

□-Buffered Networks

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*based on a proposal submitted to NSF by UCSD,
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Motivation: Technology Trends

- Cost of transporting a bit over long distances continues to decrease (advances in optical fiber communication)
- Cost of digital processing continues to decrease (Moore's law)
- High speed RAM is expensive (densities improving)

Problem:

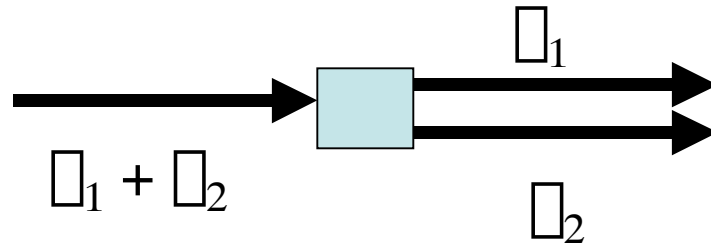
- As the demand for bandwidth increases with time, what is the best way to utilize advances in optics and digital processing?
- Is the current architecture of store and forward packet networks adequate to meet the challenge, or *is a new type of network architecture needed?* Circuit switching?
- Clean Slate Approach: Look beyond one for one replacement of electronics with optics : think “out of the box” - top down as well as bottom up - ten years out and beyond

Requirements for Network Architecture:

- Scalable
 - end user bandwidth (up and down)
 - number of users
 - core link bandwidth
- Flexible
 - heterogeneous application requirements: QoS
 - circuits and datagram services
 - transparency to data formats
 - for a *network underlay*, want *simple* core
- Reliable
 - Resilient to failures

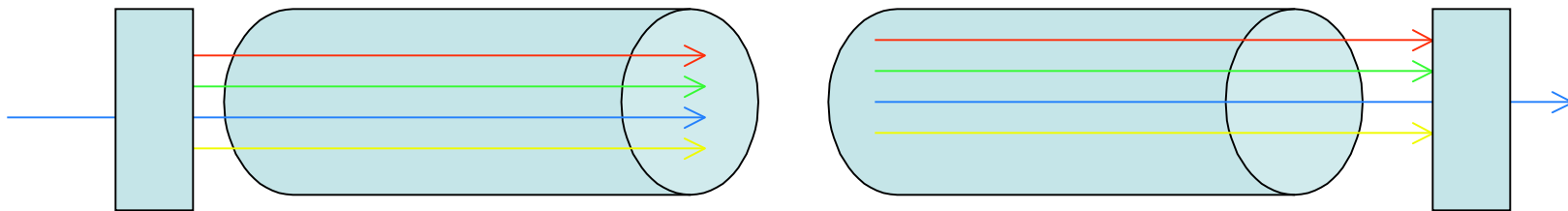
Optical WDM Circuit Switched Networks

- advantage: can use wavelength-based routing



(lightweight processing)

- advantage: end user BW \ll total link BW



Optical WDM Circuit Switched Networks

- disadvantage: very large granularity of switching
(need many wavelengths)
- disadvantage: no statistical multiplexing
(increases complexity)

Optical *Packet* Switched Networks?

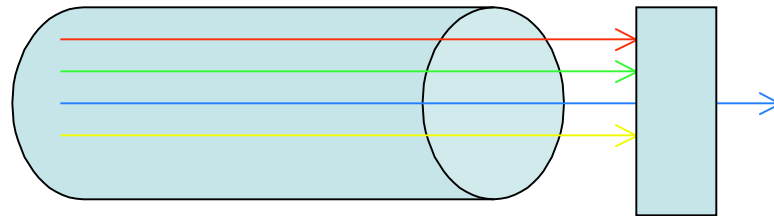
- “optical buffer memory” problematic

BOTTOM UP: Can we do packet switching without any buffers in the core? or a small amount of buffers in the core?

- Yes, if
maximum sustained BW of end user \ll total link BW
- this will be true if total link BW continues to increase
- What about packet loss?
 - handle with forward error correction
(leverage recent advances in coding theory)

