



**IP over ...
... ATM ... SDH ... DWDM**

Mario Baldi
Politecnico di Torino
(Technical University of Turin)
www.baldi.info





Nota di Copyright

This set of transparencies, hereinafter referred to as slides, is protected by copyright laws and provisions of International Treaties. The title and copyright regarding the slides (including, but not limited to, each and every image, photography, animation, video, audio, music and text) are property of the authors specified on page 1.

The slides may be reproduced and used freely by research institutes, schools and Universities for non-profit, institutional purposes. In such cases, no authorization is requested.

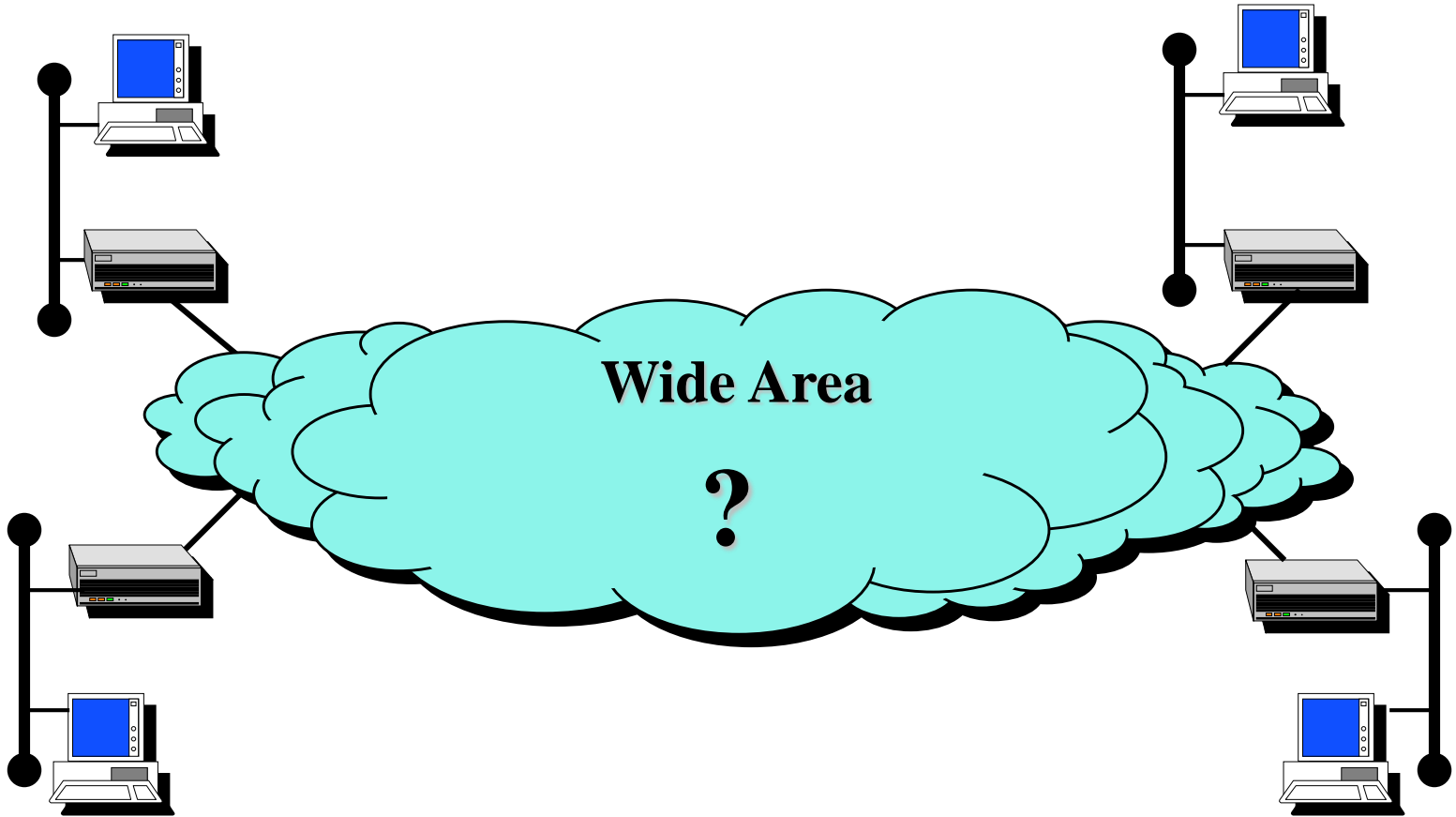
Any total or partial use or reproduction (including, but not limited to, reproduction on magnetic media, computer networks, and printed reproduction) is forbidden, unless explicitly authorized by the authors by means of written license.

