IP over …
… ATM … SDH … DWDM

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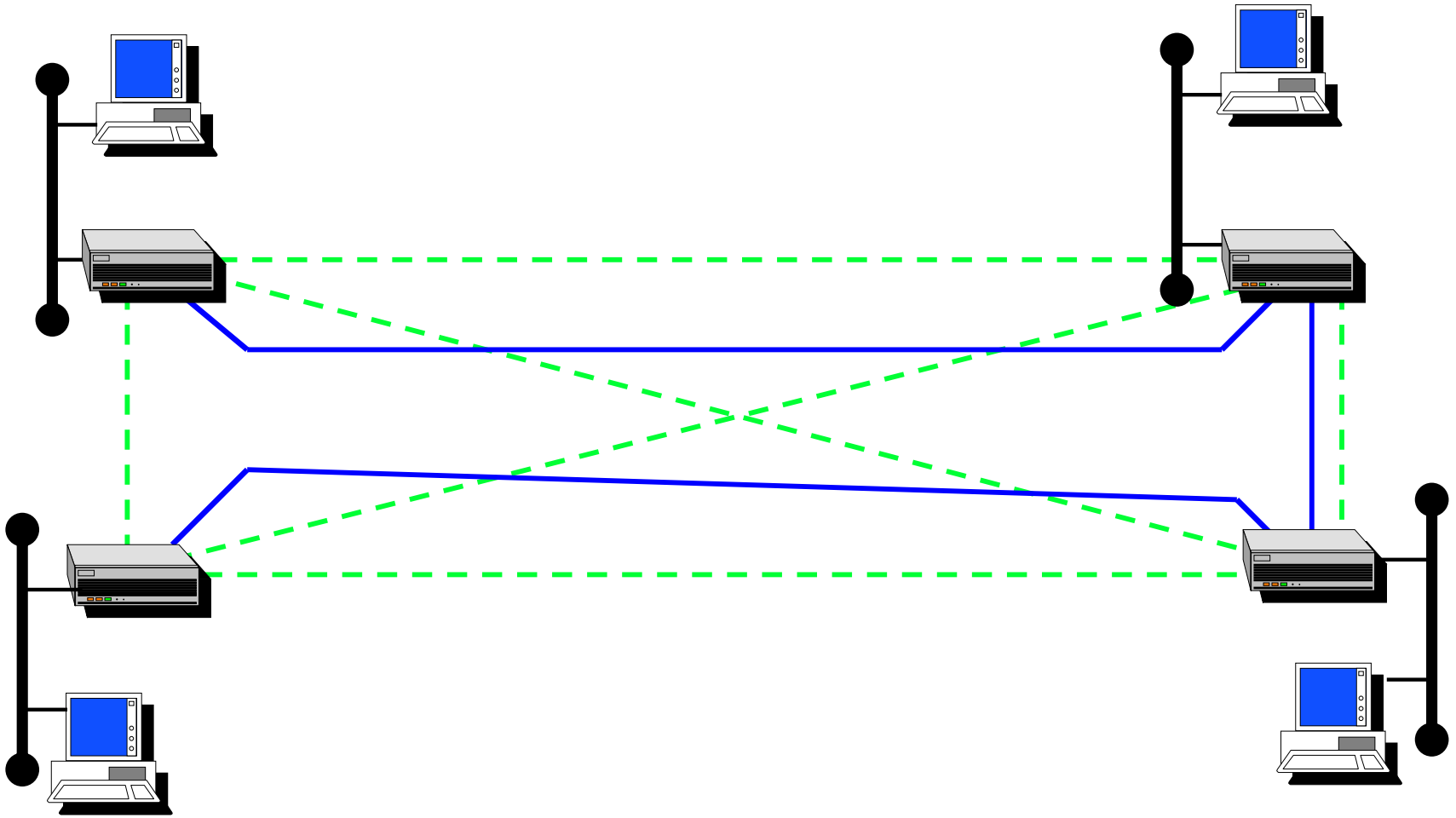
IP Everywhere. Anything else?

Which is the Best Interconnection Topology?