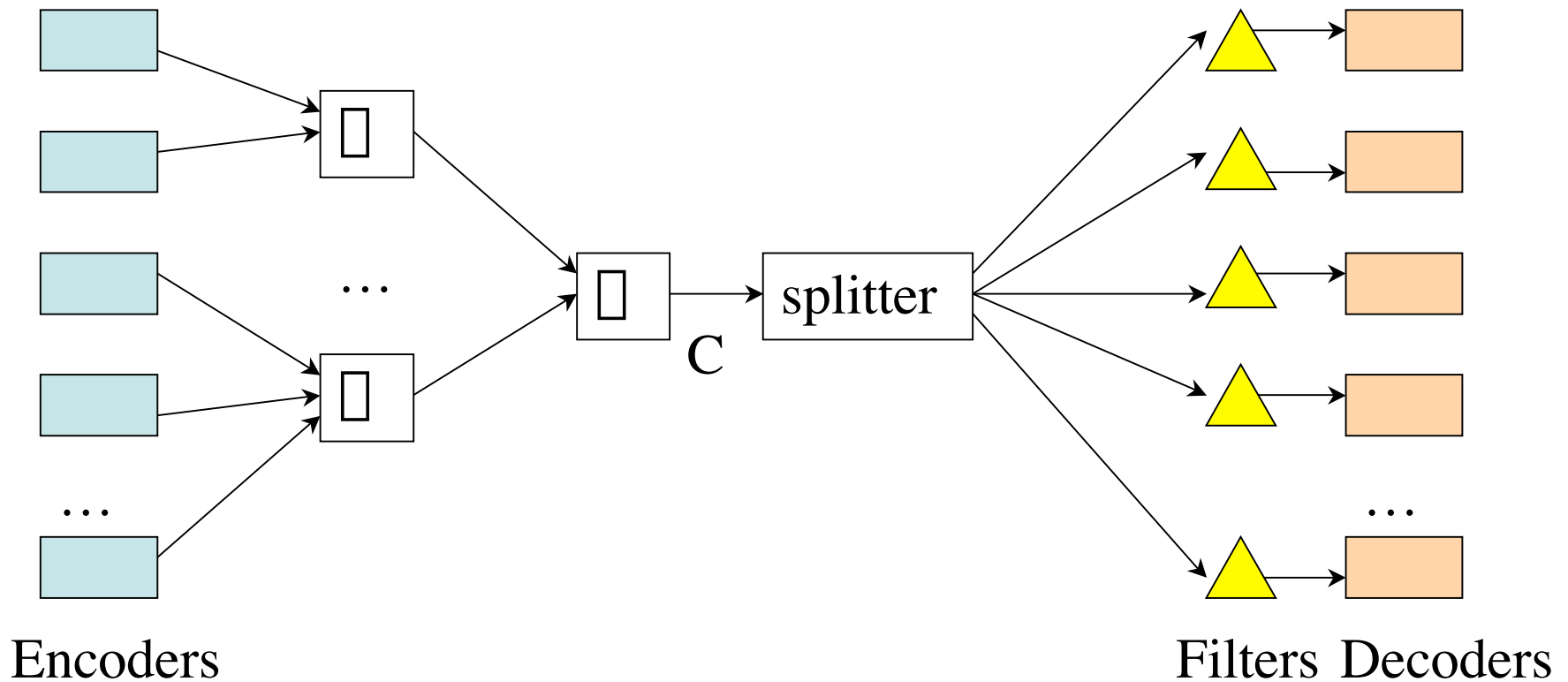
TOP DOWN: What “new” optical devices are needed?

- low cost, programmable “filter”
 - “digital” filter preferred, fast response time



- low cost transmitter (data rate \ll total link data rate)
- low cost receiver (data rate \ll total link data rate)

