Optical Burst Switching: Current status, problems, new solutions

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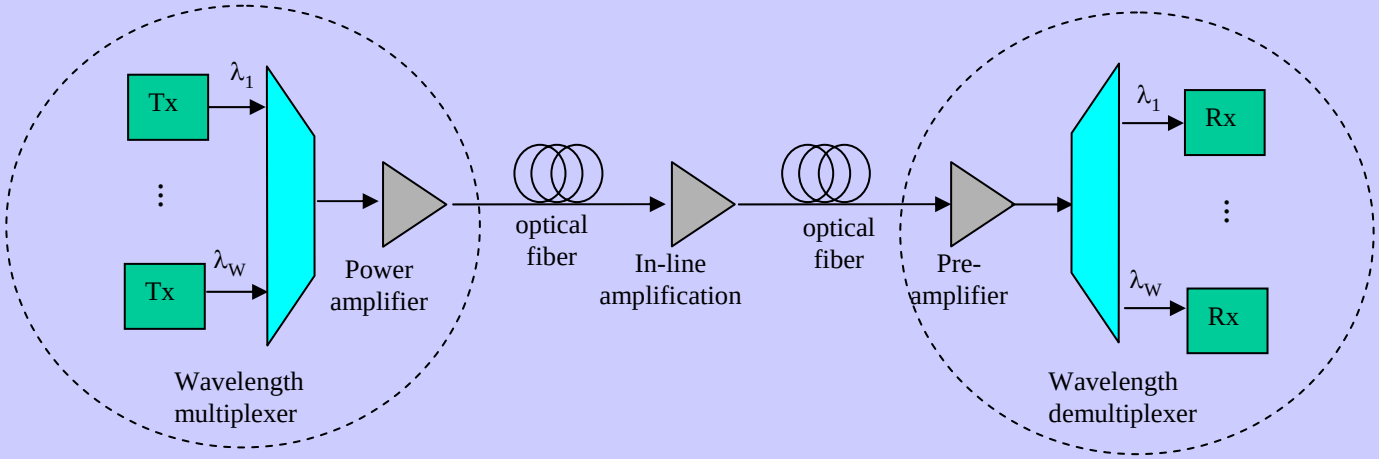
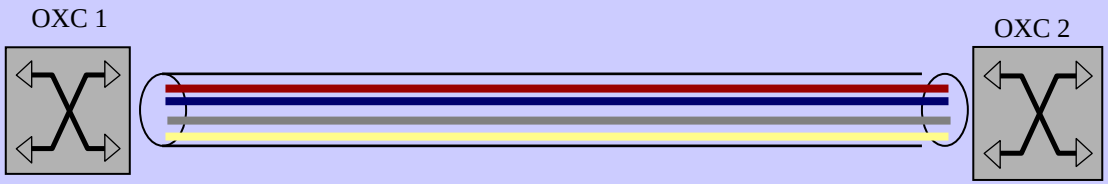
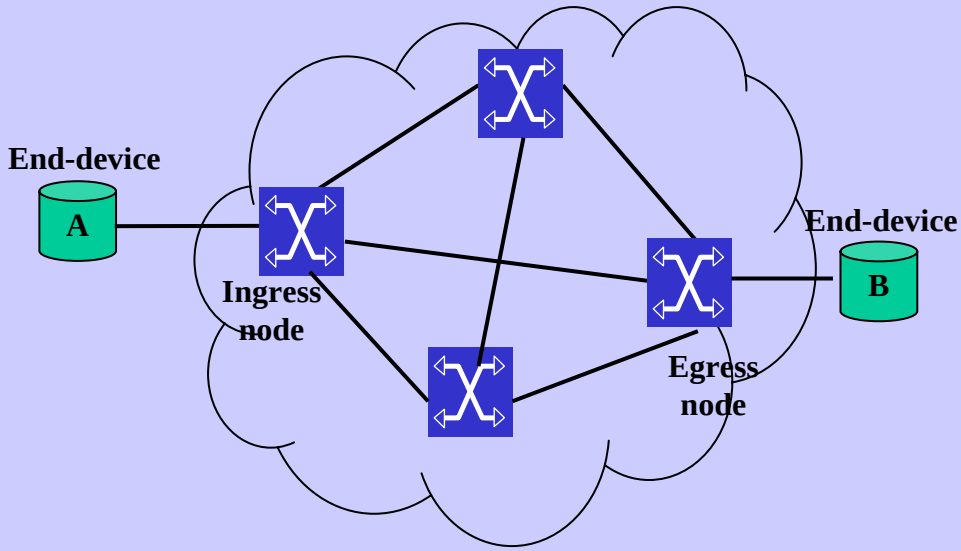
A point-to-point WDM link