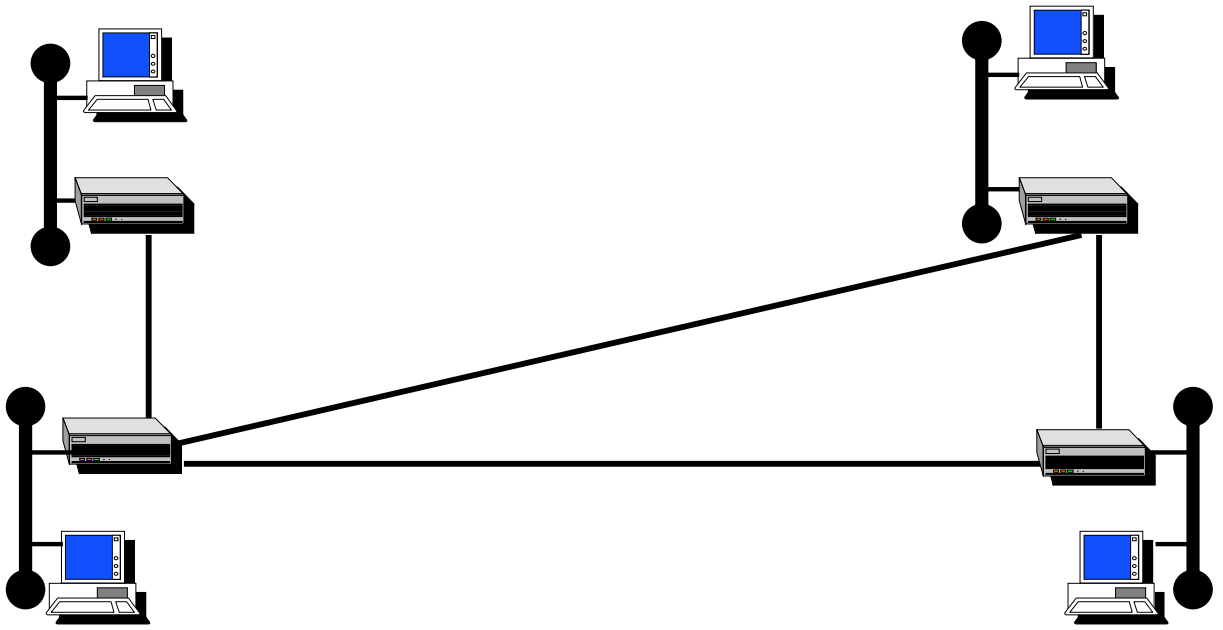
Even if You Know It, You Know It only *Now*!

- It can change on a monthly base
  - different customers
  - different customer needs
- It can change on a weekly base
  - events
- It can change on a daily base
  - business users during week-days, residential users during the week-end
- It can change on a hourly base
  - business hours
  - evening entertainment

Traffic Engineering

IP over Photons

- Routers are connected by optical fibers
  - The optical signal transmitted by a router is received by the other
- Layer 2 framing as in any synchronous transmission
  - PPP
  - IEEE 802.3



