



Migrate to cost-effective mobile infrastructure

Communication Service Providers around the world are under pressure to renew and improve performance of their mobile network infrastructure.

Consumers expect HD movies to play without interruption and gamers demand fast loading and smooth 3D or VR experiences. At the same time, mobile business users, industry and healthcare applications require high bandwidth and low-latency connectivity.

The current transition from 4G to 5G mobile equipment is the key enabler to such enhanced performance, but it must be supported by upgrades in the network infrastructure.

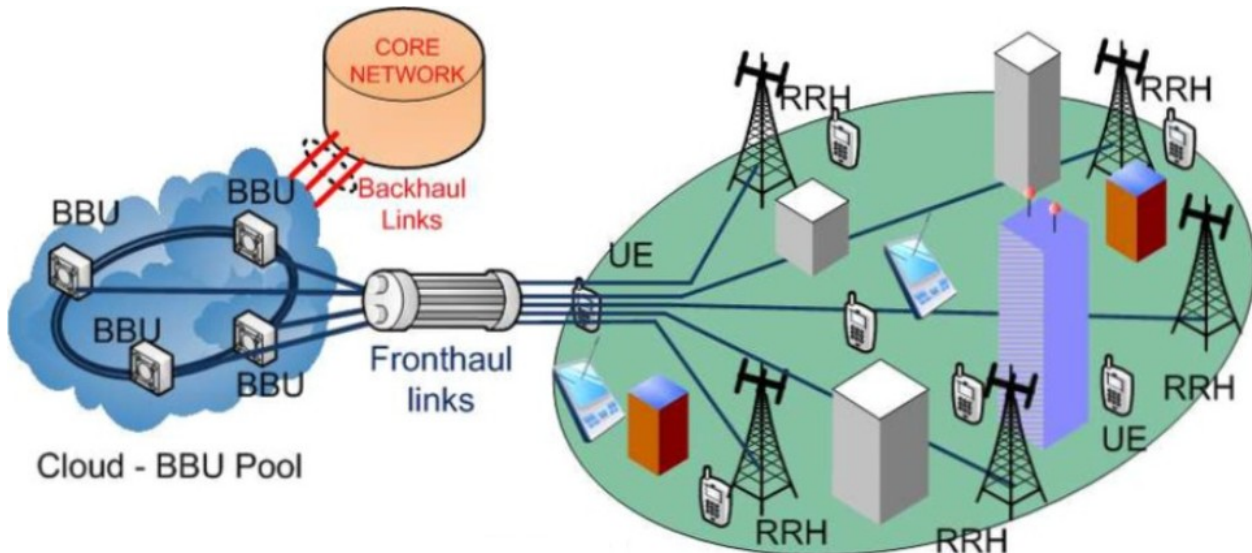
The first generation infrastructure was based on legacy TDM connections between base stations and the mobile switching location.

As bandwidth demand grew with each mobile generation, these legacy connections were upgraded to higher capacity optical or microwave connections.

Today, the typical mobile infrastructure networks consist of separate fronthaul and backhaul segments.

- The fronthaul consists of high-speed point-to-point optical links, often based on CPRI, connecting radio units or remote radio heads (RRH) to a distribution unit or base-band unit (BBU).
- The backhaul segment is based on packet networking to connect to the mobile core sites.

The key elements of the mobile network infrastructure with the fronthaul and backhaul links are shown in the figure below.



The introduction of massive MIMO, Carrier Aggregation, Coordinated Multi Point and other new features in 5G have led to the realization that CPRI is not scalable for future 4G and 5G deployments.

The scalability issues and the proprietary nature of the standard have created a consensus that another Radio Access Network is needed, based on packet technology, on open standards and enabling virtualization of resources. These new concepts, such as eCPRI, v-RAN, and Open RAN, cater to multiple deployment scenarios, reduce bandwidth usage, enable to efficiently scale and deploy large numbers of antennas per radio head and allow evolution to all packet based RAN, independent of proprietary implementations.

Today, the key challenge for network operators is to maintain a cost-effective mobile infrastructure. At the same time, due to competitive pressures, they are forced to introduce new features and capabilities to support new use-cases and keep up with demand for higher performance.

