

Understanding the Basics of CPRI Fronthaul Technology

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By now, we should all know what has been driving Mobile Network Operators (MNOs) to upgrade their cell towers: fierce competition between each other to provide higher bandwidth and quality of service. Typical Internet traffic has been constantly increasing. Mobile video traffic by the usual suspects, such as YouTube, Vine, Netflix, just to name a few, are growing very fast. MNOs have been forced to look outside of the box and come up with solutions that keep them competitive—all while offering the level of service their customers have come to expect.

Traditional coaxial-based systems on cell towers or legacy cell towers around the world are being completely overhauled. Bulky, expensive and power-hungry copper cabling is being ripped out and replaced by fiber for more capacity and longer-reach distances. The shift to a fiber-optic infrastructure now offers more scalability that will help guarantee coverage and bandwidth growth as well as cost efficiency for years to come.

As fiber optic cabling is found at each and every new green field cell tower installation, so is a new protocol called Common Public Radio Interface (CPRI). Fiber and CPRI together allow MNOs to deliver better quality and faster service to all mobile device users.

Let's have a look at the main differences between a legacy cell site versus an updated site that is ready to deliver 4G LTE. As we can see from Figure 1, legacy cell towers can consist of long runs of copper cabling that connect the remote radio unit, which is located at the base of the tower, all the way up to the top of the tower where the antennae are located. Unfortunately, this type of infrastructure is quite restrictive. MNOs are required to have a large footprint with a dedicated hut, power supply and backup (UPS), and air conditioning facilities. Copper cabling is also quite restrictive due to the inherent power-hungry amplifiers, appropriate cooling, and battery backups to make sure everything is running according to spec. As a result, the cost to run a cell site becomes prohibitive as there is more and more need to build and maintain even more cell sites to satisfy the expected mobile user demand. While the current legacy cell towers do work, they are not ready for what the future holds for mobile device users. Moreover, they will not be cost-efficient down the road.

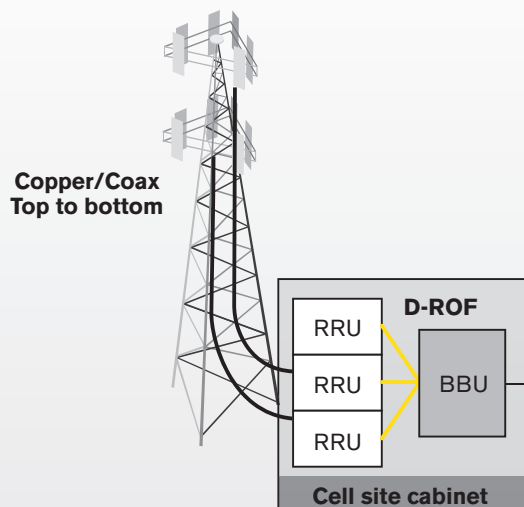
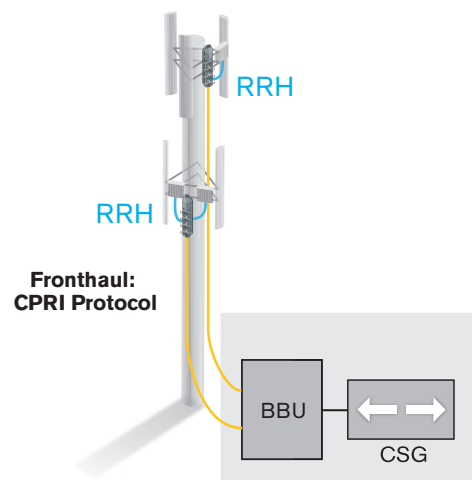


Figure 1. Traditional coaxial-based systems on cell towers with large overhead (copper cabling, large footprint, power, A/C, lower bandwidth)

If we take a look at a similar cell site that has been upgraded, we see that the main difference is the copper cabling has been all but replaced by fiber between the base station and the cell tower antennae (refer to Figure 2). Moving from copper to fiber cabling offers MNOs less noise, lower power requirements, higher bandwidth, and, more importantly, longer distances required for emerging Cloud-RAN (C-RAN) networks. Another clear difference is that the remote radio unit, which was located at the bottom of the legacy cell tower, has now been moved to the top of the cell tower right alongside the antennae, and, in more recent cases, completely incorporated into the cell tower's multiple antennae.