Pros and Cons


No overhead

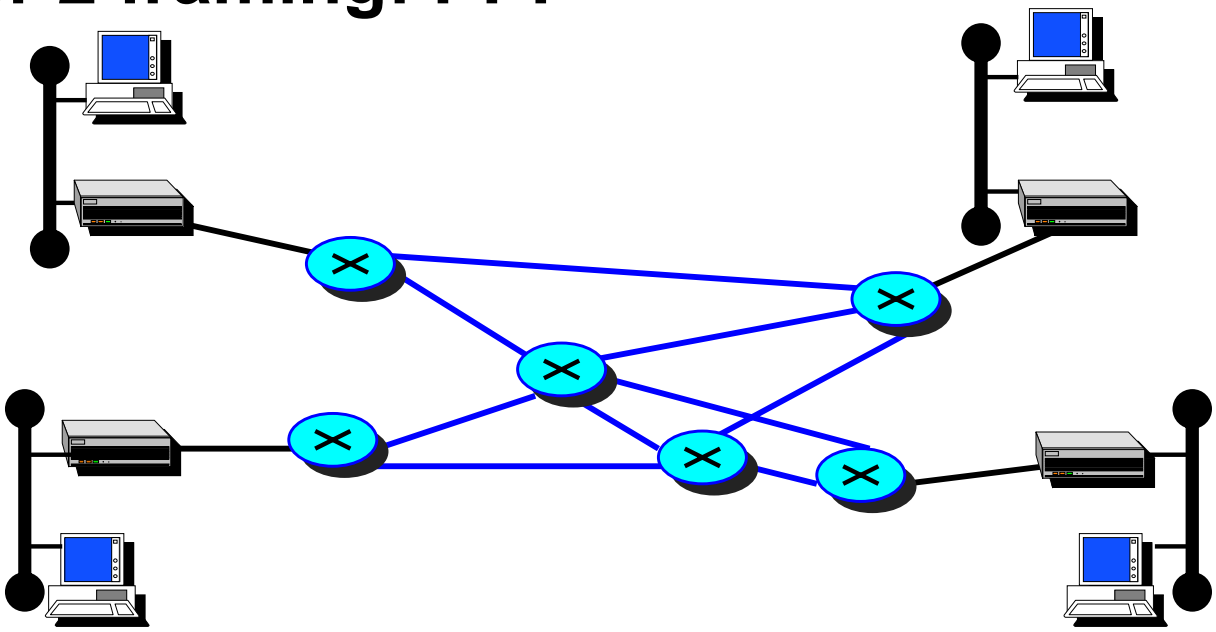

Physical connections: no reconfigurability


One interface per connection


No standard management infrastructure

IP over Dense Wavelength Division Multiplexing (DWDM)

- Many transmissions with different wavelengths (colors) on the same fiber
- Multiplies fiber capacity
- Optical switches with wavelength routing
- Layer 2 framing: PPP