Consolidation of Legacy, 4G and 5G on single network

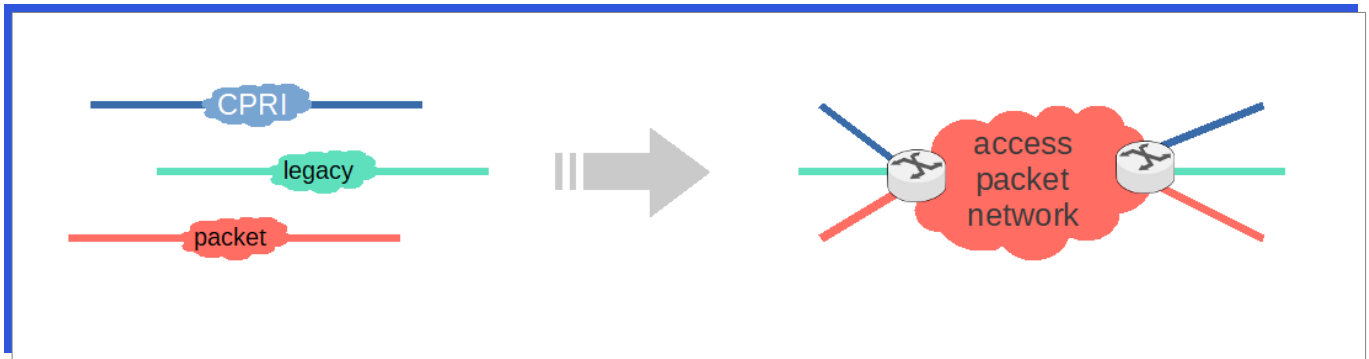
The CPRI interface carries demodulated signals in a proprietary format from base station antennas, signals that cannot be statistically multiplexed. This results in high capacity demands for the transport networks even for legacy and 4G deployments. Operators could opt to maintain 2 parallel networks, one based on CPRI for 4G and another packet based eCPRI for 5G and future evolution; but this makes only sense for the short term.

A cost-effective and future proof solution is to migrate to an all-packet fronthaul network, handling data from 4G and 5G stations, that also can be used to transport legacy services and enterprise business services.

Interface	Data rate	Line code	Protocol
CPRI option 3	2.4576 Gbps	8B10B	Constant bit rate, CPRI frame format
CPRI option 5	4.9152 Gbps	8B10B	Constant bit rate, CPRI frame format
CPRI option 7	9.8304 Gbps	64B66B	Constant bit rate, CPRI frame format
eCPRI 10GE	10.3125 Gbps	64B66B	Packet based, IP or Ethernet
eCPRI 25GE	25.78125 Gbps	64B66B	Packet based, IP or Ethernet
legacy T1 backhaul	1.544 Mbps	B8ZS	Constant bit rate, T1 frame format

An overview of popular mobile transport interface characteristics

The CPRI and legacy transport interfaces are serial fixed bitrate signals that cannot be served by the packet network directly, requiring a conversion to packets. Well-known and standardized methods for such protocol conversions are Circuit Emulation Service, also known as TDM over Packet (IETF RFC 4553) and Radio over Ethernet (RoE), defined for CPRI transport over packet networks (IEEE 1914.3).



Consolidation of separate CPRI, legacy TDM and packet fronthaul traffic on a single access packet network.

Operators that plan to use this technology must ensure that their equipment is fully compatible with the installed base of 4G and legacy equipment. Key requirements for CPRI transport over packet are to limit the maximum delay and to ensure an equal transfer delay in both upstream and downstream directions to the radiohead, down to the sub-micro second level. This is a critical parameter for the overall performance of the radio layer, as it prevents interference among near-by base stations, and enables a higher amount of mobile users and bandwidth per cell tower. Furthermore, to enable advanced radio layer features such as TDD, MIMO and carrier aggregation, it is critical to maintain the strict jitter requirements of the CPRI signals across a packet network.

Functionalities and requirements for packet-optimized mobile fronthaul

Standard Ethernet switching equipment does not cater for these demanding requirements. Equipment with one or multiple 100GE network interfaces and dozens of 10/25GE client ports are needed to transport the massive amount of mobile fronthaul traffic to the core network.

Key features to look for in equipment are support for Synchronous Ethernet (Sync E, ITU-T G.82xx), Precision Time Protocol (PTP, IEEE 1588) and Time Sensitive Network protocols (TSN, IEEE 802.1). A TSN packet switch should perform this encapsulation function in a standardized manner (IEEE 1914.3 RoE) and combine it with 5G eCPRI to maximize transport capacity. By using these standards-based approaches to enhance Ethernet, operators will get a deterministic network that can address stringent fronthaul requirements. They will also gain the flexibility, traffic efficiency and openness of packet Ethernet networks in a technology that is well understood.

