



EXECUTIVE SUMMARY

The last few months have ushered a digital acceleration on an unprecedented scale and scope, and there is a prevailing sense that many of these new trends are sustainable over the long term. Service providers have added a significant amount of capacity to meet the sudden spikes in demand. However, the demands on their networks are only expected to increase: the need for capacity (upstream and downstream), low latency, service velocity, and elasticity. Unlike the short-term remediation to which operators resorted recently, meeting market requirements in 2021 and beyond will require more permanent, sustainable, and flexible solutions.

Operators must continue to add capacity in the downstream and upstream and refine their plans to deliver on 10G. A migration to a distributed access architecture (DAA), and in some cases PON, will become essential as the current methodologies for augmenting capacity reach their limits. The pace of change that the world has experienced recently will become the norm, necessitating the ability to introduce and evolve services continuously and to align capacity with demand elastically. These imperatives can only be met by virtualizing portions of the service delivery infrastructure, starting with the headend. The accelerating demand for upstream capacity will drive operators to start planning to evolve to a more symmetrical infrastructure, particularly as DOCSIS 4.0 becomes a market reality. Services will demand low latency. As Wi-Fi 6E products are introduced in 2021, operators will need to introduce the right solutions and support.

Although a long and complex list, it is only a partial one, and operators' needs will vary based on multiple parameters and considerations. Operators will increasingly need comprehensive and flexible solutions that cater to their needs, which can vary across their footprints and evolve over time. They need these solutions to be backed by various levels of support, which can range from basic to end-to-end, depending on the complexity of the solutions and their own organizational capabilities. Today more than ever, they need to work with the right vendors and partners that can display a deep understanding of their needs, that can innovate and deliver a spectrum of solutions to meet their needs, and that can provide an uncompromising level of support.

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ACCELERATION OF DIGITAL TRENDS

The recent months have brought into focus the critical role that communication networks play in virtually every aspect of life. Within weeks, new business models have emerged in almost in every industry, cementing the role of broadband networks as the fabric that is keeping the world connected and enabling the delivery of essential services, such as telemedicine, eLearning, virtual office, and others. Although digital enablement is not a new concept, and indeed many firms had already embarked on a digital transformation journey, today, many companies are accelerating their shifts toward digital-first models at warp speed¹, resulting in a digital acceleration of an unprecedented pace and scale. This acceleration is permeating every industry and will continue to grow for the foreseeable future. At the same time, consumers' behavior has changed, resulting in significantly increased video conferencing, binge watching, online gaming, and other activities.

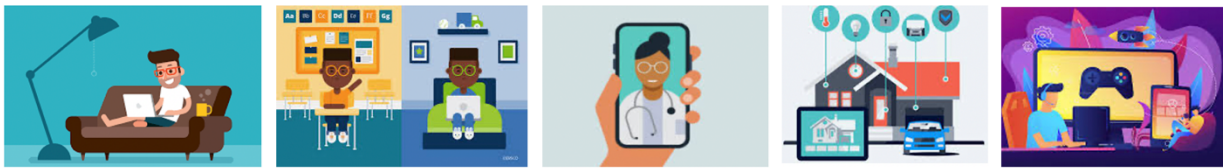


Figure 1. Some of the Use Cases Driving Bandwidth Utilization

Powering these digital trends is an insatiable demand for bandwidth, both downstream and upstream; services that are developing and evolving at high velocity and are imposing requirements, such as low-latency; and the need for elastic scalability to align capacity with the demands of a fast-changing market environment.