Next-generation fiber-based cell tower with lower overhead (reduced power consumption, fiber replaces copper cabling, RRH at top of tower, digital radio over fiber, CPRI protocol)

The communication protocol running over the fiber between the baseband unit and the remote radio head is the Common Public Radio Interface (CPRI). CPRI was established in 2003 by base station vendors, such as Ericsson, Nokia Siemens Networks, Alcatel Lucent, NEC, and Huawei Technologies, to define a publicly available specification that standardizes the protocol interface between base station devices (baseband unit and remote radio head). Figure 3 demonstrates how the CPRI protocol works from getting the RF signal transmitted over fiber towards the IP Backhaul—and vice versa.

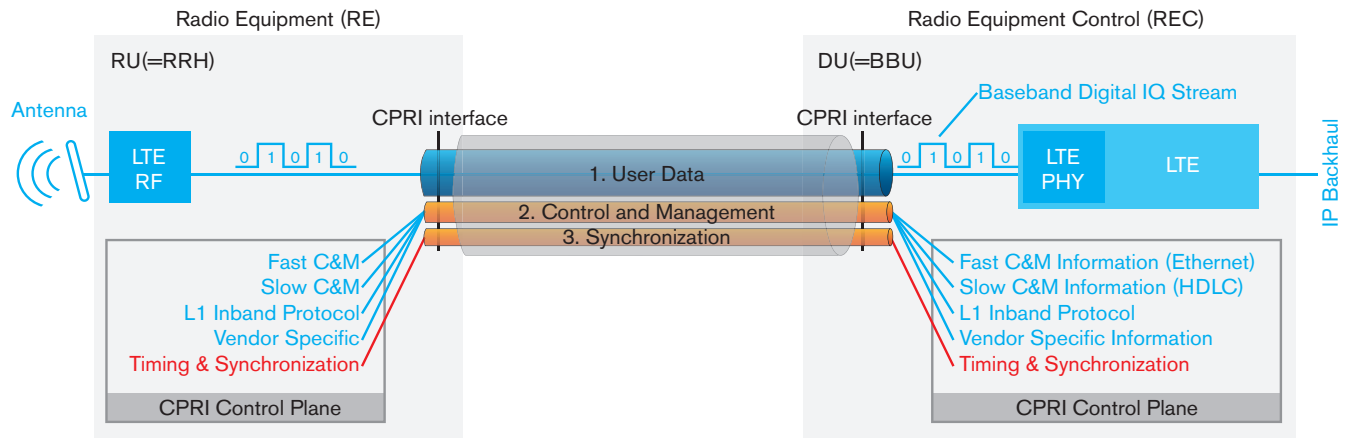


Figure 3. CPRI transport concept

Furthermore, Figure 3 illustrates that the incoming RF data is digitized via the remote radio head (RRH), commonly referred to as Digital Radio over Fiber (D-RoF). The digitized data is then wrapped up into the CPRI protocol's "User Data" signal flow, known as IQ Data; "I" refers to In-Phase and "Q" refers to Quadrature. The same process takes place as traffic is entered via the IP Backhaul; the traffic enters the Digital Unit (DU) and is wrapped again within the user data signal flow of the CPRI protocol. Once the RRH receives this data, it then converts it back to analog, amplifying and radiating it over the air, and eventually making it to the User Equipment (UE).

The most recent CPRI specification is version 6.1, which recognizes the following interface rates/ options:

- › CPRI line bit rate option 1 = 614.4 Mbps
- › CPRI line bit rate option 2 = 1.2288 Gbps
- › CPRI line bit rate option 3 = 2.457 Gbps
- › CPRI line bit rate option 4 = 3.072 Gbps
- › CPRI line bit rate option 5 = 4.915 Gbps
- › CPRI line bit rate option 6 = 6.144 Gbps
- › CPRI line bit rate option 7 = 9.830 Gbps
- › CPRI line bit rate option 7A = 8.110 Gbps
- › CPRI line bit rate option 8 = 10.137 Gbps
- › CPRI line bit rate option 9 = 12.165 Gbps

Now that we understand the basics and main drivers of the Fronthaul revolution, we can delve a little deeper into where things are headed, given that the end game for MNOs does not just stop at the replacement of copper to fiber. With these two key factors introduced in today's cell tower upgrades, fiber optic cabling and Common Public Radio Interface (CPRI), MNOs can now look to the future, which is C-RAN. C-RAN, also referred to as Cloud-RAN or Centralized-RAN, is a new cellular network architecture for the future mobile network infrastructure. It is essentially a new cloud based radio access network. Traditional radio access networks, as illustrated in Figure 1 and Figure 2, are built with many stand-alone base stations (BTS). These traditional cell towers are expensive to build and operate, and remain quite limited in capabilities. C-RAN is an evolution that aims to take full advantage of the fiber optic cabling and CPRI protocol. With both of these key new components comes flexibility and reliability. Fiber and CPRI, when combined together, offer IP bandwidth of up to 600 Mbps—and eventually even higher.

