MPLS FOR MISSION-CRITICAL MICROWAVE NETWORKS

BUILDING A HIGHLY RESILIENT MICROWAVE NETWORK WITH MULTI-RING TOPOLOGY

TECHNICAL WHITE PAPER

High resiliency and service availability are key design considerations when building mission-critical microwave networks. The traditional architecture of ring-and-spoke topology can provide strong protection against failure in the ring sites but leaves the spokes in access sites vulnerable to upstream failure because there is no path diversity protection. This white paper discusses how deploying a multi-ring topology in access sites can provide the protection required and explains why only Layer 3 microwave technology can be used to leverage the full path diversity.

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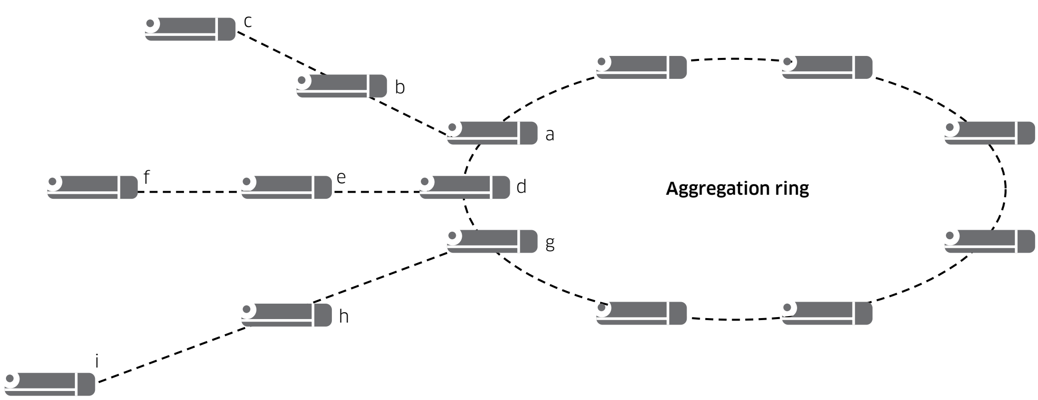
INTRODUCTION

Deployment of microwave links in mission-critical networks will continue, particularly in scenarios where wireline alternatives such as fiber link are not feasible or would be too costly to deploy. Microwave is also an attractive technology to provide a backup path for a fiber link in some cases, particularly in the network core.

As shown in Figure 1, a typical microwave network topology is based on an aggregation ring with spokes to the most distant sites.

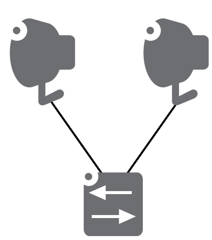
Figure 1. A typical ring-and-spoke microwave topology



As shown in Figure 2, a typical microwave platform typically consists of

- An indoor unit (IDU), which also functions as an Ethernet switch supporting advanced Ethernet features, including ITU-T G.8032[1] Ethernet ring protection switching and different variants of Spanning Tree Protocol (STP)
- One or more microwave radios

Figure 2. A typical Layer 2 microwave platform



SHORTCOMINGS OF RING-AND-SPOKE TOPOLOGY

In a typical ring-and-spoke architecture, aggregation ring nodes have high resiliency because a SONET/SDH-like ring protection mechanism has been standardized and is available in carrier-grade data communications through Layer 3 IP/MPLS fast re-route Label Switched Path (LSP) protection [2] or Layer 2 Ethernet ITU-T G.8032 Ethernet ring protection.

1 ITU-T G.8032, *Ethernet Ring Protection Switching, February 2012* and Amendment July 2013. http://www.itu.int/rec/T-REC-G.8032/en

However, the spoke sites in Figure 1 (b, c, e, f, h and i) are vulnerable to upstream spoke site failures. For example, service availability at Node c is subject to path access to Node b and Node a. If any failure occurs along the path c-b-a, service at Node c would be down due to lack of path diversity. The worst case is when Node a fails: service at Node b and Node c also fail.

