Achieving End-to-End Intelligence in the Cable Access Network

Liliane Offredo-Zreik

The ever-growing demand for bandwidth, which only accelerated over the past few months, and the emerging importance of delivering mission-critical services in a residential environment is imposing increasingly stringent demands and requirements on cable operators and vendors. Although the trend toward more downstream bandwidth consumption has been well understood, the sudden growth of upstream bandwidth consumption, driven by work and school at home, home-based healthcare, and other applications, is a new development, but one that will persist as new applications and business models centered around delivering services in the home continue to grow and evolve. These notable developments are happening at a time when labor markets are constrained and when other restrictions are being imposed on service providers.

Evolving the Access Network to Meet Market Requirements

As they strive to meet the demand for more bandwidth, particularly in the upstream, and to realize the 10G vision, cable operators are pursuing a number of alternatives:

- **Node splits,** which have been the "go to" strategy for operators. However, they require more equipment in the headends and provide only modest augmentation in the upstream.
- **Distributed access architectures (DAAs),** enable operators to add capacity without adding equipment in headends and hubs and also pave the way for virtualization and for improved signal quality. There are two primary DAA alternatives:
  - **Remote PHY:** The PHY layer is moved to the access node in a Remote PHY device (RPD).
  - **Remote MACPHY:** Both the MAC and PHY layers, are moved to the node in a Remote MACPHY Device (RMD).
- **Mid-split** extends the amount of spectrum allocated to upstream to 5 MHz–85 MHz from an upper limit of 42 MHz in North America and 65 MHz in Europe, resulting in more upstream capacity.
- **High-split** is where the upstream spectrum is extended to 204 MHz for even more upstream capacity.

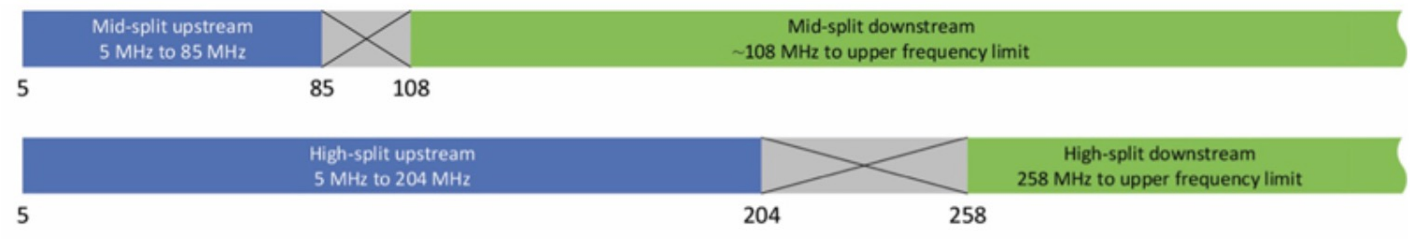

Figure 1. Typical Mid-Split and High-Split Bands

- **DOCSIS 4.0** enables operators to increase upstream capacity to 6 Gb/s and to deliver more symmetric bandwidth. There are two approaches to DOCSIS 4.0: Extended Spectrum DOCSIS, which requires increasing the spectrum to 1.8 GHz and possibly to 3.0 GHz in the future, and Full Duplex DOCSIS, which works within the 1.2 GHz spectrum using overlapping frequencies for upstream and downstream.

These approaches are not mutually exclusive, quite the contrary. For example, DAAs will be an essential part of the DOCSIS 4.0 migration.

Intelligence and Resilience in the Access Network

Cable operators have started introducing intelligence in many parts of the access network, including CMTS and cable modems, to improve performance and boost efficiency by proactively addressing impairments and mitigating faults. However, to fully realize the benefits of intelligence, it has to be extended to the remaining parts of the access network to achieve end-to-end intelligence.

Intelligent Amplifiers Deliver Signal Quality with Lower Operating Cost

Many operators, particularly in North America, are pursuing mid-split strategies in the short term, while some are exploring high-split and are beginning to assess DOCSIS 4.0 implementations in the lab. As part of these upgrade plans, operators are often replacing existing actives and passives (located between the node and the subscriber) with 1.8 GHz passives and 1.8 GHz capable actives. This is because older components are coming up short of meeting the stringent requirements of a plant that must deliver a high-quality service and because they do not support the spectrum extensions that they need today and in the near future.

