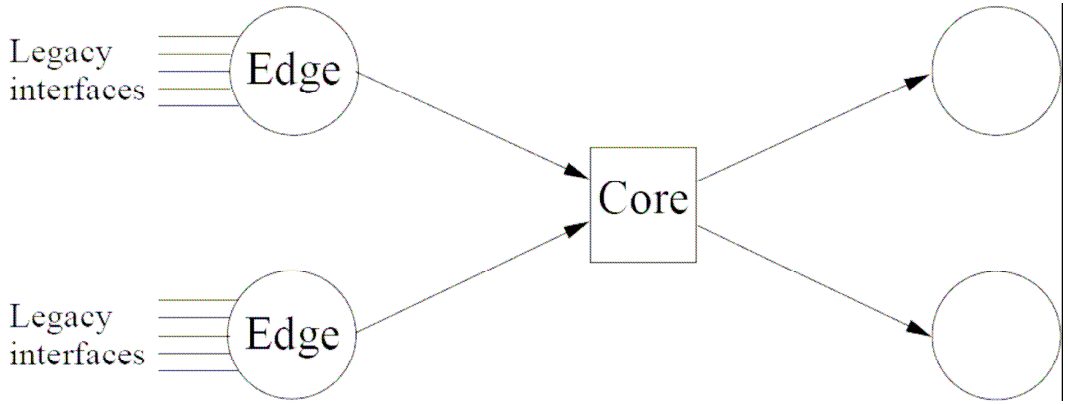
LA-FFVF Algorithm

- 2 burst classes to implement QoS (loss-sensitive with extra-offset and delay-sensitive)
- No VF for class A (high priority)

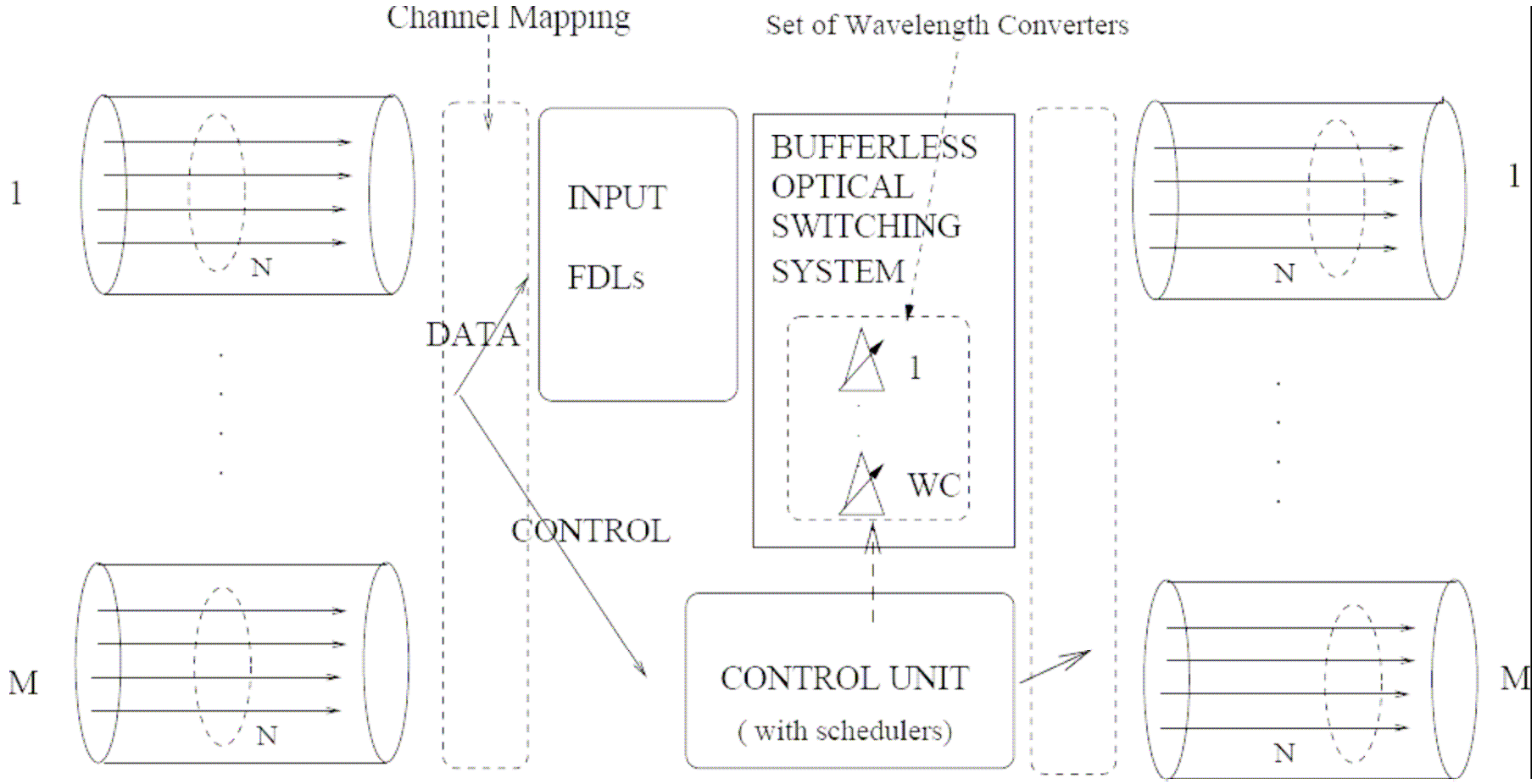
LA-FFVF (hybrid algorithm):