Information included in these slides is deemed as accurate at the date of publication. Such information is supplied for merely educational purposes and may not be used in designing systems, products, networks, etc. In any case, these slides are subject to changes without any previous notice. The authors do not assume any responsibility for the contents of these slides (including, but not limited to, accuracy, completeness, enforceability, updated-ness of information hereinafter provided).

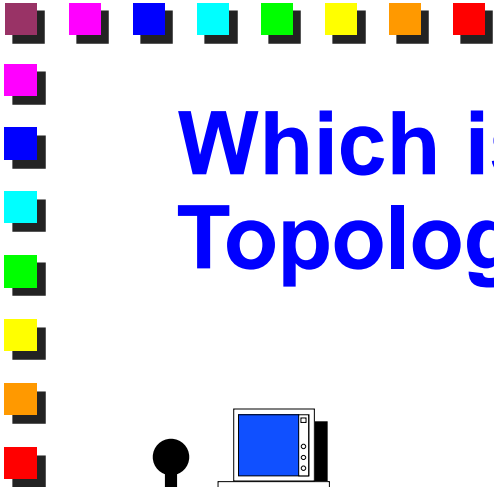
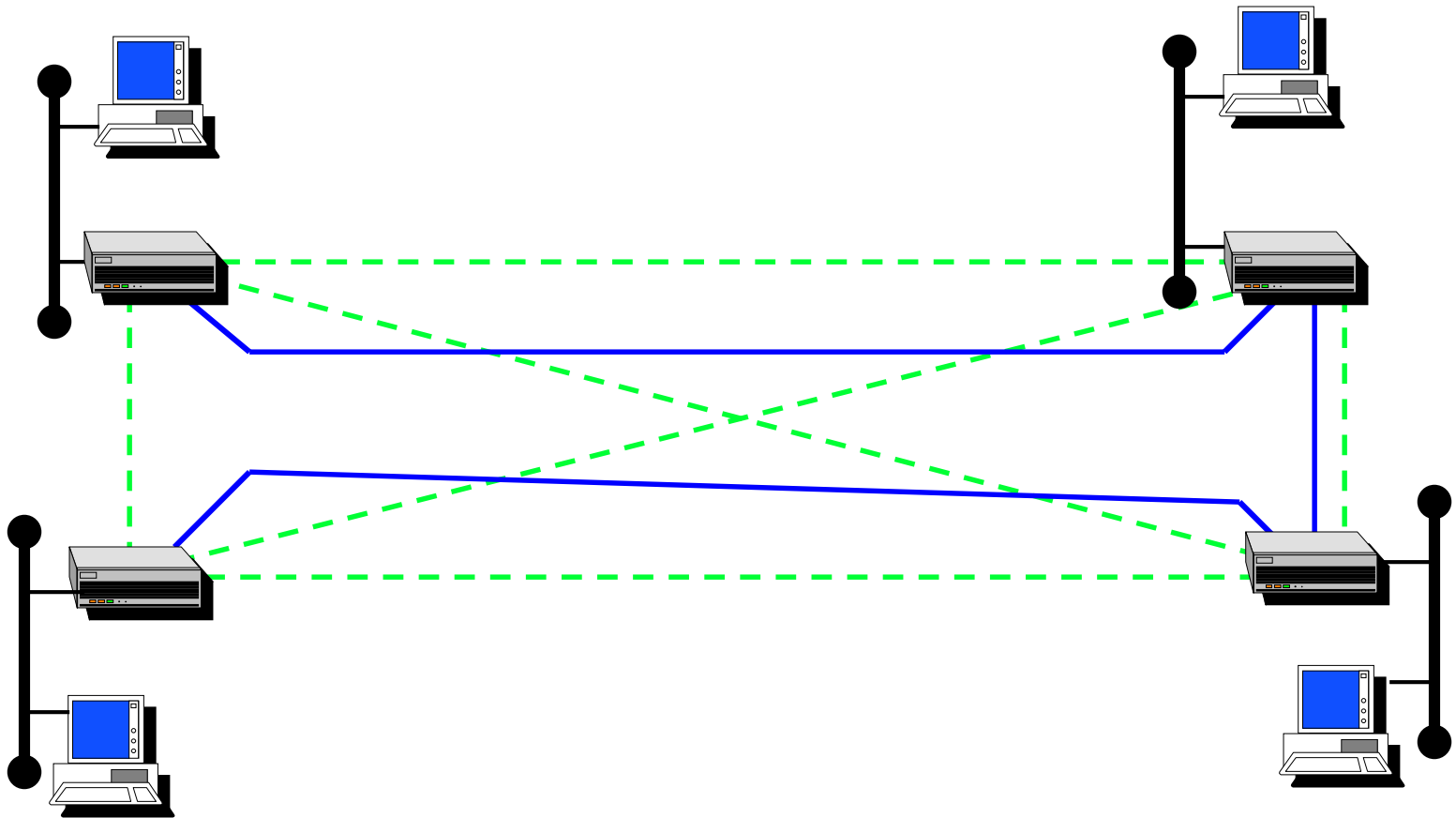
In any case, accordance with information hereinafter included must not be declared.