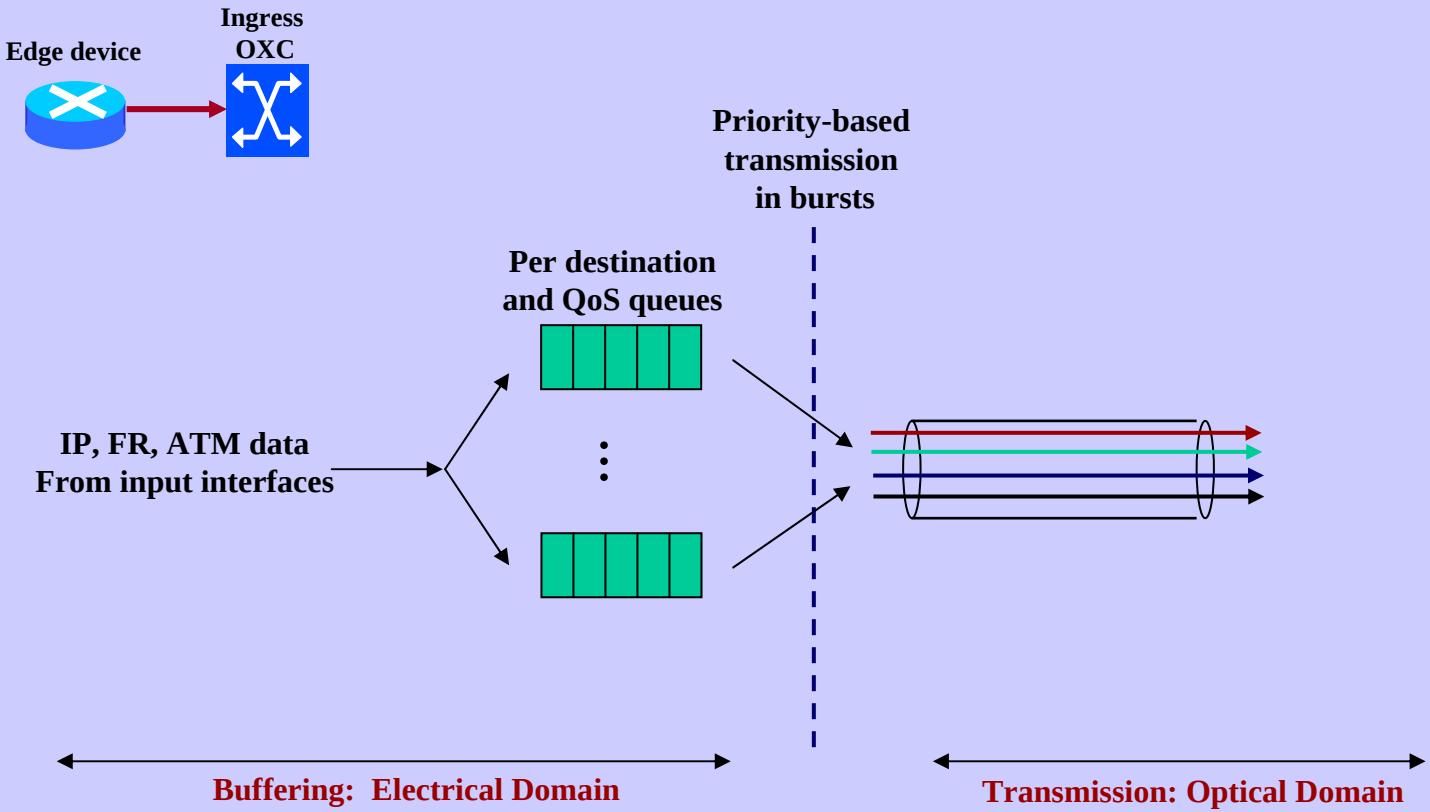




An OBS Network



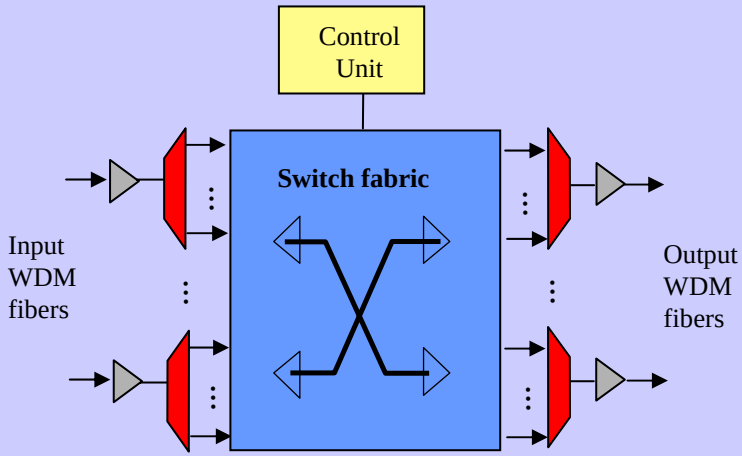
Buffering in an edge node



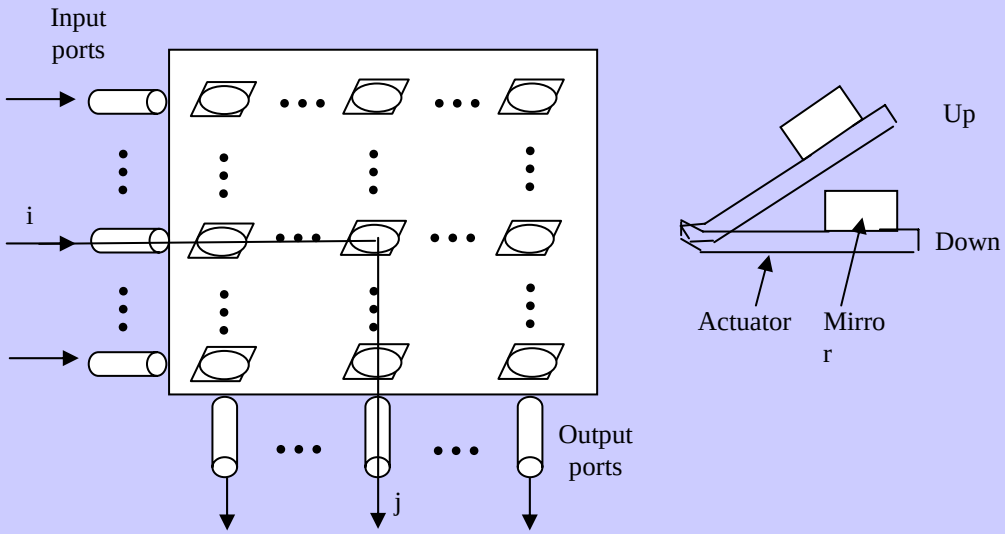
An OBS node

An OXC with a very low configuration time, due to the fact that connection do not stay up for a long time.