With the advent of C-RAN, together with fiber and CPRI, MNOs now have the ability to centralize base station deployment up to 40 KM away. This offers a low-cost, highly reliable, low-latency and high-bandwidth interconnected network—a major win for MNOs.

The two most common types of C-RAN architectures are depicted below. Figure 5 illustrates how not just one but many baseband units (BBUs) can now be setup within a central office, referred to as BBU hosting, stacking or centralization. Figure 6 illustrates a similar situation; however, in this case, one BBU is used to run multiple cell towers.

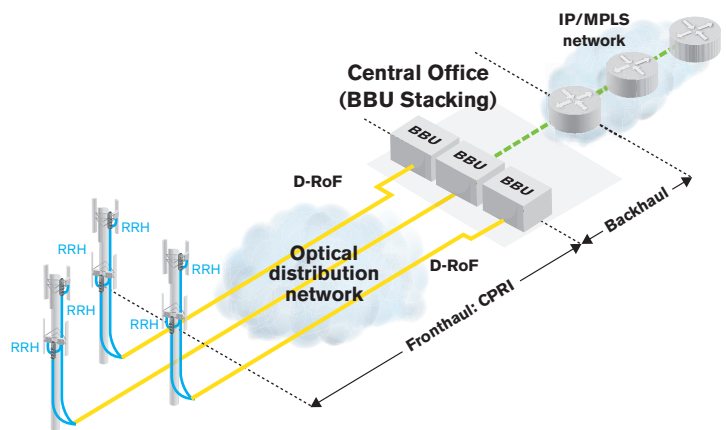


Figure 5.

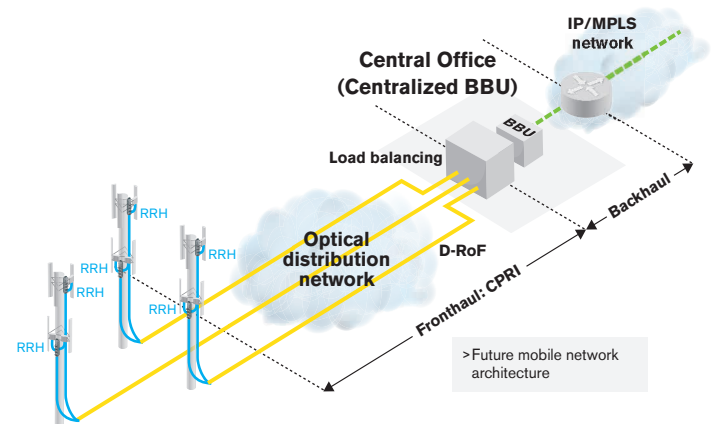
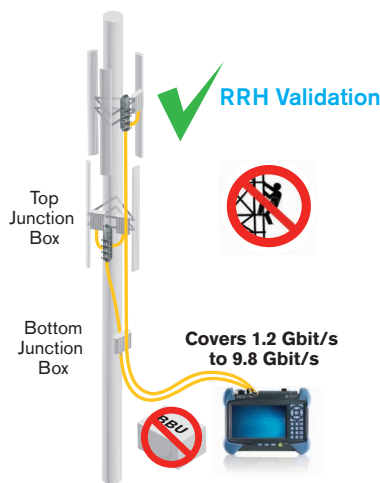


Figure 6.

The great strides made in the telecommunications industry give rise to new challenges for cell technicians who have to learn and test these new technologies. The main challenge that MNOs are faced with is the ability to install and troubleshoot equipment that uses the new CPRI protocol.

During the construction phase when the actual CPRI equipment (such as the RRH and BBU) is installed, there is no clearly defined process that states each equipment must be installed and tested simultaneously. As such, below are a few scenarios that demonstrate how MNO field technicians could benefit from a test instrument that incorporates fiber testing, Ethernet testing, and the CPRI protocol in one easy to use solution, thus saving them time and money.

