WIA

The Impending Wireless Data Crunch:

Overcoming the Deployment Challenges of Fronthaul and Backhaul Infrastructure

Content

Abstract

This white paper outlines the requirements for fronthaul and backhaul transport solutions that are essential for the projected increases in cellular network usage, including the anticipated proliferation of equipment that will be necessary as the Internet of Things (IoT) emerges. In addition, this paper quantifies investments, justifies the time and expense associated with deployments and recommends affordable implementation strategies.

Introduction

The high value and limited availability of commercial licensed radiofrequency (RF) spectrum has forced the wireless infrastructure industry to develop innovative radio features, functions and configurations to increase efficiency in cellular networks. Some of these innovations include the collocation of baseband units (BBUs) in a Centralized Radio Access Network (C-RAN) architecture, implementing the LTE Advanced (LTE-A) protocol, and Carrier Aggregation (CA). Along with these innovations, robust fronthaul and backhaul transport solutions will be integral to deliver voice and data services efficiently. Although fronthaul and backhaul deployments can be challenging because of high costs and time-to-market barriers, these difficulties can be remedied.

For this white paper, the definition of backhaul is any methodology necessary to transport voice and data from the carrier's Base Transceiver Station (BTS) back to its core network.

Fronthaul is what exists between the baseband unit of a cell site and the remote radio units (RRU). In C-RAN networks, the Common Public Radio Interface (CPRI) protocol is used to communicate information with the centralized BBUs and the RRUs.

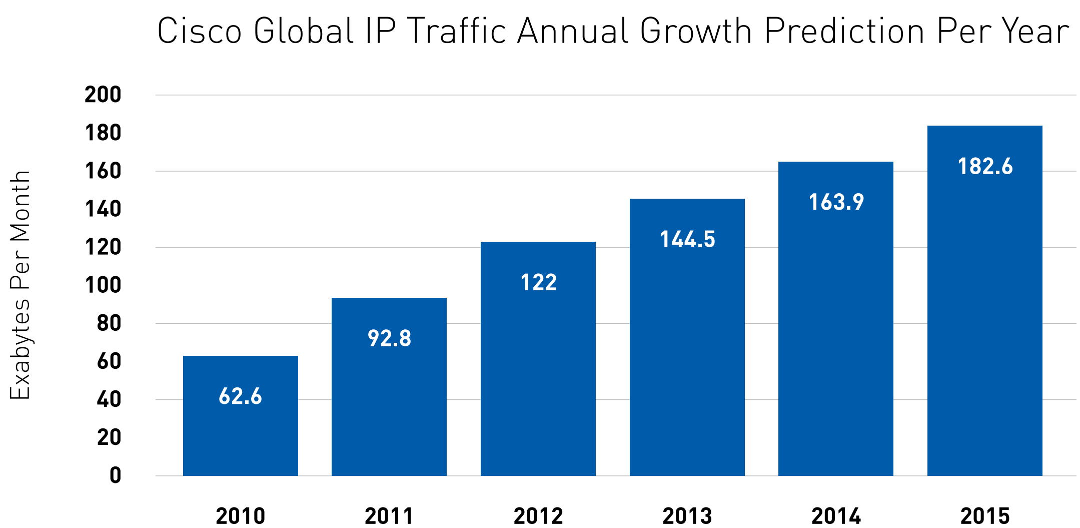
Traditionally, fronthaul connectivity has been deployed using fiber. Backhaul transport solutions increasingly are migrating to fiber-optic cable as well. This migration is enabled by technological advances in network and RF equipment, as well as the need to deliver greater capacity and reliability to targeted areas using today's LTE wireless platforms. Going forward, fifth-generation technologies (5G) likely will use fiber-optic transport. In addition, a fundamental driver for high-quality fronthaul capacity uses Coordinated Multipoint (CoMP) technology to expand and optimize radio coverage and is required in C-RAN architectures. The link between RRUs and BBUs is no longer a simple one-to-one relationship because of the increase in distance and the subsequent transmission latency, which impact radio performance.[1]

Although many people think of the cellular network as RF antennas and the BTS, the connectivity from the cell site to the baseband unit and the connectivity from the cell site to the core (backhaul) are essential to a working cellular network.