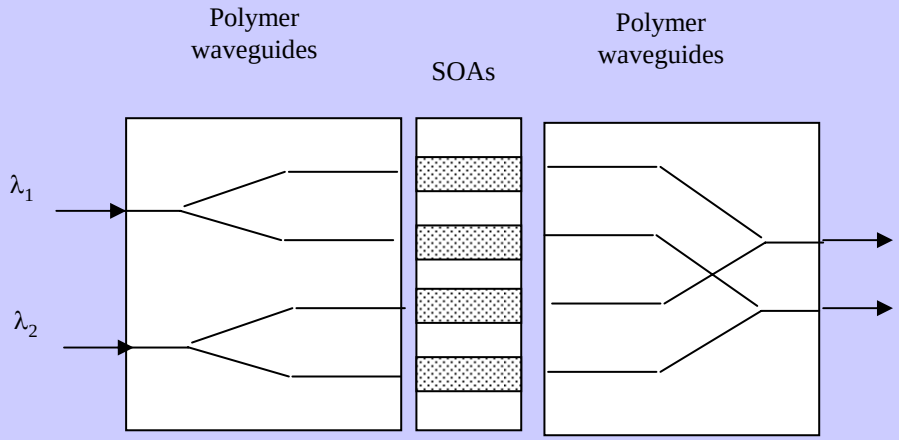
- MEMS (a few msec), SOA (1 μsec)



2D MEMS switching fabric

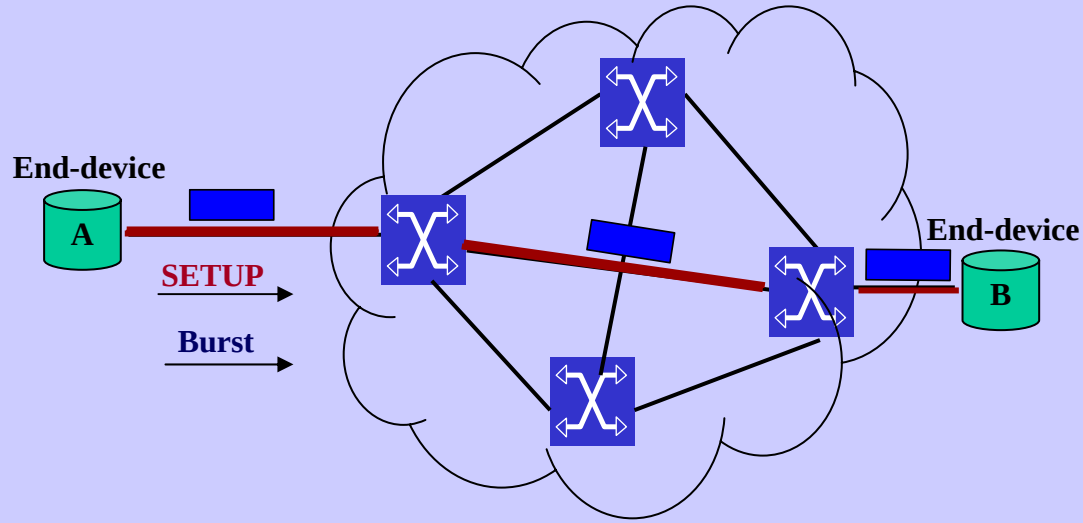


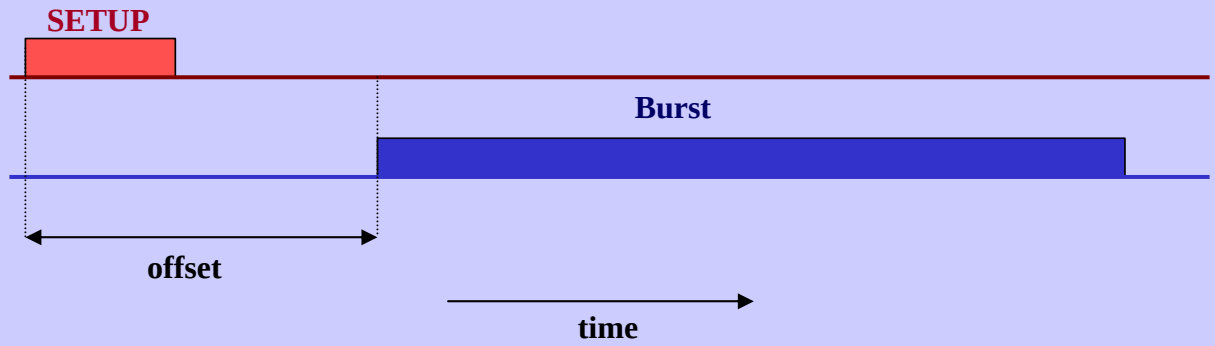
Semiconductor optical amplifier (SOA)