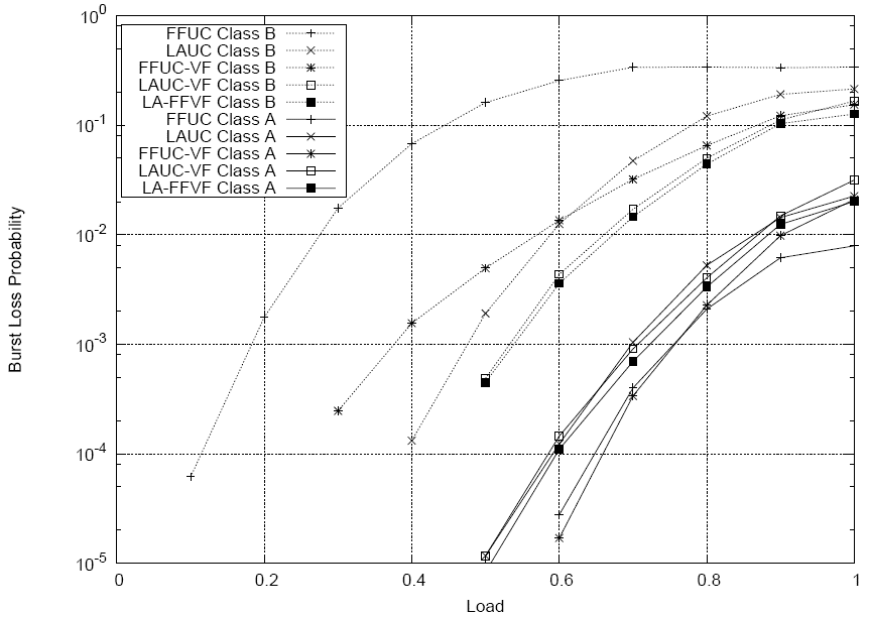
- LAUC for class A bursts
- FFUC-VF for class B bursts

