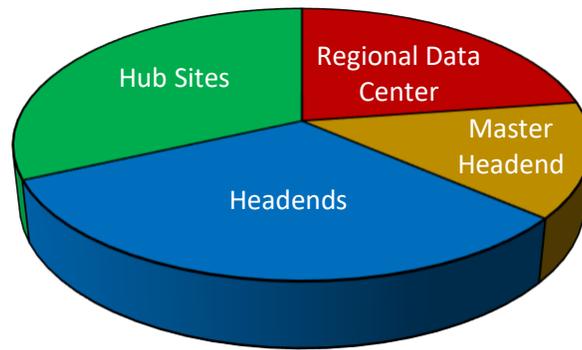


Cable Operators & Edge Computing: Drivers, Opportunities & Challenges



Where will edge equipment be located?



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Cable Operators & Edge Computing: Drivers, Opportunities & Challenges

Introduction

What do AR/VR, cloud gaming, smart cities, 5G, autonomous vehicles, healthcare sensors, surveillance and facial recognition all have in common? The need for low-latency connectivity enabled by networks architected with edge computing. In other words, a distributed, open IT architecture that features decentralized processing power – bringing computation and data storage closer to the location where it is needed

For some MSOs, edge computing trials have started. For others, edge computing plans won't be formulated for a few years. But whether they've already set their edge computing strategy or haven't begun, they must ask this question first: "How do we define edge computing?"

At Broadband Success Partners, we have done just that. We've asked this question and seven others of 24 network engineering and business services executives at Tier 1 and Tier 2 MSOs across North America.

Before viewing the complete story, let's look at the headlines:

1. Headends and hub sites are preferred locations for edge equipment – together chosen by close 2/3 of executives. However, Tier 1s are 4x more likely to place hardware in hub sites rather than headends. Tier 2s are twice as likely to pick headends over hub sites.
2. Almost 60% of executives view "Improved Customer Experience" or "Enablement of New Revenue Streams" as the most important edge computing driver. This is especially true of Business Services executives; Network Engineers view all drivers comparably.
3. Cloud gaming is the primary edge computing use case – after video caching.
4. Operations to support monetizing new services is greatest edge computing challenge.
5. Cable operators believe Programmable Infrastructure and Network Automation are the top investment areas in order to move to edge compute.

Research Methodology

We interviewed 24 executives from eleven Tier 1 and Tier 2 MSOs during the first quarter of 2020. As reflected below, diverse perspectives, within and across organizations, were captured.

Executives by Function and Company Size



Tier 1 is defined as Comcast, Charter, Cox and Altice USA

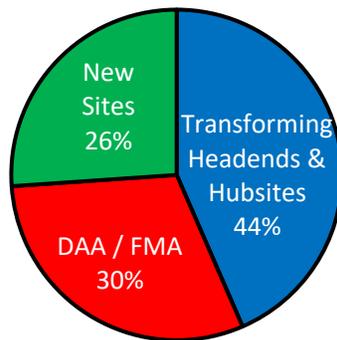
The Definition of Edge Computing

We started each interview by asking this question: “Which of these descriptions best matches your company’s edge computing initiatives?”

- A. Transforming headends and hub sites to mini data centers, or Headend Re-architected as a Data Center (HERD)
- B. Distributing compute and virtualization via Distributed Access Architecture (DAA) and/or Flexible MAC Architecture (FMA)
- C. Building new edge sites with compute and storage closer to end customers

As you can see here, executives are split on how edge compute is defined.

Description of Edge Computing Initiative



These varied views are likely due to the executive's preferred edge computing use cases. For example, if their primary applications are less latency sensitive such as video caching or SD-WAN, they skew toward a less distributed compute architecture. In contrast, those thinking in terms of Augmented Reality, Virtual Reality, gaming and/or autonomous vehicles with little to no tolerance for latency will gravitate towards another edge configuration with equipment closer to the end user.

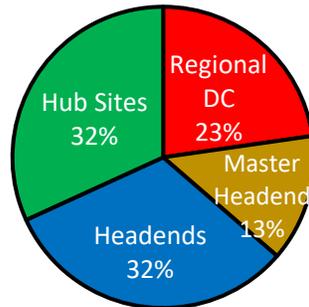
The Location of Edge Equipment

As a logical follow-on to the first question, we next asked “Where will the edge computing equipment be located for your company?”