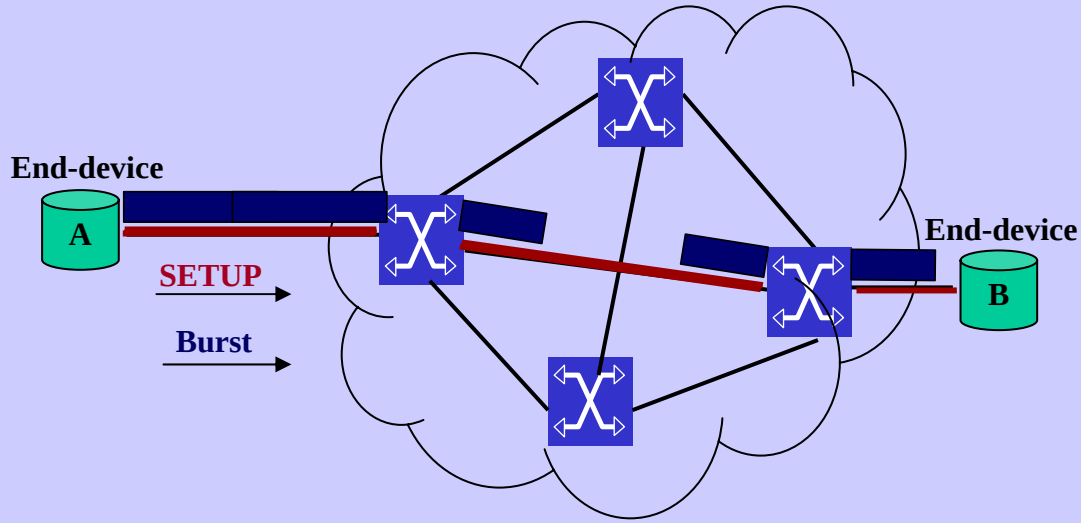


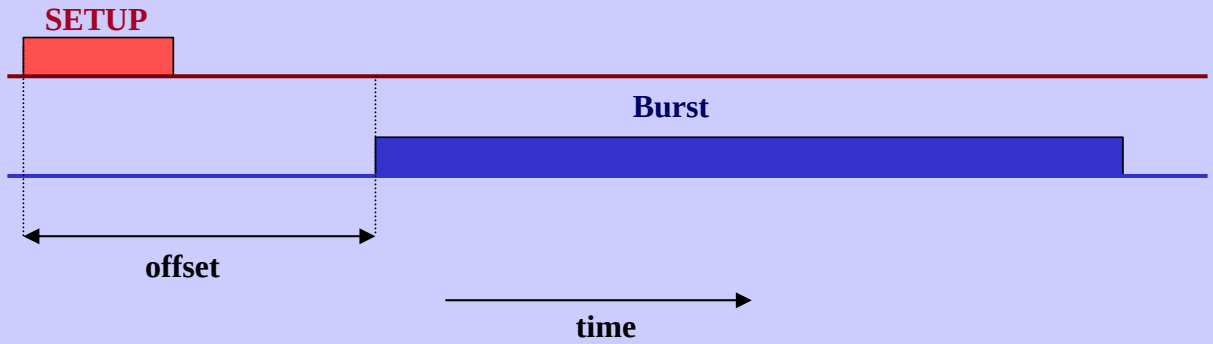
Main features of OBS networks

- Each user transmits data in bursts.
- For each burst, it first sends a *SETUP* message to the network, to announce its intention to transmit.
- Transmission of the burst takes place after a delay known as *offset*.
- The network nodes allocate resources for just this single burst.