Relevant timing requirements for CPRI transfer across a packet network

Parameter	Limit	Unit	Notes
Absolute delay	< 100	µs	includes the fiber delay of 5 ns/m
Delay difference US/DS	<1	µs	
Jitter	<2	ppb	300 Hz low pass

AimValley Expertise on CPRI & Wireless Fronthaul

Through our extensive background in Telecom equipment design experience, our engineers have become experts in all relevant aspects required for the development of equipment that enable cost-effective migration of mobile infrastructure networks.

This includes the optical interface design with strict jitter and wander requirements, or the CPRI to packet encapsulation and protocol conversions, as well as Ethernet packet networking.

We have developed a broad portfolio of Smart SFPs, integrating TDM over Packet and Ethernet in the smallest form factor, simplifying legacy access network modernization. Our Smart SFP solution exceeds jitter and wander requirements for legacy TDM interfaces, removing any concerns that these small devices cannot be used on an operators' critical infrastructure that generates significant recurring revenues.

Accurate and reliable synchronization is a fundamental prerequisite for the correct operation of all Telecom networks. Its importance has grown in 4G and it will be more important than ever in 5G future networks.

A broad range of architecture and system design aspects are covered by our legacy migration solutions:

- synchronization, PLLs, Time-of-Day and clock recovery for legacy TDM and CPRI interfaces
- design for low jitter and wander, including extensive knowledge of SerDes design on FPGAs
- test and measurement, including MTIE, TDEV using impairment generators
- thermal design for environmentally hardened and outdoor cell-tower equipment

Use cases and dedicated solution scenarios

Each network has unique requirements, depending on various parameters, such as: the amount of cell sites to be covered, the current and future bandwidth demands, time-to-market, ease of migration and cost points.

AimValley helps customers with evaluation and provides different implementation solutions.

Let's review some of those solutions:

- For small scale or private mobile networks and point-to-point links based on micro-wave transport technology: Replace point-to-point CPRI links with packet based solution based on CPRI over Ethernet Smart SFPs
- For medium scale mobile infrastructure, ring-based fiber network topology: deploy CPRI over Ethernet Smart SFPs at radio sites
- For dense fronthaul network with high amount of legacy sites: deploy L2 switches with integrated CPRI support. The implementation options are 1) a dedicated box purpose built and cost optimized for CPRI over packet, or 2) a multi-purpose L2 switch with support for CPRI, eCPRI and generic packet transport using TSN profiles and 100 GE upstream ports.
- Consultancy on network level synchronization design
- Clock recovery scenarios, ensuring all CPRI, PTP/ Synchronous Ethernet requirements are met. This includes modeling, prototyping, including evaluation and testing of jitter and wander performance of the overall fronthaul network.

Project Examples & Technology Briefs

[TDMoP in Smart SFP](#)

[TDMoP FPGA and board designs](#)

[Custom Ethernet](#)

[Time Sensitive Networking](#)

[Network Software Stack – AimOS](#)

[Synchronization](#)

AimValley proven track record

Our expertise is successfully deployed in many product designs across many Telecom equipment manufacturers, including solutions for SONET/SDH, OTN, legacy TDM and TDM circuit emulation over packet. Our design services range from development of complete turnkey product solutions, to focused projects delivering system consultancy, architecture definition, or part of FPGA, hardware and software design, integration and test.

Why AimValley?

AimValley is a reliable provider of CPRI & Wireless Fronthaul technology since 2003, delivering solutions for:

- High speed data processing applications
- Complex FPGA-based accelerated systems
- High speed, low power hardware equipment
- Robust embedded software
- Early adopter of Acceleration Technology

AimValley understands the full complexities as well as the subtle nuances of designing great edge solutions. We excel in building complex systems that are part of your product in the fields of Industry 4.0, Big Data, Healthcare and Transportation markets. Our combined skills represent all the important aspects required for the development of end-to-end systems.

Our customers enjoy the benefits of working with a strong team with over 2000 years engineering experience. AimValley is a trusted partner of Tier 1 customers.

Quality Focus

- Outstanding track record of on-time delivery
- Best in Class Designs – Time, Budget & Quality
- ISO9001, ISO14001, Ecovadis Platinum CSR