For commercial carriers, non-self-recoverable failures might be acceptable at the remote spoke sites because service impact at far-flung sites might be minimal. However, in mission-critical sectors such as public safety or utilities, it is often equally important, and also mandated by government regulations, to extend a similar level of network protection to spoke sites.

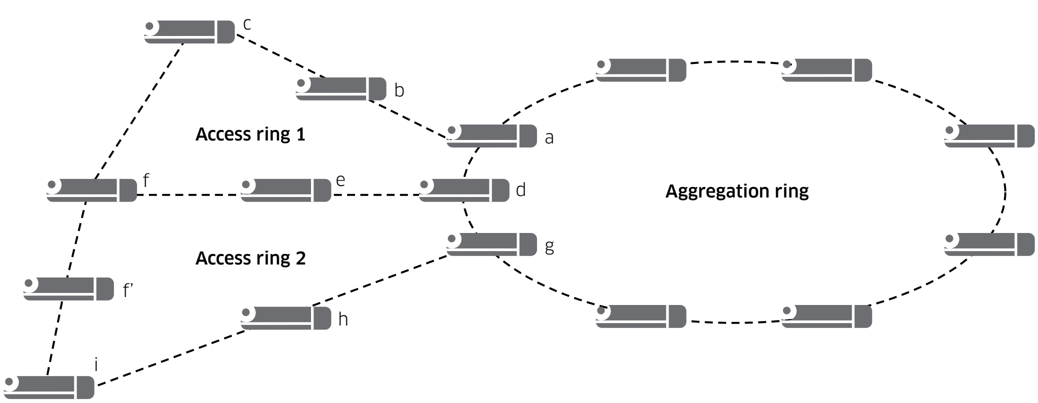
How can service availability be improved for spoke sites?

MIGRATING FROM RING-AND-SPOKE TO MULTI-RING TOPOLOGY

Service availability for spoke sites can be improved by using a multi-ring topology, , in which subtending spoke end sites (c, f and i in Figure 3) are interconnected to form two access rings (Access Ring 1 and Access Ring 2), which are joined together with an aggregation ring.

If there is a large distance between subtending spoke end sites (f and i in Figure 3), an intermediate relay site might need to be commissioned between them.

