White Paper

The Importance of Backhaul Performance in Wireless Networks

Wireless Networks are at the core of modern communication and enable ubiquitous, high-bandwidth connectivity independent of the user's location. While the term "wireless" may imply that all the communication happens in a wireless fashion, it is actually only the last-mile from the radio tower to the end user device which is traversed "over-the-air". The majority of the communication path is still wireline. In this scenario the radio towers act as collection devices that receive wireless calls and data which are then forwarded, a.k.a. "backhauled", on to the core of the communication network for further processing. In this role, "backhaul links" serve as the veins and arteries of the wireless communication network.

In technology terms, backhaul describes the transport infrastructure used to connect the radio access network (RAN) back to the core of a mobile network. This vital link between cell tower location and provider hub is a central component of wireless network infrastructure.

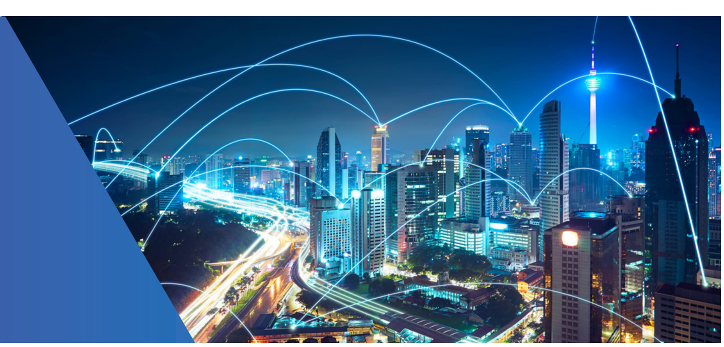
Why are Backhaul Networks Important?

The importance of a backhaul network is frequently understated. Backhaul performance in terms of bandwidth and capacity, reliability, and transmission delay are critical in support of any radio access (RAN) and directly impact the wireless user's experience. Without a reliably working backhaul infrastructure no wireless network will ever function to anyone's satisfaction. Packet loss, high latency, and carrier jitter, and consequently an aggravating user experience are just a few of the issues to be expected when backhaul links are not performing as expected or have been configured incorrectly.

The Impact of 5G on Backhaul Networks

Although each new generation of mobile technology has ratcheted the pressure on backhaul networks, the impact of 5G is unmatched by all previous iterations. The diversity of use cases, MIMO, and network slicing have influenced backhaul for 5G in profound ways. In addition, network densification and the reduced coverage capacity of millimeter wave have exacerbated the 5G backhaul challenges.

