Resilient Metropolitan Area Networks
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Technologies for wide area network (WAN) and metropolitan area network (MAN) connectivity were traditionally based on technologies such as Frame Relay, ISDN, T1/T3, or ATM and have moved more towards Multiprotocol Label Switching (MPLS) in recent years. Ethernet-based technologies are currently emerging as a strong contender for MAN and WAN connectivity, thanks to inexpensive equipment, vast knowledge-base, and a host of supporting standards.

Carrier Ethernet standards such as IEEE 802.1ad Provider Bridges (Q-in-Q) and IEEE 802.1ah Provider Backbone Bridges (MAC-in-MAC) improved the network scalability required by carriers and service providers. Other standards have increased Ethernet capacity to 10Gbps and more, beyond many other network technologies. For availability, Ethernet remains, fundamentally, a layer-2 technology that relies on multiple links among network nodes to enhance reliability and on a spanning tree protocol (STP) to provide loop-free and self-healing topology.

As a result of these advances, Ethernet technology can be used as a LAN technology providing connectivity among computing devices in a contained environment, as an access technology connecting a customer’s premises to a service provider’s network, or as a backbone infrastructure that spans a metropolitan area, a geographical region, or even a country. As Ethernet reach may extend to tens of kilometres, long haul fibre links are used for connectivity beyond the 100-meter limit of copper wires.

Fibre Rings

Fibre infrastructure is usually expensive to construct or lease, making a ring topology that encloses all network nodes a desirable alternative to topologies that employ full or partial mesh. The ring topology delivers a significant improvement in reliability at the cost of one additional link over the minimum number of links required to connect all nodes. However, as the ring size becomes larger, the benefit of the topology diminishes. Therefore, the topology may be broken into smaller, overlapping rings to maximize the reliability of the topology. Small rings also help keep the capacity and latency within desired limits as well as maintain short failover times.

The overlapping ring topology has many applications. For instance, the topology may be a backbone of a multi-campus LAN for an educational institution or a regional store chain. Another example is to provide reliable connectivity between dispersed security cameras and a central command centre within the perimeters of a large campus, an airport, or a seaport. Similarly, the topology can provide connectivity between traffic monitoring stations and central control site within a city.

Network availability provided by various ring topologies is demonstrated using a simple model where the network of N nodes is assumed to be available only if any node is reachable from all other nodes in the network. In the topologies shown in Figure 1, the network is fully available only when all links are available regardless of the number of branches or the depth of the branch. On the other hand, a ring topology tolerates any single-link failure, adding substantial improvement to the availability of the network. A dual-ring topology can improve the availability further because
the network can tolerate two or more simultaneous link failures if the occur in different rings. Figure 2 shows the three types of topology and the corresponding availability given the same number of nodes and link availability\(^1\). The figure shows that there is significant improvement in availability provided by the ring topologies over a tree topology of the same size. In fact, the reliability of small rings can exceed the reliability of the individual links.

Employing rings of large number of nodes pose some practical problems, such as increased network delays, which will diminish the benefits gained in reliability. Therefore, it is important that the size of the ring is kept relatively small for the topology to be effective.

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\(^1\) Individual link reliability is 90% in this particular example.
IAI Services

With the above lessons in mind, Internetworking Atlantic Inc. (IAI) has built its fibre infrastructure in several cities in the Maritime Provinces in form of rings. This infrastructure allows IAI to offer its customers Ethernet-based connectivity that takes full advantage of this technology over reliable fibre infrastructure.

IAI’s fibre infrastructure in Halifax-Dartmouth metro area is an example of an overlapping ring topology that was built with reliability in mind. Figure 3 shows the main fibre rings that cover most of the Halifax peninsula and key commercial and industrial districts in Halifax and Dartmouth. IAI fibre also spans both Halifax Harbour bridges, making IAI the only carrier that can offer reliable connectivity across the harbour over shorter distances. Unlike centralized, tree-like topologies adopted by many carriers, IAI’s network topology allows it to offer services to customers in a distributed fashion that maximizes the benefits to the customer. As the network expands and customer concentration increases, more rings are built and large rings are split into smaller ones to maintain the level of service availability that IAI customers come to expect.

Two of IAI services that take direct advantage of this topology are Dark Fibre and Metro Ethernet services. The Dark Fibre service offers dedicated and transparent fibre connections between two or more customer sites that allow the customer to utilize any technology and bandwidth without restrictions from IAI. With multiple rings covering the area, IAI can offer its customers many diverse routes between their sites to achieve the desired levels connectivity and availability. In fact, some of IAI customers use this service to connect tens of sites across both sides of the harbor using several overlapping fibre rings.

Figure 3
As Ethernet is becoming a dominant MAN/WAN technology, IAI has developed its Metro Ethernet service over its extensive network infrastructure. This service is delivered from IAI’s many points-of-presence (POP) in the metro area to the customer’s sites using the most direct link available. As with the Dark Fibre service, IAI infrastructure provides the advantage that customers’ data traffic traverses the shortest possible route among their sites without the need for centralized infrastructure. This not only eliminates single points of failure but also reduces delays and congestions. Users of this service can utilize the features of Metro Ethernet technology to build their topology transparently over IAI infrastructure with no interference from other customers or involvement with IAI staff beyond the initial service setup.

**Closing Remarks**

As the ubiquitous Ethernet Technology widens its applications into the area of MAN and WAN, organizations now have the option of utilizing this technology to obtain connectivity that a short while ago was available only via more expensive technologies that require high capital investment and specialized skills set.

For IAI customer organizations, building a network core topology that connects multiple sites and extends geographically anywhere from hundreds of meters to tens of kilometers is possible anywhere there is an IAI fibre in the Maritimes. The customers can build the topology themselves using the Dark Fibre service that IAI offers over its multi-ring fibre infrastructure and standard Ethernet components. Alternatively, a customer may choose IAI Metro Ethernet service that provides cost effective, high bandwidth and reliable point-to-point or multi-site connectivity. Both services, and others, are backed by IAI’s Service Level Agreement (SLA) that guarantees the high availability of service.