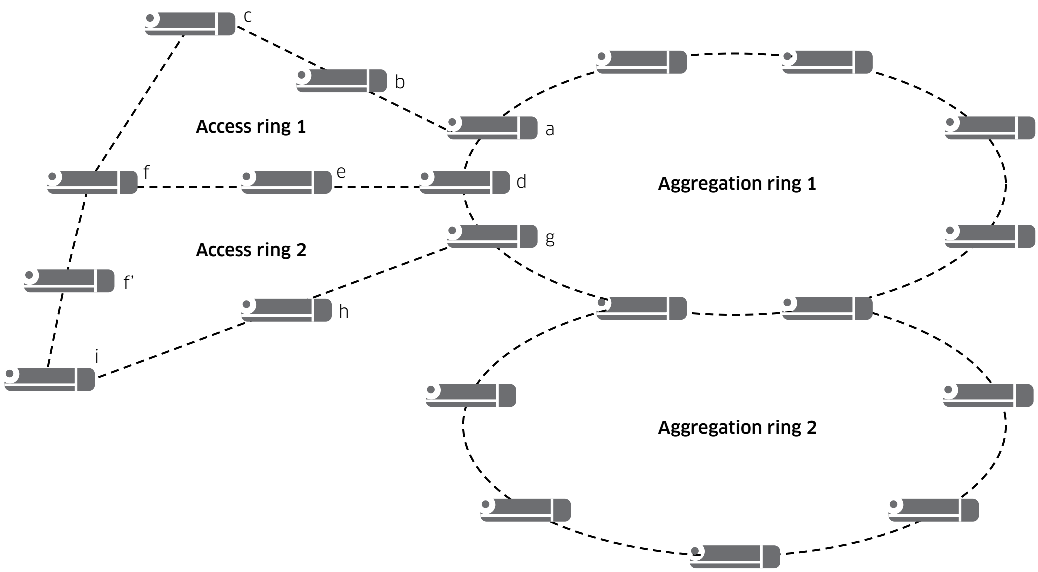
Figure 3. A multi-ring topology



Deploying a multi-ring topology provides multi-path diversity and improves the availability for all spoke sites. For example, Node b and Node c now have alternate paths to the aggregation ring through f-e-d. Even if a double fault occurs (for example, both Node a and Node e fail), a third path is still available for Node b and Node c through f-i-h-g. This level of protection is vital to ensure that critical operations continue to serve the general public.

This same multi-path diversity protection can also be applied to an aggregation ring by co-joining aggregation rings as shown in Figure 4.

Figure 4. Multi-aggregation ring providing multi-path diversity protection



MULTI-RING DEPLOYMENT WITH A LAYER 2 MICROWAVE PLATFORM

There are two major Layer 2 options to implement a multi-ring network:

- Spanning Tree Protocol according to IEEE Recommendation 802.ID
- Ethernet Ring Protection Switching (ERPS) according to ITU-T Recommendation G.8032

Option 1: STP

STP was originally standardized in IEEE 802.1D as a loop prevention and network recovery mechanism [1]. Because it was designed mainly for enterprise applications, recovery speed was not optimized and could range from seconds to tens of seconds, depending on network size and topology.

To improve recovery performance, new variants such as Rapid Spanning Tree Protocol (RSTP)[2] were standardized that improve performance to the order of seconds depending on network topology. However, RSTP still falls short of traditional SONET/SDH-based network recovery speed, which is the benchmark for mission-critical network technology considerations and is still network size- and topology-dependent. Therefore, STP and RSTP are not attractive technical options.

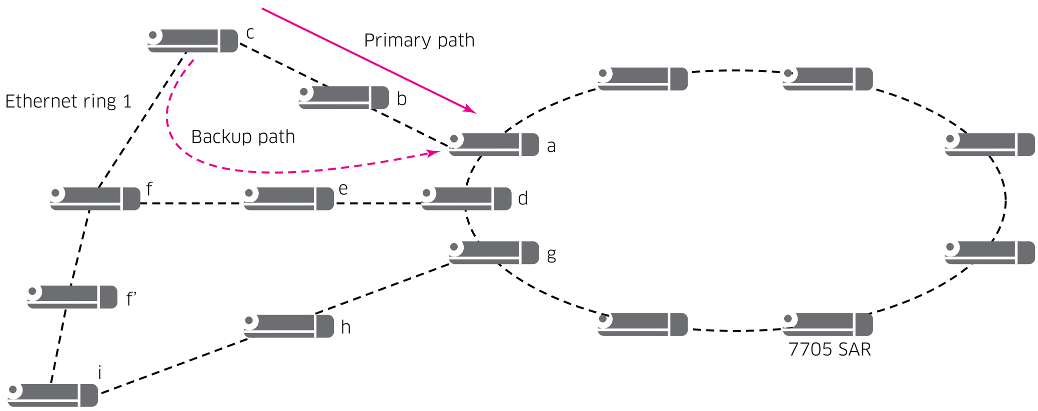
Option 2: ERPS

In an effort to make Ethernet networks as resilient as SONET/SDH-networks, particularly in a ring topology, the ITU-T developed ERPS Recommendation G.8032 to allow an Ethernet ring to recover in 50 ms.