The Continuing Exponential Growth of Mobile Broadband

More people are using smartphones and accessing more content than ever before. That increased network traffic means carriers will have to deploy more wireline aggregation points to distribute the RF signal to and from devices. Essentially, more fiber will be necessary because RF spectrum is limited, both in the amount of available spectrum and its capabilities.

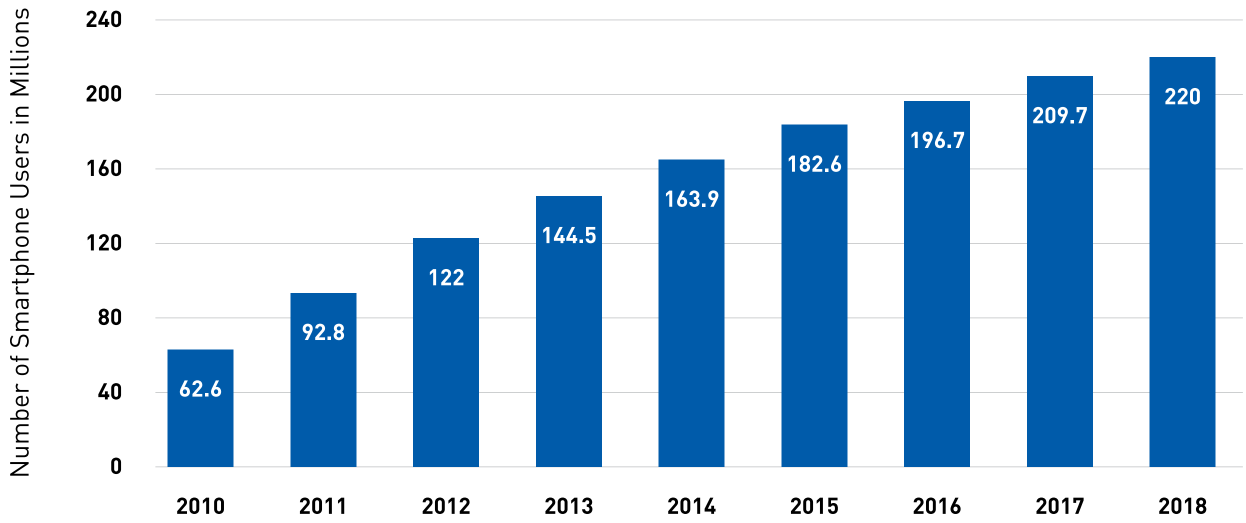
Annual global IP traffic is expected to pass the zettabyte (1,000 exabytes) threshold by the end of 2016, and could reach 2 zettabytes per year by 2019, according to Cisco.[2] To put this in perspective, global IP traffic in 2019 will be the equivalent of the content from 504 billion DVDs per year. North America is expected to account for about 30 percent of the global estimate of global traffic – about 49.7 exabytes per month, according to Cisco.



Source: Cisco "VNI Global IP Traffic Forecast, 2014–2019"

Cisco also predicts that two-thirds of all IP traffic will originate from non-PC devices by 2019. In 2014, only 40 percent of total IP traffic originated from non-PC devices; however by 2019, the non-PC share of total IP traffic is expected to increase to 67 percent. PC-originated traffic is expected to grow at a Compound Annual Growth Rate (CAGR) of 9 percent. TV traffic is expected to rise 17 percent in the same timeframe. But the most growth is expected from mobile devices, with smartphones increasing 62 percent, tablets growing 65 percent and machine-to-machine (M2M) communications growing 71 percent.

Meanwhile, the number of smartphone users in the United States has tripled since 2010 and is expected to grow by another 40 million by 2018, according to Statista.com.[3] This increase is not only driven by the user needs, but also by competitive pricing and packaging of mobile data plans offered by wireless carriers. As affordability increases, so does utilization.