Pros and Cons


Very high capacity


Virtual connections with optical routing

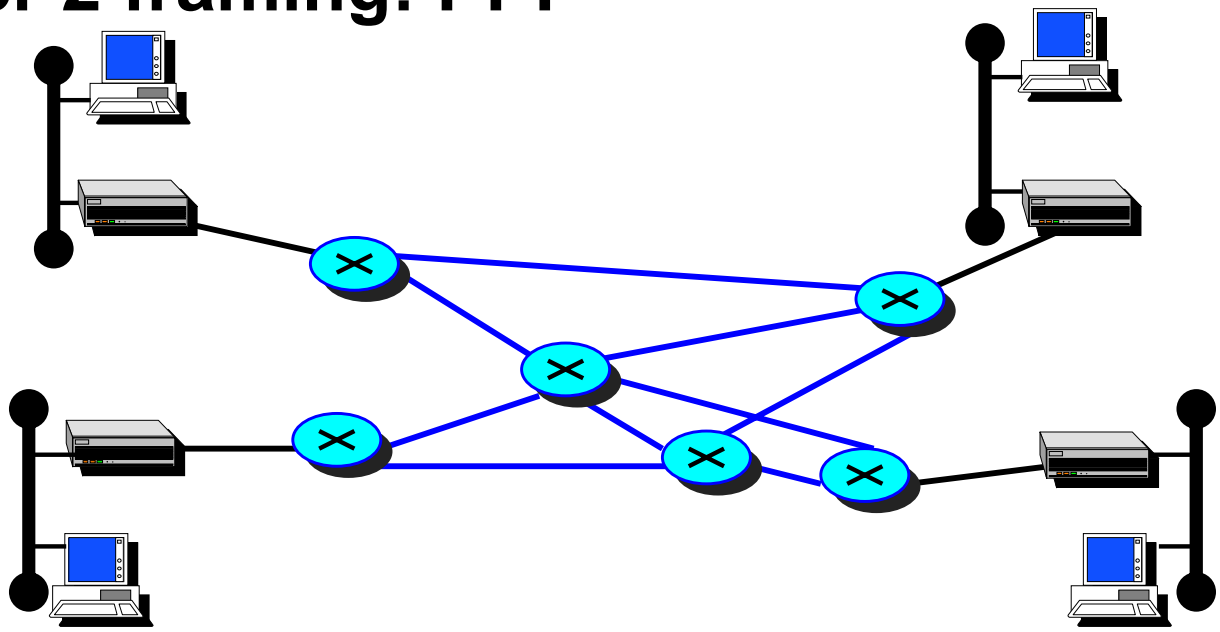

No standard management infrastructure


Static multiplexing

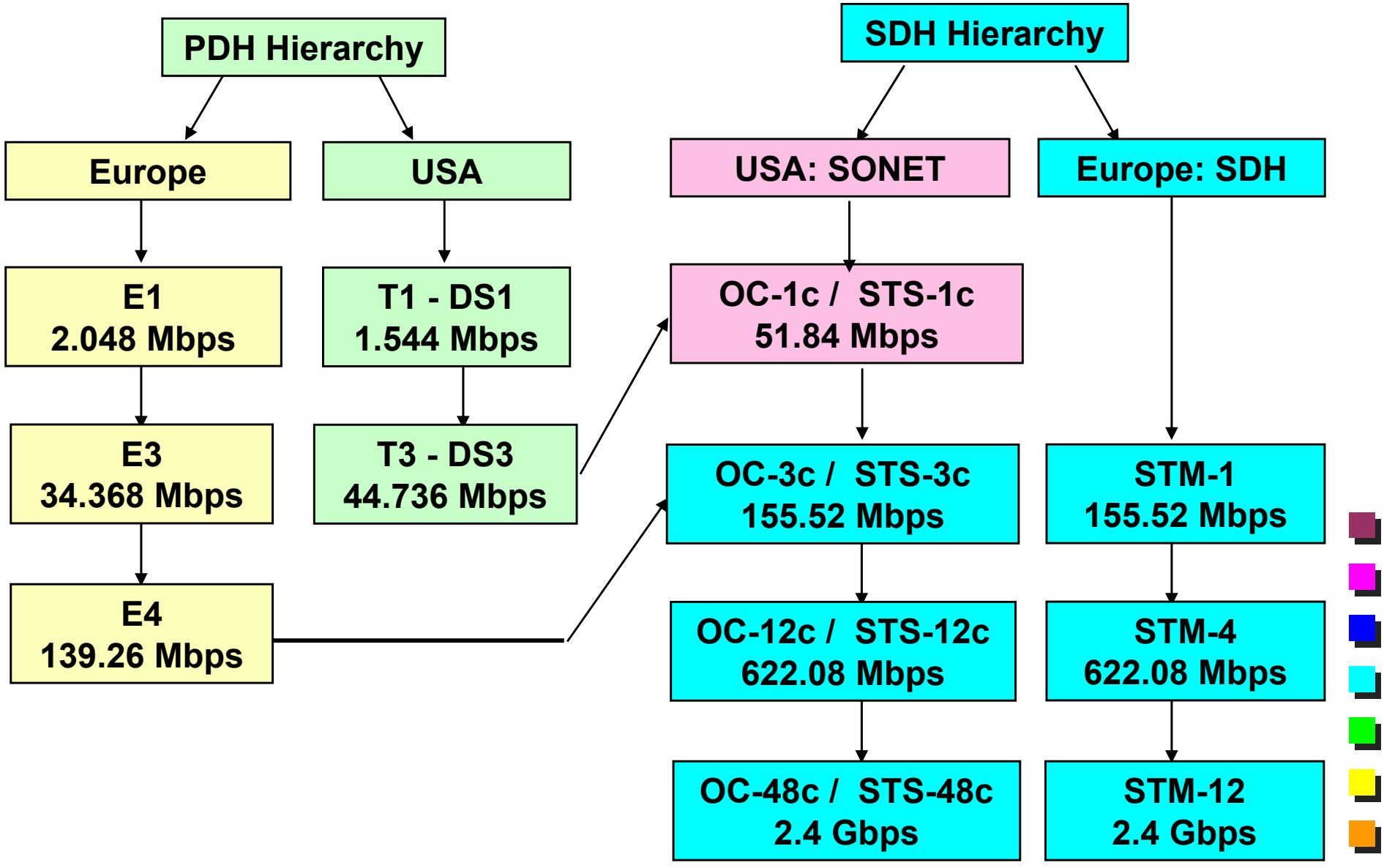
- Reconfiguration Flexibility?
- One interface for many connections?
  - How about IP addresses?
    - One per physical interface?
    - One per wavelength?

IP over SONET/SDH
(Synchronous Optical NETwork Synchronous Digital Hierarchy)

- Physical layer framing
- Cross connect
- Fine allocation granularity
- Management framework
- Layer 2 framing: PPP