- A. Regional Data Center
- B. Master Headend
- C. Headends
- D. Hub Sites

Not surprisingly, headends and hub sites are the locations preferred for edge equipment – together chosen by 2/3 of executives.

Location of Edge Equipment



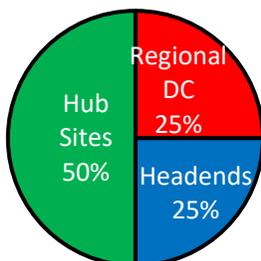
A real difference emerges when you view the results by company size. Tier 2 cable operators are far more likely to place edge computing hardware in headends rather than hub sites.



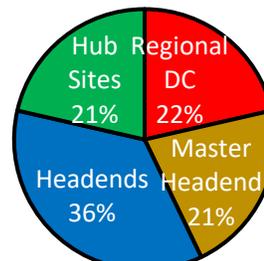
This is due to the cost of scaling up and out to place edge devices in relatively fewer headends versus many hub sites. As one executive explained, "Our decision depends on the tipping point of finances and latency tolerance." Also of interest is the selection of master headends and regional data centers by Tier 1s as their regional data centers are closer to customers.

The contrast by functional area is also stark. Half of the Business Services executives prefer hub sites versus a fifth of Network Engineers. Another fifth pick master headends while none of the Business Services executives did. They're less likely to think about plant architecture.

Business Services



Network Engineering



The executives who select hub sites or headends explain they need to get as close to the end user as possible in order to lower latency. One executive who picked hub sites cited “the one millisecond latency requirement of a 5G provider.” Another primary reason given is that these locations already have the needed space, power and equipment. Those who chose master headends or regional data centers viewed these locations as the best aggregation point with which to start - both in terms of cost efficiency and ease of administration. For a complete list of insights on location considerations from the executives, please see Exhibit A.

It’s important to recognize that these perspectives are at a point in time. More than a few executives commented that the application (latency) requirements and the economics could cause a shift in the preferred location in the future. As one executive noted, “Could be headends and over time hub sites. Depends on performance factors of solution and customer needs as well as the most efficient use of the environment.”

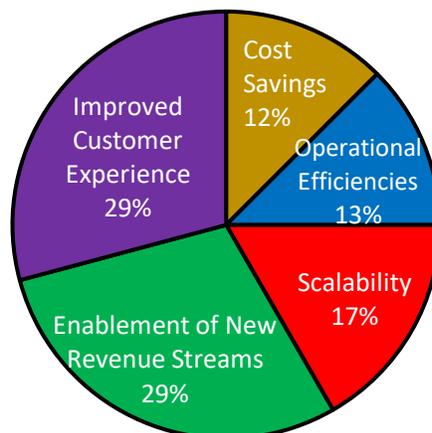
The Drivers of Edge Computing

As MSOs move towards edge computing, an important question is why. We asked “What are the drivers for your company? Rank order from the most important (1) to least important (6).”

- A. Cost Savings
- B. Operational Efficiencies
- C. Scalability
- D. Enablement of New Revenue Streams
- E. Improved Customer Experience
- F. Network and Data Security

Over half of executives noted either “Improved Customer Experience” or “Enablement of New Revenue Streams” as the most important driver for edge computing for their company.

Edge Computing Drivers



For Tier 1s, financial factors are the more important – namely, new revenue and cost savings. Tier 2s expressed, it’s customer experience and scalability. Network Engineers value all these factors while Business Services executives focus on customer experience and new revenue.

The reasons why these executives chose the driver they did are quite varied – ranging from “an improved customer experience due to lower latency for gaming and video optimization” and “we must monetize these services being in a capital-intensive business” to “choosing something that’s scalable is key so as to not augment later” and “cost savings is the #1 priority for us.” For a complete list of insights on the drivers from these executives, please see Exhibit B.

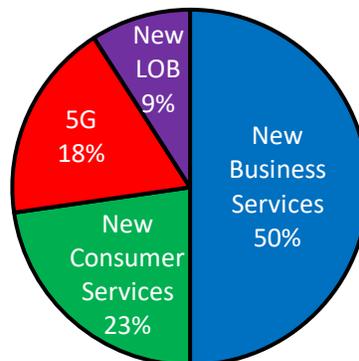
Edge Compute Opportunity Areas

Closely aligned with the drivers are the opportunity areas and use cases prioritized by these executives. Next, we asked “Which of these is the largest opportunity areas for your company with edge computing?”

