Shortest-Cycle Photonic Network Restoration

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Abstract: As the deployment of photonics becomes accepted within today's ubiquitous optical networks efficient photonic path protection and restoration mechanisms will be essential. This paper highlights a demonstrated approach to photonic path configuration and control which utilises the notion of the shortest-cycle algorithm for protected network connections.

1 Introduction.

The deployment of optical networks equipment is currently based upon point-to-point optical connections organised into physical rings. This architecture has many benefits, not least that demand paths can be protected using physically disjoint working and protection paths and nodes configured in the ring. This is the basis of protection in SONET/SDH ring networks. The simplest form of this ring protection is "one-plus-one" (1+1) where two copies of the data, counter-propagate around the ring, the decision as to which copy is used being made at the destination receiver. From a network perspective this is the least efficient, as you more than double the bandwidth requirements, but it is the fastest as the decision is local. The network efficiency can be increased by sharing the protection path between multiple connections, not having copies of the data carried. Other, lower priority traffic, that is unprotected, but revenue generating, may be carried in the protection bandwidth. During a failure event this traffic is dropped from the network so that the high priority, and high revenue, traffic can be restored.

The desire for more flexibility in network architectures as a means of safeguarding a degree of tolerance to both traffic and service demands is driving the adoption of mesh architectures. This trend, together with that of decreasing granularity of traffic bandwidth to the wavelength level, is giving rise to the photonic mesh network.

2. Photonic mesh Network.

The concept of mesh networking is not new, indeed data networks at ISO layer 3 (network) are meshed, but currently still mapped into a ring based ISO layer 1 (physical). However, it is possible to use layer 3 techniques to control layer 1 photonic equipment. Simulations of this architecture have been suggested [1].

The adoption of photonic switching network elements is aimed at exploiting the nascent network flexibility allowing, for example, time of day network bandwidth optimisation and fast wavelength service delivery generating additional revenue from existing equipment. The rapid service delivery is seen as a valuable business differentiator for both network operators and equipment suppliers.

3. Test Network Topology.

Figure 1 illustrates the photonic network test-bed equipment integrated with the shortest-cycle control scheme. It should be noted that there is an instance of control at every photonic switch point, an isomorphic control topology, together with the ability to have multiple photonic paths through the network mesh including direct shortest paths (not illustrated, but possible for example from node A to node D) and shortest cycles (illustrated).

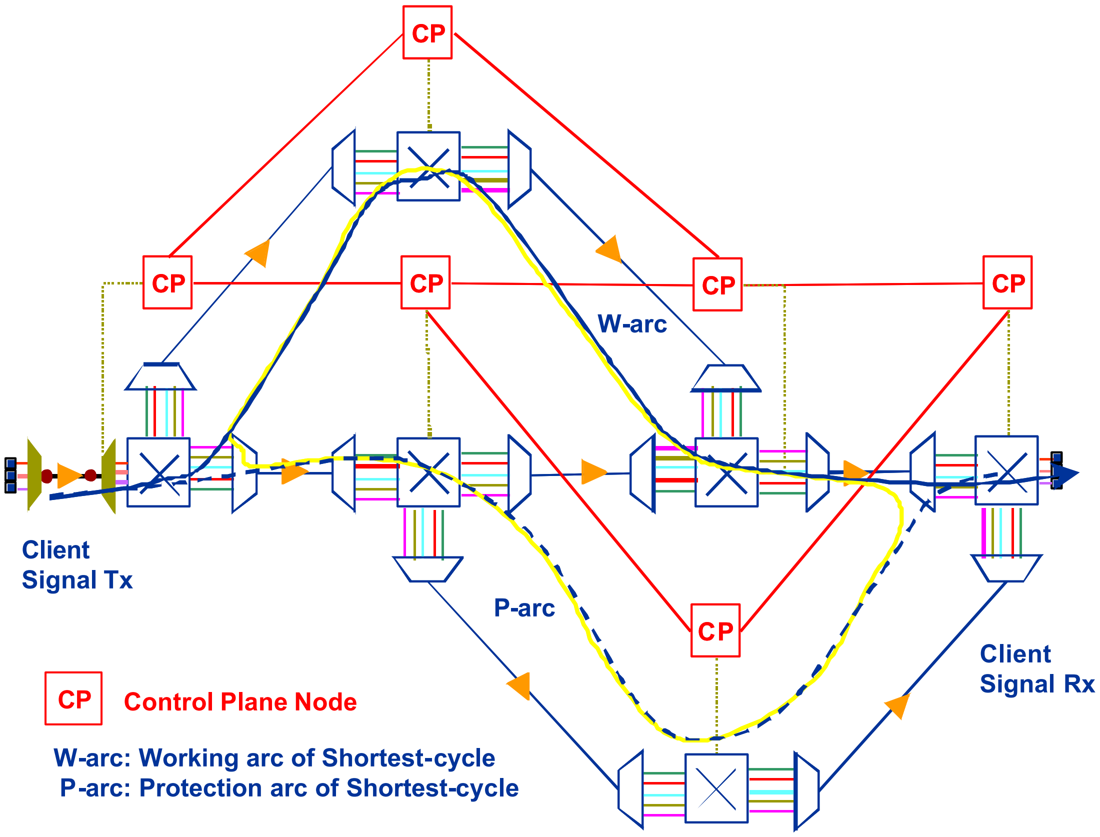

Figure 1. Photonic Test Network Topology.