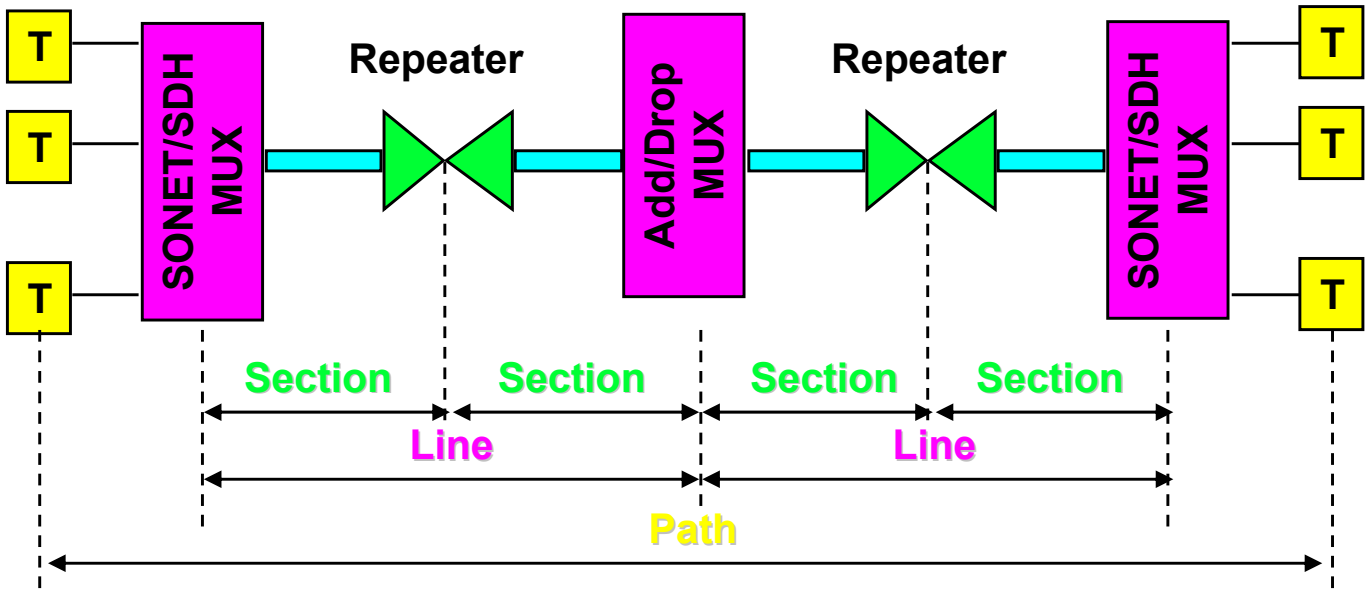


Transmission Hierarchy



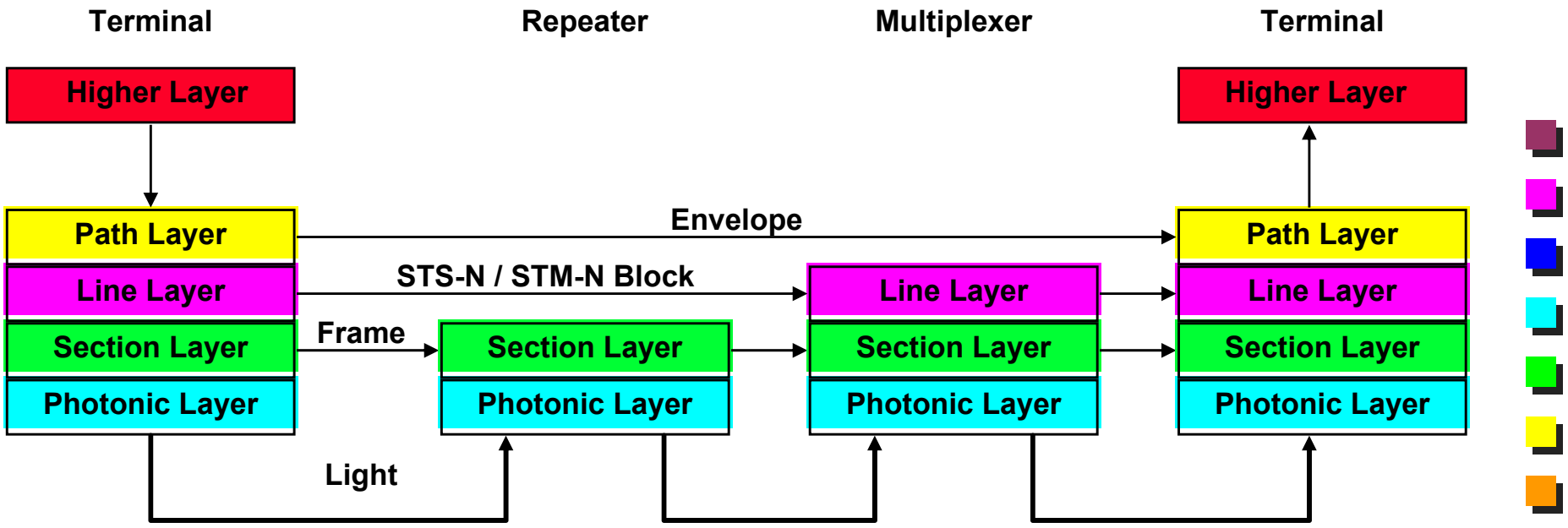
Physical Architecture

- **Section:** fiber optics trunk between transceivers
- **Line:** sequence of sections between devices which operates on the frame
- **Path:** end-to-end leased line