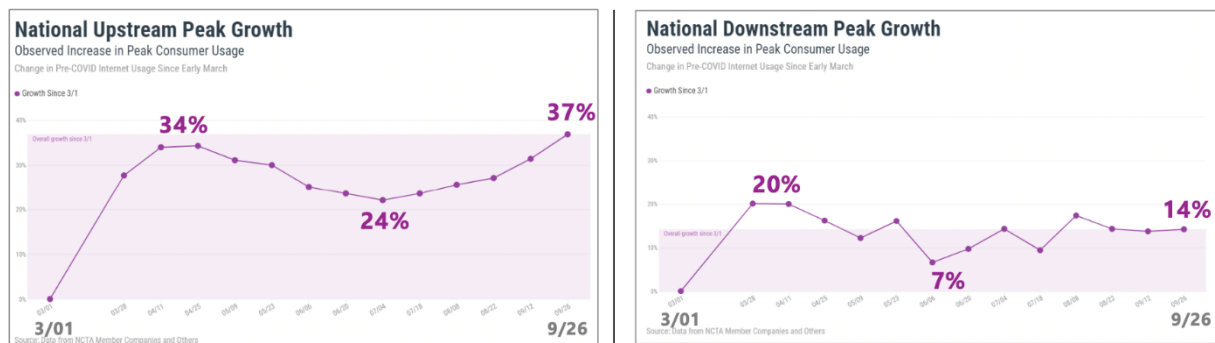


Figure 2. Bandwidth Utilization Trends (Source: NCTA)

Delivering these capabilities means maximizing networks at an unprecedented scale and aligning them with business goals; it requires evolving those networks to ensure continued alignment with market needs; it demands a continuum of solutions to satisfy ever changing needs, complemented by the committed support and expertise of teams of professionals from key vendors and partners that have the depth and breadth of solutions, along with the extensive levels of support the operators need.

¹<https://www.mckinsey.com/business-functions/mckinsey-digital/our-insights/the-covid-19-recovery-will-be-digital-a-plan-for-the-first-90-days>.

Delivering the bandwidth to the home is only part of the story; the bandwidth needs to be delivered to the end device. This means that Wi-Fi must evolve to match the increased performance of the access network and the changing behavior of consumers. Working from home, education from home, healthcare and entertainment from home also means that Wi-Fi coverage in the home is more important than ever.

The future is uncertain, but there is also tremendous opportunity. 2021 and beyond will usher in a new era where broadband is the runtime enabler for the world and where new services will be needed at an unprecedented scale. Cable operators are uniquely positioned to play a major role through the digital acceleration but will need the right partners with the depth and breadth of solutions for all parts of their networks combined with expertise and commitment from large professional services organizations to help them align their network transformation with their current and evolving business objectives.

SOLUTIONS FOR 2021 AND BEYOND

Although each operator will have unique requirements, the following solutions have broad appeal as they address the most pressing needs of the industry worldwide.

Increased Upstream Capacity

The trend toward higher upstream bandwidth consumption is clear, as was demonstrated in the last few months. As shown in Figure 2, within a few weeks in 2020, peak upstream bandwidth utilization increased 37%. Although the recent level of upstream utilization may taper somewhat, there is a clear trend toward more bandwidth utilization upstream and downstream as some of the business models that emerged during the past few months will be sustained. A plant that optimizes downstream capacity is no longer well suited to the applications that are prevalent, such as video conferencing, telehealth, video sharing, and others. A better allocation of spectrum to provide more upstream capacity has become a must. There are two prevalent approaches to augmenting upstream capacity: mid-split and high-split.

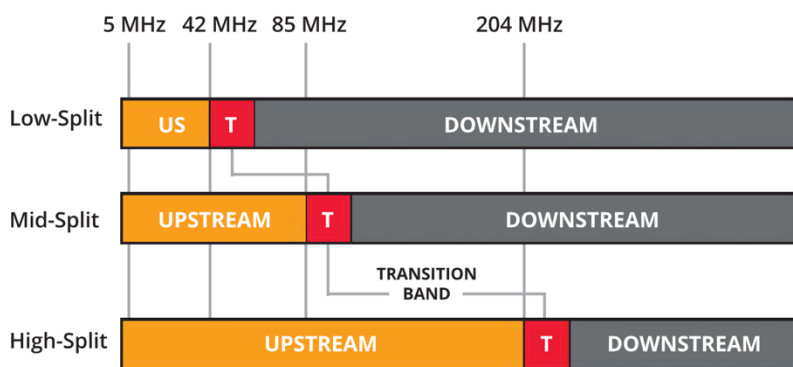


Figure 3. Spectrum Split Options to Increase Upstream Capacity (Source: CommScope)

The mid-split option is the simplest to implement as it enables the operator to retain legacy equipment while increasing upstream capacity by about 2.5X. However, it may fall short of upstream throughput. The high-split option can deliver up to 1 Gbps upstream; however, it may necessitate the replacement of some network equipment, such as diplexers or RF bridgers or swapping out some legacy set-top boxes. Given the amount of spectrum allocated to the upstream, it may be necessary to extend the spectrum to 1.2 GHz to preserve sufficient capacity in the downstream in the high-split case.