4. Shortest-Cycle photonic protection.

The algorithms to generate simple cycles in graphs, where no edge or vertex is visited twice are well known [2]. The one used in this work, attributed to JW Surballe is referenced in [3]. The following diagram (figure 2) illustrates the manipulation of the network graph data in executing the algorithm.

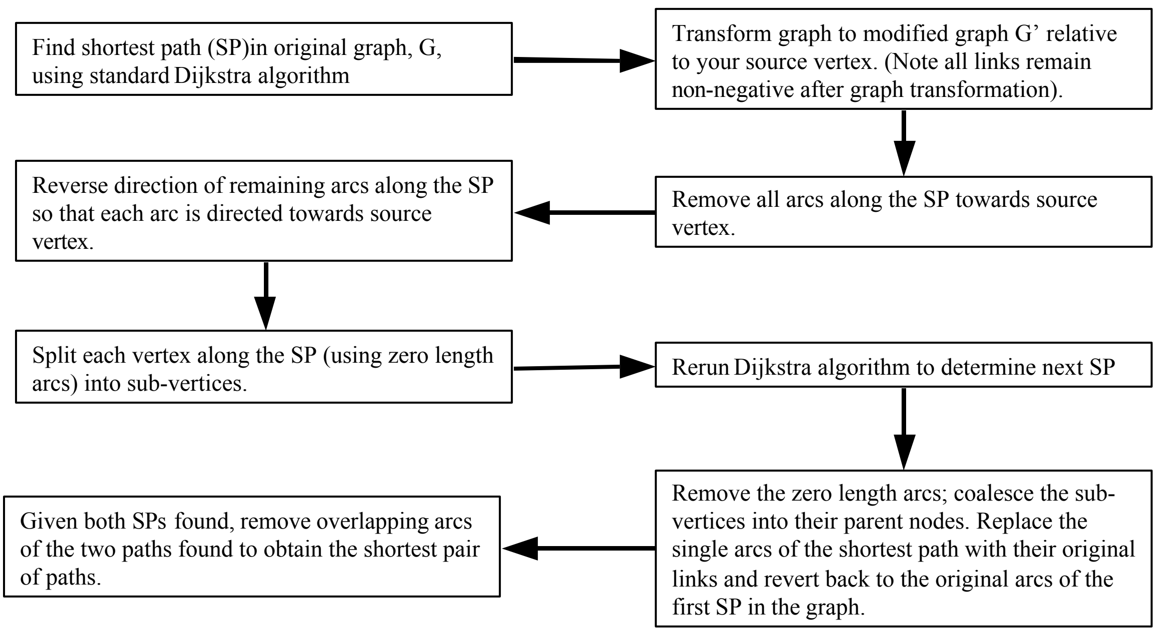

Figure 2.

The shortest-cycle algorithm flow diagram.

5. Operation and Testing.

The shortest-cycle between the source and destination nodes in the network is established using the Dijkstra shortest path algorithm [3] using the network topology implied by the link-state-data-base (LSDB), generate within the open-shortest-path-first (OSPF) protocol, refer to figure 2 for details.

The multi-protocol-label-switching (MPLS) label switched path (LSP) is then configured in the control plane using explicit routing to define the working arc. This configuration is then passed to the photonic switches to open the photonic path.

A fault is then triggered in the working arc of the control plane connection to simulate a network fault.

This fault is detected at the control layer and the protection arc LSP is explicitly routed and passed to the photonic switches to restore the network traffic.

The control is configured such that when the fault is repaired then the traffic does not automatically revert to the original working arc, but awaits management intervention. This is to avoid "route flap" occurring in the presence of an intermediate fault.

6. Conclusions.

We have demonstrated the use of a shortest-cycle algorithm in conjunction with OSPF protocol and MPLS to configure working and protection arcs within the control layer of a photonic mesh network.

The established LSP's for the working and protection arcs, have been mapped to the configuration of the photonic switch layer during a simulated network fault.

Photonic restoration through the protection LSP on failure of the working arc has been demonstrated.

This demonstration describes the first steps in realising photonic mesh network control enabling reconfigurable mesh connectivity and the value it can bring to future photonic networks.

Acknowledgments.

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References.

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