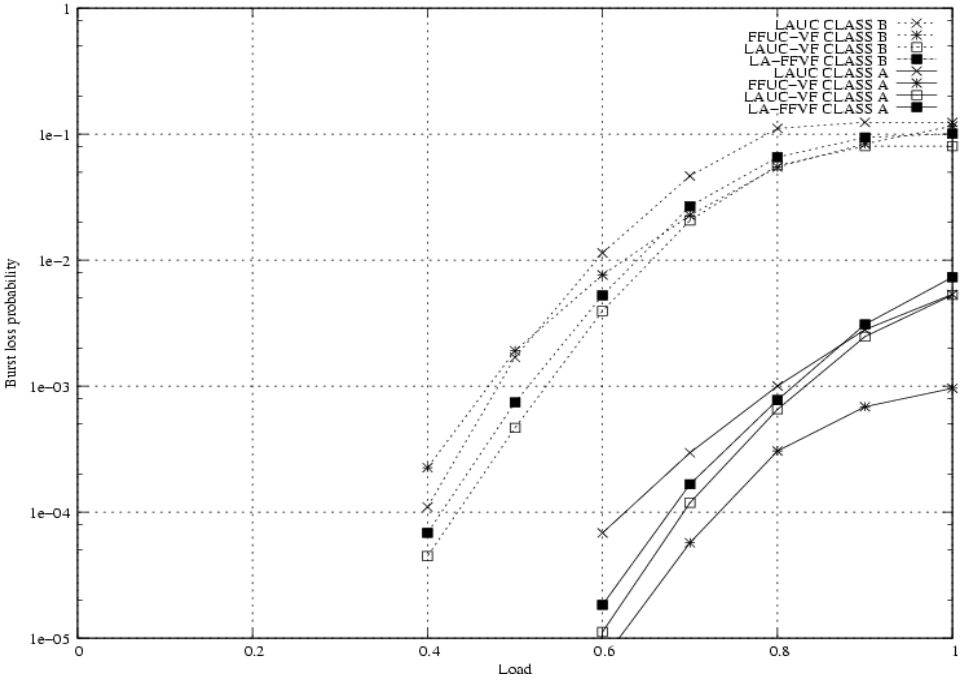
- **Metrics**: *Burst Loss Probability* and *Scheduling Time* (search, T_s, + update or refresh, T_r) computed by means of a ad-hoc C++ simulator (M_OBS_SIM)
- Singol symmetric core node analysis
  - **2 x 2, WDM I/O with 8 λs at 10Gbit/s**
- Legacy networks traffic: IP M/Pareto
- Time-based Assembly algorithms T_{max} = 2 μsec
- 2 classes of service through different T_{offset}: class A e.o. = 18 μs
- Full Wavelength Conversion Capacity