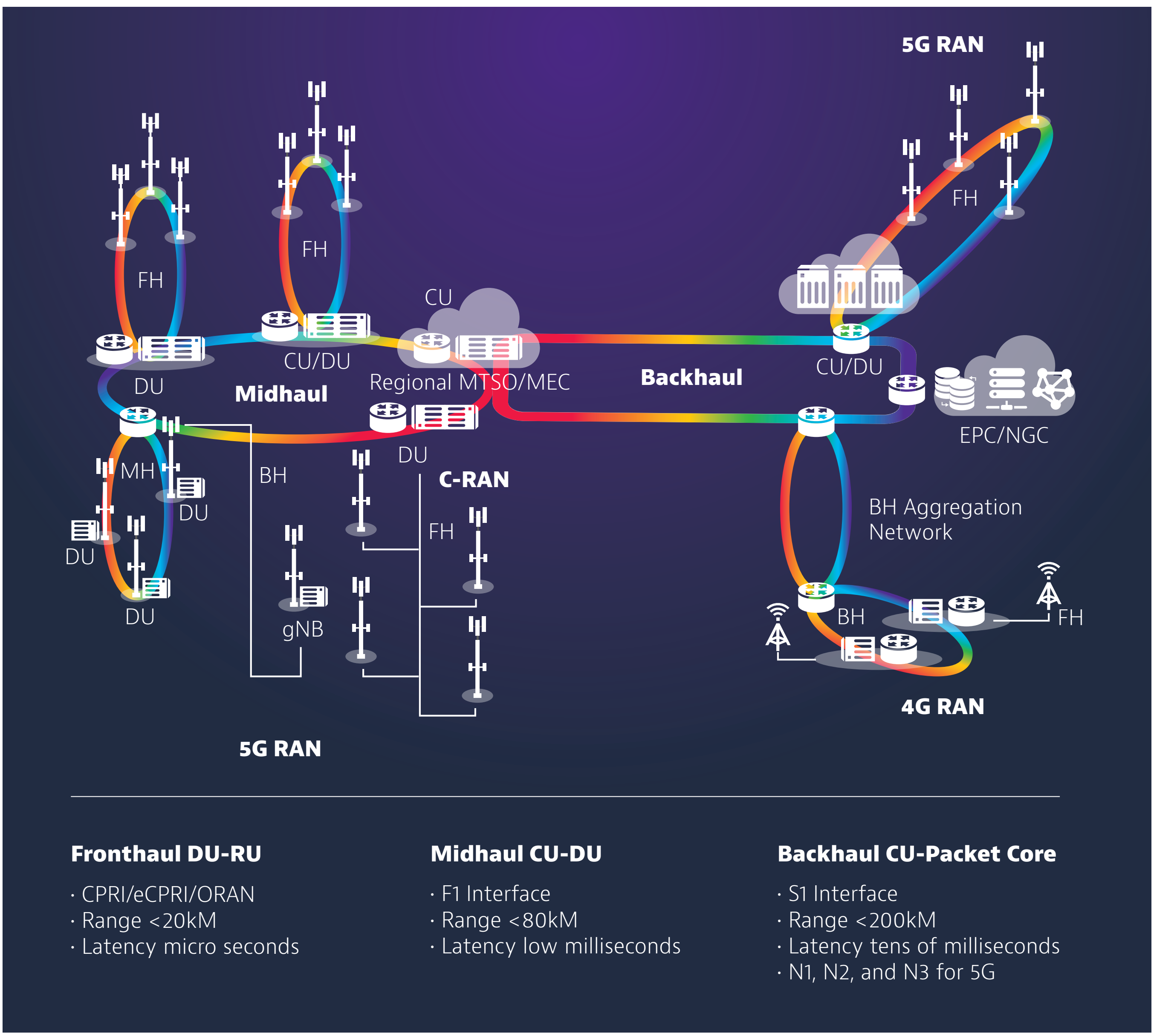
Although each new generation of mobile technology has ratcheted the pressure on backhaul networks, the impact of 5G is unmatched by all previous iterations.



As a consequence, a new architecture has been proposed to enable these new use cases. Split architectural models have given rise to the fronthaul and midhaul, which augment the traditional backhaul definition. Combined backhaul, fronthaul, and midhaul architecture are also known as x-haul, with the backhaul component distinguished by its connecting link to the core.

Ulimately 5G wireless backhaul has to overcome multiple new challenges. At peak throughput and download speeds of up to 10Gbps, exponentially higher data loads must be backhauled from infinitely more locations. Each of the primary 5G use cases, including Enhanced Mobile Broadband (eMBB), massive Machine-Type Communication (mMTC), and ultra-reliable Low-Latency Communications (urLLC), are very demanding when it comes to bandwidth requirements, low latency transport and high service availability.

Furthermore, in an attempt to address mission critical, low latency applications 5G deployments are moving the compute function out to the edge of the network, thereby adding additional points of complexity into the backhaul architecture.



Ethernet Backhaul

Although there are many different types of transport protocols used for backhaul circuits, packet-based Ethernet supports backhaul for 5G particularly well. Bit rates and link distances have increased through the introduction of fiber-based Ethernet, and bandwidth limitations have been alleviated. Since Ethernet lacks the precise frequency synchronization of TDM backhaul, the precision time protocol (PTP) has been developed by the IEEE to address Ethernet synchronization, including long-distance backhaul links. This fidelity is essential for 5G use cases like driverless cars that rely on precise timing an ultra-low latency level.

Common Backhaul Network Problems

Backhaul networks are vulnerable to the same performance risk factors as other wired and wireless networks. The physical layer backhaul links (Fiber or Copper) are subject to unintended physical damage, weather events, and security breaches (tapping). Ethernet backhaul segments, while superior in capacity and cost, must contain network timing and synchronization information. Poor network synchronization leads to neighboring towers interfering with each other, dropped calls, and diminished data throughput. An unmitigated backhaul problem can manifest as latency, jitter, or packet loss that negatively impacts user the experience and satisfaction levels.

