Lecture 12

Conditional Dependence

- ⇨ What if we now remove the assumption that the probability of wavelength usage on each link is mutually independent.
- ⇨ For a network with no wavelength conversion, we define any lightpath that has already been established and uses one of the *H* links that we want to use for a new lightpath, is an ***interfering lightpath***.
- ⇨ Place the constraint that an interfering lightpath that uses link *i* on one of the *H* links, will not use the next link *i+1* with probability π_l.
- ⇨ For any λ, we assume a new lightpath request that does not interfere on link *i-1*, will interfere on link *i* on the route with probability π_n.
- ⇨ We have the following conditional probabilities:

$$\text{Prob}(\lambda \text{ used on link } i \,|\, \lambda \text{ is not used on link } i-1) = \pi_n$$

$$\text{Prob}(\lambda \text{ used on link } i \,|\, \lambda \text{ used on link } i-1) = (1-\pi_l) + \pi_l \pi_n$$

- ⇨ And the probability of blocking with no wavelength conversion can be shown to be

$$P_{b,nc} = (1-(1-\pi_n)^H)^W$$

Conditional Dependance

- If we now consider full wavelength conversion, the probability is linked to all wavelengths on any one link along H hops being blocked

$$P_{b,fc} = 1 - \prod_{i=1}^{H} \left(1 - \frac{\pi_i^W - (1 - \pi_l + \pi_l \pi_n)^W \pi_i^W}{1 - \pi_{i-1}^W} \right)$$

- With

$$\pi_i^W = \frac{\pi_{n+}}{\pi_n + \pi_l - \pi_l \pi_n} \left(1 - (1 - \left(\pi_l + \pi_n - \pi_l \pi_n \right))^i \right)$$

- Solving for π_{nc} and π_{fc} we can calculate the wavelength conversion gain

$$\frac{\pi_{fc}}{\pi_{nc}} \approx H^{1-1/W} \left(\pi_l + \pi_n - \pi_l \pi_n \right)$$

Interference Length

- We can now define the expected number of links that an interfering lightpath will use on the path chosen during a lightpath request.

$$L_i = \frac{1}{\pi_l}$$

- Assuming that $H >> L_i$ is saying that the number of hops in a lightpath request is much greater than the average number of hops it will share with another lightpath.
  - This is a good assumption in highly connected networks (e.g. meshes)
  - Not a good assumption in low connected networks like rings
- When $\pi_l = 1$, the conversion gain for non-conditional probability is approximately $H^{1-1/W}$ and it is lowered by a factor $(\pi_n + \pi_l - \pi_n \pi_l)$ when conditional probability is considered.
- This is called a ***mixing probability factor***, so there is more conversion gain in networks where there is more mixing.

Maximum Load Dimensioning Models

- It is useful to understand how using partial wavelength conversion can be used to affect the performance (rather than no-conversion or full-conversion).
- Two broad categories
  - Off-line requests: Static network design where only a single set of lightpaths is supported.
    - This set can be supported in a network with full wavelength conversion with at most L wavelengths per link. The maximum load of this set is L.
    - If not full wavelength conversion, then more than L wavelengths needed per link to support the same lightpaths.
    - The problem is then to determine how many additional wavelengths are needed to support a given load.
  - On-line requests: Dynamic network assignment where one lightpath is setup at a time and requests are setup in real time without knowing what future requests are going to be.
    - No more than L lightpaths use a link at any one time.
    - Network with fully wavelength conversion that supplies L wavelengths on each link can support all lightpaths requests.