5G radio access networks: the way forward

C-RAN

Centralized radio access networks (C-RAN) started with 4G and is expected to become prevalent in 5G. The migration towards C-RAN aims to take full advantage of the fiber-optic infrastructure and the CPRI protocol. This type of centralized architecture brings many advantages to mobile network operators, including:

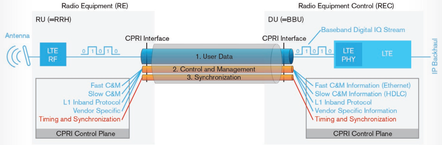
- CAPEX and OPEX savings through simplified antenna sites
- flexible operations
- network scalability
- future-proof networks in preparation for 5G

The requirements of 4G LTE and 5G will have an impact on the fronthaul and backhaul—and will require improved coordination of radio resources. In anticipation of the massive 5G deployment slated for 2020, there is growing pressure on mobile operators to adopt a centralized-RAN architecture, which will evolve to a virtualized RAN architecture (or Cloud-RAN) in order to reap all the benefits of new 5G concepts.

CPRI

The Common Public Radio Interface (CPRI) is the mainstream communication protocol in current fronthaul networks that transports the digital RF signal on the optical link between the BBU and the RRH. The BBUs main function is to convert the IP/Ethernet data coming from the mobile backhaul into digitalized radio frequency signals (I-Q data). Today, CPRI rates are designed to support up to 24.3 Gbit/s of RF data capacity. CPRI operates at data rates from 614 Mbit/s at the low end to more than 10 Gbit/s at the high end but only up to 600 Mbit/s are available for customers. The delta between the link rate and the customer speed is due to heavy processing in the CPRI protocol (i.e., the conversion from digital to analog RF).

The main features of CPRI include a User Plane that transports the IQ data, a Control & Management Plane that provides control signaling to and from the RRH, and a Synchronization Plane that transfers synchronization and timing information between nodes.

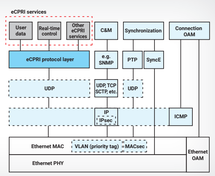


Source: Netmanias

CPRI line bit rate option	CPRI bit rate	Line coding	Protocol version (scrambling)
1	614.4 Mbit/s	8b/10b	Version 1: No scrambling
2	1228.8 Mbit/s		
3	2457.6 Mbit/s		
4	3072.0 Mbit/s		
5	4915.2 Mbit/s		Version 1: No scrambling Version 2: Scrambling
6	6144.0 Mbit/s		
7	9830.4 Mbit/s		Scrambling recommended
7A	8110.08 Mbit/s		
8	10137.6 Mbit/s	64b/66b	Version 2: Scrambling
9	12165.12 Mbit/s		
10	24330.24 Mbit/s		

eCPRI

As the industry migrates to LTE-Advanced Pro and 5G, requirements including latency, power loss and CPRI bit error rate will become concerns, given the need for faster fronthaul and backhaul speeds. Fronthaul networks will be required to support speeds of up to 25 Gbit/s, 50 Gbit/s, even 100 Gbit/s with the higher traffic loads and more demanding services. New specifications such as Enhanced CPRI (eCPRI) are being released to support new 5G services and massive MIMO deployments. This new fronthaul packet-based protocol is dedicated to transporting radio data over Ethernet or IP networks between the DU and the RU in 5G networks.



New 5G technical requirements

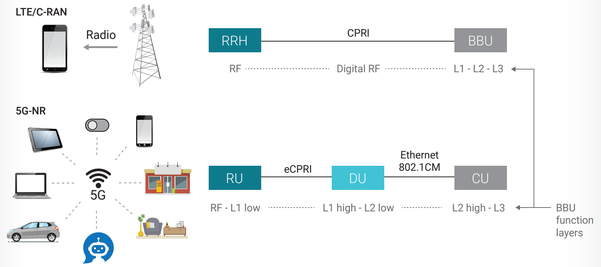
Reliability/reactive		Mobile broadband		Massive IoT	
URLLC		eMBB		mMTC	
<1 ms	**1.4x**	**20 Gbit/s**	**100 Mbit/s**	**1000x**	**100x**
Ultra-low latency	Mobility [500 km/h]	Download	Throughput	Connection density [106 devices/km2]	Network energy efficiency
		Throughput, capacity, coverage			

This can be achieved through:

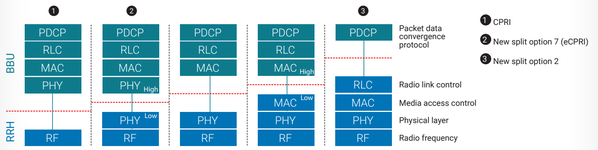
New spectrum bands & new radio antennas	Centralization and RAN functional split	Network slicing (E2E virtualization)	Ultra-low latency < 1 ms 99.9999% reliability

Requiring highly reliable RAN (5G-NR) based on Cloud-RAN

5G-NR new functional split options



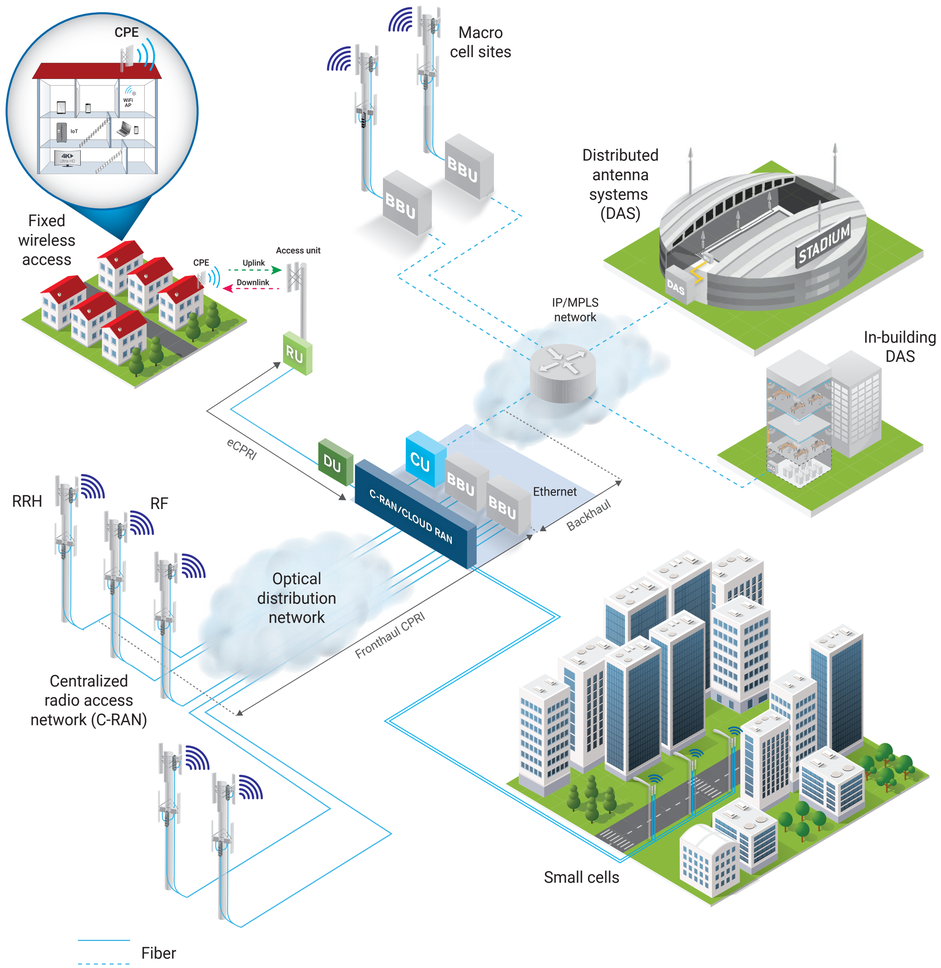
eNB/gNB functional split



Function split impact

Connection	CPRI	Split PHY	MAC-PHY	Split MAC	PDCP-RLC
Data rate	2500 Mbit/s	1075 Mbit/s	152 Mbit/s	151 Mbit/s	151 Mbit/s
Latency	< 0.25 ms	0.25–2 ms	2 ms	6 ms	30 ms
Impact on CoMP gain	0%	–5%	–15%	–25%	–55%
Technology	WDM-PON	WDM-PON	EAD, FTTP?	EAD, FTTP, Gfast?	EAD, FTTP, Gfast

Source: British Telecom



Boost your network's performance

CPRI and eCPRI

Link validation - RRH/RU Testing

Objectives (deployment and troubleshooting)