In any case, this copyright notice must never be removed and must be reported even in partial uses.

IP Everywhere. Anything else?



Which is the Best Interconnection Topology?





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

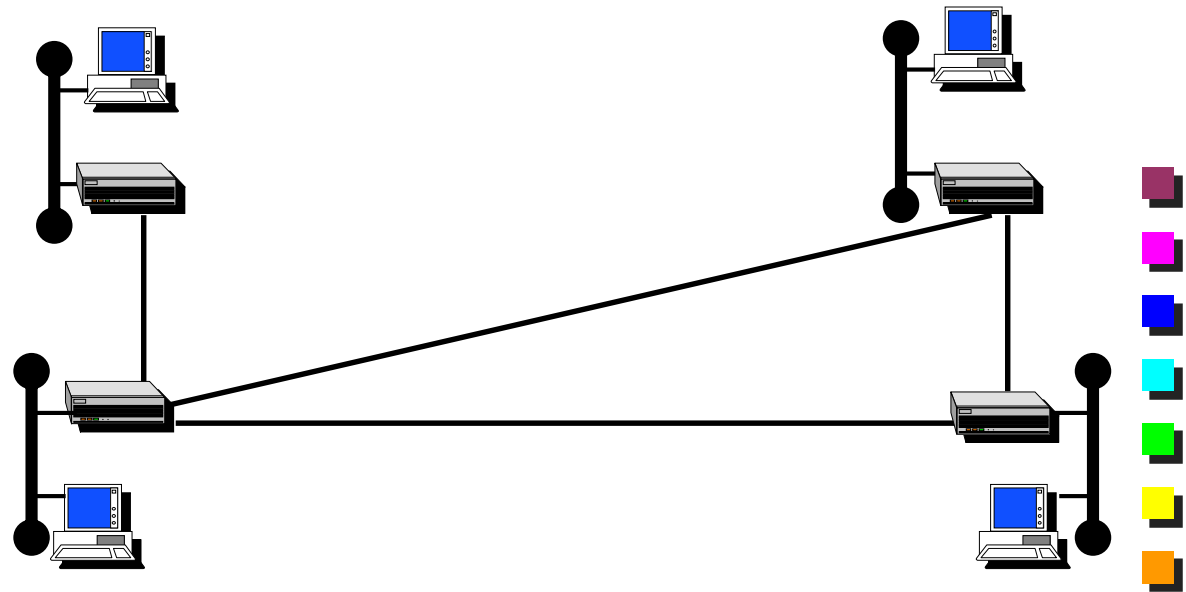
- It can change on a monthly base
 - different customers
 - different customer needs
- It can change on a weekly base
 - events
- It can change on a daily base
 - business users during week-days, residential users during the week-end
- It can change on a hourly base
 - business hours
 - evening entertainment