Core Router Architecture

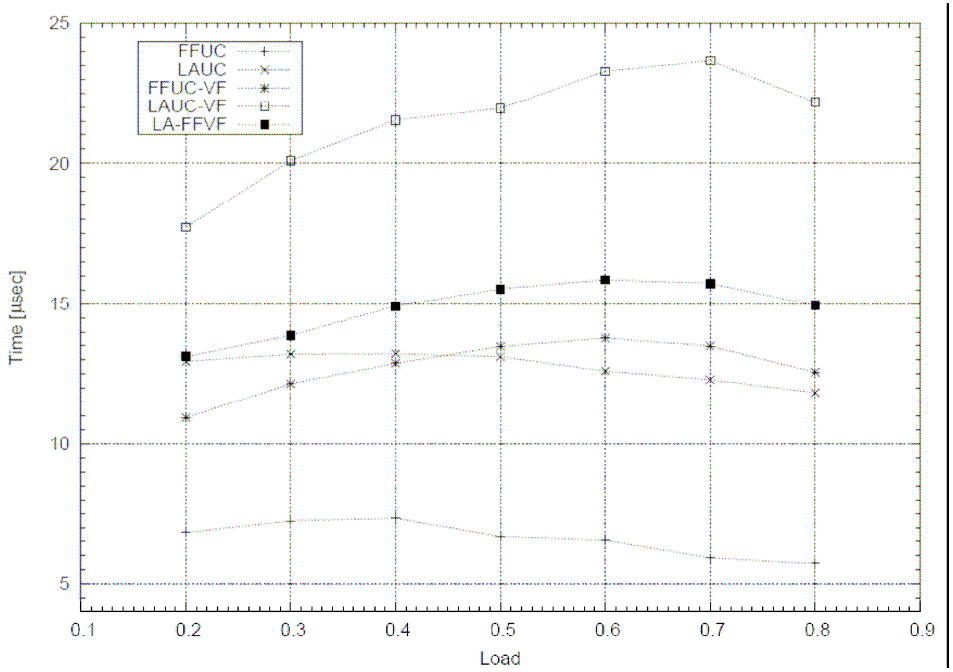


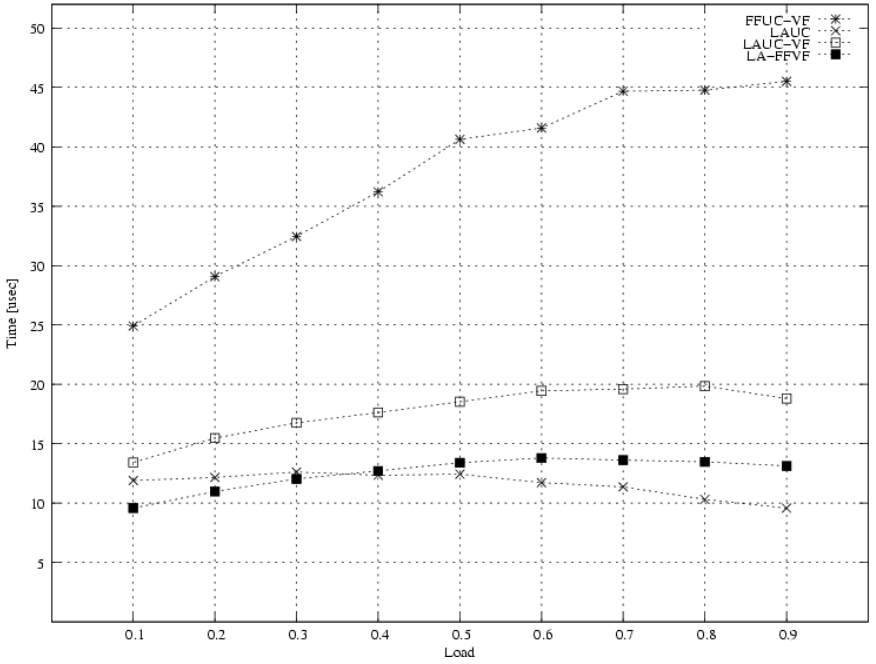




- Traffic load: 0.5 for class A and class B
- LAUC-VF and LA-FFVF for class B
- FFUC-VF for class A

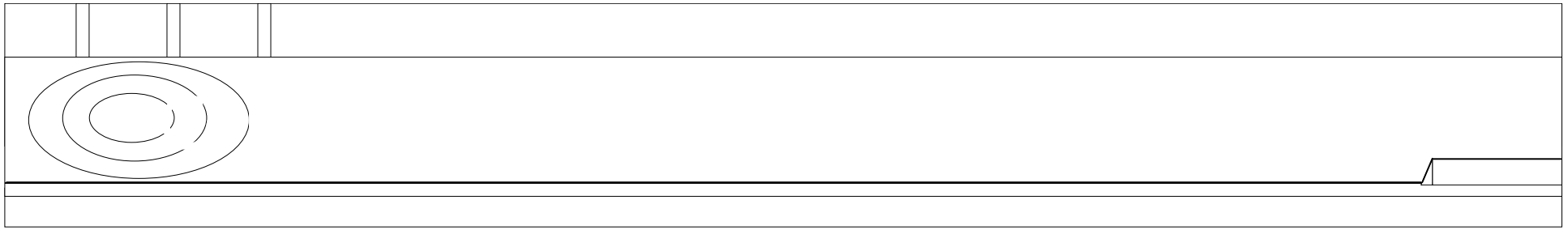
- Traffic load: 0.2 class A and 0.8 class B
- LA-FFVF performs as LAUC-VF





