Introduction to Optical Burst and Packet Switching

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Outline

- Evolution of traffic and its requirements
- Answers of optical technology
- Network architecture
- Principle of OBS and OPS
- Necessary components
- Challenges and ongoing research
- Conclusions
Evolution of Traffic

- Mainly voice calls in the 80ies
  - circuit-switched demands

- Growing Internet penetration
  - increasing significance of packet switching due to expanding data traffic

- Multiservice networks
  - convergence entails traffic blending
  - data traffic to outweigh voice traffic
  - uncertain traffic distribution and behaviour
Evolution of Traffic Requirements

- Core networks
  - large capacities between nodes for ‘traffic trunks’

- Metro networks
  - transparency
  - scalability and granularity
  - flexibility and (re)configurability
Evolution of Traffic Requirements

- Metro networks
  - packet switching over circuit switched technology
    - cheap transfer → circuit switching
    - cheap processing → packet switching
  - better adaptation to packet switched traffic
Answers of Optical Technology

- Synchronous Digital Hierarchy, Synchronous Optical NETwork
  - suits voice traffic
  - provided sufficient capacities for aggregated traffic

- Real optical layer - Wavelength Division Multiplexing
  - increased concentration - increased cost-efficiency
  - issue of transparency
Answers of Optical Technology

- Automatically Switched Optical Network
  - intelligent network
  - provides large capacities on demand
  - fast reconfiguration allows for dynamic demands
  - issue of granularity and scalability
  - no statistical multiplexing gain at optical layer
Answers of Optical Technology

- Transition towards PS optical transport
  - Optical Tag Switching
    - principle similar to MPLS
    - tag equals to a label in MPLS
  - Optical Burst Switching
    - short-lived channels established for each burst
  - Optical Packet Switching
    - switching packet-by-packet
Network Architecture

- Economic issues
  - Market-driven investments
  - No killer application found yet
  - Probably suitable in a metro environment
Network Architecture

- Integration possibilities

IP router

Optical packet/burst switch
Network Architecture

- Metropolitan scenario

Access \(\rightarrow\) E/O \(\rightarrow\) X \(\rightarrow\) E/O \(\rightarrow\) Backbone
Optical Burst Switching

- Control information stored in Burst Header Cells
- BHCs transported on dedicated channels
- BHCs injected into the network $\Delta$ offset time earlier than the burst
- BHC contents
  - destination, burst size, incoming channel, $\Delta$
- BHC to set up temporary channel w/o ack
- Bursts stored only at edge nodes
Optical Burst Switching
Optical Packet Switching

- Control information in packet header
- Packets *stored at each node* to allow for header processing
- OPS network
  - slotted or unslotted
  - packet size may vary in unslotted networks
- Slotted networks require synchronization
Optical Packet Switching
Components: OBS Node Architecture

- Core node architecture is shown (Turner)
- Edge node must also include storage (may be implemented in E)

ASE: ATM Switch Element
BP: Burst Processor
BSM: Burst Storage Manager
BSU: Burst Storage Unit
Components: OPS Node Architecture

- Generic node architecture of an unslotted network is shown (Yao, Mukherjee, Dixit)
- Contention resolution is not included here
- Slotted networks require synchronization
Components: Optical Buffer

- Single- or multistage
- Forward or feedback
- Example: single-stage feedback (Karol)
Components: Optical Switch

- Not a critical problem
- Micro-ElectroMechanical Systems based solution is available as a product
- Other solutions also exist
Components: Synchronization

- Fiber Delay Loop-based
  - $n$ cascaded 2-by-2 switches
    - The $n^{th}$ switch decides whether divert signal to a loop causing a delay of $1/2^n$ packet length
    - May cause severe SNR degradation
  - Wavelength converter and highly dispersive fiber
    - Utilizes chromatic dispersion
    - Limited granularity
Components: Optical Wavelength Conversion

- Current proposals based on non-linear effects
  - Kerr effects
  - Scattering effects
- Still only in laboratories
Components

- Contention resolution
  - buffering
  - wavelength conversion
  - deflection routing
    - may also be used to avoid buffering
    - limited packet/burst lifetime is necessary in asynchronous networks (timestamp, not TTL)
Challenges and Ongoing Research

- Reduce burst dropping probability
- Ensure priority for traffic
- Flow and congestion control
- Multicast traffic
- Fault-tolerant routing
- Mathematical performance evaluation
Challenges and Ongoing Research

- Fast, large port-count switch fabrics
- Wavelength converters
- Optical RAM
Conclusions

- Avoid O/E/O solutions
- Reduce the number of layers
- Push down more functionality into the optical domain

![Diagram showing WDM point-to-point currently available and OBS/OPS future]
Conclusions

- OBS
  - Incorporates advantages of CS and PS
  - Relies mainly on existing technology
  - Demonstration of feasibility is yet to come

- OPS
  - Many open problems
  - Still somewhat futuristic
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