Source: Statista.com Anticipated Growth of Smartphone Users in the United States

Methods Available to Augment Fronthaul and Backhaul

The estimates above illustrating surging demand for wireless data represent the primary drivers for fronthaul and backhaul infrastructure. It is important to discuss the methods of delivery to understand the most efficient ways to increase the infrastructure available to help transport this traffic. Several methods can deliver backhaul transport. Copper, fiber-optic cables and high-speed microwave are common infrastructure options for backhaul, while fiber is used for fronthaul, along with some wireless solutions.

Wireless carriers have begun to use small cells with remote radio units and picocells as alternatives to Distributed Antenna Systems (DAS) to get cellular coverage and capacity inside buildings. Corporate enterprises and commercial real-estate owners and managers are following suit, and are planning for infrastructure to enable indoor mobile connectivity. However, property owners may find the capital expense of installing additional infrastructure in existing facilities can be daunting and time-consuming. Partnerships between carriers and third parties like neutral-host companies to install and manage more backhaul and fronthaul could ease some of those costs.

Property owners increasingly recognize the importance of wireless connectivity to attract and retain tenants, and are showing more willingness to help plan and pay for wireless infrastructure in their buildings as they already do for other necessary utilities.

Fiber is becoming the technology of choice for both fronthaul and backhaul for a number of reasons. Fiber-optic cables carry more bandwidth at higher throughput speeds, and are more robust and dependable in most environments than copper. Other transport solutions such as microwave and millimeter wave (MW) are well suited for short-hop outdoor backhaul, and are being considered for short-hop fronthaul connectivity. MW backhaul is commonly used, but bandwidth delivery is limited by the amount of available spectrum, whether licensed or unlicensed.

In order to use microwave-based backhaul at the macrocellular network, improvements will need to be made to microwave equipment so it can deliver new modulations, multi-channel support, bulk-compression technologies and wider frequency bands. In particular, industry is considering using E-band spectrum for mobile backhaul. The E-band is regulated globally and not widely used so it could be more cost-effective for operators as well. However, it still has limitations on how it can be used over longer distances.

How Other Options Stack up against Fiber Fronthaul and Backhaul

Despite the benefits of using fiber for deployments, sometimes fiber installation can be challenging due to site placement, zoning restrictions and construction costs. These challenges make it impractical to deploy fiber in every case, and particularly in certain urban areas. As wireless carriers seek to augment their networks with small cell solutions in densely populated areas, alternatives to fiber are being evaluated.

Ultimately, the architecture will dictate the best wireless technology. It is too early to predict how wireless backhaul will coexist and interact with the macrocellular network or how wireless backhaul will work between proprietary small cells. Possible implementations include small cells interacting in a mesh architecture with designated gateway connections to the backhaul network, point-to-multipoint with multiple small cells connecting to a designated backhaul entry point, point-to-point wireless connections (line of sight (LOS) and non-line of sight (NLOS)) and combinations of the above.

The benefits of wireless technology are obvious, but with any technology, there are trade-offs. Maintaining a consistent reliable connection between points is a huge challenge. As the number of wireless links expands, the complexity increases significantly.

The most obvious challenges to maintaining robust and reliable wireless connections include distance, alignment and environmental conditions. As distance between wireless links increase, connectivity speed and reliability both decrease. As the need for precise alignment increases, the opportunity for misalignment increases with obvious impacts on reliability and throughput speeds. Finally, environmental conditions have been shown to have a dramatic impact on connectivity. If fog, rain and snow are prevalent in a given area, links must be shortened to ensure reliable connectivity and throughput.

That's not to say robust, cost-effective wireless solutions are impossible. Some carriers have begun testing a number of innovative technologies, including Fixed TD-LTE and UE Relay. Fixed

TD-LTE is a fixed wireless broadband fronthaul solution that enables carriers to leverage existing licensed spectrum to target unserved and underserved consumers (i.e., those with slow or no Internet access), especially in rural areas that may have excess capacity to dedicate to fixed broadband. UE Relay is a point-to-multipoint backhaul solution that enables high-capacity wireless backhaul to enterprise users from existing macrocellular sites using licensed spectrum that carriers already own and operate.

