NEC’s Noble Multiband radio leveraging E-band high capacity and traditional microwave long reach.
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Market Drivers:
Increase in demand for capacity in backhaul is on the rise with 5G on the onset and its underlying technologies such as eMBB, mMTC requiring 10 fold the data rate currently available. Low latency in the order of micro seconds will have to be achieved for the proliferation of applications stemming from new technologies such as URLLC. At the forefront, wireless backhaul will dominate this stage with 80% of data backhaul projected to go over wireless.

Challenges:
Current spectrum allocation provides larger channel bandwidth the higher we move up the frequency ladder. As an example, a 6GHz is at 30MHz, 11GHz is at 40MHz, 80GHz is at 2000MHz. However, quality of transmission is greatly affected by the frequency band; the higher the frequency i.e. the shorter the wavelength, the shorter the range by which a signal can propagate. Thus, the more susceptible the signal will be to rain fade and space loss.

Modulation was introduced to increase spectral efficiency by virtue of increasing the number of bits per symbol, thus increasing throughput per hertz. Fixed modulation was traditionally used to carry TDM based SONET/SDH signals. And in the advent of packet based networks, adaptive modulation was introduced to handle the elasticity of services and the statistical nature of packet multiplexing. AMR in parallel with QoS played a pivotal role in addressing the service’s availability and performance objective within a given link. This is achieved by utilizing CoS levels assigned to packets belonging to an Ethernet service. This ensured that high priority packets stay in the network, thus, compromising lower priority packets as they traversed the network.

AMR addressed the predicament but fell short of dynamically adjusting traffic forwarding rules when modulation adjusted downward to correct for a degraded path. The upstream device sending the packets was not made aware of the drop in throughput due to drop in modulation and as a result, packet drop occurred.

What is needed?:
- Better utilization of the spectrum. While the traditional licensed microwave is highly congested, the higher frequency bands such as E-band are still underutilized and untapped in certain geographic locations.
- Leverage the mmWave high data rate capacity and microwave long span reach by combining both bands in a dynamic fashion. This will contribute to a boost in capacity on a microwave link and extends span reach on a millimeter wave link without impacting availability and associated SLAs.
- A mechanism to dynamically adjust throughput without causing buffer overflow and consequent packet drop and increased latency.

Multiband Technology Enablers:
A noble approach that utilizes existing technologies used in NEC’s iPASOLINK radio to boost capacity and range without compromising availability.
**AMBR:**
As a mechanism to maintain carrier to noise C/N levels during adverse conditions, AMBR extends reliability by adjusting modulation and channel bandwidth according to signal quality.

**Hierarchical QoS:**
Hierarchical QoS provides needed granularity to provision dynamic bandwidth allocation to each service in order to enable differentiated Carrier Ethernet services. In this case, multiple QoS shaper profiles corresponding to each service’s capacity needs may be created.

**Bandwidth Notification & Service Switch:**
Bandwidth profiles are created on iPASOLINK corresponding to Ethernet flows. The granularity of which is distinctively identified from the top down by the In-port, VLAN ID, and CoS/ DSCP/ MPLS TC internal classification. Bandwidth Notification provides a standardized mechanism whereby upstream radio notifies the downstream of bandwidth changes as a result of signal fade and AMBR activity.
NEC’s noble Service Switch mechanism works by examining bandwidth reported by ETH-BN and compares it against established Ethernet flows’ threshold. If the ETH-BN notified bandwidth is lower than the established flow’s bandwidth threshold, it will trigger a reroute of the affected flow to the microwave link.

Service Switch works in orchestra with Bandwidth Notification on iPASOLINK radios to determine the optimal path and to ensure guaranteed service delivery.

Traffic routing based on Ethernet services with Bandwidth Notification

*SSW: Service Switch

NEC’s multiband solution compared to other multiband solutions:

Other multiband solutions utilize L1 Aggregation where by both mmWave and microwave bands may be bonded to create a wider pipe. This solution presents challenges wherein an E-band radio is needed for back to back connectivity at each relay site. While Layer 1 Bonding offers a simple method to achieve capacity boost, larger buffers are needed for packet fragmentation and subsequent overhead bytes for disassembly and reassembly resulting in increase in latency and reduction in throughput efficiency.
Applications:
Multiband Applications and use cases can be summarized in three categories:

Capacity boost on an existing Microwave Links:
In this scenario, an E-band radio can be added in parallel to an existing microwave link thus increasing capacity.

Traditional method is to add another channel using L1 link aggregation in 2+0 configuration to provide near double the capacity. This requires a service provider to coordinate and license an additional channel. Alternatively, a service provider can augment an E-band to the existing microwave link using multiband technology and achieve higher capacity increase at varying availability rates.

This results in a more cost efficient solution as compared to obtaining two microwave frequencies. The cost per Mb/s are significantly lower in E-band given the lower cost to license an E-band and the wider channel provided.

Increase range on an existing E-band link:
In this scenario, a microwave link can be added in parallel to an existing E-band link to improve availability without compromising link distance. As an example, a service that requires 99.999% can now be achieved using multiband by adding a microwave link which otherwise will not supported on a link that strictly uses E-band.
Greenfield:
Dual band antenna will facilitate the deployment of multiband radios thus minimizing tower real-estate and load bearing. Antenna manufacturers have collaborated with equipment vendors to produce such antennas.

Conclusion:
Multiband radio will enhance microwave backhaul performance by an order magnitude in orchestra with the network evolution to 5G and various bandwidth hungry applications. NEC is in the forefront of offering a noble multiband solution that is superior in innovation, performance and more importantly in leveraging existing, field proven NEC technologies.

Abbreviations:

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AMR</td>
<td>Adaptive Modulation Radio</td>
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<tr>
<td>AMBR</td>
<td>Adaptive Modulation and Bandwidth Radio</td>
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<tr>
<td>CFM</td>
<td>Connectivity Fault Management</td>
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<td>CoS</td>
<td>Class of Service</td>
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<tr>
<td>eMBB</td>
<td>enhanced Mobile Broadband</td>
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<tr>
<td>QoS</td>
<td>Quality of Service</td>
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<tr>
<td>mMTC</td>
<td>massive Machine Type Communications</td>
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<td>mmWave</td>
<td>Millimeter wave</td>
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<tr>
<td>Ethernet OAM</td>
<td>Ethernet Operation, Administration and Maintenance</td>
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<tr>
<td>URLLC</td>
<td>Ultra-Reliable Low Latency Communications</td>
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