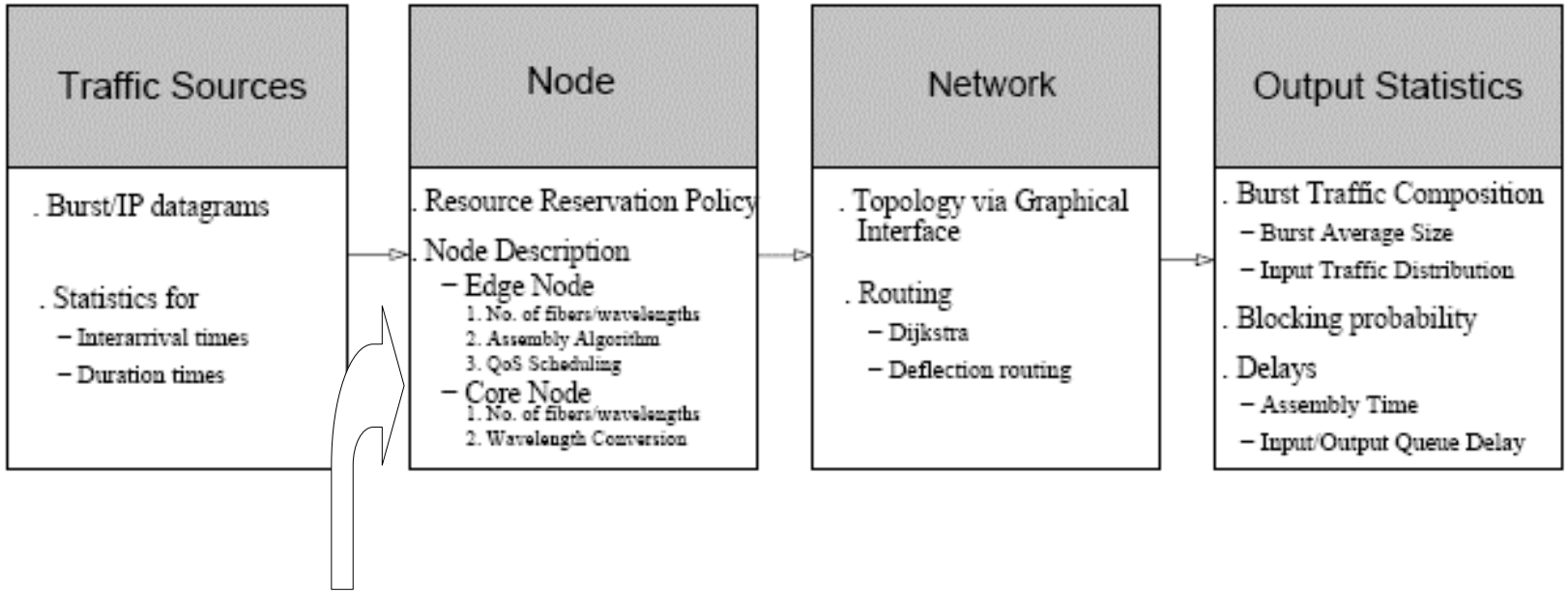
- Traffic load: 0.5 for class A and class B
- LAUC-VF difficult to implement
- FFUC is the fastest but worst for blocking
- LA-FFVF: good trade-off, so as FFUC-VF

- Traffic load: 0.2 class A and 0.8 class B
- LAUC-VF AND FFUC-VF difficult to implement
- LA-FFVF: good trade-off