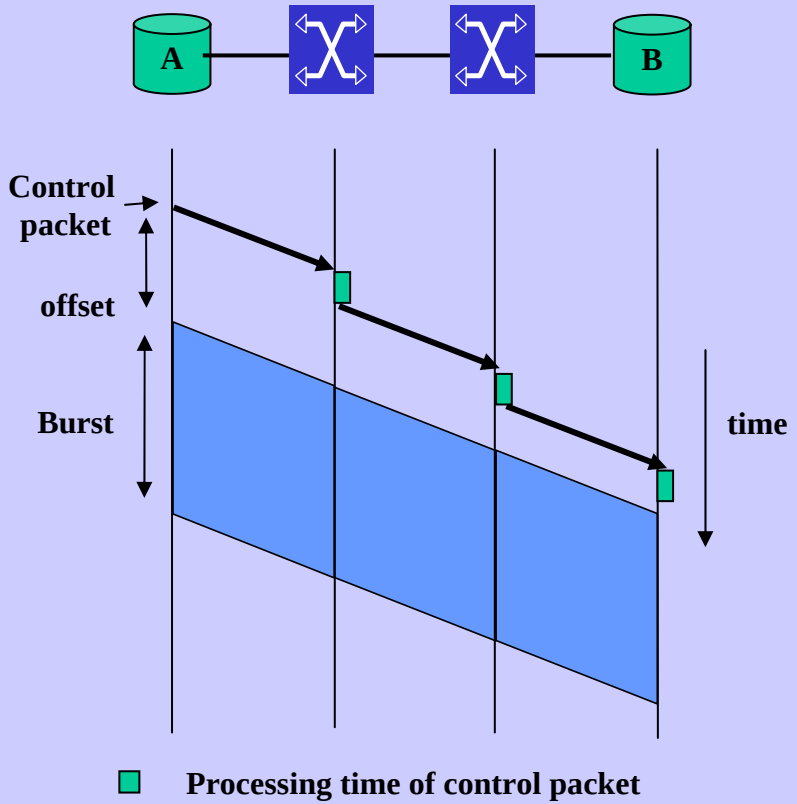

End-device
A
SETUP
Burst
End-device
B


SETUP
Burst
offset
time


End-device
A
SETUP
Burst
End-device
B

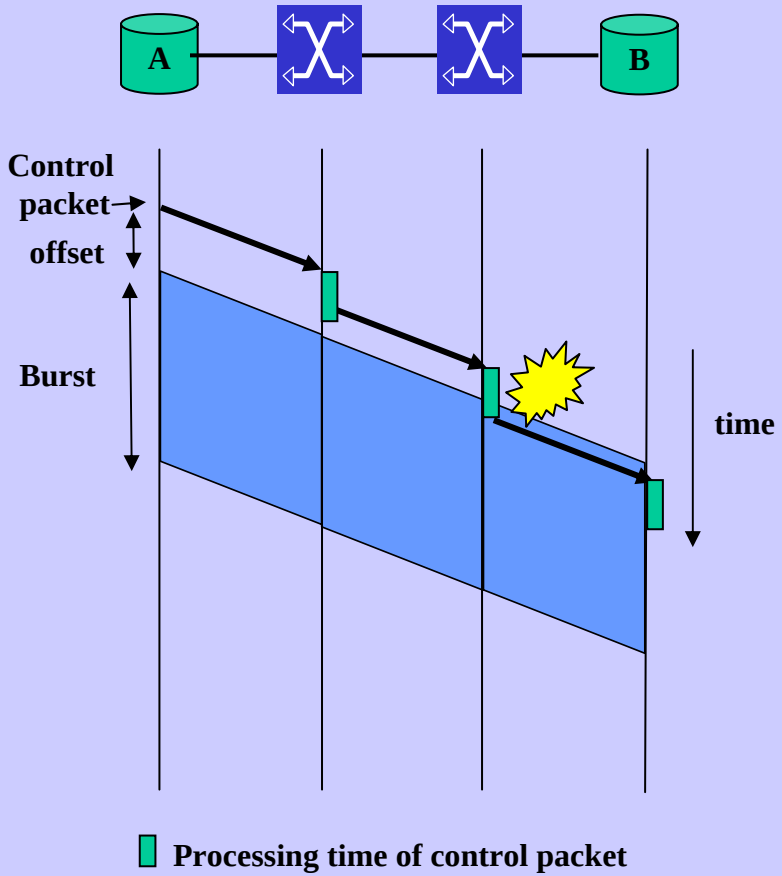

SETUP
Burst
offset
time

On-the fly connection setup



Burst is transmitted without knowing if the connection has been successfully established

Offset = Sum of processing at each OXC
+
1 configuration delay



If the offset is not long enough, then the burst may arrive at an OXC before the SETUP request, or before the OXC has a chance to configure its switch!!

Reservation/release of resources in an OXC

- *Reservation: Immediate setup*
  - The switch is configured immediately after the SETUP request has been processed.
- *Release: Timed burst*
  - The control packet contains information re. the length of the burst. This permits the OXC to know when to release its resources.

Lost bursts

- A burst is blocked when upon arrival at a node, its wavelength is at the output port is not free.

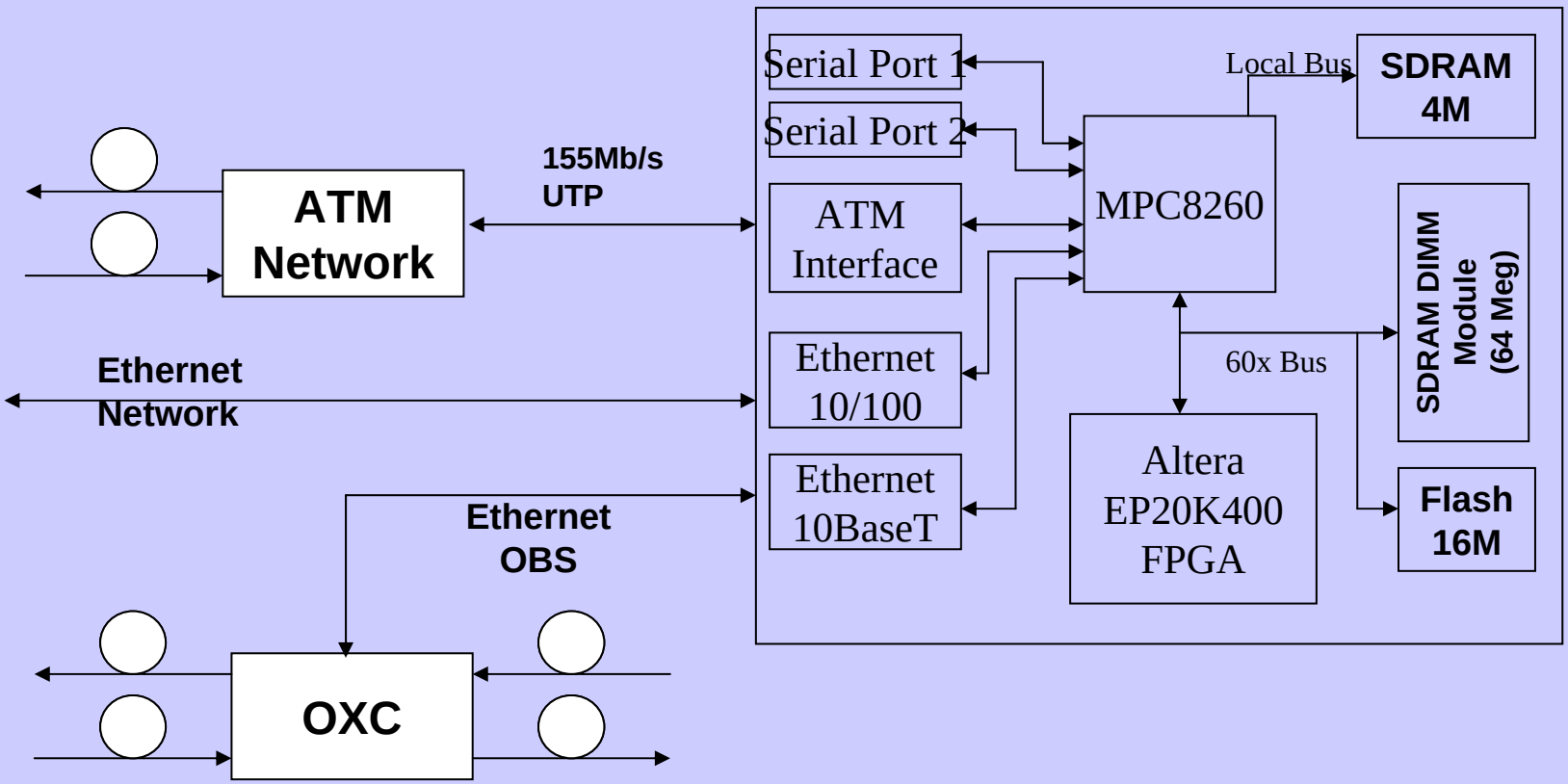
The *Jumpstart* architecture

- *Jumpstart* was a DoD-funded project carried out by
  - NC State University and
  - MCNC, an RTP-based non-profit research organization.