T
r
a
f
f
i
c
e
n
g
n
e
r
a
t
i
o
n



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

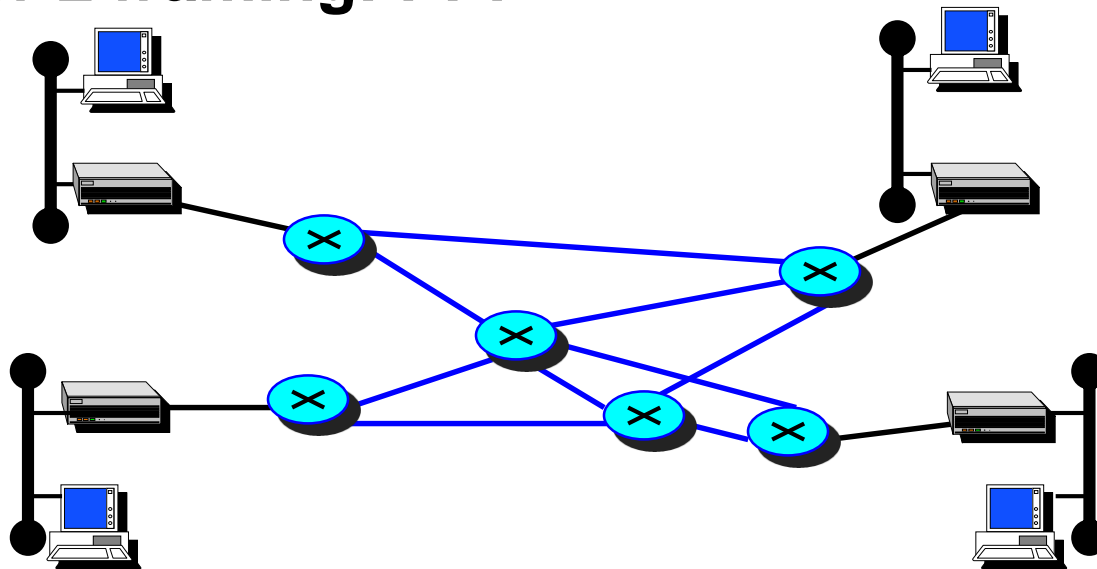


No standard management infrastructure