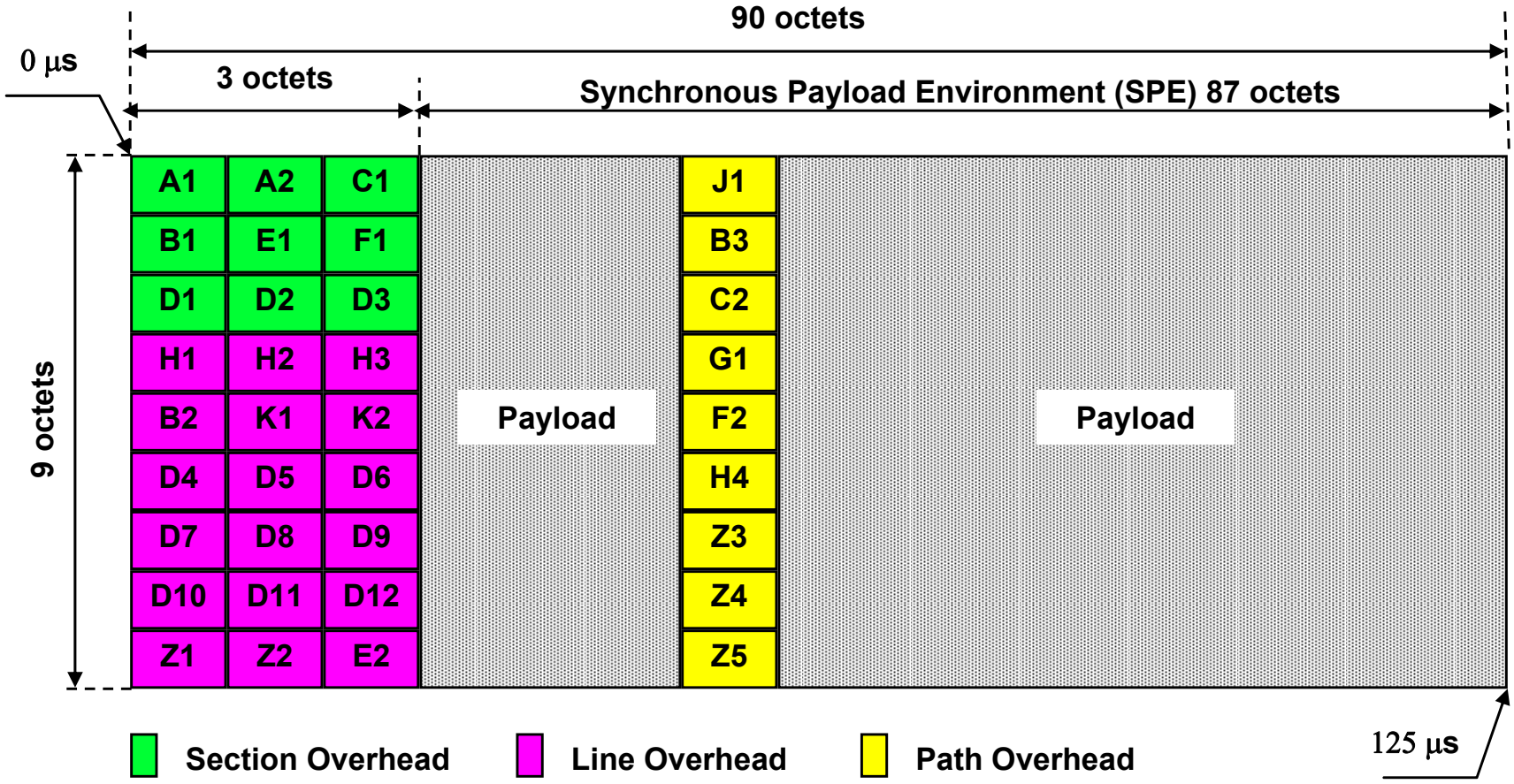
Protocol Architecture

- **Photonic Layer:** fiber, laser
- **Section Layer:** frames, OAM (Operation Administration and Management)
- **Line Layer:** synchronization, multiplexing, switching, OAM
- **Path Layer:** end-to-end data (bytes) transfer