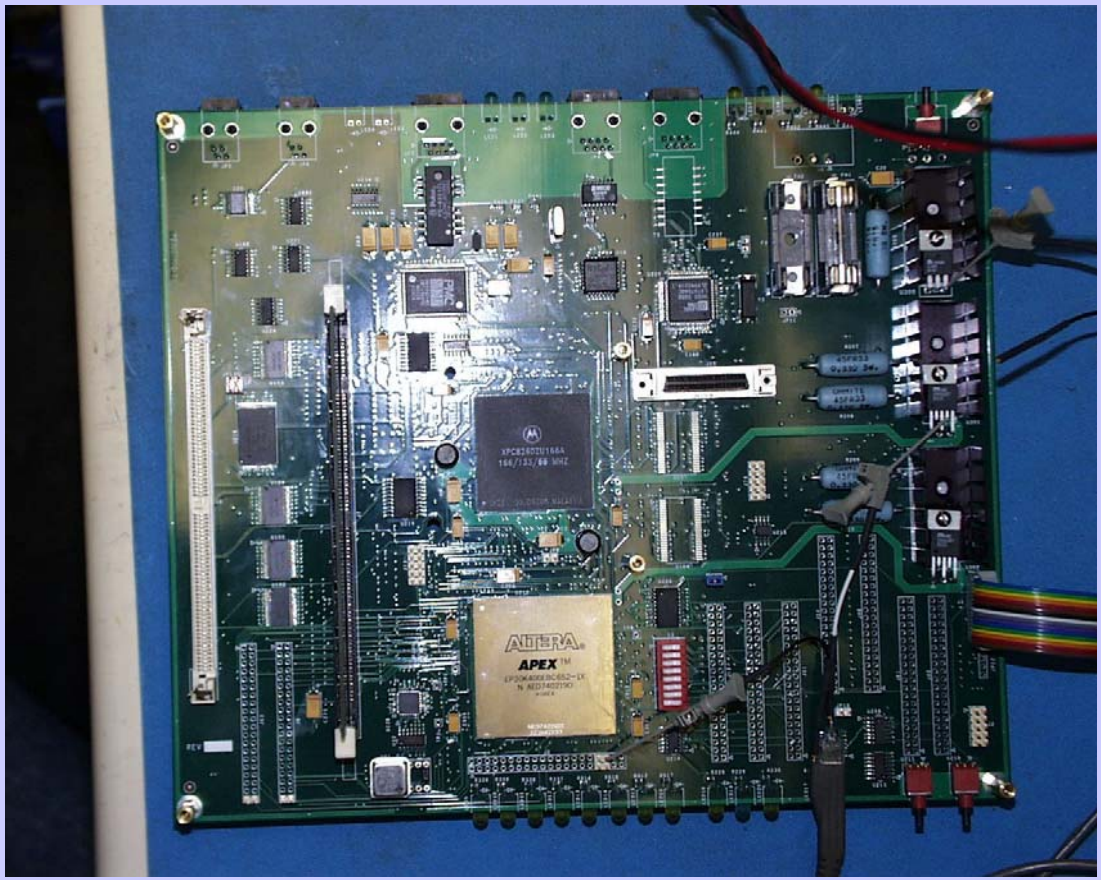
Summary of the *Jumpstart* project

- *Definition of a signaling architecture*
  - Signaling messages
  - Flexible format
- *Define a routing architecture for OBS*
  - Data plane routing
  - Routing for signals and mgmt messages
- *Prototyping and proof of concept.*