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?**

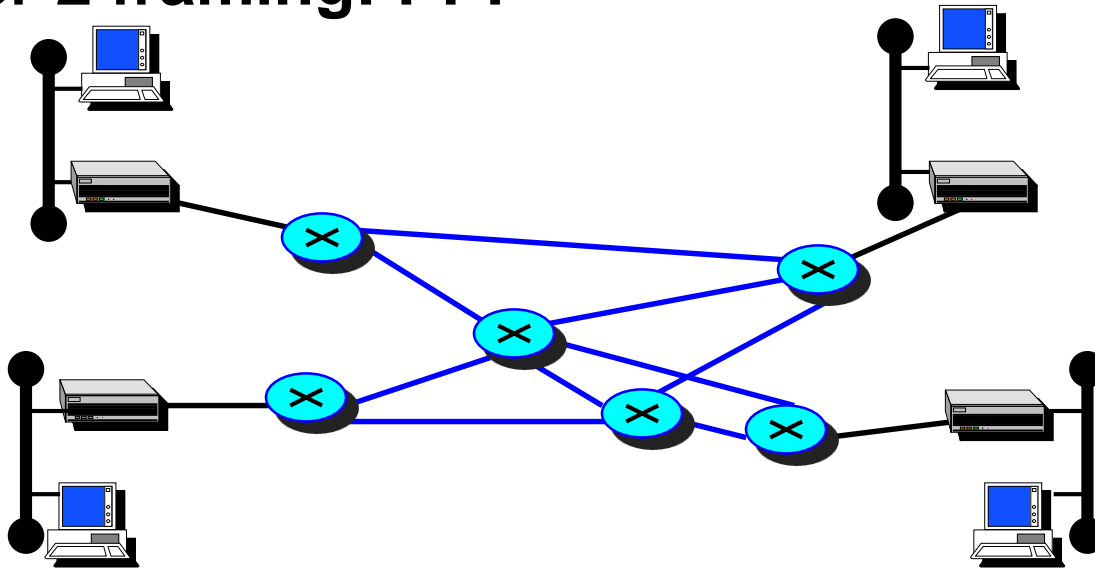




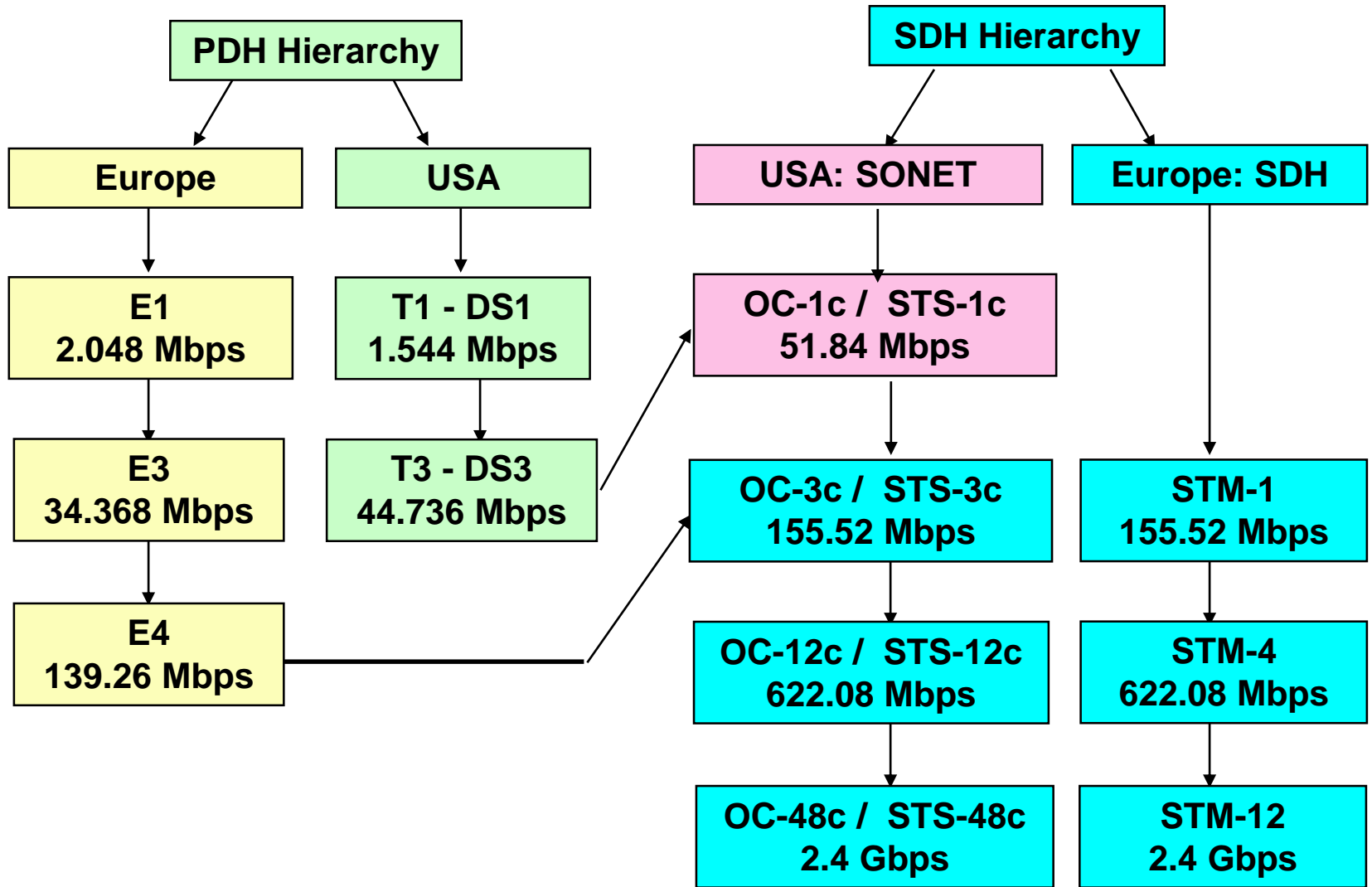
IP over SONET/SDH

(Synchronous Optical Network
Synchronous Digital Hierarchy)