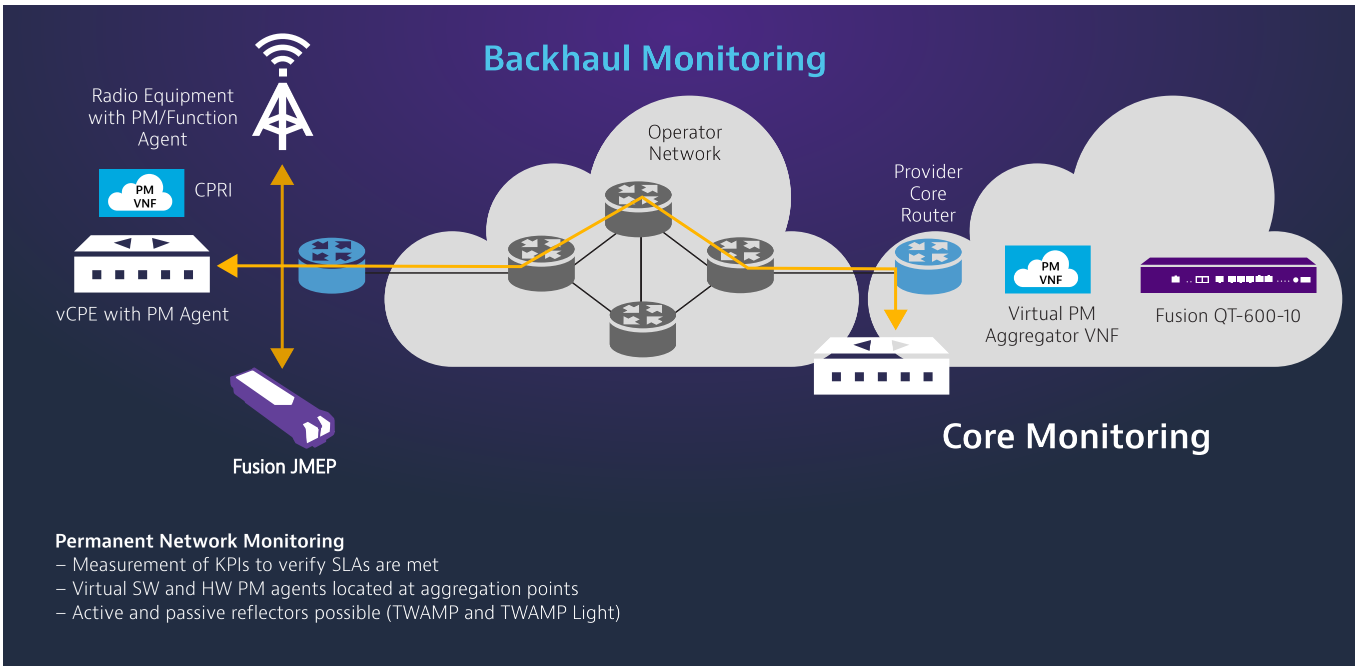
Small cell proliferation, throughput demands, and massive traffic challenges brought on by 5G continue to raise the network operations bar for carriers. Moreover, 5G is mandating latency values which are significantly more stringent than in previous generations of wireless networks. While 3G and 4G network could operate with 10s of milliseconds of backhaul latency, 5G networks now require sub 1ms latency values.

While these issues are widely recognized, 5G mobile backhaul solutions to them vary by operator. Backhaul aggregation at “super cells,” wireless backhaul via millimeter wave, and an unlimited number of holistic solutions merit consideration and preparation.

Why Test Backhaul?

Earlier generations of mobile backhaul technology were designed to support macrocell infrastructure in a predictable manner resulting in only a few, easily manageable backhaul links. As TDM has transitioned to Ethernet/IP and small cells supplant the traditional macrocell model, base station architecture and traffic management strategies are adapting accordingly, manifesting in a dramatic increase in the sheer number of links and aggregated traffic transported over them. These incremental changes combined with the strict latency and latency variation (jitter) requirements have altered mobile backhaul test strategies from a “test it and forget it” verification approach to a philosophy based on continuous performance monitoring.