Obstacles to Timely, Inexpensive Backhaul Deployment

In the United States, the time and expense associated with deploying backhaul and fronthaul are key factors stymieing the buildout of wireless infrastructure networks. A lack of awareness and understanding of the need for this infrastructure can stall deployments at local and state levels. There is also a misconception that deployments represent revenue opportunities for local jurisdictions that might want to charge high fees to deploy network equipment in public areas. In areas where local resistance or demands are high, wireless carriers may choose to spend their deployment budgets in other areas of the country, where they can get a better return on their investment.

Fronthaul deployments have their own challenges. The National Electrical Code does not require hardened conduit, a junction box for fiber or low-voltage copper cable, but many municipalities and some private property owners insist on those features. This is a significant drawback in getting equipment deployed because it is difficult to rationalize the added costs. A more favorable regulatory environment could lower costs and thus expedite deployments.

Proliferation of Fronthaul and Backhaul as Wireless Densification Occurs

Most 5G experts visualize an infrastructure that requires extreme densification in order to achieve the goals for downlink speeds, latency and coverage. While it is difficult to quantify at this stage of development, the consensus is that future networks will rely heavily on small-cell technologies in densely populated, urban areas.[4]

Small cells have been in the news for several years as carriers look for new ways to meet the exploding demand for capacity and coverage. To date, small cells have not been as cost effective as originally forecast for technical, economic, regulatory and administrative reasons. As a relatively new technology, improvements in technical features likely will be overcome, but economics, regulatory and administration may be more problematic.

The economics of backhaul in small-cell deployments remain challenging. Small cells are typically deployed to fill macrocellular coverage gaps. They can be installed on the sides of buildings, rooftops or street furniture, like lamp posts and utility poles. However, getting backhaul to these locations can be difficult for reasons mentioned above.

Today's zoning and siting environment sometimes does not differentiate between small-cell deployments and macrocellular sites. The result is a cumbersome process that creates a drawn-out approval process for small-cell deployments in some communities. Some experts predict wireless carriers will need to deploy anywhere from 10 to 50 times more access points for 5G technology as they have to date, necessitating the same multiple for additional fronthaul and backhaul transport links.The sheer number of deployments underscores the need for changes in zoning and siting.

While the exact architecture for 5G is still under discussion, it is likely some hybrid model that combines distributed RAN (D-RAN) and centralized or Cloud RAN (C-RAN), utilizing combinations of massive MIMO, enhanced Wi-Fi and small cells.

Conclusions and Recommendations

Key points that can be extrapolated from the sections above in this white paper are as follows:

- The demand for U.S. wireless broadband access is increasing, both in user numbers and volume of use by individual users.
- This increase in demand is causing a degradation of service in the United States, primarily due to the cost of deployment.
- The regulatory environment in the United States is not uniform and causes significant negative impact on cost, schedule and quality.

While these points are hurdles for wireless broadband deployments, the U.S. government is well aware of these challenges. There is an understanding that the economy, public safety and leadership in global technology suffers if these issues are not addressed, and policymakers are taking up the challenge at the federal, state and local levels, despite resistance that remains.

At the federal level, efforts are underway to stimulate the proliferation of broadband wireless service. The President's Broadband Opportunity Council (BOC) and the Federal Communications Commission's Connect America Fund (CAF) are examples of how government and business can combine to improve the quality and safety of life through better broadband access for all. These two relatively young programs are already having a noticeable impact.[5]
While these efforts have been worthwhile, they do not necessarily address end-to-end needs in a cohesive manner from the user perspective.

For example, wireline carrier CenturyLink obtained CAF funding for $514 million.[6] The carrier plans to use these funds to deliver broadband fiber-optic backhaul to the areas stipulated in the CAF agreement. While providing backhaul for eventual use by the wireless users (including federal, state, county and municipal government) in these areas is a necessary first step, these agreements do not always cover delivery of necessary added local fronthaul or radio equipment to deliver wireless services. Parallel implementations that provide both CAF availability and/or tax incentives to carriers within the same region would increase the quality of service and reduce overall deployment time.

A uniform regulatory environment would ultimately lower deployment costs. For example, capping permit and Rights-of-Way (ROW) fees in local jurisdictions, as well as providing a timetable for local approvals would be beneficial.