- A. New Business Services (e.g. leveraging edge compute/storage for SD-WAN)
- B. New Consumer Services (e.g. low latency broadband service for cloud gaming)
- C. Enabling MSOs to play a larger role in 5G
- D. New Line of Business (e.g. Infrastructure as a Service, application hosting)

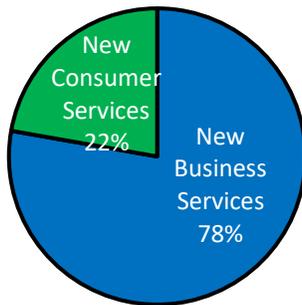
Half of the executives see “New Business Services” as the largest edge compute opportunity. This isn’t a surprise considering that 38% of the interviewees are Business Service executives.

Edge Computing Opportunity Areas

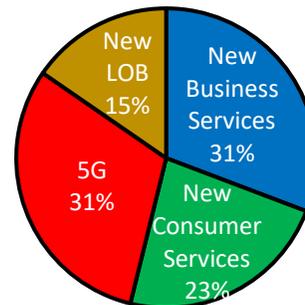


As you see on the next page, 78% of Business Services executives choose “New Business Services.” Network Engineering executives are split between “New Business Services” and “Enabling MSOs to Play a Larger Role in 5G” – each at 31%. By size of MSO, there are no significant differences.

Business Services



Network Engineering



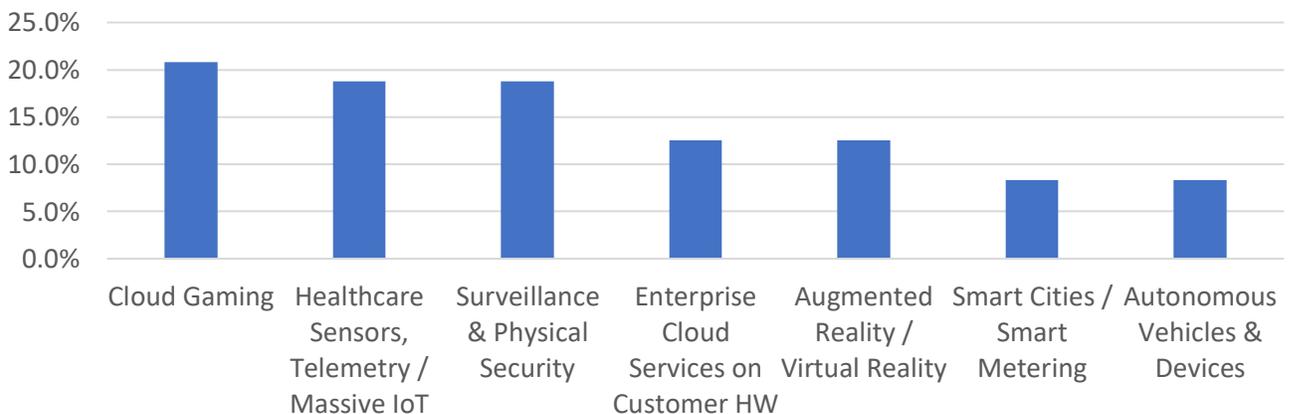
As you might expect, a number of the executives who cited “New Business Services” as the largest opportunity area mentioned SD-WAN as the reason why. For example, one interviewee stated that “SD-WAN is a focus to compete on national basis without infrastructure. We’re using edge hardware to talk to other networks.” Another explained that edge computing enables vertical services parallel to the core, such as firewall, IaaS and malware detection.

In terms of new consumer services as the greatest opportunity area, one executive noted that “30% of customers would pay \$10 per month for low latency gaming service.” On the 5G front, one interviewee said that “with extensive regional fiber assets, we’re ideally suited for multi-carrier 5G buildouts.” For a complete list of insights as to why these executives selected these opportunity areas, please see Exhibit C.

Edge Compute Use Cases

Getting more granular beyond opportunity areas, we then asked “Beyond widespread distributed video streaming (i.e. video caching near the edge), which of these edge computing use cases do you expect will develop next, or further?”