2 RSTP was first standardized in 802.1w and later incorporated into a newer edition of 802.1D http://www.ieee802.org/1/pages/802.1D-2003.html

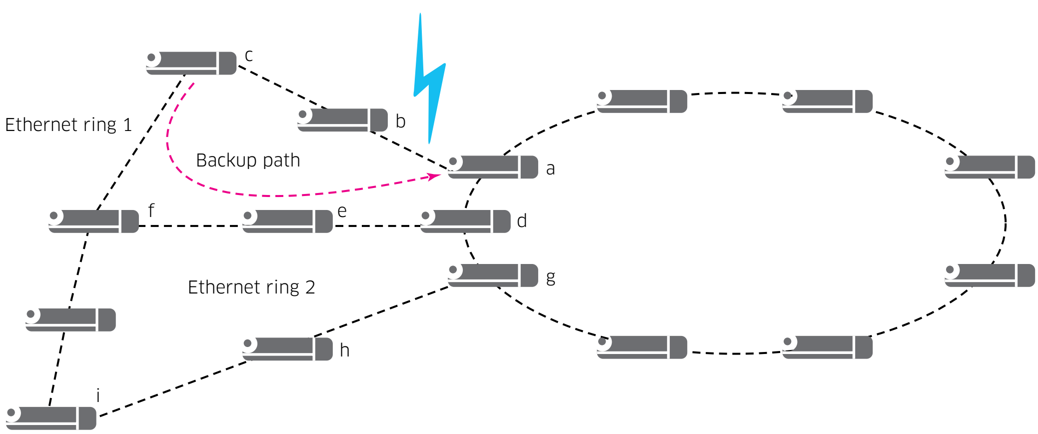
In general, ERPS works well at providing protection from a single failure in a ring. As shown in Figure 5, Node c normally uses path c-b-a to reach the aggregation ring.

Figure 5. Multi-ring deployment with normal traffic flow scenario



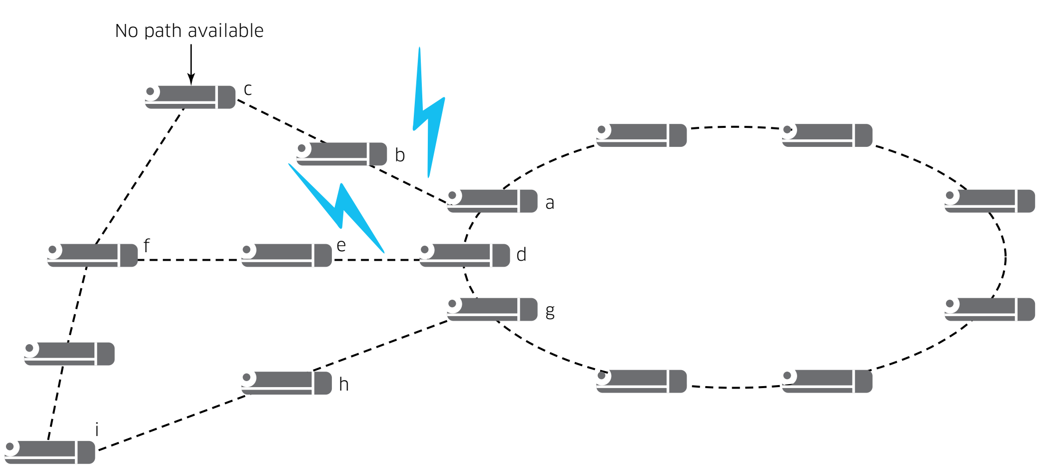
If c-b fails, Ethernet ring protection re-directs traffic to path c-f-e-d-a (see Figure 6), which becomes the active path.

Figure 6. Traffic flows along backup path



However, if another failure occurs along the alternate path f-e-d (see Figure 7), the Ethernet ring will no longer be able to recover because G.8032 only works with a single ring.

Figure 7. No Ethernet communication despite available communication path



To overcome this shortcoming, ITU-T standardized the second version of G.8032, commonly known as G.8032v2, adding the support of multi-ring protection. However, this capability is not commonly available in the Layer 2 microwave platforms described earlier in this paper.

Therefore, when high availability is required and multi-path diversity is available, a Layer 2 Ethernet-based microwave platform is not a viable solution because it cannot make use of the diversity to protect traffic.