Federal, state, county and municipal governments would benefit by making their own land, towers and rights-of-way more readily and inexpensively available to qualified infrastructure providers that want to offer broadband services. The president issued an executive order in 2012 to aid this process. However, it has not been fully realized. A 2015 report said the lack of inter-governmental agency communication and cooperation were major causes for continued lack of deployment on federal lands.[7] This is noteworthy as one-third of the total land mass in the United States is owned by the federal government.

Digging once and overbuilding backhaul in all of the aforementioned locations is sensible and encouraged at the federal level.[8] Encouraging similar methods for fronthaul deployments is prudent as well. It should be noted that both the delivery of backhaul and fronthaul may become more expensive as time passes. Providing tax incentives and/or mandates to new structures for both indoor and outdoor for backhaul and fronthaul should be considered.

Lowering the cost and time to deployment of fronthaul and backhaul infrastructure overall might also be assisted by discussing remedies to the local and private requirements above NEC code that are often considered as financial roadblocks to the installation of low voltage or fiber-optic fronthaul.

Fronthaul and backhaul transport solutions are integral to robust mobile broadband networks, enabling the United States and its citizens to compete in a global economy. Removing barriers to mobile broadband adoption must continue at the federal, state and local levels. As such, fronthaul and backhaul solutions must be included in any discussion on deploying mobile broadband networks.

Axcess Ontario: One Community's Solution

A strong wireless infrastructure foundation enables productive citizens, who require mobile broadband services to work, play and live. Indeed, if a company is considering locating a business or branch in a local jurisdiction, they often check to ensure there is proper connectivity.

Axcess Ontario is a nonprofit entity formed in 2005 to build fiber infrastructure in its community. Ontario County is located in upstate New York with a population topping 100,000 (as of 2000) and a total area of 662 square miles. Axcess Ontario completed its 200-mile fiber ring around the county at a cost of $5.5 million.

"To date, Axcess Ontario has signed master agreements with eight telecom and broadband companies, including Verizon Wireless and national broadband provider TW Telecom. Axcess Ontario is in continual discussions with other service providers, and is working aggressively on its next goal of luring a fiber-to-the-home (FTTH) service provider to Ontario County. With the fiber ring complete, businesses and municipalities now have access to faster and less expensive broadband, as well as bandwidth equal to global broadband leaders. Businesses can gain access to the ring simply by contacting any of the eight service providers that work with Axcess Ontario," according to the entity.

There are several interesting aspects of this build including:

- Verizon Wireless, seeking dark fiber for backhaul, was one of the first customers of Axcess Ontario.

- The open-access philosophy isn't limited to just offering the dark fiber and access to all service providers that desire transport, but open access also to promote the delivery of innovative services provided by non-carrier companies.

- Axcess Ontario already has executed agreements with service providers, indicating that demand exists for new dark fiber from multiple network operators in areas where it did not exist previously. Where there is cash flow, project financing can be structured.

The open-access model for providing dark fiber is not the only critical component to success. Once this basic foundation has been established, it is also important to ensure that the dark fiber system provides neutral access. To ensure neutrality, the following options should be considered:

- Determine the location of the closest carrier-neutral collocation facility. Factor in the cost of extending the local dark fiber network to that point and establish a presence. This gives the local dark fiber network the physical proximity necessary to effectuate interconnections to the greatest number of potential customers in a neutral environment.

- Determine the location of the closest long-haul neutral dark fiber system. Factor in the cost of extending connectivity to the closest access point to it and establishing a physical fiber splice point with that system. This will enable the customers that seek the local dark fiber access to it through the long-haul dark fiber.

If neither of these two options exist due to distance constraints, lack of local providers of either neutral collocation or of long-haul dark fiber, the location in question might not be economically feasible.

A strategy of "low-hanging fruit" then should be considered. As the easier targets are identified, selected and built, it brings the more difficult-to-reach locations that much closer. This process requires a nationwide perspective when network planning.