Top Edge Computing Use Cases



As you might expect, Cloud gaming is the next edge compute use case expected to develop further. This is followed by healthcare sensors, telemetry / massive IOT and surveillance & physical security.

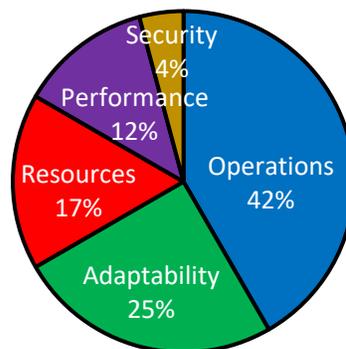
A typical explanation as to why cloud gaming: “these are delay-sensitive applications which benefit most from edge compute.” In terms of sensors for healthcare and telemetry, “Money is being invested to extend life and the quality of life. Smart home enables seniors to age in place. Surveillance and physical security was chosen as a major use case because the “industry is ripe for disruption.” For the complete list of the use case insights, please see Exhibit C.

Edge Computing Challenges

We then asked “Which is the most significant challenge to support edge compute?”

- A. Operations to support monetizing new services and business models
- B. Adaptability - knowing when and where to adjust network resources
- C. Resources to support and manage the edge compute facilities
- D. Performance - delivering the low latency requirements of edge compute
- E. Security of edge devices

Edge Computing Challenges



Over 40% of executives see operations to support monetizing new services as the major challenge in advancing edge compute. Then, network resource adaptability. There are no significant differences in results when segmented by MSO size and network engineering vs. business services executives.

The executives who cited operations to support monetizing new services and business models as the greatest challenge did so for several reasons:

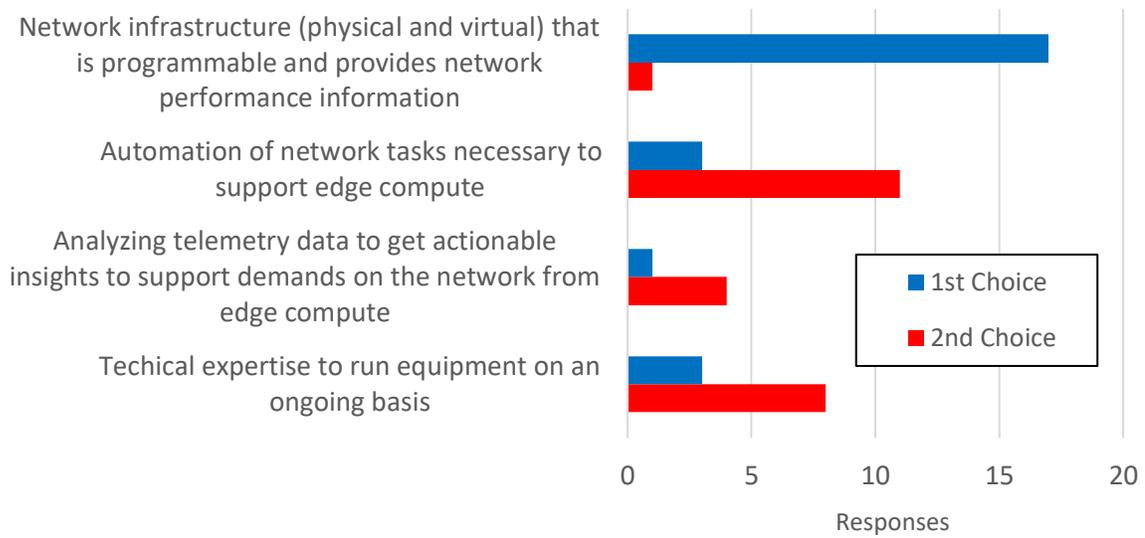
- “Edge compute is a new paradigm driving new workflows. Tackle through automation.”
- “Many operational things need to be done to support cloud gaming.”
- “Our inflexible OSS/BSS systems prevent agile approach to innovation.”

As for the second greatest challenge, namely adaptability, executives explained that lots of development and automation is needed to adjust devices to meet consumer needs and that network automation tools are necessary to monitor where and when to augment. For a complete list of insights on the challenges chosen by the executives, please see Exhibit E.

Edge Compute Investment Areas

To make the move to edge compute, it's important to understand where these MSOs are investing their financial resources. We asked "To enable the move to edge compute, where is the greatest investment? Rank order from greatest (1st) to least investment (4th)."