MULTI-RING DEPLOYMENT WITH A LAYER MICROWAVE PLATFORM

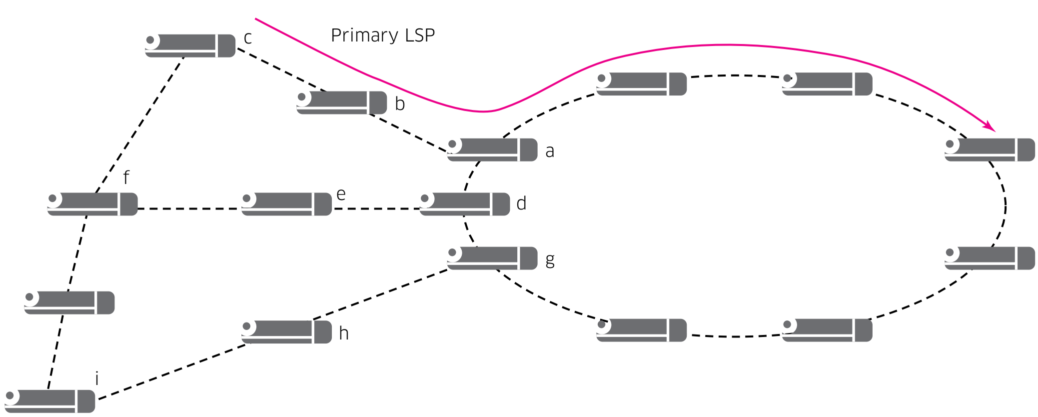
As shown in Figure 8, a Layer 3 microwave platform has:

- An IDU that is a full-fledged IP/MPLS router
- One or more microwave radios
- Versatile support of optical fiber interface for Gigabit Ethernet (GE) and 10 GE

Layer 3 IP/MPLS protection excels in a single-ring scenario, a multi-ring scenario and with partial/full mesh topology due to the inherent MPLS intelligence with full routing information of the network.

In Figure 8, the primary LSP is c-b-a.

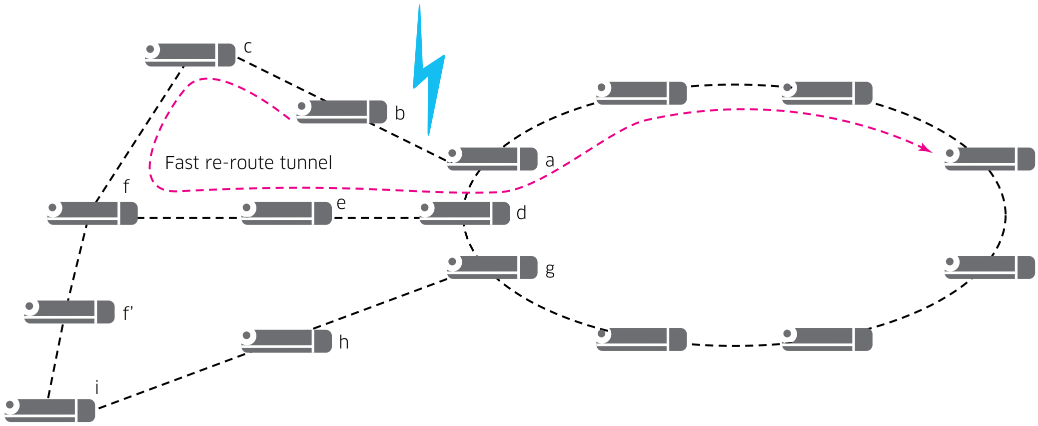
Figure 8. Traffic flows along primary LSP



If a fault occurs at path b-a, the MPLS router at Node b shunts all traffic to the pre-established Fast Reroute (FRR) tunnel b-c-f-e-d-a) (see Figure 9) to keep the applications from being interrupted. In the meantime, Node b and Node c could either trying to re-establish the primary LSP through another path or just switch traffic to a secondary LSP, depending on their LSP recovery option chosen. However, it is important to emphasize that the applications are always protected by FRR.

