Microwave transport and IP networking coming together in a multivendor environment

IP networking equipment is becoming present in mobile networks in several scenarios. When this is deployed in the backhaul next to microwave transport, the coexistence and interworking is fundamental to the network performance.
Cisco and SIAE MICROELETTRONICA developed the Microwave Adaptive Bandwidth (MAB) feature to provide reliable QoS management and optimized performance for both ring and non-ring based topologies, even under worst-case radio propagation conditions. Although MAB is generic in nature, this paper describes MAB with specific application to Mobile Backhaul network architectures.

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Introduction

Traditional time-division multiplexing (TDM) enabled mobile operators to deploy stable networks with well-defined deterministic traffic flows and fixed bandwidth circuits. Although perfect for voice traffic, this model cannot support the recent explosion in data traffic. Packet networks, the only solution to this problem, are characterized by quality of service (QoS)-based traffic flows and variable bandwidth circuits. This shift requires a Unified Remote Access Network (RAN) environment and new features to integrate different network elements.

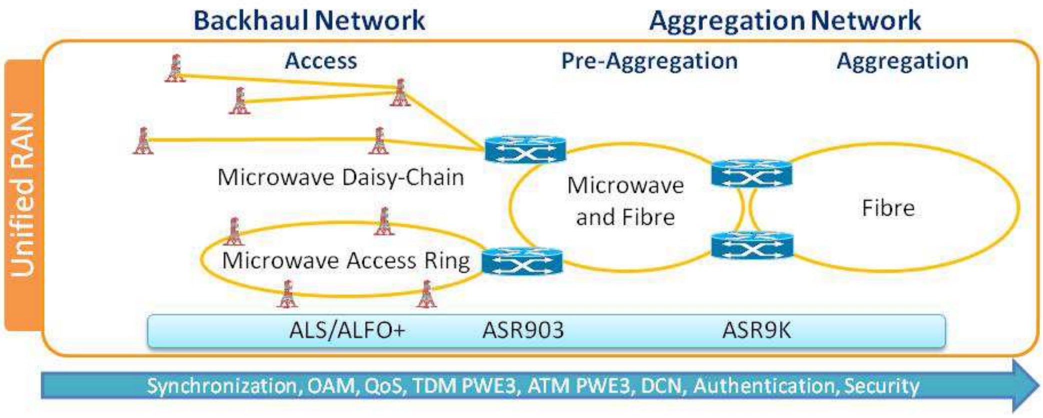

Figure 1: Unified Ran

With the advent of small cells and Cloud Radio Access Network, Cloud RAN (CRAN), models in mobile networks, many operators want to reuse their installed microwave infrastructure to address new challenges and opportunities. In many mobile networks, microwave equipment represents a very significant component of the backhaul, and at times represents a large majority of base station interconnections. Operators are looking for high capacity solutions to address the increased capacity requirements of data traffic from small cell Long Term Evolution (LTE) deployments and fiber extension connectivity.

The migration of data networks, coupled with data growth caused by densely deployed base stations with small cell deployments, drives the use of ring architectures to provide better network protection. Until now, microwave ring architectures were implemented with fixed microwave modulation schemes because ring protocols are not designed to react to dynamic bandwidth changes. In traditional fixed modulation schemes, any degradation in wave propagation (for example, due to adverse weather conditions such as heavy fog or rain) led to a complete loss of signal and a disruption of traffic. Using fixed modulation, the microwave radio link was either “available” (on) or “unavailable” (off).

More advanced microwave radios can use adaptive modulation schemes. The radio changes its modulation to a more robust scheme when the microwave link degrades due to adverse weather conditions, (this also lowers bandwidth). The radio continues to transmit, maintaining connectivity, and forwards traffic in proportion to the adopted modulation scheme. As a result, the radio link can be in several capacity or bandwidth states, not just on or off.

In an Ethernet ring, capacity degradation can affect one part of the ring, while the rest remains unaffected. If congestion occurs, the microwave radio frequently utilizes QoS to prioritize the Ethernet traffic with higher importance, ensuring that those packets get a fixed amount of the available bandwidth.

Traffic shaping in the packet transport network becomes another consideration. Traffic shaping is required to optimize bandwidth and avoid traffic overflow due to bursty LTE traffic. Unlike ring topologies, other topologies (chain, star, tree, and so on) do not have alternate paths to forward traffic because of adverse conditions in one part of the network. Traffic shaping and QoS are widely used to manage the traffic flows. In these cases, changes in microwave modulation must be reported to upstream Ethernet switches or routers, which in turn must adapt traffic shaping and forwarding rules to the new network reality.

Cisco and SIAE MICROELETTRONICA have developed a generalized Microwave Adaptive Bandwidth (MAB) feature to provide reliable QoS management and optimized performance even under worst-case radio propagation conditions for both ring and non-ring based topologies. This solution is generic, although the following description highlights its applicability to mobile backhaul networks.