Edge Computing Investments: Top 2 Areas

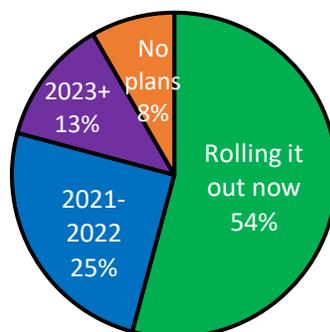


Far and away, network infrastructure is the #1 investment area for edge compute. Automation of network tasks ranks #2. Why network infrastructure? It's a "different operating model. We need to rethink our network topology." Another executive said "to move to a distributed architecture requires a massive number of new elements, and it must integrate with existing hardware." For a complete list of investment insights, please see Exhibit F.

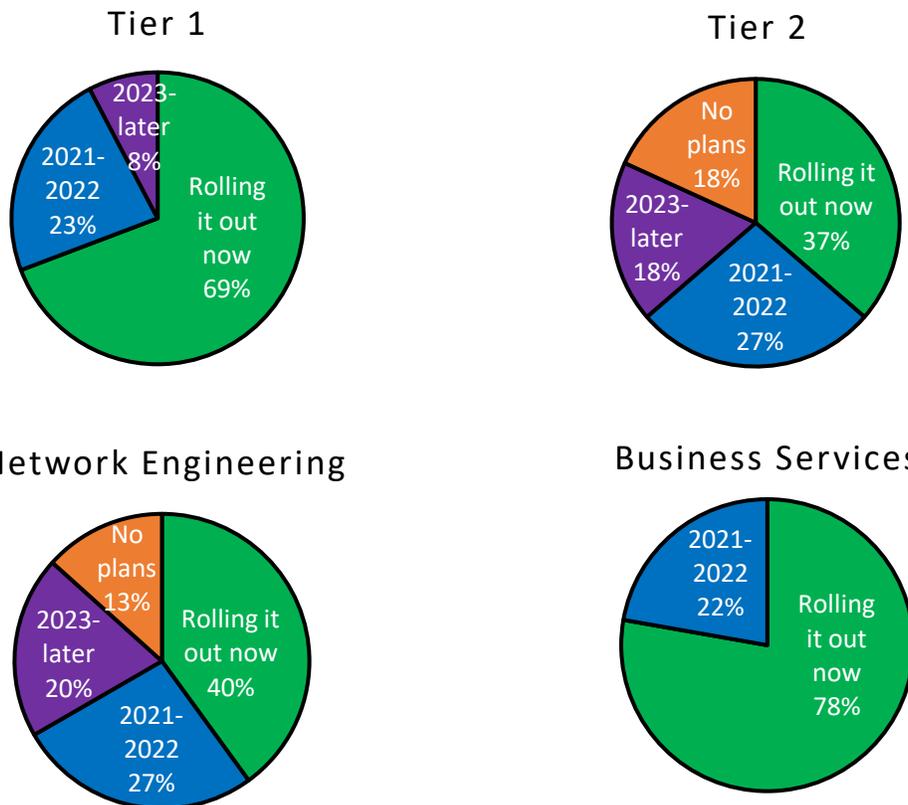
Edge Compute Strategy & Plan Timing

Lastly, we asked about the timing of their edge compute strategy and plan: "Does your company have a strategy to incorporate edge compute?" Over half of the executives say their edge compute plans are rolling out now. Another 25% will have a plan by 2022.

Timing of Edge Computing Plan



The differences in timing by MSO size and job function are revealing. Tier 2 executives are planning and executing their edge compute strategies later than their Tier 1 counterparts. Almost twice as many Tier 1 MSOs are rolling out their plans now. Interesting to see that close to 20% of Tier 2s don't expect to have a plan. As for job function, twice as many Business Services executives than Network Engineers executives say edge compute is rolling out now.



Key Take-Aways

Beauty is in the eye of the beholder. The same can be said of edge computing. The heterogenous responses to our questions are proof positive that MSO executives view the role of edge computing differently based on their specific circumstance. Even so, a critical mass surfaced in several areas:

1. Headends and hub sites are preferred locations for edge equipment – together chosen by close 2/3 of executives. However, Tier 1s are 4x more likely to place hardware in hub sites rather than headends. Tier 2s are twice as likely to pick headends over hub sites.