- Validate CPRI transport link
- Validate RRH operation
- Identify source of RF interference
- Complete FTTA infrastructure validation
- Validate antenna and coax cable system using VSWR and RSSI levels
- Validate RF transmission using over-the-air spectrum analyzer

Benefits

Eliminate unnecessary tower climbs by testing RRH health from the bottom of the tower via BBU emulation

RF spectrum analysis over CPRI

Objectives (deployment and troubleshooting)

- Access RF signals at the BBU location either at the bottom of the tower or at the C-RAN hub via the CPRI link
- Analyze the standard RF metrics such as DTF, VSWR and RF power
- Validate CPRI RF spectrum by accessing the digital uplink , where the CPRI protocol carries the RF signal in a digital format (IQ data)
- Identify and troubleshoot RF signal quality in cell sites

Benefits

- Fast diagnosis of issues such as external RF interference, internal and external PIM
- Quickly eliminate RF interference sources
- Simplify and speed up cell site deployment
- Reduce maintenance and troubleshooting expenses by eliminating unnecessary truck rolls and tower climbs
- Optimize network reliability and service quality at fiber-based cell sites

Fiber

Fiber inspection

Objectives (deployment and troubleshooting)

Inspect and clean:

- Active equipment (BBU and RRH)
- CPRI panel
- Junction box
- Test jumper
- Cable connectors
- MUX/DEMUX

Benefits

- Assess connector quality which is an essential step during fiber commissioning and installation
- Ensure a problem-free network by avoiding issues that stem from dirty or bad connectors
- Maintain connector certification records which can be important for future reference

Fiber characterization (OTDR)

Objectives (deployment and troubleshooting)

Validate:

- Total fiber length
- Total link loss (attenuation)
- ORL: the ratio of the forward optical power to the reflected optical power
- Splice loss: loss of optical power at a (fusion) splice point
- Connector loss: the loss of light at a mated pair of connectors
- Connector reflection: the percentage of power reflected back from a mated pair of connectors

Benefits

- Ensure proper transmission by controlling the power loss in the network against the link loss budget specifications from the network design requirements
- Complete fiber characterization to identify issues on the fronthaul fiber

Dispersion testing

Objectives (deployment and troubleshooting)

- Ensure that the fiber chromatic dispersion (CD) and polarization mode dispersion (PMD) are below the link dispersion thresholds
- Choose the proper dispersion compensation modules for 10G signals

Benefits

- Ensure that there will be transmission on the link
- Avoid optical pulse overlap and errors in transmission

Optical spectrum analyzer

Objectives (deployment and troubleshooting)

- Validate signal wavelength
- Validate signal power
- Check that signal power is higher than the receiver sensitivity

Benefits

- Ensure that there will be transmission on the link
- Eliminate BER on the link

Ethernet

Fixed wireless access and backhaul testing

Backhaul/packet-based fronthaul

Objectives (deployment and troubleshooting)

- Test and validate transmission performance of backhaul links to ensure that BER, throughput, latency, jitter and frame loss rates are met
- Troubleshoot issues by segmenting the investigation and identifying the root cause from the backhaul perspective
- Full line rate gigabit capability for wired electrical RJ45 interface, optical SFP and WiFi, providing latency and download and upload measurements
- Validate residential network performance from the wired to the wireless connection

Benefits

- Fast and efficient deployment of the backhaul network with easy validation of optical power budgets and KPIs at the installation phase
- Lower OPEX by dispatching the right teams to quickly resolve network issues in the backhaul and fronthaul (in most cases, the technical skills of both backhaul and fronthaul teams include different technologies)
- Guarantee speeds delivered match subscriber SLAs
- Improve subscriber quality of experience and reduce churn

EXFO's fronthaul and backhaul network test solutions

FIP-400B Series

Fiber inspection probe

These intelligent fiber inspection probes (USB or wireless) perform automated pass/fail connector endface analysis against standards (IEC, IPC or custom). They offer a fast and easy one-step process to detect, center, focus, capture, analyze and save results automatically, while removing any risk of false positives or misinterpretation of results. The wireless solution uses a smart device, eliminating the need to carry a platform to the top of the tower, and the LED indicator quickly communicates results for screenless, single-handed operation. All models are compatible with a multifiber inspection tip designed for easy access to recessed connectors in dense panels.

iOLM

Intelligent optical link mapper/OTDR

This innovative OTDR-based application uses multipulse acquisitions and advanced algorithms to deliver information on every element in the link by providing a one-touch, automatic analysis and clear link view display. iOLM minimizes training and avoids misconfiguration via automatic parameter settings and clear go/no-go results, turning complex OTDR information into simple and accurate analysis via Link-Aware™ technology. It also provides the ability to test two fibers simultaneously with the loopback testing method.