[1] https://broadbandlibrary.com/understanding-band-splits-in-two-way-networks/

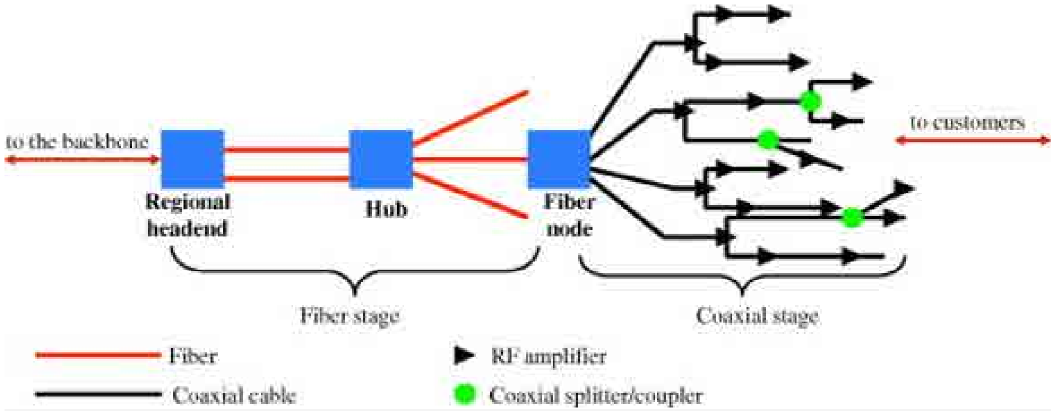

Figure 2. Cable Access Network (Source: ScienceDirect.com)

As plants are upgraded and extended to 1.2 GHz and eventually to 1.8 GHz and beyond, low dB margins in areas with environmental and operational variability could lead to signal degradation when traditional amplifiers are used. This is because ambient temperature variations cause changeable attenuations of coaxial cables, resulting in signal-level fluctuations. Such degradation leads to a poor customer experience and is particularly problematic when the cable infrastructure is enabling mission-critical applications such as telemedicine, home hospital, and others.

To mitigate this degradation, operators use tools such as forward and return sweep or complex signal level meters to ensure linear alignment of RF levels [2] or have regular preventive maintenance programs. However, these approaches are largely manual, making them operationally expensive and inefficient. With skilled labor in short supply, particularly labor with highly specialized analog expertise, this approach becomes more complex.

For better signal quality, RF amplifiers should have features such as Automatic Level and Slope Control (ALSC) and intelligent return path control based on forward path measurements, known as the Return Follows Forward principle or return ALSC. Embedding intelligence in the amplifier opens the way for automatic alignment, which can be done by pressing a button upon installation or when the diplexers are changed in the field. The ability to manage and monitor the amplifier remotely enables diagnostics, allowing technicians to locate ingress sources and isolate return path ingress sources so that they do not influence return path signals coming from other network segments. These enhancements lead to better network resilience and to improved service quality, while at the same time significantly reducing operating costs and complexity as they decrease the need for truck rolls.

[2] https://broadbandlibrary.com/intelligent-amplifiers-for-1-8-ghz-hfc-extended-spectrum-a-smart-idea/

DAAs Delivers Cost-Effective Capacity, Better Service Experience

DAAs will be an essential component of delivering on the cable 10G promise. The benefits of DAAs are many:

- Increase broadband capacity and overall network performance without adding equipment in overburdened hubs and headends.
- Bring the fiber closer to the customer, resulting in better signal quality and higher throughput.
- Digitize the fiber part of the HFC network.
- Enable better diagnostics and preventive maintenance.
- Pave the way for virtualization and its benefits, such as service velocity and better flexibility, because elements that cannot be virtualized (for example, the PHY) are moved out of the headend.
- Provide better spectral efficiency, more wavelengths per fiber.

As they deploy DAAs, operators are bringing intelligence to the node. Both RPDs and RMDs are intelligent devices that can be monitored and controlled remotely, yielding benefits in terms of cost savings and service quality improvements.

Key Consideration for Access Network Implementations

There has been significant focus—and for good reason—on how to evolve the network from the headend to the node. It is also important to consider upgrading the network between the node and the subscriber's premises. Key criteria:

- **Intelligence:** It is essential to build automated resilience in the amplifiers to mitigate signal degradation caused by ingress or ambient conditions.
- **Interoperability:** As DAAs mature, operators will become more comfortable with purchasing equipment from multiple vendors.
- **Compatibility with 1.8 GHz:** Although 1.8 GHz deployments are far from prevalent (1.2 GHz remains largely the upper limit for now), 1.8 GHz equipment will be introduced in the network soon (trials are happening in many labs). As operators upgrade their access network for mid-split (or high-split), they should replace existing amplifiers with ones that also support 1.8 GHz. Collaborating with a vendor that has experience with 1.8 GHz is essential.

The cable access network is fast evolving to meet the needs of a highly dynamic market. Introducing intelligent in every part of the network is a definitive must that is required to meet the market's demand imperatives for service quality and operational efficiency.

Liliane Offredo-Zreik is a Principal Analyst with ACG Research; her research and advisory efforts focus on the evolution of the broadband delivery infrastructure and on how broadband, and technology more broadly, are driving a profound change in healthcare and powering the fast evolution of digital health. She has extensive telecommunications and cable industry experience with a focus on market dynamics and product and go to market strategies. She brings to her research areas significant industry experience, having held leadership roles with many major service providers and industry vendors, and as a Wall Street industry analyst. Liliane has an MBA from Harvard Business School, a master's in electrical engineering from Cornell University, and a BSEE from Syracuse University.