About the Authors

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Don Bach is the Vice President of Engineering for SAC Wireless. After graduating from the Electrical Engineering program at DeVry University in 1986, Don went to work as a technician in the Public Safety and LMR two way radio industry. In 1994, Don was hired as a System Performance Engineer on the iDEN Network by Fleet Call, later to be renamed Nextel. After 22 years in a variety of RF Engineering positions, Don left Sprint in 2007 to start a regional RF Engineering and implementation company focused on DAS networks. In 2012, Don sold this company to SAC Wireless. SAC wireless was purchased in 2014 by Nokia Networks.

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Arnold Kim is the Chief Operating Officer at Advanced RF Technologies, where he oversees various functional departments including Sales and Engineering. He has 15 years of experience covering the telecommunications industry. His former clients include ARINC, EarthLink, Frontier Communications, Global Crossing, MRV Communications, Motorola, Sorrento Networks, SK Telecom, Teleglobe, and WaveSplitter Technologies. He previously worked at Bear Stearns, Evercore Partners, J.P. Morgan, and Salomon Smith Barney. He earned his MBA in Finance and Economics and his BA in English and Economics, both from Columbia University. Arnold is passionate about bringing ADRF's innovative solutions to market in an effort to solve the in-building industry's most challenging needs.

Allen Dixon, HMI Technical Solutions

Allen Dixon is a 25 year veteran of the telecom industry. During his career, Allen has held positions of increasing responsibility ranging from field engineer, marketing, and product line management to his current role as an account executive with HMI Technical Solutions. He is a strong advocate of the role of standards in telecom and has participated in the ATM Forum, Fibre Channel, IEEE, and TIA. He is currently the Chair of the HetNet Forum. Allen is a 1985 graduate of the University of Florida and a US Navy veteran.

Larry Louk, Selective Site Consultants

Larry Louk is a founding principal of Selective Site Consultants. Established in 1997, SSC provides real estate, engineering, entitlements, and construction management services concentrated in the telecommunications industry. Larry has over 33 years of management and business experience, with 15 of those years as a practicing attorney in the areas of real estate (including acquisitions and commercial lease negotiation/litigation), mergers and acquisitions, municipal zoning matters and special assessment litigation, construction litigation, licensing agreements, and public hearing presentations.
Presently, Larry serves as general counsel to SSC and is president of SSC's affiliated company, Selective Site Development, which currently concentrates on tower development. Larry is a graduate of the University of Kansas where he received his bachelor's degree in Civil Engineering in 1979 and a Juris Doctorate in 1982.

Hunter Newby, Allied Fiber

Mr. Newby is an entrepreneur with a highly successful, 15-year track record in creating new, network-neutral interconnection businesses that treat communications infrastructure as real estate. He is the Founder, CEO and a Director of Allied Fiber, the nation's first integrated, network-neutral colocation and dark fiber infrastructure provider. Prior to founding Allied Fiber, he was a Founder, Chief Strategy Officer and a Director of The Telx Group, Inc., one of the leading carrier hotel interconnection facility operators in the U.S. Mr. Newby is a recognized authority in the industry, has served on several Advisory Boards, is a published author, public speaker and the recipient of numerous awards including being named to the Global Telecoms Business Top 40 Under 40 in 2010. Mr. Newby earned a B.S. in Communications from Drexel University.

Footnotes

1 Ericsson Fronthaul http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&c-d=1&ved=0CB8QFjAAahUKEwiu_KLI15THAhXWGpIKHctEDsY&url=http%3A%2F%2F-www.ericsson.com%2Fourportfolio%2Fproducts%2Ffronthaul%3Fnav%3Dpro-ductcatagory006%257Cfgb_101_0516&ei=ZXHDVe61Fda1yATLibmwDA&usg=AFQ-jCNEF9Tm0pRy7zCKW5lmygEBhj9glRA&sig2=06E4Y2qxKb3NX7ORbqGGpA&b-vm=bv.99556055,d.aWw

2. Cisco Visual Networking Index
http://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-network-ing-index-vni/VNI_Hyperconnectivity_WP.html

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6 http://news.centurylink.com/news/centurylink-to-bring-broadband-to-1-2-million-ru-ral-households-in-33-states

7 Broadband Opportunity Council Report and Recommendations August 2015. https://www.whitehouse.gov/sites/default/files/broadband_opportunity_council_report_final.pdf

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