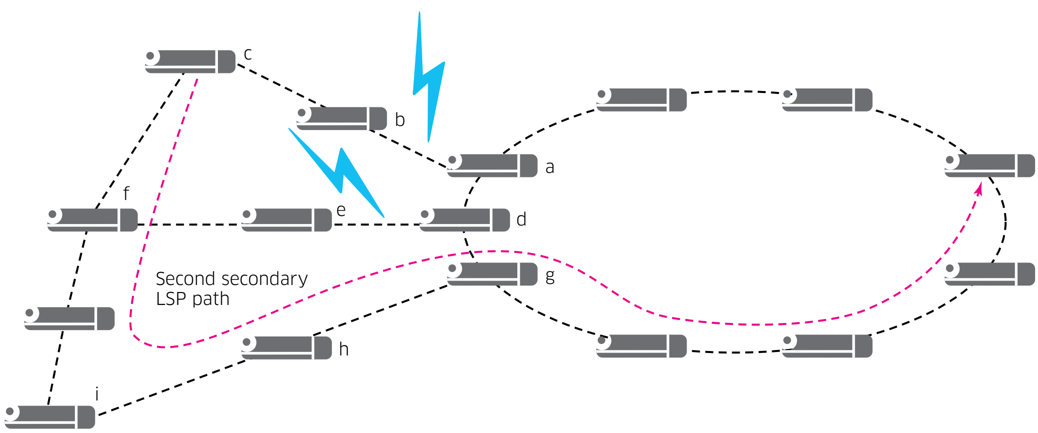
3 The FRR tunnel is typically automatically established by the network nodes. The path of the FRR tunnel is calculated based on traffic engineering database information provided by the routing protocol.

Figure 9. MPLS recovers traffic by re-directing data to the first secondary path



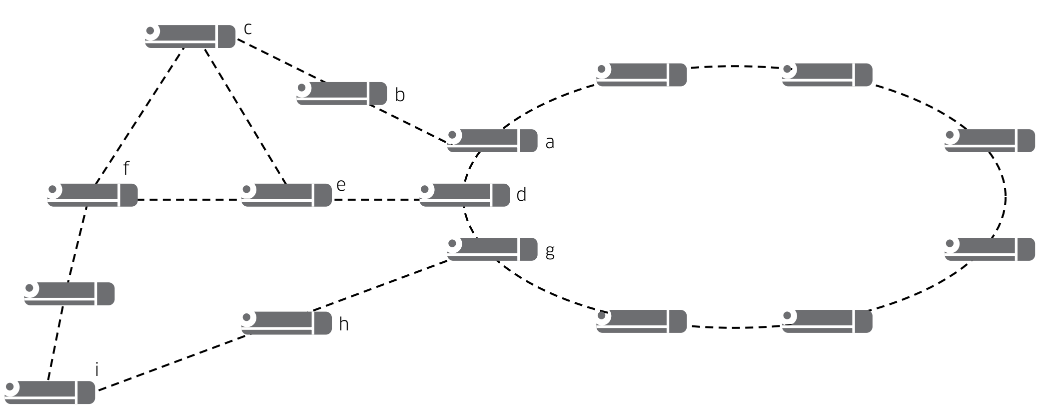
If another fault occurs along path e-d, as shown in Figure 10, another secondary path (c-f-i-h-g) is also available.

Figure 10. MPLS recovers traffic in a double-fault situation



In the future, if the network operator wants to add even more network resiliency (for example, further protection for Node c), it can add a link between Node c and Node e, as shown in Figure 11; this changes the topology to a partially-meshed one that can be handled by Layer 3 IP/MPLS easily.