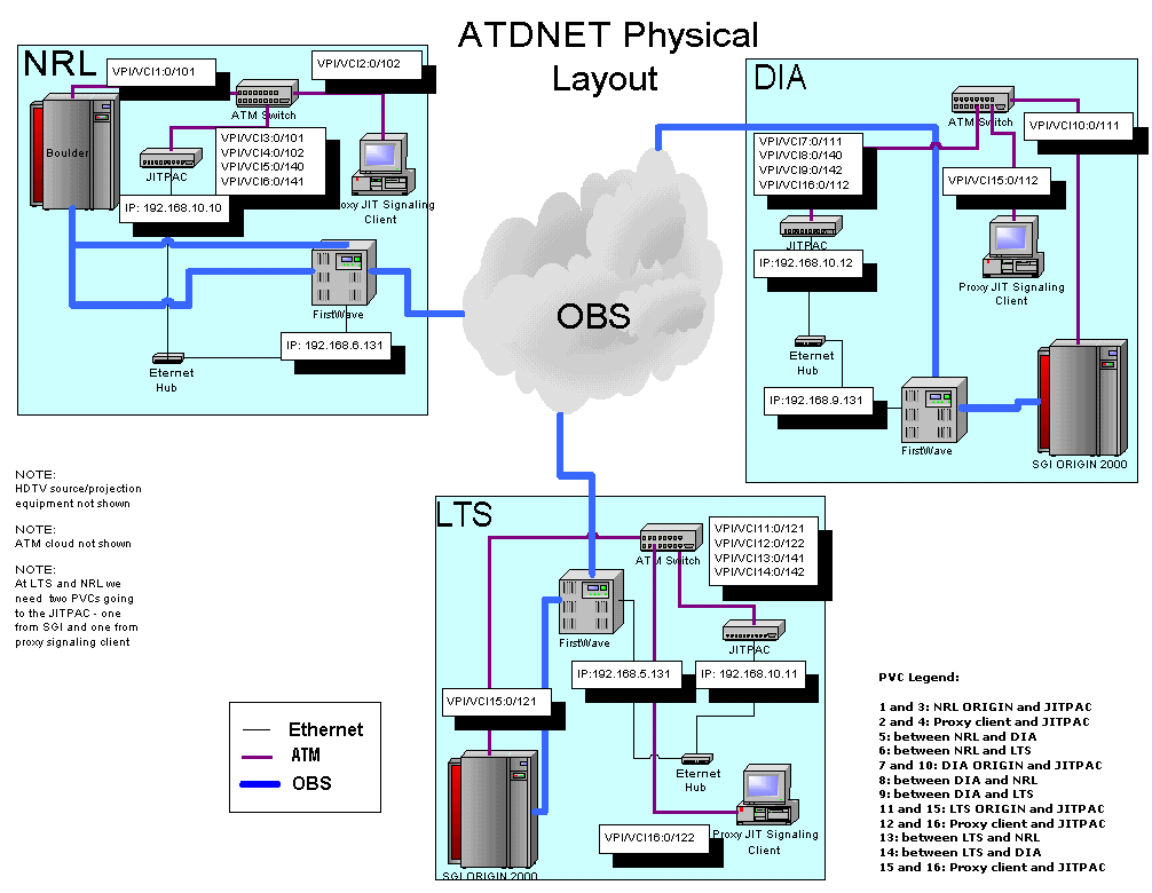
JITPAC


Serial Port 1
Serial Port 2
ATM Interface
Ethernet 10/100
Ethernet 10BaseT
Local Bus
SDRAM 4M
MPC8260
SDRAM DIMM Module (64 Meg)
60x Bus
Altera EP20K400 FPGA
Flash 16M
ATM Network
155Mb/s UTP
Ethernet Network
Ethernet OBS
OXC

JITPAC prototype



ADTNET


ATDNET Physical Layout
NRL
VPI/VCI1:0/101
VPI/VCI2:0/102
ATM Switch
Boulder
JITPAC
VPI/VCI3:0/101
VPI/VCI4:0/102
VPI/VCI5:0/140
VPI/VCI6:0/141
IP: 192.168.10.10
Proxy JIT Signaling Client
FirstWave
IP: 192.168.6.131
Eternet Hub
OBS
DIA
ATM Switch
VPI/VCI10:0/111
VPI/VCI7:0/111
VPI/VCI8:0/140
VPI/VCI9:0/142
VPI/VCI16:0/112
VPI/VCI15:0/112
JITPAC
IP:192.168.10.12
Proxy JIT Signaling Client
Eternet Hub
IP:192.168.9.131
FirstWave
SGI ORIGIN 2000
LTS
ATM Switch
VPI/VCI11:0/121
VPI/VCI12:0/122
VPI/VCI13:0/141
VPI/VCI14:0/142
FirstWave
JITPAC
IP:192.168.5.131
IP: 192.168.10.11
VPI/VCI15:0/121
Eternet Hub
VPI/VCI16:0/122
Proxy JIT Signaling Client
SGI ORIGIN 2000
NOTE:
HDTV source/projection equipment not shown
NOTE:
ATM cloud not shown
NOTE:
At LTS and NRL we need two PVCs going to the JITPAC - one from SGI and one from proxy signaling client
Ethernet
ATM
OBS
PVC Legend:
1 and 3: NRL ORIGIN and JITPAC
2 and 4: Proxy client and JITPAC
5: between NRL and DIA
6: between NRL and LTS
7 and 10: DIA ORIGIN and JITPAC
8: between DIA and NRL
9: between DIA and LTS
11 and 15: LTS ORIGIN and JITPAC
12 and 16: Proxy client and JITPAC
13: between LTS and NRL
14: between LTS and DIA
15 and 16: Proxy client and JITPAC

Congestion Control schemes

- This an over-studied subject!
- However, unlike IP and ATM, in an OBS networks there are *no* buffers at each OXC
- A limited number of FDLs can be used
  - Not enough to absorb a large number of bursts
  - Not commercially viable

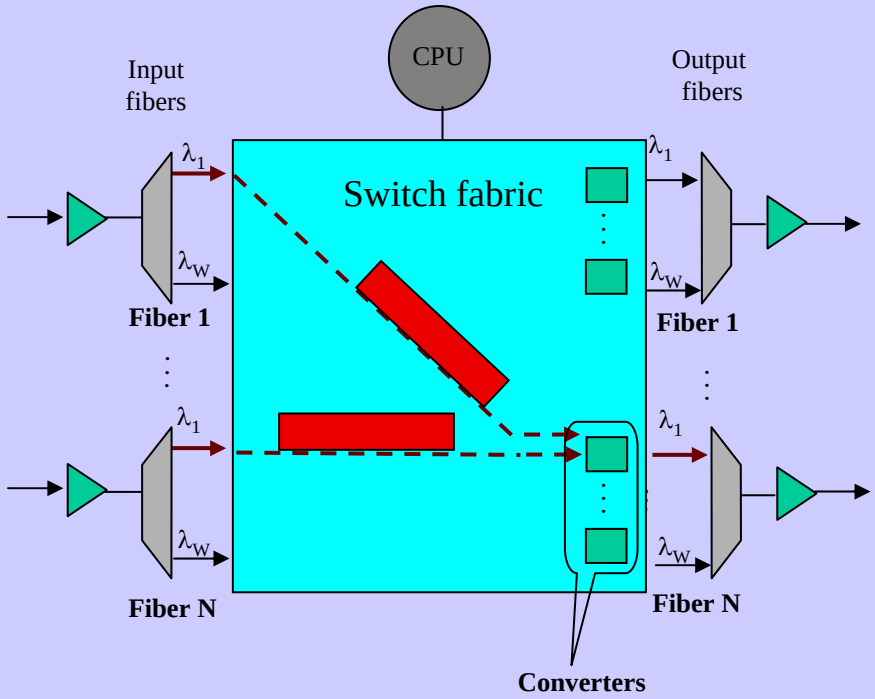
When does congestion arise?