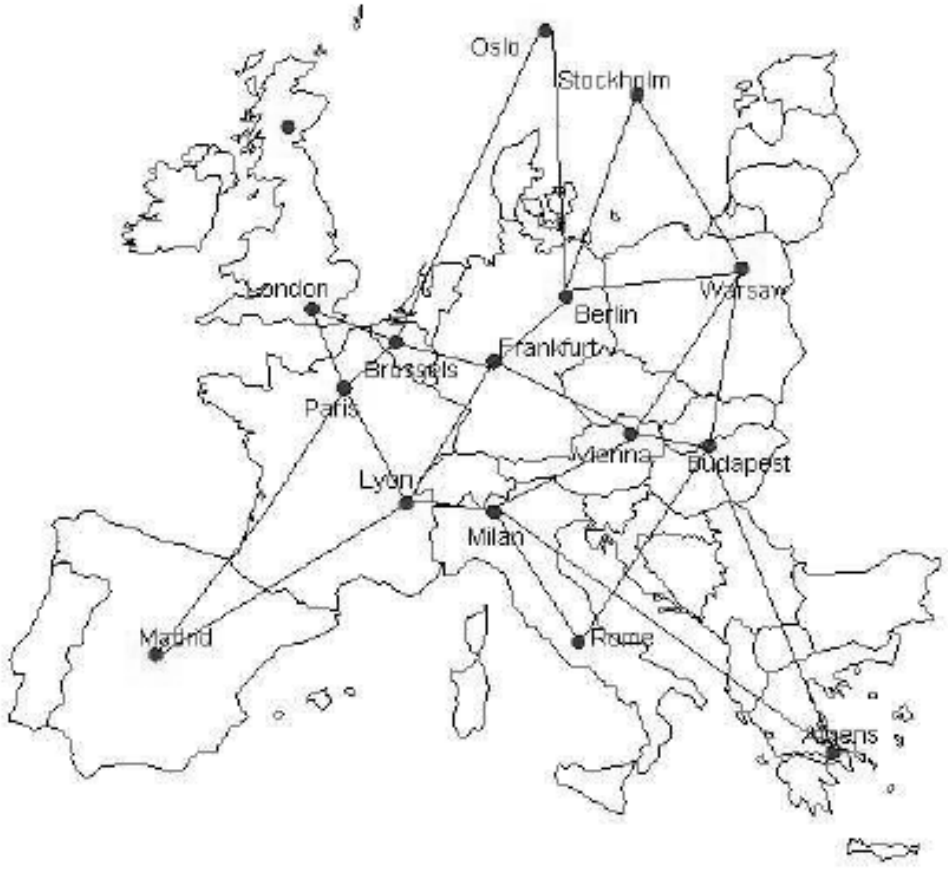
- OBS network has been investigated focusing on core nodes and the scheduling function
- Many different algorithms have been studied
- New scheduling algorithm has been proposed : LA-FFVF
- LA-FFVF has shown a good trade-off in terms of burst loss probability and scheduling time (30% lower than LAUC-VF)
- Our OBS network simulator M_OBS_Sim has been completed with all fundamental functions*

* 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, Elsevier Journal*, available on line.



Scheduling

(available at *www.dii unimore.it/wonet/en*)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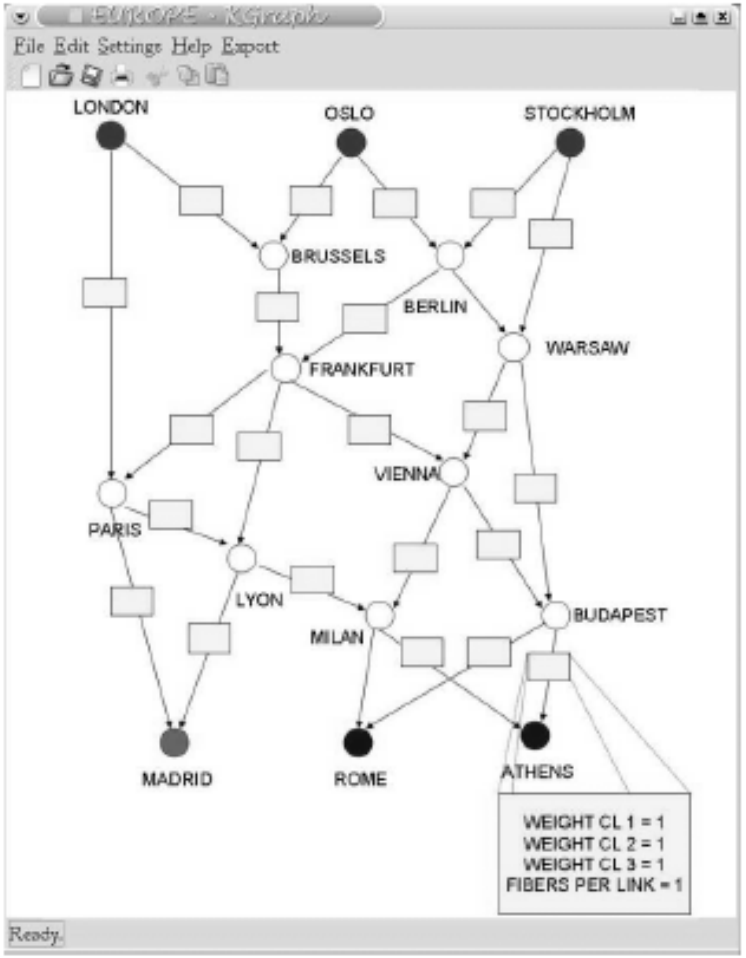
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… suggestions are very very welcome