Solution Overview

The joint solution addresses the consequences of microwave variable bandwidth techniques in relation to traffic shaping and QOS configuration in networking equipment and dynamic ring topology reconfiguration. This enables operators to deploy ring or non-ring topology backhaul networks in the RAN, while cooperating with adaptive modulation radios, to exploit the maximum available air bandwidth under any atmospheric conditions.

MAB is based on IEEE 802.1ag Connectivity Fault Management (CFM) and ITU-T Y.1731 protocols, and uses Cisco IOS Embedded Event Manager (EEM), a powerful and flexible subsystem that provides real-time network event detection to trigger traffic changes. A CFM Vendor Specific Message (VSM) has been defined to communicate between SIAE MICROELETTRONICA microwave radios and Cisco switches and routers.

When the microwave radio detects Signal Degradation (SD), the radio triggers a modulation change, notifies the adjacent Cisco equipment using specially designed VSM messages, and periodically sends updates until the standard maximum bandwidth is restored. The switch receives these VSM messages from the microwave radio port and notifies the EEM subsystem of a SD event.

The EEM subsystem checks new available bandwidth values from the SD event information against configured thresholds. If the new value crosses a defined threshold, traffic forwarding is managed according to the topology (ring) or hierarchical QoS (HQoS) shaping application. If a complete link failure causes a loss of microwave signal, a Signal Failure (SF) event is signaled. SF events take priority over SD events.

Network topology, e.g. ring can be implemented either at layer 2 or at layer 3.

Ring Topology Application

The MAB feature developed by Cisco and SIAE MICROELETTRONICA enables operators to benefit from adaptive modulation, even in a ring topology. The feature extends the functionality of the G.8032 Ethernet Ring Protection Switching (ERPS) mechanism and Ethernet CFM to achieve this.

Microwave links are often deployed in redundant ring topologies based on ERPS techniques based on ITU-T G.8032. Typically, adaptive modulation is not activated in these deployments because capacity variation within a ring was not foreseen by protocols such as ERPS. Nevertheless, in this case, the ability to use adaptive modulation would bring tremendous advantages; operators could couple protection with the ability to exploit the maximum available bandwidth.

For microwave links with adaptive modulation, the normal Operation, Administration, and Maintenance (OAM) protocols used by ring protection protocols cannot make the best use of the available bandwidth because:

- If the OAM protocol used for failure detection is tagged as high-priority traffic, frames bypass degraded (congested) microwave links and no protection switching is triggered.
- If the OAM protocol used for failure detection is tagged as low-priority traffic, then momentary congestion over the native Ethernet links could lead to loss of continuity and spurious protection switching.

Although the network topology must be provisioned with enough redundant bandwidth to handle a complete failure, in certain situations in which the service Committed

Information Rate (CIR) is very low, forwarding as much traffic above the CIR as possible still represents an important value. Treating bandwidth degradation as a complete failure is not desirable.

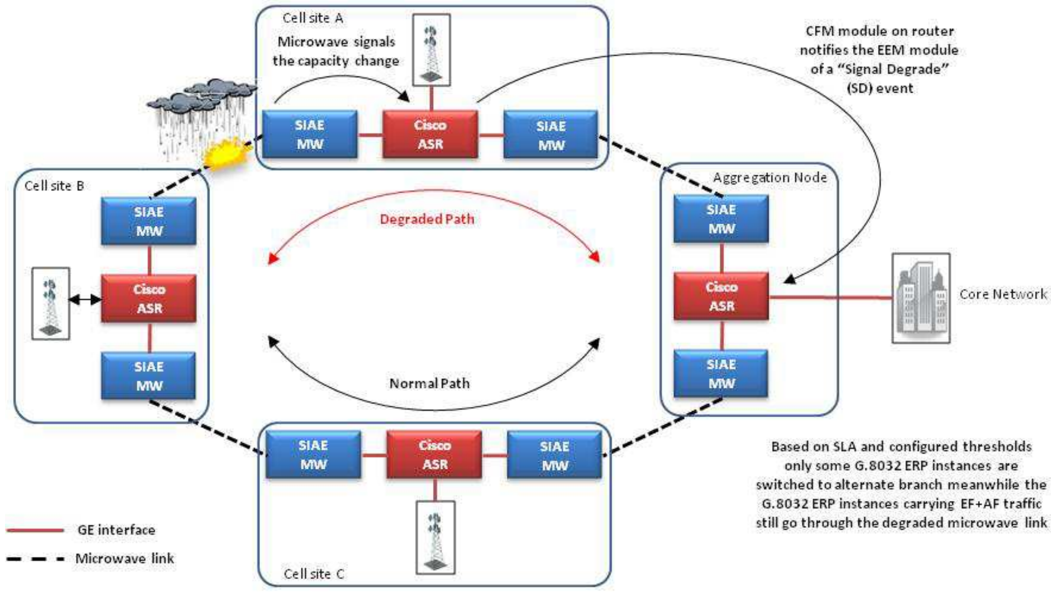

Figure 2: Ring Topology

As bandwidth capacity changes because of switching to a different modulation scheme, MAB triggers a CFM notification toward the Cisco Ethernet switches within the ring. This enables the switches to optimize the traffic-forwarding rules of the affected traffic. Instead of reconfiguring the ring to switch all traffic to an alternate path, MAB selects a more efficient ring configuration that maximizes traffic throughput. A complete rerouting of traffic occurs only when the switches detect a complete loss of continuity, for example, through the complete absence of Connectivity Connection Messages (CCM) from CFM.