SCENARIO 1

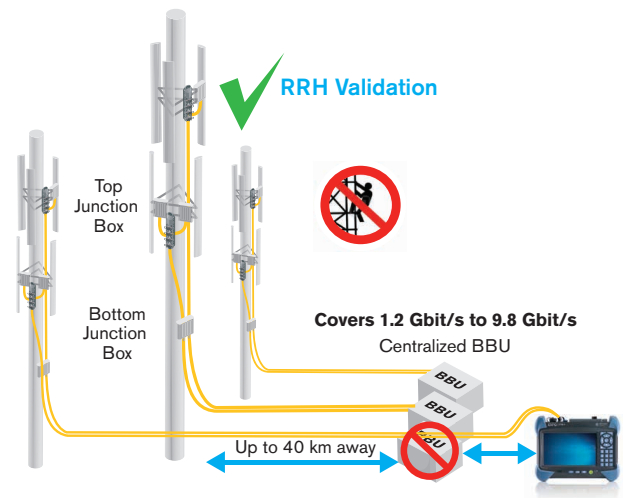


When installing a remote radio head (RRH), it is critical that all equipment at the top of the tower be verified before the riggers are finished with the construction phase.

The master CPRI protocol included with the FTB-800 NetBlazer Series portable test instrument will verify that the RRH is fully operational and that the right SFP transceivers are installed and connected correctly.

When the test unit is enabled with the master CPRI protocol, technicians can easily connect to the RRH without ever attempting to climb the cell tower. Whether or not the cell site's BBU is connected to the RRH, the NetBlazer is capable of emulating a CPRI enabled BBU. Once connected to the RRH, the NetBlazer is able to supply the field tech with a complete analysis of vital CPRI statistics, which include optical power levels, protocol version, frequency and frequency offset, hyperframe and code word counts as well as the negotiated Ethernet or HDLC control and maintenance channels. With all of this information readily available, the field technician can easily ensure that the RRH is working at the right specified line rate and that it is timed and fully transmitting continuous frames from the top of the tower to the bottom of the tower.

SCENARIO 2

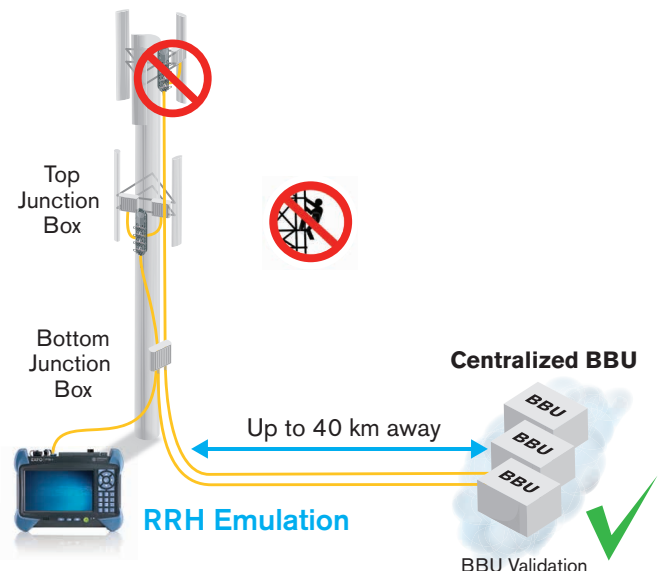


Scenario 2 illustrates a typical Cloud-RAN architecture with BBU centralization.

Similar to Scenario 1, when installing a RRH, it is important that all the equipment be verified before the riggers are finished with the construction phase.

The NetBlazer's master CPRI protocol feature will work just as well from the bottom of the tower (Scenario 1) as it will kilometers away, which is the case in a Cloud-RAN environment.

SCENARIO 3



In the above mentioned scenarios, the focus is on emulating the BBU in order to test the health of the RRH without having to climb the cell tower. Now, let's present the reverse scenario; without having to climb the cell tower, a field technician can use the NetBlazer portable field tester to emulate the RRH to test the CPRI protocol. This is referred to as the remote portion of the CPRI protocol. With the combination of both the CPRI master protocol (emulating the BBU) and the CPRI remote protocol (emulating the RRH), calling in a costly team of riggers can be avoided.

CONCLUSION

When it comes to troubleshooting issues at the cell tower, verifying CPRI links between the remote radio head (RRH) and baseband unit (BBU) plays a key part. Once a problem is detected and the cell technician has confirmed that the fiber and junction boxes are all testing with ZERO issues, that only leaves one last point of intervention: testing the CPRI protocol. However, cell technicians today do not have the right means for testing the CPRI protocol. Therefore, a costly next step is to call in a team of riggers to scale the tower and change expensive equipment—blindly. This again can be avoided by providing the cell technicians field-friendly test equipment that will do everything at one time: fiber testing, Ethernet testing and the new CPRI protocol analysis.

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