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

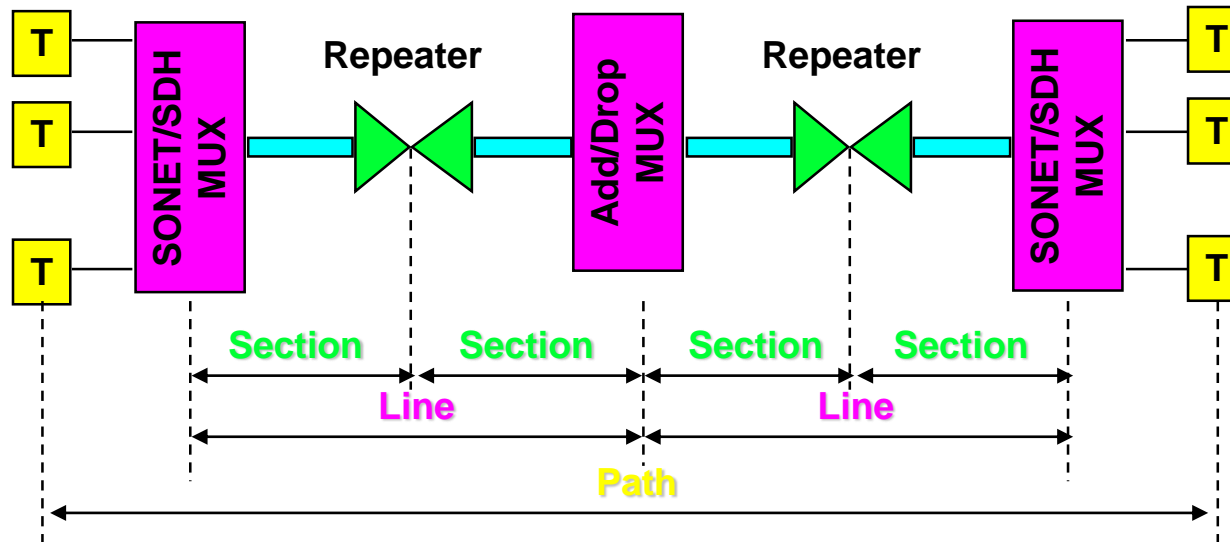


Transmission Hierarchy



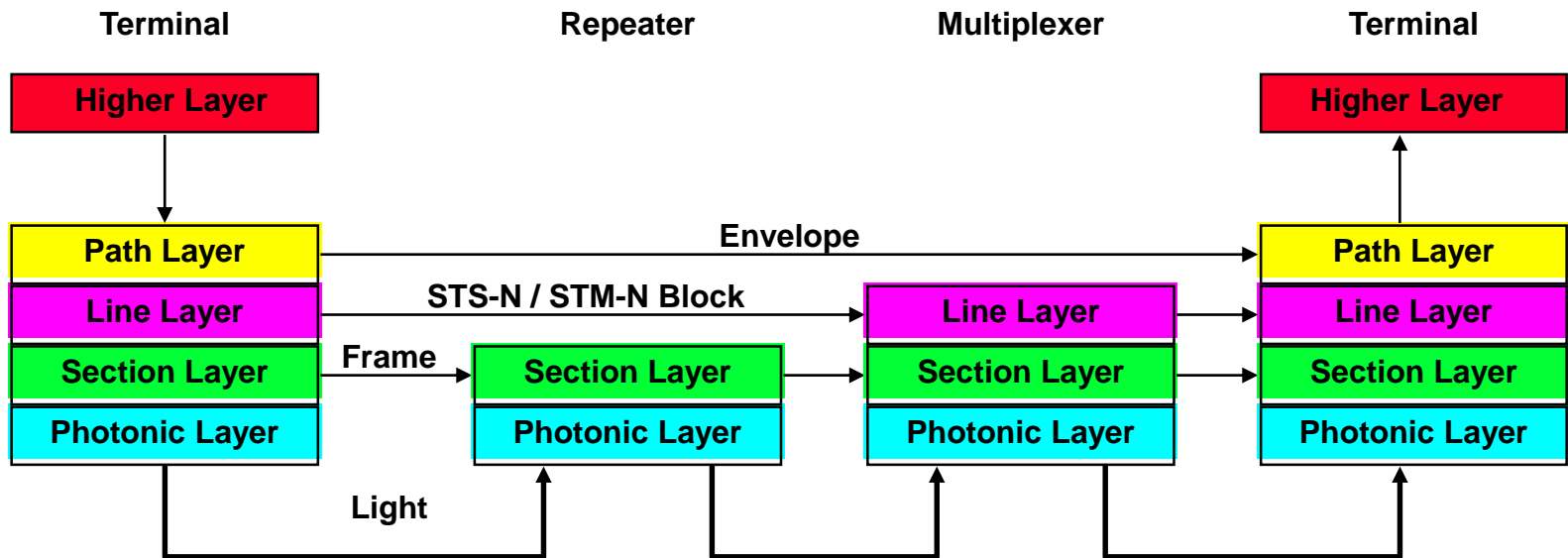
Physical Architecture