- There are several inter-related indicators:
  - *Number of bursts dropped at an OXC exceeds a threshold.*
  - *Buffer size at an edge device exceeds a pre-defined threshold.*
  - *Extreme case: The input signaling queue in an OXC exceeds a pre-defined threshold.*

Congestion avoidance schemes

- Short-term:
  - *Converters*
  - *Deflection routing*
  - *Feedback messages*
- Long-term:
  - *Re-calculation of paths to alleviate long-term congestion.*

Wavelength conversion



Converters

- The use of converters at an output fiber permits a better utilization of the fiber's wavelengths.
- A few converters can significantly lower burst blocking probabilities
- In the future, there will be full conversion at each output fiber.

Can we afford it??

- From analytical and simulation results we know that:
  - For 1% burst drop rate, the utilization per wavelength (at the source) should be 12%
  - For 5% burst drop rate, the wavelength utilization (at the source) should be 25%

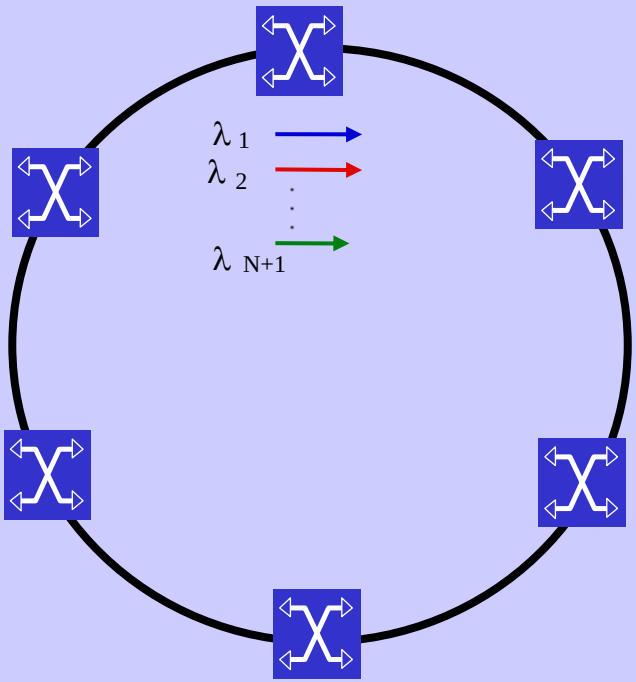
A few observations...

- OBS will not be used in an IP-like form, i.e., transmit whenever you want, because this will require low utilization, in order to maintain an acceptable burst loss.
- Proposed congestion control scheme (converters, deflection, rate control) do not eliminate burst loss

Zero burst loss OBS schemes

- So far we have developed zero-burst loss schemes for
  - OBS rings
  - Star OBS networks

An OBS metro ring

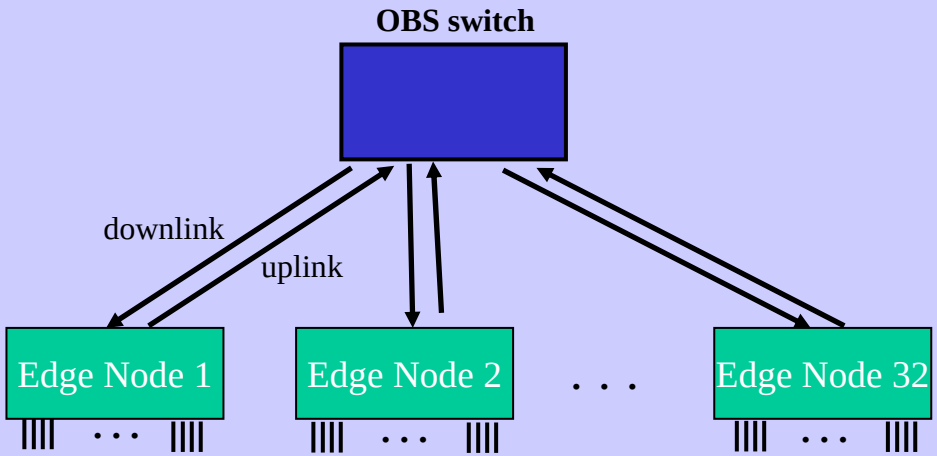


- Optical data transfers
- Optically or electrically transmitted control signals
- Fixed transmitters
- Tunable receiver
- Unidirectional transmission

Traffic types

- Class 1: Variable bit rate traffic with stringent end-to-end delay constraints, e.g., HDTV traffic
- Class 2: Variable bit rate with no delay constraints, e.g., SAN
- Class 3: Non-real time variable bit rate best effort traffic, e.g., delay insensitive IP traffic.

A star OBS network



Edge devices may be close to the switch (<100 Km), or far away from it (1000 Km or more)

Challenge ..

- Develop an efficient (i.e. high-utilization) scheme that permits no losses in a mesh topology.
- Some good news:
  - Long Haul transmissions without amplification
  - In view of this the mesh network may not consist of many nodes