2. Almost 60% of executives view "Improved Customer Experience" or "Enablement of New Revenue Streams" as the most important edge computing driver. This is especially true of Business Services executives; Network Engineers view all drivers comparably.
3. Cloud gaming is the primary edge computing use case – after video caching.
4. Operations to support monetizing new services is greatest edge computing challenge.
5. Cable operators believe Programmable Infrastructure and Network Automation are the top investment areas in order to move to edge compute.

Closing Thoughts

Now, that you've "heard" what 24 MSO executives have to say about their edge computing journey, how can this help you? In devising or re-evaluating your edge compute strategy, start by prioritizing the use cases you envision will be the most popular. Understand the latency requirements needed to deliver an excellent customer experience. Where will you place edge equipment to achieve this experience while investing at an acceptable level? Striking the right balance today and in the future is critical. Re-visit the insights in this report to give you valuable views and to guide your thinking. Another factor in your thinking should be DAA. By looking at your DAA and edge computing plans together, you may leverage operational and financial synergies.

We hope that the insights of these MSO executives and our related perspective will make it easier for you to achieve your edge goals.

Exhibits

Following each quote, a letter corresponds to the interviewee who said this:

- A = Network Engineering Executive at a Tier 1 MSO
- B = Business Services Executive at a Tier 1 MSO
- C = Network Engineering Executive at a Tier 2 MSO
- D = Business Services Executive at a Tier 2 MSO

Exhibit A: Why This Location?

Hub Sites

- *Gets us as close to the home as possible. A*
- *Hub sites are here to stay. Since have equipment there already, why not put it there. Had an effort underway to consolidate Hub Sites. But, with edge computing advantages over centralized approach, we're re-thinking the consolidation thrust. A*
- *Migrate computing power into Hub Sites. Greater capacity. Lower latency. On mobility side, small cells are a big part of our activity. D*
- *1 millisecond latency requirement of a 5G provider. B*

Headends

- *Getting service closer to end user - in a market where you can do it. 1-2 Headends per market - video distribution - some compute. DAA management in Headends. C*
- *Matter of scale and capital investment required. Fewer edge devices in Headends than in the Hub Sites. C*
- *Existing facilities and power. Place where HFC plant starts/stops. Building has space. C*
- *For company of our scale (mid-size), can't offer as much as scale with regional data center as AWS, Comcast. Better to provide co-location services in your backyard. D*

Master Headend

- *Primary Site = Master Headend with compute. Secondary site = Edge Switches without compute - switch and transport gear. A*
- *For support and maintenance, better to have it centralized in Master Headend. A*

Regional Data Center

- *Best aggregation point to start with; cost efficient and ease of administration. B*
- *Excellent Latency over DOCSIS 3.1, allows MSOs to place their compute equipment higher up in the network hierarchy. A*

Exhibit B: Why This Driver?

Improved Customer Experience

- *Make sure the edge compute implementation serves the need of the customer. B*
- *Lower Latency for gaming and video optimization results in improved customer experience. A*

Enablement of New Revenue Streams

- *Being in a capital-intensive business, we must be able to monetize these services. D*
- *Because Edge drives performance of Web 3.0 (new internet); creating new revenue. A*
- *For HFC to go to 10G, need distributed architecture - no other way to achieve this. A*

Scalability

- *Edge compute allows more customers to use same platform at the same time. A*
- *Scalability and Operational Efficiencies are the first things we focus on. Choosing something that's scalable is key so as to not augment later. D*

Operational Efficiencies

- *Equates to dollars. Less hardware dependent, less cost. Only pay for where you need it. B*
- *Remote PHY. Must virtualize. Add complexity with virtual core. With PON, it's simpler. A*

Cost Savings

- *Cost savings is #1 priority for us. Drives whole philosophy. Boils down to cost. A*
- *With rapidly growing traffic, continue to reduce cost of transporting data on network. A*

Exhibit C: Why This Opportunity Area?