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



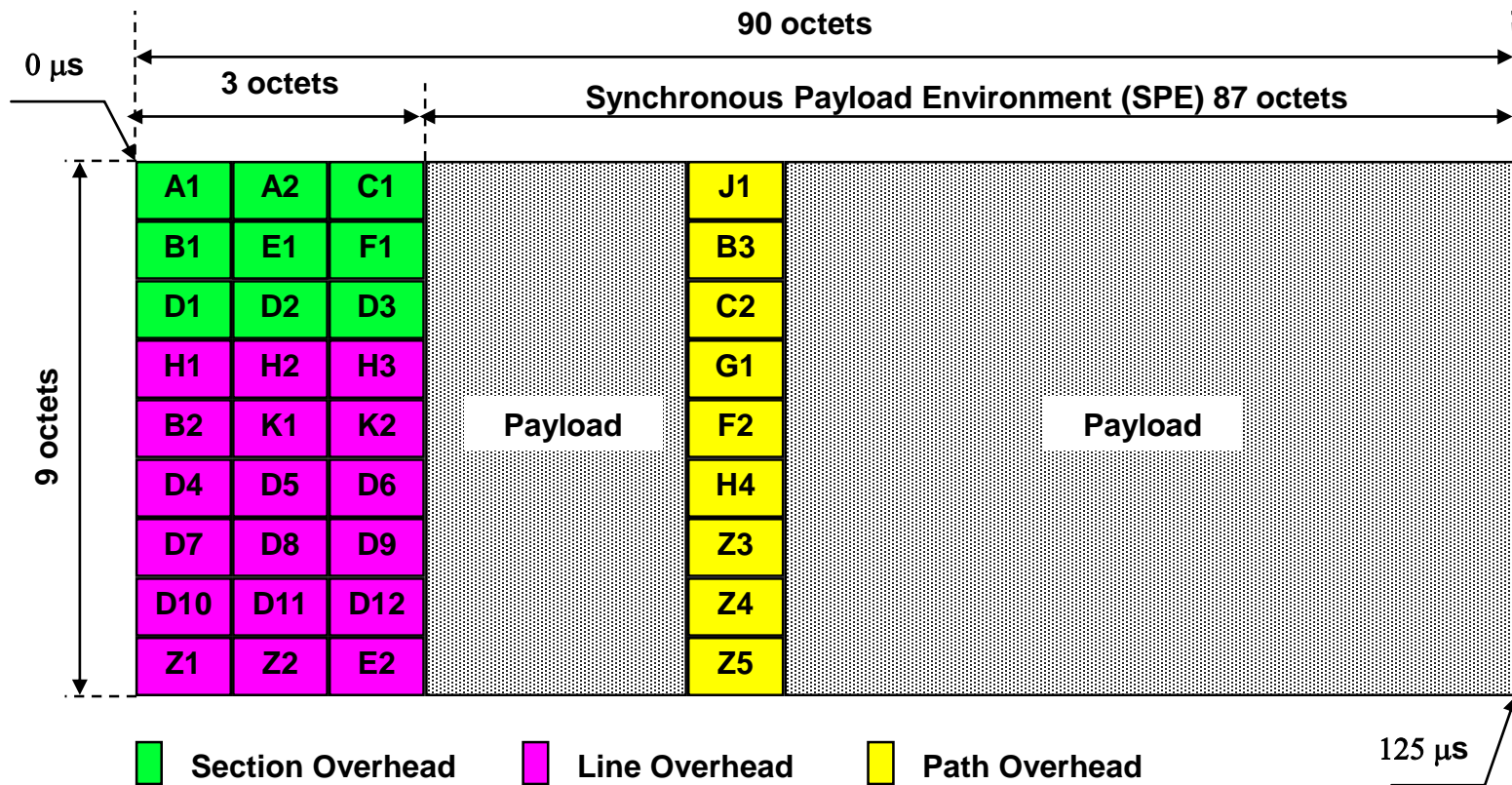
Protocol Architecture

- **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 μ s \rightarrow 51.84 Mbps









