Lecture 18

Protection Schemes
Reliability of Optical Networks

• Must be available 99.999% of the time
• Restoration time: 60ms for SONET/SDH
• Failure events:
  - component aging
  - physical damage
  - mishandling during maintenance
• Protection realization:
  - at physical layer
  - at network layer
Fault Management: Protection Techniques

"1+1"

Dedicated protection

"1:1"

"1:N"

Shared protection

Ivan Avrutsky, ECE 5870, Optical Communication Networks, Fall 2007, Lecture 18

Slide # 3
Revertive and Nonrevertive Protection Schemes

Revertive – traffic returns to the working fiber after restoration

Nonrevertive – traffic remains in the protecting fiber
Data traffic is often bidirectional, typically with separate fibers caring traffic in different directions.

- Unidirectional protection: only the failed fiber is switched
- Bidirectional protection: once link fails, traffic in both directions is rerouted
Unidirectional and Bidirectional Protection Schemes

**Figure 10.1** Unidirectional and bidirectional protection switching. (a) The link is shown under normal operation. (b) Unidirectional protection switching. After a unidirectional fiber cut, only the affected direction of traffic is switched over to the protection fiber. (c) Bidirectional protection switching. After a unidirectional fiber cut, both directions of traffic are switched over to the protection fibers.
Path and Line Switching

Path switching = total rerouting
Line switching = rerouting between the notes where the fault is detected

Normal operation

Path switching restoration

Span protection

Line protection (Line switching)
Ring Network: Major SONET component

Unidirectional path-switched ring (UPSR)

No limit on the number of nodes in the ring

1+1 protection: signal launched simultaneously into both fibers

Note, opposite directions provide better reliability
4-Fiber Bidirectional Line Line-Switched Ring (BLSR-4)

Traffic sent along shortest path. Both span and line protection are used to restore service after the failure.

Number of nodes limited to 16 (4 bits reserved for addressing the nodes).
Max ring length 1200km.
Span Protection in BLSR-4
Line Protection in BLSR-4
2-fiber Bidirectional Line-Switched Ring (BLSR-2)

2 fibers, half the bandwidth, line protection after the failure.
BLSR

- Supports up to 16 nodes (limited by the 4-bit addressing)
- Max length 1200km (limited by 6ms propagation time)
Mesh Network Decomposed into Rings

- Protection cycle $C(p(e))$
- Protection edge $p(e)$
- Working edge $e$
Mesh Network with Working and Protection Fibers

--- Working fiber

--- Protection fiber

Diagram showing mesh network connections between nodes A, B, C, D, E, and F, with solid lines indicating working fiber and dashed lines indicating protection fiber.
Line Protection in a Mesh Network

Normal operation

Line protection
Protection at the Network Layer and at Physical Layer
Physical Layer Protection

Optical Multiplex Section (OMS)

(a)

Optical Channel Section (OCh)

(b)
Topics for in-class presentations


2. Optical Technologies for High Bit Rate Fiber Communication (Bell Labs Technical Journal, 2006)

3. Modulation Formats for High-Bit Rate WDM (Journal of Selected Topics in Quantum Electronics, 2006)


5. Optical Packet Switching (Journal of Optical Networking, 2007)