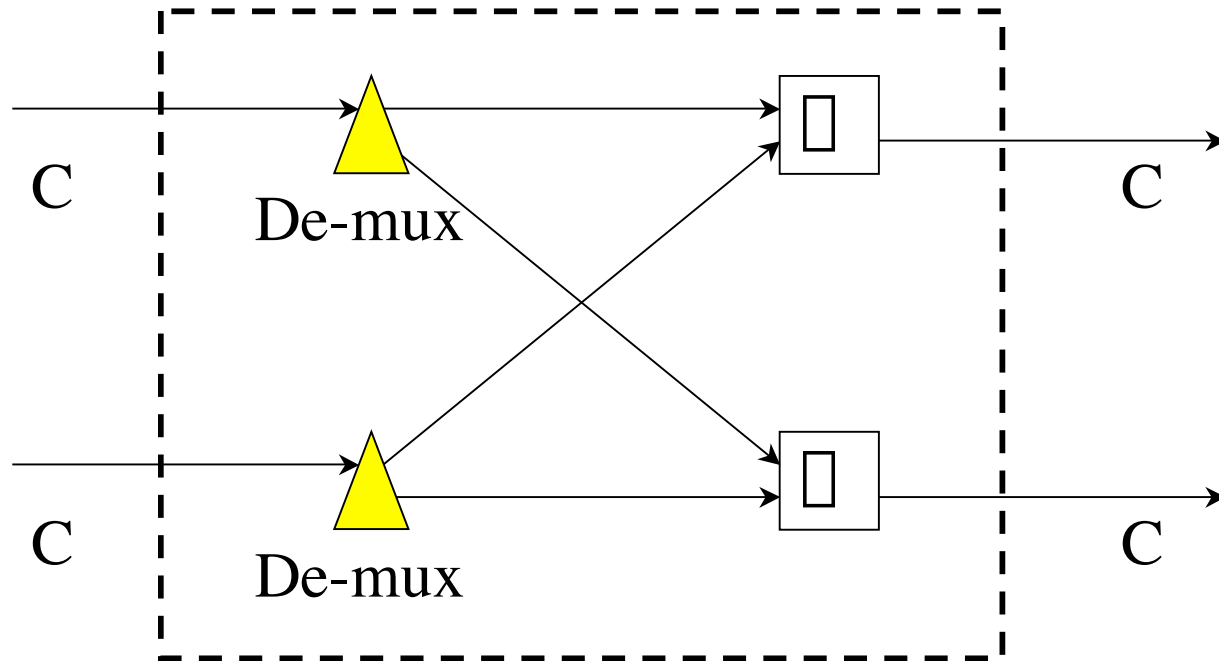
Example: Optical Broadcast & Select Network



Capacity = $0.368 C$, where C is the transmission link capacity available

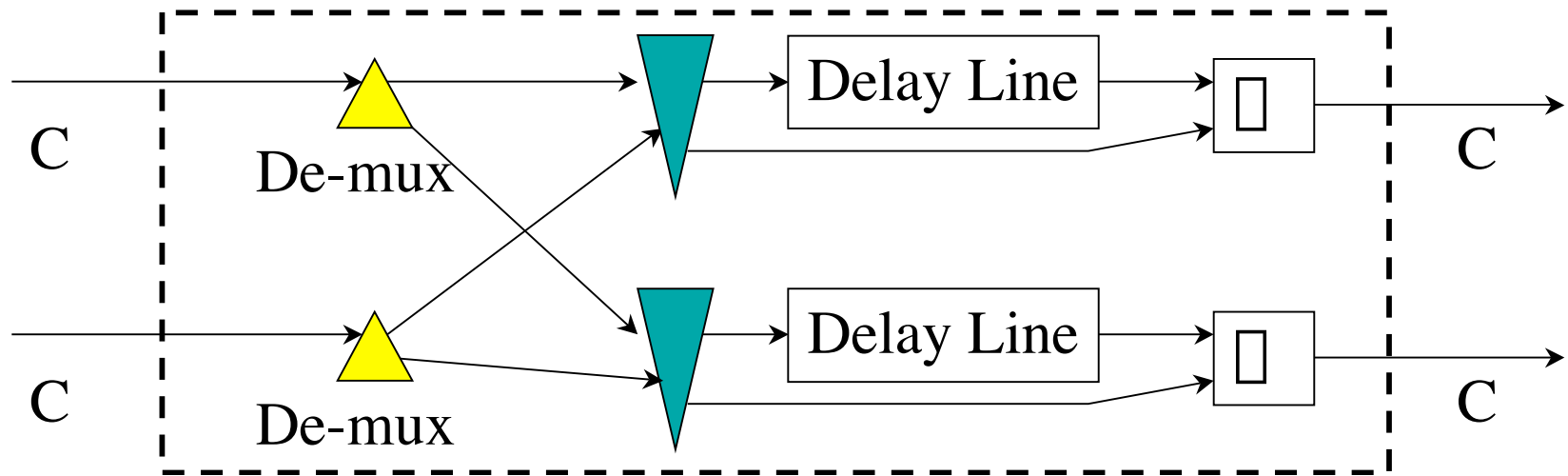
“The Collision Channel without Feedback,” by J. L. Massey and P. Mathys, IEEE Transactions on Information Theory, March 1985.