■ Section Overhead
 ■ Line Overhead
 ■ Path Overhead

125 μ s

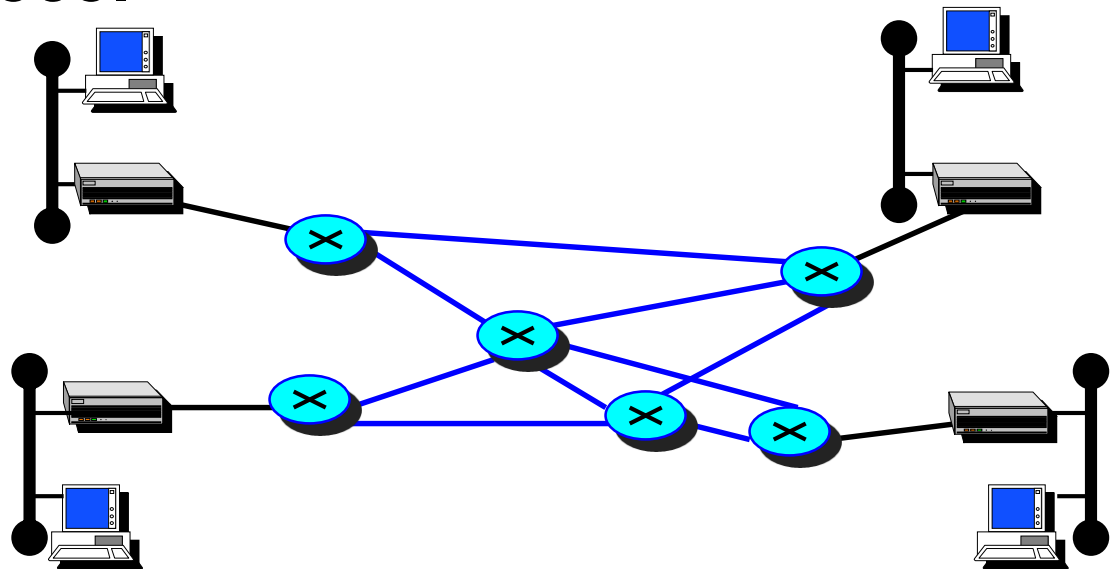


Pros and Cons

-  **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



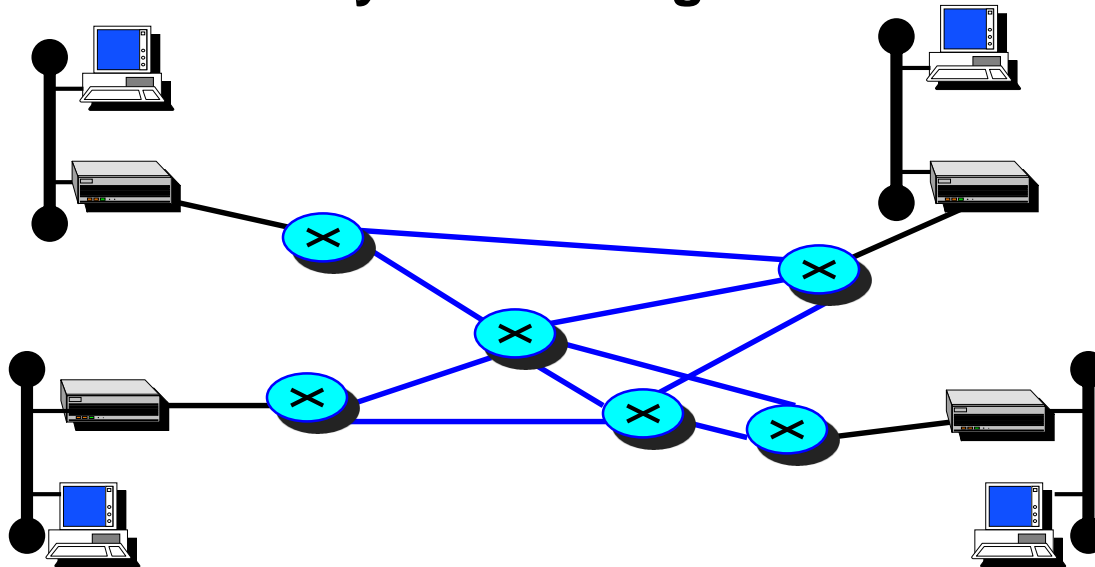


Pros and Cons

-  **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?

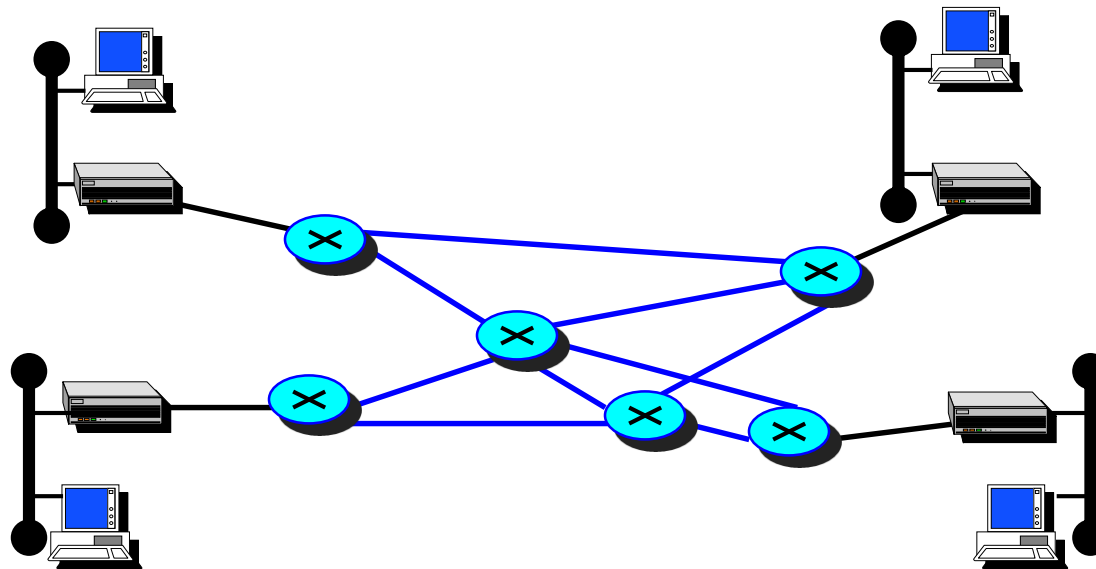
Because IP lacks traffic engineering capability



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**
- 