Enabling 10G and Beyond with Distributed Access Architecture

Operators have well-honed strategies for adding capacity, which typically involve node splits and adding DOCSIS channels; they have also recently activated the OFDMA capability of DOCSIS 3.1 to add upstream capacity. These strategies, although proven and effective in the short term, will come up short as the need for bandwidth continues to rapidly grow.

To achieve the promise of 10G, the cable industry initiative to deliver 10 Gb/s, operators need to add capacity at a higher rate. Some cable operators have opted to bring fiber deeper into the access networks to meet the growing demand for bandwidth capacity. Whether taking fiber deeper or not, many operators have already started to make plans to migrate to a Distributed Access Architecture (DAA), including architectures defined by CableLabs® and with broad industry support. DAA has two prevalent configurations: Remote PHY topology, where the PHY layer is moved to the node or a shelf in a Remote PHY Device (RPD) or a Remote MACPHY topology, where the PHY and the MAC layers are moved to the node or a shelf in a Remote MACPHY Device (RMD). Until recently, operators had to choose one alternative, but this presented challenges because one architecture might be suited in some areas and another could be better suited for a different area. More recently, the industry has introduced the Flexible MAC Architecture, which gives operators more flexibility in the location of the MAC, removing one of the hurdles related to DAA migration².

Some of the advantages of DAAs:

- Opens the way for virtualization.
- Supports more service group growth with existing headend space and power.
- Delivers higher speeds from higher-order modulations.
- Sends more wavelengths on a WDM fiber.
- Provides ability to set and forget with no need for level tuning and maintenance of digital optics.
- Uses open APIs between subsystems, enabling operators to select best-of-breed vendors for every component.
- Provides an additional advantage specific to the RMD approach: smaller service group and potentially lower latency due to having both the MAC and PHY closer to the end user.

The benefits of DAAs in enabling significant capacity have already been proven in a number of active field deployments. Recent demonstrations provide a perspective on the advanced capabilities DAAs can enable:

- **The Mediacom 10G Smart Home trial** is the first US field trial of the 10G platform of the cable industry, demonstrating the ability to realize a 2.5G downstream/1G upstream solution to support the future of home automation, virtual reality, augmented reality, gaming, holographic display, and consumers' applications in a real-world environment. The trial uses technologies from CommScope and other vendors.

² It is important to note that aside from DAAs, existing cabling and passives play a major role in enabling 10G.

- Holographic display over 10G** use cases shown at the recent 2020 SCTE Cable-Tec Expo Opening Session, where holographic data was streamed over a 10G network with edge compute capability, was an industry first. Using high bandwidth and low latency with a compute network enabled real-time 3D movement tracking in multiple applications, providing a glimpse of what is possible when the potential of the network is fully realized. The demonstration used CommScope equipment for the cable network and the home.

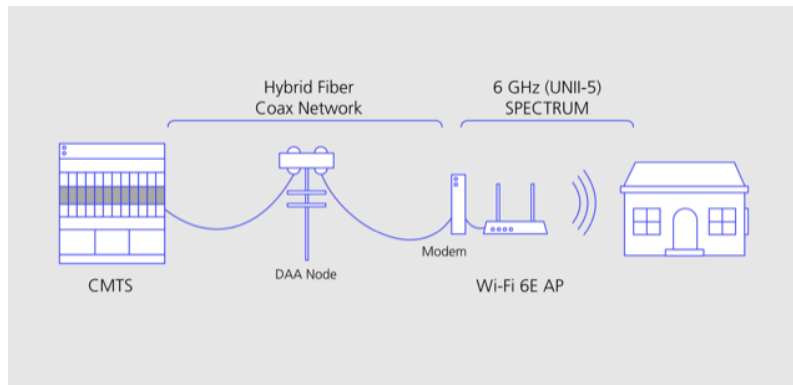


Figure 4. Holographic Applications over 10G (Source: CommScope)