Extension to Arbitrary Mesh Networks (Spatial Reuse)

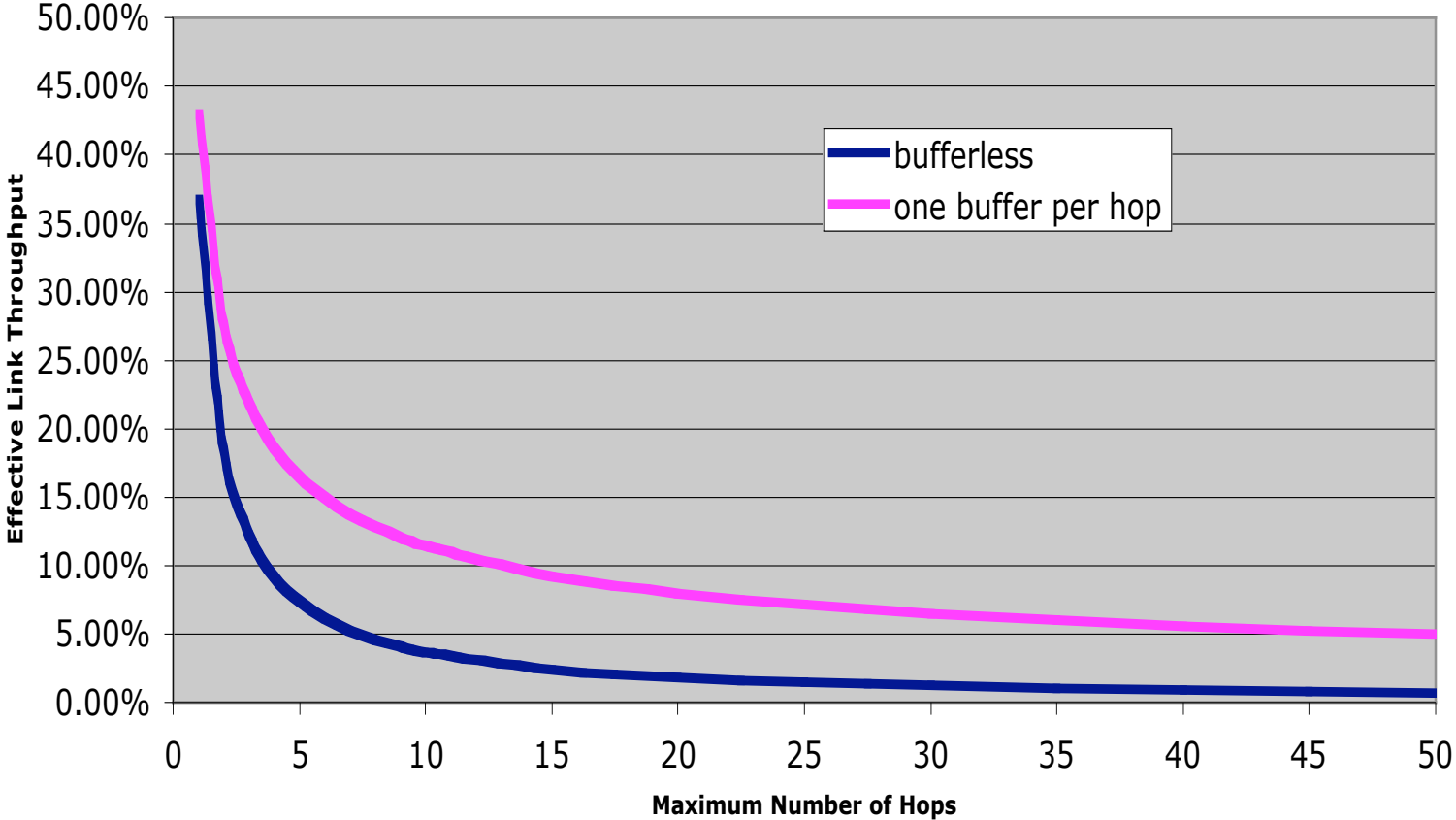


Effective link capacity = $e^{-1}C / H$, where H = diameter of network


A \square -buffered switch with a simple buffering:



Capacity of Micro-Buffered Optical Network



Issue 1: Encoding/Decoding of Packets

 source packet

 source packet w/ redundancy



Fragments w/ packet headers + CRC

Low Density Parity Check Codes:

- known to achieve (Shannon) capacity (Erasure channel)
- iterative decoding: linear complexity

Issue 2: Routing

- Route Diversity (Maxemchuk, 1975)
- Can be done as an overlay: route servers
Load dependent?
- no re-writing headers (i.e. no laser required at switch points)
- source routing
- “deflection routing”?

Issue 3: Flow Control (for adaptive services)

- can be done as an overlay
- issue: what to feed back from core to edges
- fairness: transmission rate or information rate (goodput)
Max min fairness?
- what to adapt: transmission rate or redundancy rate or both