MAB enables G.8032 ERPS mechanisms to be used as a control mechanism in response to bandwidth degradation (such as an SD indicator) on microwave links. Ethernet CFM interacts with the microwave system to continuously monitor the quality and bandwidth of the microwave link. When microwave link degradation is detected, CFM notifies the EEM facility on the Cisco switch to invoke G.8032 ERPS mechanisms. Based on service level agreement (SLA) information and configured thresholds, some ERPS instances (for example, when based on VLAN) can be switched to an alternate path, while other ring instances carrying high priority traffic may still be switched through the degraded microwave link.

HQoS Traffic Shaping Application

The Adaptive Modulation of SIAE MICROELETTRONICA microwave radios can be used to guarantee that high priority Ethernet traffic continues to pass through a degraded link, even under the worst weather conditions. In daisy-chain or star topologies of SIAE MICROELETTRONICA microwave links and Cisco switches, MAB dynamically controls HQoS class-based traffic shaping.

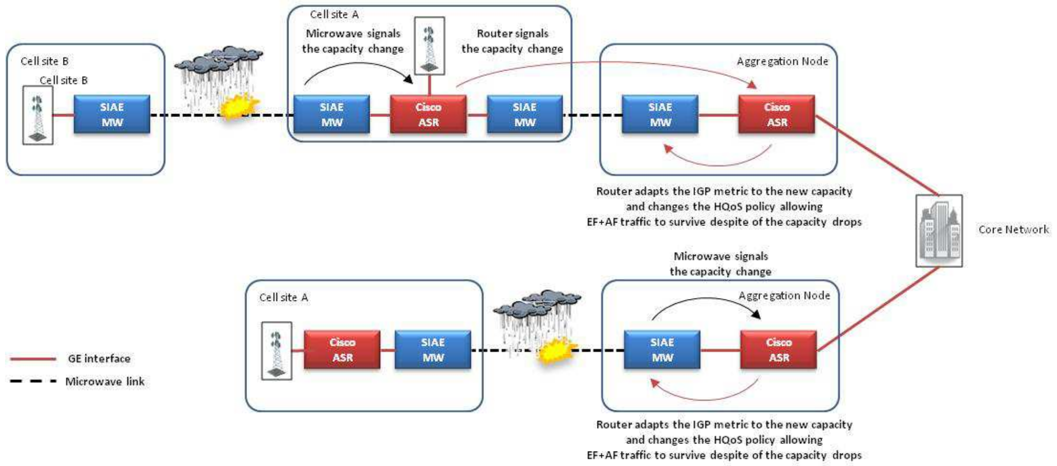

Figure 3: HQoS Traffic Shaping

As in the ring topology, Ethernet CFM continuously monitors the quality and bandwidth of the microwave link. When bandwidth capacity changes due to changes in the modulation scheme, Ethernet OAM triggers a CFM notification toward the Cisco switches so that they can optimize traffic-forwarding rules for the affected traffic flow. However, in this case, instead of changing the ERPS ring configuration, Ethernet CFM modifies HQoS traffic shaping rules to dynamically maximize high value traffic throughput across the degraded link.

This mechanism is achieved by the following steps:

- The operator specifies a rate for traffic shaping on the Cisco router that avoids bottlenecks and packet loss on the SIAE MICROELETTRONICA microwave links during normal operation.
- Traffic shaping is configured in a hierarchical policy map structure (primary (parent) and secondary (child) policy maps) to ensure that a packet adheres to a stipulated contract according to available bandwidth.

- The Cisco switch or router is also configured with alternate traffic shaping rules that are appropriately tuned for circumstances in which microwave links run in a degraded or constrained state.

- The alternate traffic shaping rules are defined to maximize the value and utilization of newly determined available resources; this means that microwave equipment presented only with high value traffic, and with only the amount of traffic that be handled without dropping.

- As the bandwidth changes on the microwave links, the SIAE MICROELETTRONICA radio will use a CFM message to initiate an SD event in the EEM facility on the Cisco switch, which then reconfigures HQoS to switch to alternate traffic shaping rules.

Summary

Operators have invested a number of resources in building robust and high capability RAN backhaul networks based on microwave radio. Additionally, SIAE MICROELETTRONICA has substantially vested in designing and delivering sophisticated adaptive modulation techniques that maximize available bandwidth and functionality under adverse conditions. What has been missing, until now, is the ability to apply new intelligence in backhaul applications.

The MAB feature developed by Cisco and SIAE MICROELETTRONICA enables operators to use adaptive modulation to maximize the use of available resources so that subscribers experience improved service under challenging conditions. MAB enables high priority, high-value traffic to be forwarded under conditions that would normally lead to service outages and promotes much more intelligent use of available resources.

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