FTB-1 Pro dual carrier platform

Ultra-portable multiservice test solution

The FTB-1 Pro handheld test platform delivers unmatched operational efficiency and is truly the only all-in-one intelligent test solution that combines connector endface inspection, fiber characterization testing, CPRI link validation up to option 8, 10/25G eCPRI, BBU emulation, RF spectrum analysis over CPRI, over-the-air interference hunting and up to 10G Ethernet and SONET service validation. This solution integrates all the testing functionalities required to effectively activate, validate, troubleshoot and maintain fixed and mobile wireless networks.

OpticalRF

RF spectrum analyzer over CPRI

OpticalRF provides the industry's most powerful real-time high-resolution RF spectrum analysis over CPRI. Integrated into EXFO's intelligent fronthaul portable test solution, the FTB-1 Pro, as well as its remote testing and monitoring solution, SkyRAN, OpticalRF quickly and easily identifies external RF interference and internal and external PIM issues, providing cell techs with the speed, granularity and clarity to get the job done right, the first time.

Tektronix RSA306B

Over-the-air spectrum analyzer

This portable, USB-powered device delivers real-time spectrum analysis, streaming capture and deep signal analysis capabilities for signals from 9 kHz to 6.2 GHz. Combined with OpticalRF, it performs over-the-air RF interference hunting to validate carrier frequency, track down interference sources and maintain high-quality service levels. With BBU emulation, it monitors and measures RF signal quality and verifies BBU signal performance to validate the complete fronthaul infrastructure.

FTB-5235

Optical spectrum analyzer

The FTB-5235 entry-level optical spectrum analyzer is an easy-to-use instrument perfectly tailored for C-RAN analysis, thanks to its support of DWDM and CWDM technology. This compact, easy-to-use optical spectrum analyzer addresses various applications with a single product, and provides accurate channel power and channel wavelength measurements.

FTB-5700

Dispersion tester

The powerful FTB-5700 is the industry's only single-ended dispersion tester that accurately measures chromatic dispersion and polarization mode dispersion (PMD) from a single measurement location. It significantly reduces OPEX when compared with other products that require the use of devices at two locations.

SkyRAN

Fronthaul remote access and monitoring solution

This future-proof, scalable solution provides real-time, on-demand testing and 24/7 monitoring of the radio frequency (RF) spectrum and optical fiber networks. It features OpticalRF—the industry's best real-time, high-resolution RF interference analysis solution over CPRI as well as the patented OTDR/iOLM and Link-Aware technology.

EX1

Gigabit and WiFi test solution

EX1 is the industry's first pocket-sized, app-enabled gigabit & WiFi test solution designed to qualify broadband connections delivered to both residential and business Ethernet customers. The EX1 validates the delivery of full line rate Gigabit Ethernet speeds using Speedtest® by Ookla™ to provide latency and download and upload measurements, as well as complete WiFi testing with channel stats analysis.

Acronyms

4G/5G	4th/5th generation mobile network
BER	bit error rate
BBU	baseband unit
CPRI	common public radio interface
C&M	control and management
C-RAN	centralized radio access network
CU	central unit
CWDM	coarse wavelength division multiplexing
DAS	distributed antenna system
DU	distribution unit
DWDM	dense wavelength division multiplexing
EAD	Ethernet access device
eCPRI	Enhanced Common Public Radio Interface
eMBB	enhanced mobile broadband
eNodeB	evolved node B
FTTA	fiber-to-the-antenna
FTTP	fiber to the premises
HDLC	high-level data link control
LTE	3GPP long-term evolution (4G)
LTE-A	LTE-advanced
MAC	media access control
MIMO	multiple input multiple output
mMTC	massive machine type communication
NFV	network function virtualization
NR	new radio
OADM	optical add-drop multiplexer
OBSAI	open base station architecture initiative
OSA	optical spectrum analyzer
OTA	over-the-air
PDCP	packet data convergence protocol
PON	passive optical network
RAN	radio access network
RF	radio frequency
RLC	radio link control
RRH	remote radio head
RU	remote unit
URLLC	ultra-reliable low latency communication
WDM	wavelength-division multiplexing