Unlocking Agility and Elasticity by Virtualizing the Headend

The rigid, hardware-based infrastructure in the cable headend is not always well-suited for a world that is rapidly demanding change and new services. The rigid infrastructure does not provide the elasticity that is becoming essential to match capacity with demand, especially as demand patterns continue to evolve.

Cloud-native virtualization is the major enabler of elasticity and agility. Cloud-native architectures increase service velocity because they rely on software, continuous integration and continuous delivery, and DevOps; these are principles and practices that enable teams to deliver software changes frequently and reliably.

Virtualizing the headend means virtualizing the management plane, the video engine, and/or the CMTS core.

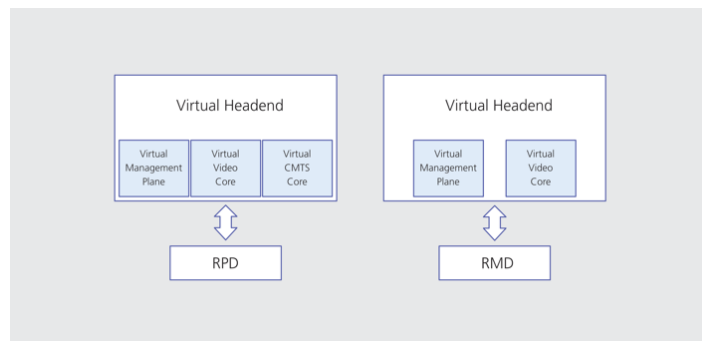


Figure 5. The Virtual Headend, Two Prevailing Architectures

The virtual management plane is microservices based; it provides a comprehensive and cohesive capability to facilitate deployment, configuration, and management and sets the stage for machine

learning, artificial intelligence, and software-defined networking. The virtual management plane is used by both Remote PHY and Remote MACPHY.

The virtual video core is a software-based solution that virtualizes the legacy video delivery infrastructure. It also creates video streams that can be injected into the new interfaces defined for DAA solutions (both Remote PHY and Remote MACPHY).

The virtual CMTS core is a cloud-native implementation of the CMTS core; it leverages the cloud-computing delivery model where applications are packaged in separate containers that are dynamically orchestrated to optimize resource utilization and enable them to be modified or scaled independently of one another. Although the virtual CMTS core is required for Remote PHY, for Remote MACPHY architectures, the CMTS data plane is distributed further to the edge of the network and handled by RMD hardware that is optimized for that purpose.

Enabling 5G Densification

As mobile network operators embark on broad 5G rollouts, they need cost-effective solutions to achieve the network densification to deliver the speeds and latency that are inherent to the 5G mmWave spectrum. The wide footprint in the access network of cable operators, as well as the presence of power in those areas, positions them well to provide the transport for the substantial amounts of small cells required in some 5G deployments (typically estimated to be over 10x that of 4G). This will be a significant business opportunity for cable operators as long as they meet the stringent latency requirements and significantly increase upstream and downstream capacity.

Beyond 10G with DOCSIS 4.0

As demand for upstream capacity continues to grow, operators will look beyond the capabilities inherent to DOCSIS 3.1. The DOCSIS 4.0 specifications, released in early 2020, enable operators to increase upstream capacity to 6 Gb/s and to delivery symmetric capacity. There are two approaches: Extended Spectrum DOCSIS, which involves increasing the highest plant frequency from 1.2 GHz to 1.8 GHz and later to 3.0 GHz, and Full Duplex DOCSIS, which works within 1.2 GHz using overlapping frequencies for upstream and downstream but may impose restrictions on the number of amplifiers and other legacy equipment between the node and the customers' premises.