Figure 11. Expanding a multi-ring topology to a partially-meshed topology



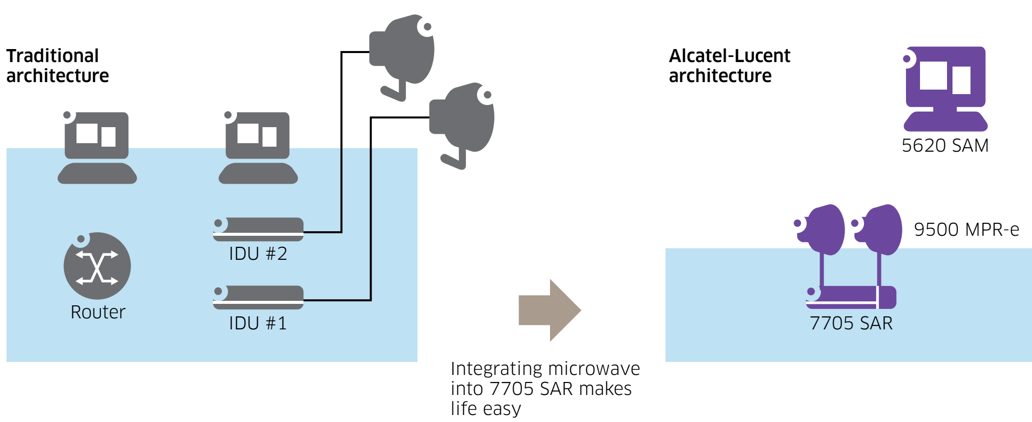
Layer 3 IP/MPLS can take advantage of any path diversity available without any limitations and is also ready for any future topology change to improve network resiliency. These capabilities are the result of the full network topology knowledge possessed by MPLS routers through IP routing.

THE ALCATEL-LUCENT LAYER 3 MICROWAVE SOLUTION

In a traditional architecture, IP/MPLS is overlaid on the microwave transmission as two types of platform, one for the higher IP/MPLS layer and the other for the microwave transmission layer (see Figure 12). This requires the network to be built on two independent layers and managed by two network management platforms, increasing the complexity for network operators.

The innovative Alcatel-Lucent Layer 3 microwave solution (see Figure 12) enables seamless deployment of IP/MPLS over microwave networks by integrating the Alcatel-Lucent 7705 Service Aggregation Router (SAR) and the Alcatel-Lucent 9500 Microwave Packet Radio (MPR-e). One 7705 SAR incorporates the functions of the IDU the in a traditional architecture. One network management platform, the Alcatel-Lucent Service Aware Manager (SAM) replaces the two network management platforms in a traditional architecture.

Figure 12. Integrated Alcatel-Lucent Layer 3 microwave transport



The key advantages of the Alcatel-Lucent solution are:

- Elimination of dual network managers because the 7705 SAR and 9500 MPR-e are functioning as a single network element managed by one network manager, the 5620 Service Aware Manager
- Convergence of multiple IDUs and an IP/MPLS router on one platform
- One management IP address, one network element software image and one maintenance upgrade procedure
- Rapid direct detection of microwave link failures, including high bit error rate
- 1 + 1 hot standby support with hitless radio protection switching (RPS)
- In-chassis direct power to the 9500 MPR-e
- Less equipment and rack space, easier management lower CAPEX and OPEX

CONCLUSION

Because network outages in mission-critical networks can have immense economic, security and even legal consequences, service availability becomes ever more important in network topology design. Traditional ring-and-spoke topology, with its limited path diversity, does not satisfy service availability requirements in all cases, and many operators of mission-critical networks have a strong interest in moving toward a more resilient multi-ring topology. However, Layer 2-based microwave platforms available in the general market do not yet have the capability to support a multi-ring topology.

The Alcatel-Lucent Layer 3 microwave solution combines the full-fledged IP/MPLS capabilities of the 7705 SAR with the leading performance of the 9500 MRR-e and the network management capabilities of the 5620 SAM. This solution empowers operators of mission-critical networks with virtually unlimited options in network topology design as networks continue to grow and expand.

ACRONYMS

ERPS	Ethernet Ring Protection Switching
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IP	Internet Protocol
ITU	International Telecommunication Union
LSP	Label Switched Path
MPR	Microwave Packet Radio
MPLS	Multiprotocol Label Switching
RPS	Radio Protection Switching
SDH	Synchronous Digital Hierarchy
SONET	Synchronous Optical Network
STP	Spanning Tree Protocol
RSTP	Rapid Spanning Tree Protocol

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   https://standards.ieee.org/findstds/standard/802.1D-1990.html
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