Dynamic Light-path Establishment & Connection Management

Overview

- Paper review: Dynamic light-path establishment in wavelength-routed WDM networks
- DLE
  - Control mechanism for setting up and tearing down
    - Centralized
    - Distributed
  - Network state information update
    - Link-state
    - Distance-vector

Dynamic Light-path Establishment

- Enable service providers to respond quickly and economically to customer demands
- Challenges
  - Develop efficient algorithms and protocols for establishing light-paths
  - RWA selects routes and assign wavelengths to efficiently utilize network resources and max the # of light-paths established
  - Signaling protocols must effectively manage the distribution of control messages and network state info
  - Need a network control and management protocol
Adaptive Routing and Global Info

- Global information is made available
- Decisions made with full information as to which wavelengths are available on each link
  - **Centralized**
    - A single entity, i.e., network manager
    - Maintains complete network state information
    - Find routes and set up light-paths
    - Possible single point of failure

Adaptive Routing and Global Info

- **Distributed**
- **Link-state approach**
  - Each node maintain complete network state information
  - Each node find a route for a connection request
  - Whenever the state of the network changes, all of the nodes must be informed
  - Establishment & tear down broadcast of update messages to all nodes in the network
  - Update messages significant control overhead
  - Outdated information possible incorrect routing decision

Adaptive Routing and Global Info

- **Distance-vector**
  - Not require that each node maintain complete link-state information
  - Each node maintain a routing table which indicates, for each destination and on each wavelength,
    - The next hop to the destination
    - The distance to the destination
  - Use a distributed Bellman-Ford algorithm to maintain the routing tables
  - Require nodes to update their routing table information upon a connection establishment or a tear down
  - Updates periodically sent to neighbors or whenever the status of the node’s outgoing links changes
Adaptive Routing and Global Info

- Advantages
  - Make the most optimal routing decisions if the state information is up-to-date
  - Suited for networks in which light-paths are fairly static and do not change much with time

- Disadvantages
  - Maintain a potentially large amount of state information which changes constantly

Adaptive Routing and Neighborhood Info

- Least congested path using neighborhood info
  - Not examine all links on a candidate path
  - Only examine the first k links on each path → neighborhood info
  - K = 2, this algorithm can achieve similar performance to fixed-alternate routing

Adaptive Routing and Local Info

- Deflection routing or alternate link routing
  - Choose from alternate links on a hop-by-hop basis rather than from alternate routes on an end-to-end basis
  - Each node maintains a routing table that indicates, for each destination,
    - one or more alternate outgoing links to reach that destination
  - Pre-computed and ordered
  - An alternate link is chosen if resources are not available on the preferred link
  - Each node maintain information regarding the status of wavelength usage on its own outgoing links → no update messages needed
Signaling and Resource Reservation

- Require to exchange control information among nodes and reserve resources along the path
- Signaling protocol is closely integrated with the routing and wavelength assignment protocols
- Classification
  - Parallel reservation
  - Hop-by-hop forward
  - Hop-by-hop backward
  - Also depend on whether or not global info is available

Parallel Reservation

- Based on link-state routing and global info
  - Network topology & current state including wavelength usage on each link
- Calculate an optimal route to a destination on a given wavelength
- Source node attempts to reserve the desired wavelength on each link in the route by sending a separate control message to each node in the route
- Each node, upon receipt of the reservation request, attempt to reserve the specified wavelength
- Return either a positive or a negative ack back to the source
- All positive acks establish; otherwise, release reservation
- Advantage
  - Shortens light-path establishment time

Hop-by-Hop Reservation

- Control message is sent along the selected route one hop at a time
- Intermediate node process the control message before forwarding it to next hop
- At the destination, control message is processed and sent back toward the source
- Actual reservation of link resources may be performed
  - Forward direction
  - Backward direction
Forward Reservation

- Wavelength resources are reserved along the forward path to the destination on a hop-by-hop basis
- **Global info available**
  - Source decides a wavelength
  - Send a connection setup message along the forward path
  - Reserve the same available wavelength on each link

Forward Reservation

- **No global info**
  - Only know the status of immediate links
  - **Conservative approach**
    - Source chose a single wavelength and send a control message to the next node to attempt to reserve
    - If the wavelength is blocked, source node may select a different wavelength and reattempt the connection
    - Long setup time
  - **Aggressive approach**
    - Intermediate node reserve all wavelength available
    - The destination node chooses one wavelength and release the reservations on the remaining wavelengths
    - Resources over-reserved for a short period of time
    - May block subsequent request and lower network utilization

Backward Reservation

- To prevent over-reservation, reservations are made after the control message has reached the destination and is headed back to the source
- Source send control messages to destination w/o reserving any resources
- Control messages collect information about wavelength usage along one or more paths
- Destination decides on a route and a wavelength
- Destination sends a reservation message to the source node along the chosen route
- Reserve appropriate resource along the way
- **Drawback**
  - Multiple simultaneous connection setup; late reservation messages will see available resources in the forward direction taken away by other reservation messages
Comparison between Link state and Distributed routing

- **Link state approach**
  - Shorter stabilizing delay
  - Under low load, lower blocking probability
  - Explicit routing possible for traffic engineering
  - Easier for implementing fault-tolerance by calculating two link-disjoint paths
  - Make shared protection possible with the knowledge of full network topology and network state info

- **Distributed routing**
  - Shorter connection establishment delays
  - Under high load, lower blocking probability