Frame Format

STS-1: 810 octets every 125 μs → 51.84 Mbps



Pros and Cons


Standard OAM architecture


Virtual connections

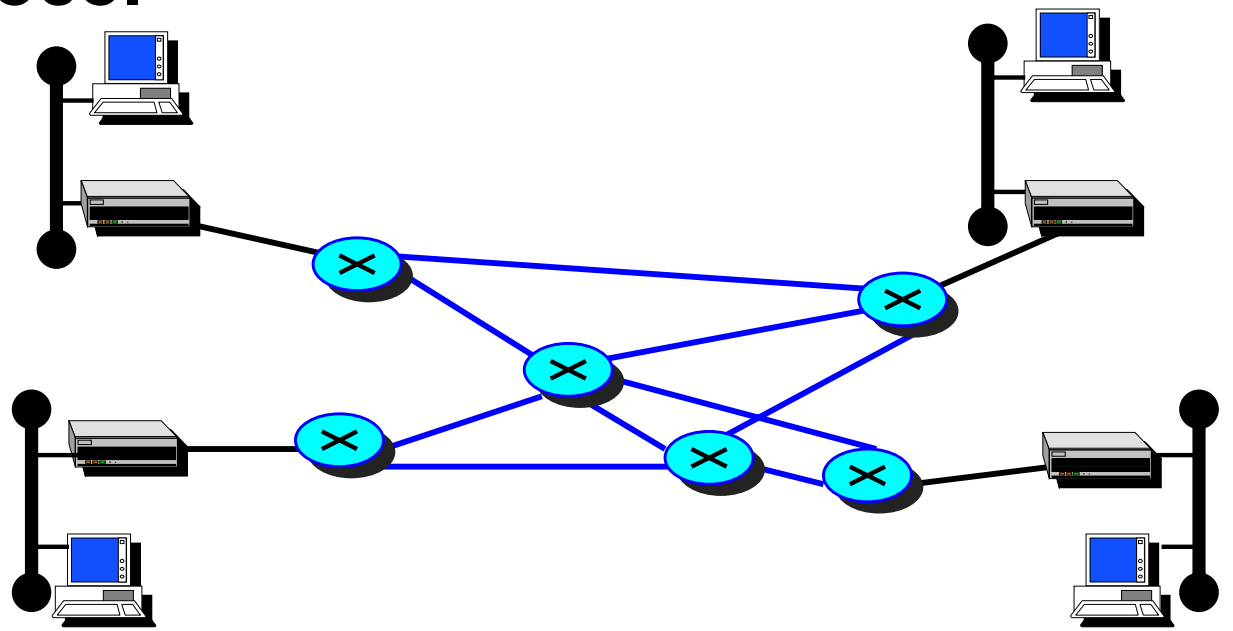

One interface per connection


Static multiplexing


Limited reconfiguration flexibility

IP over ATM (Asynchronous Transfer Mode)

- Cell switching
  - flexible multiplexing
- Semi-permanent and switched virtual connections
- Layer 2 protocol
  - no need for layer 2 framing



