Wavelength Conversion

(a) without converter

(b) with converter

\[ \lambda_s \rightarrow \text{Wavelength Converter} \rightarrow \lambda_c \]

\[ s = 1, 2, \ldots, N \]

\[ c = 1, 2, \ldots, N \]
Wavelength Converter Switch

A switch with dedicated converters at each output port for each wavelength.

Share-per-node wavelength-convertible switch architecture

Share-per-link wavelength-convertible switch architecture
• Probability $P_b$ that the connection request from A to B will be blocked equals the probability that, along this H-link path, there exists a fiber link with all of its $W$ wavelengths in use.

• Probability $P_b$ that the connection request from A to B will be blocked equals the probability that, along this H-link path, each wavelength is used on at least one of the H links.
Wavelength Conversion Benefits

$W = \text{Number of wavelengths}$

$\rho = \text{Probability that a wavelength is used} \ (\rho W \text{ is the expected number of busy wavelengths on any fiber link, } p \text{ is also the "fiber utilization" of any fiber.})$

$P'_b = \text{Blocking probability of H-link path}$

$q = \text{Achievable utilization}$

* consider an H-link path for a connection from node A to node B

With Wavelength Converters:

$$P'_b = 1 - (1 - \rho^W)^H$$

$$q = [1 - (1 - P'_b)^{1/H}]^{1/W} \approx \left( \frac{P'_b}{H} \right)^{1/W}$$
Wavelength Conversion Benefits

W = Number of wavelengths

\( \rho = \) Probability that a wavelength is used

\( P_b = \) Blocking probability of H-link path

\( p = \) Achievable utilization

**No Wavelength Converter:**

\[
P_b = [1 - (1 - \rho)^H]^W
\]

\[
p = 1 - (1 - P_b^{1/W})^{1/H} \approx \frac{1}{H} \ln\left(1 - P_b^{1/W}\right)
\]

* consider an H-link path for a connection from node A to node B
• Achievable utilization is inversely proportional to the "length of the lightpath connection" (H).

• $G = q/p$ is a measure of the benefit of wavelength conversion, which is the increase in (fiber or wavelength) utilization for the same blocking probability.