Passive Optical Network (PON) Solutions

FTTx implementations via PON solutions provide robust, cost-effective, and scalable migration paths for symmetrical and multigigabit services to residential and commercial customers. PON solutions can be deployed in centralized or distributed architectures. They provide a path to 10G via cost-effective solutions to deploy fiber to the premises.

Wi-Fi 6 and Wi-Fi 6E

Wi-Fi 6 or 802.11ax brings higher capacity, efficiency, and performance and is quickly becoming a must for communication needs. Wi-Fi 6E, which takes advantage of the recently released 1,200 MHz of spectrum in the 6GHz band, delivers significantly more capacity than prior Wi-Fi releases, including Wi-Fi 6. Delivering high-performance Wi-Fi 6E uses the largest amount of new, clean spectrum being made

available for Wi-Fi use (1.2 GHz in USA, 500 GHz in Europe). It allows for faster speeds because of the wider channel widths and enables the delivery of deterministic, low-latency services. Service providers can use it to create a reliable, high-performance, low-latency wireless back-bone networks in the home. Devices supporting this capability are expected on the market in the latter part of 2020, and 2021 will be a big year for Wi-Fi 6E.

Looking forward, Wi-Fi 7 will deliver even higher levels of performance to track access network evolution and customers' demands.

Low Latency

Low latency is essential for online gaming, telemedicine, and other applications. CableLabs added Low Latency DOCSIS (LLD) to the DOCSIS 3.1 specifications in late 2019. LLD targets a round-trip latency below 5 ms. Wi-Fi 6E delivers assured low latency all the way to the end device.

ENABLING OPERATORS TO SUCCEED IN A VOLATILE MARKET ENVIRONMENT

Delivering the infrastructure to enable digitalization on this scale is no small task. To their credit, operators are stepping up to the task, but they need the right support and solutions from their vendors and partners. Some of the essential elements of success for the operators include the following:

Flexible Solutions that Simplify Deployments

Operators have variability across their footprints and often have multiple constraints, such as availability of skillsets, regulatory issues, topology variations, environmental requirements, and others. They need flexible solutions that fit their needs, accommodate the variability across their footprints, and simplify deployments as much as possible.

Total Cost of Ownership Optimization

Operators have to consider a number of parameters in making business decisions:

- Services and roadmap
- Market dynamics and demographics
- Operational capacity
- Business and financial metrics
- Regulatory
- Geography and environment
- Network and infrastructure

They need to select a partner with the intrinsic capacity to consider all their parameters and to guide them through their transformation journey.

Breadth of Solutions

Given the variability of their needs and the dynamics of a fast-changing market, operators require a vendor that has a comprehensive portfolio of field-proven solutions and services that enable lasting connectivity and that offers a continuum of solutions as their needs and market conditions evolve.

Operators require a partner that continues to innovate, grow, and evolve to stay ahead of their needs in terms of customers' experiences, access network, and in-home connectivity.

Experience

A partner must have superior experience in connectivity technology. Given the complexity of infrastructure and the evolving nature of the market, this level of experience is essential. Operators require trusted advisors to manage the complexity and evolution of their networks, services, and operations.

Deep Resources for End-to-End Support

Although some operators have substantial resources in-house, others need a partner with a full suite of capabilities, including design, construction, permitting, and material supply and management. A partner must provide various levels of support, from basic product support to turn-key end-to-end setup and operational solutions.

Flexible Business Models

In a highly dynamic and hyper-competitive market environment, operators must optimize their investment and allocate capital based on success. They must align their capital allocation with their short-term business needs and longer-term business goals. A vendor must have the financial capacity to work with them each step of the way based on their business parameters.

CONCLUSION

Cable operators are poised to play a critical role in the massive digitalization that will unfold in the next few years. To successfully capitalize on this opportunity, they need to maximize their network resources and invest in new solutions and capabilities that can carry through the decade and beyond. The solutions they deploy and the partners they work with will be key ingredients of success. They need a continuum of solutions that are optimized for their evolving requirements and partners with extensive resources that help them sweat existing assets, solve problems, respond to unexpected challenges, and accelerate business transformation. Not only do they require a partner that will help them innovate, but one that also provides the level of support they need when they need it.

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