Pros and Cons


Virtual connections


Multiple connections per interface


Total reconfiguration flexibility

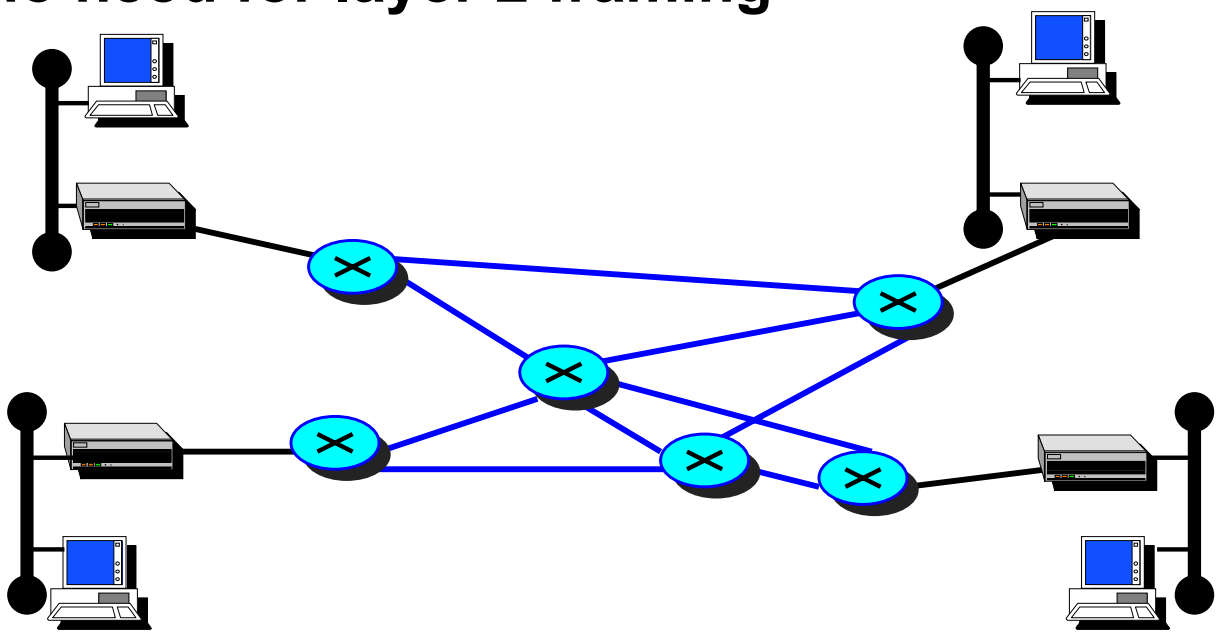

Support for other services (e.g., frame relay)


Flexible multiplexing


High protocol overhead (more than 10%)

IP over FR (Frame Relay)

- Frame switching
  - flexible multiplexing
- Semi-permanent virtual connections
- Layer 2 protocol
  - no need for layer 2 framing



Pros and Cons


Virtual connections


Multiple connections per interface


Large installed base

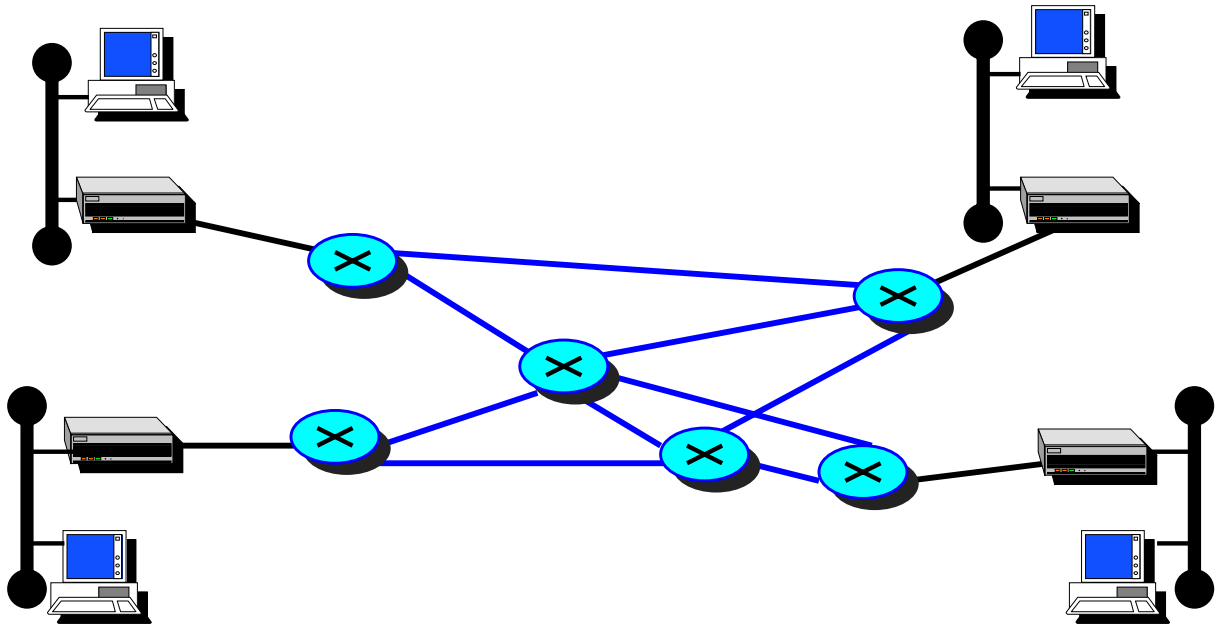

No Quality of Service Guarantees

Why is another packet switching layer needed?

Because IP lacks traffic engineering capability

MPLS (Multi-Protocol Label Switching)

- Frame switching
  - flexible multiplexing
- Dynamic virtual connections (label switched paths)
- Layer 2 protocol tightly integrated with layer 3



Pros and Cons


Virtual connections


Multiple connections per interface


One control plane: no “IP over”


No Quality of Service Guarantees