5G use cases with stringent throughput and latency requirements have slashed the margin for error. Packet-based Ethernet has streamlined the backhaul data flow, although bit error rates (BER) and packet loss must remain exceptionally low to support data-intensive applications like artificial intelligence (AI) and augmented reality (AR). Backhaul testing and monitoring of performance metrics over time can ward off potential issues quickly and accelerate troubleshooting.



Service Targets

Definitive service targets are the first step on the path to customer satisfaction. Each new site has a unique mixture of service level agreements (SLAs), coverage goals, and backhaul utilization projections that ultimately drive the backhaul architecture, capacity, and test requirements. Especially in scenarios where backhaul is sold/bought as a managed service it is essential that the SLA definitions cover all potential use cases as well as all the various stages of the backhaul circuit lifecycle from activation/handover testing via operation/monitoring to malfunction/troubleshooting.

Service Activation

Service activation is an important phase of backhaul testing to verify the installed/provisioned backhaul circuit is capable of performing according to the required service levels and performance baselines. Automated test tools streamline backhaul fiber link characterization and Ethernet service turn-up based on legacy RFC 2544 or more recent and up-to-date Y.1564 specifications. Quick diagnosis of throughput, frame loss, and latency issues can accelerate service roll-out and handover and prevent a backhaul problem from delaying site certification. Industry best practices include the creation of a circuit's "birth certificate" which acts as reference for future problems or disputes. Recently service providers also added higher layer TCP or UDP testing to the activation procedure in order to test the backhaul link using traffic that resembles actual user traffic as close as possible. In order to provide permanent testing capabilities service providers even start adding permanent test capabilities in the form of Smart SFPs or Test VNFs to their backhaul links.

Backhaul Assurance / Performance Management

The economic consequences of backhaul degradation can be devastating, so ongoing performance management and key performance indicator (KPI) trending for all backhaul links is no longer a luxury. Automated fiber monitoring solutions, transport assurance options, and a new generation of microprobes work in tandem to immediately detect faults, degradation, or security intrusions and generate alarms. With hybrid backhaul deployments combining the best transmission technologies to meet the standards of 5G, advanced test and monitoring solutions for 10G backhaul links are another essential test and monitoring element.

Troubleshooting

A non-functional backhaul link poses a major risk for the overall functionality of a Mobile Network. Hence it is imperative to have solutions in place that enable immediate troubleshooting and restoration of the non-functional link. Instead of relying on (potentially even unnecessary) service technician dispatches a lot of service providers have been turning towards including test and troubleshooting tools and systems into their initial backhaul design. Smart SFPs and Test and PM VNFs enable immediate action once a problem has been detected and impacts the performance of the mobile Network. Even automated use cases where networks detect anomalies themselves and take corrective action or troubleshooting actions themselves become realistic with such a setup. The ideal solution would nevertheless still foresee the usage of expert field tools in case the fault turns out to be more complicated.

Summary: The Future of 5G X-Haul

As operators gradually transform their 5G deployments from being extensions on existing 4G infrastructure to becoming their own standalone wireless network infrastructure, highly anticipated use cases beyond just more bandwidth (eMBB) will be enabled. The hope is that those new use cases will enable new customers and revenue streams. However, these new applications will also mandate a closer supervision and monitoring of this new wireless network architecture.

As new 5G services deliver new customers and use cases, the impact on future x-haul networks will be substantial. Significantly higher bandwidth paired with very strict traffic prioritization, latency, and jitter requirements demand a new approach regarding the testing and monitoring of backhaul links. To address this challenge proactively, out-of-box thinking will need to complement the simple multiplication of existing Ethernet and wireless backhaul links. Open RAN standards are a part of the solution, driving efficiency through interoperability, convergence, and market competition.

By splitting traditional backhaul technology into configurable fronthaul, midhaul, and backhaul segments, x-haul has produced a solution equal to the task at hand. However, it is only through effective testing and monitoring for the breadth, flexibility, and lifecycle of mobile backhaul networks that will ensure service levels and satisfaction for future generations.

VIAVI Solutions

Contact Us **+1 844 GO VIAVI**
(+1 844 468 4284)

To reach the VIAVI office nearest you,
visit viavisolutions.com/contact

backhaul-wirelessnetwork-wp-nsd-nse-ae
30193209 900 0921