New Business Services

- *SD-WAN is a focus to compete on national basis without infrastructure. Use edge HW to talk to other networks. B*
- *Enables vertical services parallel to the core (e.g. firewall, IaaS, malware detection). A*
- *Virtualize multiple services at the edge, creating a branch-in-a-box solution. B*

New Consumer Services

- *Scale there - especially in smaller markets with fewer commercial customers. D*
- *30% of customers would pay \$10 per month for low latency gaming service. A*
- *Low-latency DOCSIS development is key to staying relevant to present/future clients. A*

Enabling MSOs to Play Larger Role in 5G

- *With extensive regional fiber assets, we're ideally suited for multi-carrier 5G buildouts. C*
- *Newly launched mobile business represents high growth area. A*
- *Great interest in leveraging our position to enter the wireless arena. A*

Exhibit D: **Why These Use Cases?**

Cloud Gaming

- *Delay-sensitive applications which benefit most from edge compute. A*
- *Already introduced by competition. For example, Google Stadia and Shadow/Blade. A*

Sensors for Healthcare, Telemetry, etc. (Massive IoT)

- *Massive IoT is on the cusp of becoming mainstream. A*
- *Money invested to extend life and the quality of life. Smart home enables seniors to age in place. C*

Surveillance and Physical Security

- *With all the Internet access, it's a natural fit: Enabling surveillance via IoT. D*
- *Industry ripe for disruption. Not evolved commercially. Security services coming. D*

Augmented Reality (AR) / Virtual Reality (VR)

- *Latency sensitive and requires significant amount of computing.*
- *Headset technology will be more useful beyond gaming. Opens up other opportunities.*

Enterprise Cloud Services on Customer Hardware

- *Clients asking for cloud connectivity and what components can be maintained on the network, like IOT devices.*
- *Vertical services on top of core. Enhance existing use cases with edge compute/power.*

Smart Cities including Smart Metering

- *People are afraid. Interest from police. Lower cost; leverage existing infrastructure. B*
- *Managing power grids - track utilization of what's produced, provided and consumed.*

Autonomous Vehicles and Devices

- *Latency sensitive and requires significant amount of computing. A*
- *Need AI platform and distributed network closer to the driver for safety. A*

Exhibit E: **Why This Challenge?**

Operations to support monetizing new services and business models

- *New paradigm driving new workflows. Tackle through automation. A*
- *Many operational things need to be done to support cloud gaming. A*
- *Inflexible OSS/BSS systems prevent agile approach to innovation. A*

Adaptability: knowing when and where to adjust network resources

- *Lots of development and automation needed to adjust devices to meet consumer needs and link back to headends to make intelligent decisions. A*
- *Tools for monitoring where/when to augment aren't fully capable of on-demand ability to look at network utilization. D*

- *Unless greenfield build, need to adapt existing infrastructure at great cost without immediate payoff. Akin to start of building for cell backhaul. B*

Resources to support and manage the edge compute facilities

- *To turn company from HW to SW shop, need to re-train workforce and bring in new hires. Not everyone's equipped to support edge compute. C*
- *Manage infrastructure with limited resources; tough to add responsibilities. A*

Performance: delivering the low latency requirements of edge compute

- *Challenge to deliver low enough latency for enough customers. D*
- *Balance between performance and cost. Going in, don't know if you picked right hardware. Flexibility at core if guess wrong. Greater challenge if guess wrong at edge. A*
- *At this stage, important to validate that the edge improves performance and therefore demand a premium over the Cloud. A*

Security of edge devices

- *Security requirements are ever changing and keeping up with new vulnerabilities. C*
- *Depending on deployment of application, monetizing, efficiency and/or security is important. B*

Exhibit F: Why This Investment Area?

Network infrastructure (physical and virtual) that is programmable and provides network performance information

- *Re-thinking network topology to move to the edge. Different operating model. D*
- *To move to distributed architecture, a massive number of new elements go into infrastructure. And, integrate with existing hardware. A*
- *Large cost to upgrade facility - power & cooling. Need to update environment. A*

Automation of network tasks necessary to support edge compute

- *Make sure environment can be operationalized. Look at cost & customer perspectives. B*
- *Automation closely coupled with technical expertise. Latter drives the former. A*

Analyzing telemetry data to get actionable insights to support demands on the network from edge compute

- *To understand the true demands, significant investment in time is required. C*
- *Demands change almost daily. C*

Technical expertise to run equipment on an ongoing basis

- *Finding people that know SDN has been the greatest challenge to building infrastructure and implementing services. B*
- *Proven to be a worthwhile investment. D*