Backup Multiplexing

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23rd April, 2003
Outline

- Link based Vs Path Based
- Failure-Dependent Vs Failure-Independent
- Backup Multiplexing Vs. Primary Backup Multiplexing
- Backup Multiplexing based Routing
- The PDBWA and PIBWA Algorithms
- Experimental results obtained
Link Based Vs. Path Based

**Link-based**
- Backup path must use same wavelength
- Can only fix link failures
- Less efficient.

**Path-based**
- Backup path can use any wavelength
- More efficient.
Failure-Dependent Vs. Failure-Independent

- In failure-dependent method, associated with the failure of every link used by a primary lightpath, there is a backup lightpath.

- In failure-independent method, a backup lightpath which is link-disjoint with the primary lightpath is chosen.
Backup Multiplexing vs. Primary Backup Multiplexing

Backup multiplexing
• Less robust
• More efficient

Primary Backup Multiplexing
Wavelength channel to be shared by a primary and one or more backup paths
Backup Multiplexing Based Routing

- The algorithms are PDBWA and PIBWA
- They choose a primary-backup lightpath pair so as to minimize blocking probability
- They are proactive, use a failure-independent, path based restoration approach
- They basically use an alternate routing method, choosing from a set of candidate routes which are link-disjoint
Backup Multiplexing Based Routing

Definitions:

• *D-Connection*: A connection with fault tolerance requirements
• *Lightpath*: uniquely identified by a path and a wavelength
• *f-channel*: A channels currently not in use
• *p-channel*: A channel being used by a primary lightpath
• *b-channel*: A channel being used by a backup lightpath
A few more definitions...

- **Path Vector**: The set of links used by the route of a lightpath. If L is the number of links in the network, then
  \[ P = (p_{L-1}p_{L-2}...p_1p_0) \]

- **Cost Vector**: The set of links used by the primary lightpaths whose backup lightpaths use this channel.
  \[ C = (c_{L-1}c_{L-2}...c_1c_0) \]

- **Cost function** $C_p(L_p)$: Cost of a primary lightpath $L_p$

- **Cost function** $C_b(L_b, L_p)$: Cost of a backup lightpath $L_b$ whose primary lightpath is $L_p$.

- **Cost function** $C_d(L_p, L_b)$: $C_p(L_p) + C_b(L_b, L_p)$
PDBWA Method

• Primary Dependent Backup Wavelength Assignment Algorithm
• Assigns the same wavelength to a primary and its backup
• It may not yield best performance
• A path with higher cost could be chosen
• BUT it is simple and has a computational complexity of O(KHW)
PDBWA Algorithm

1. For each of the possible K lightpaths, compute $C_p$ and $C_b$.

2. Choose a lightpath $L_p$ whose $C_p$ is minimum.

3. Among the lightpaths other than $L_p$, choose a lightpath $L_b$ whose $C_b$ is minimum.
A simplex case – An example

- The links are assumed to be simplex
- Non-wavelength converting nodes
- Consider the <s,d> pair as <1,3>

- In this case, K=4, H=3, W=2, N=6
- Minimum C_p=1, minimum C_b=2
- This pair will then be chosen
PIBWA Method

• No restriction on selection of wavelength for the backup lightpath
• This results in better network performance in terms of connection blocking probability
• BUT it is computationally more complex
• Requires additional data structures such as Conflict Vector CV to compute the cost of backup lightpaths
• Computational complexity is $O(KKHHHW)$
The Algorithm

1. Consider a candidate route R. Choose the lightpath with minimum $C_p()$ value and call it $L_p$.

2. For each of the remaining $(K-1)W$ lightpaths, compute $C_b()$. The one with the minimum cost is $L_b$.

3. The pair $<L_b, L_p>$ has minimum cost among all pairs whose primary route is $R$.

4. Repeat steps 1 and 2 for each of the $K$ possible routes.

5. Among the $K$ minimum cost pairs found, choose the one with the least cost.
Experimental Results

- Results show that the usefulness of the backup multiplexing increases as the network connectivity increases because the number of possible link-disjoint candidate routes is greater.
- The PIBWA method performs better than the PDBWA method.
- Performance gain increases with increasing network connectivity.
References

• S. Ramamurthy and B. Mukherjee, “Survivable WDM Mesh Networks - Protection”, IEEE Infocom ‘99
• Part of these notes have been derived from engr.smu.edu/~nair/courses/8344/wdm_protection.ppt