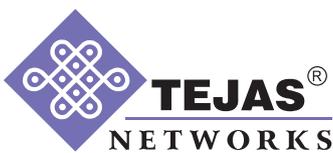


Emerging X-Haul Architecture for 5G Transport



An Integrated SDN/NFV/C-RAN solution

5G is a revolutionary next-generation mobile network that is not just a technology implementation but shifts the entire network architecture paradigm. 5G Crosshaul is an integrated transport network architecture that uses intelligent multiservice edge devices that combine heterogeneous broadband access media (wireless or wired), flexible service delivery (enterprise or residential) and packet transmission services over optical fiber. This paper discusses the nuances of how Tejas Networks is building cutting-edge products and solutions that not only cater to greenfield implementations of 5G but also to support the move from legacy systems to 5G transport in a cost-effective manner.

White Paper

Introduction

5G is the next generation technology that goes eons beyond the existing wireless technologies. It not only inter-connects people but also inter-connects personal devices and machines that are part of the IoT ecosystem. Mobile technologies are classified into different generations as 1G/2G/2.5G/3G/4G/4.5G/5G. The basic 1G technology supported a speed of 2.4Kbps supporting only simple phone calls. Gradually the technology evolved to 5G which is a lot faster than 4G. Each upgrade to the mobile technology generation provides users with enhanced services, higher data throughput, and lower latency.

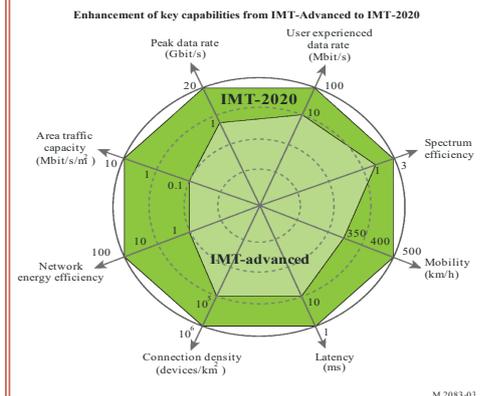
Technologies to scale data rates and capacity goals required by 5G

1. Carrier aggregation and mmWave enables RAN bandwidth scaling from 20 MHz to 100MHz. The advantages of operating at higher frequencies are:
 - Higher throughput at faster speeds to deliver high-quality video and multimedia content
 - Highly directional hence reduces signal interference
 - Improved energy efficiency due to increased throughput per unit energy.
 - Shorter wavelengths enabling shorter antennas which can cater to more devices in comparison to 4G
2. Massive MIMO offers the advantage of increased network capacity without the high cost of addition of new base stations or buying more expensive spectrum. In addition, conventional technology has proven unable to deliver the spectral efficiencies demanded by 5G. Massive MIMO uses large antenna arrays at base stations to simultaneously serve many devices while offering complete digital processing. 5G Systems benefit using Massive MIMO in case of non-Line-of-Sight scenarios. 64x64 implementations have been tested and proven to provide good compromise in terms of cost, size, and performance trade-offs¹.
3. Cloud-RAN is a centralized, cloud computing-based architecture for radio access networks. The concept of distributed small cell radios with central processing augurs well with 5G, wherein operating at higher frequencies necessitates a larger number of broadband units (BBU).

Evolution to 5G by 2020

- Ubiquitous access to information and services, anywhere and anytime
- Video download and upload drives traffic volumes and the peak bit rates demand.
- 5G network is required to create high cell-edge bit-rates and high capacity
- Multi-Radio Access technology capability
- The challenge in the customer experience dimension is to provide:
 1. E2E performance
 2. Move from network KPI to Services KPI
 3. Create automation and Self Organizing Networks

Rec. ITU-R M.2083-0



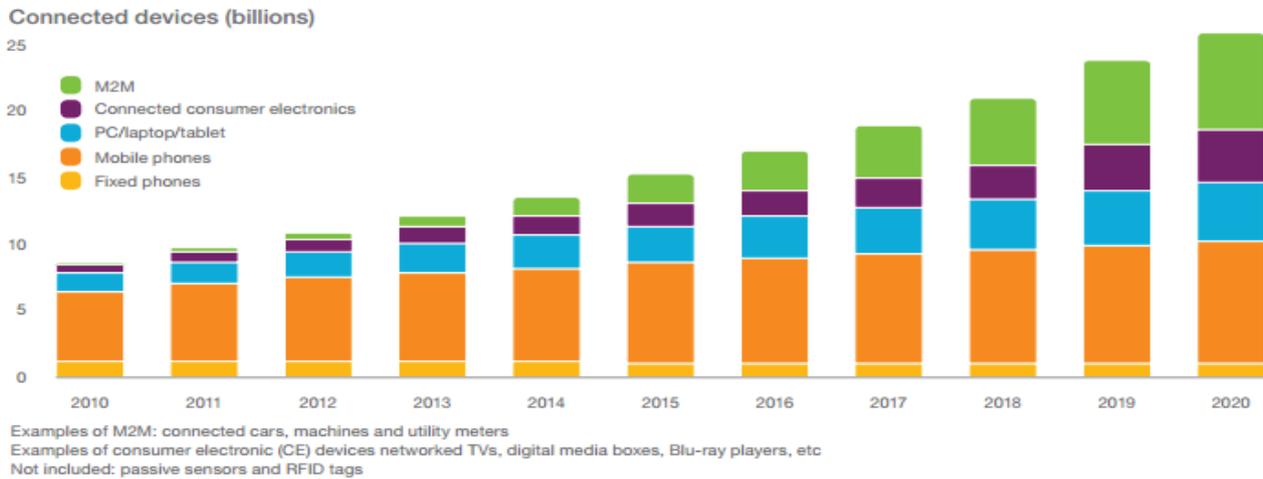
ITU IMT-2020 vision has been determined in ITU-R WP5D #22

Source: REC. ITU-R M.2083-0

¹ Ovum paper - Massive-MIMO-Comes-of-Age-0.pdf

Key drivers for a new 5G Crosshaul architecture in the transport network

The market for M2M is expected to grow exponentially in coming years while the number of mobile phone connections remain relatively constant. M2M/IoT creates a market for fixed low power, low data rate network in addition to the cellular network.



Source: Ericsson Mobility Report 2015

Diversity of access needs and bandwidth explosion produces intense pressure on today's networks. Constraints such as population density, geography and infrastructure availability are the key drivers for an efficient 5G Crosshaul architecture. A potential use-cases based on ITU's IMT-2020 Focus Group² is the Enhanced Mobile Broadband (eMBB) - enhanced indoor and outdoor broadband, enterprise collaboration, augmented and virtual reality.

Key Requirements of a 5G transport system

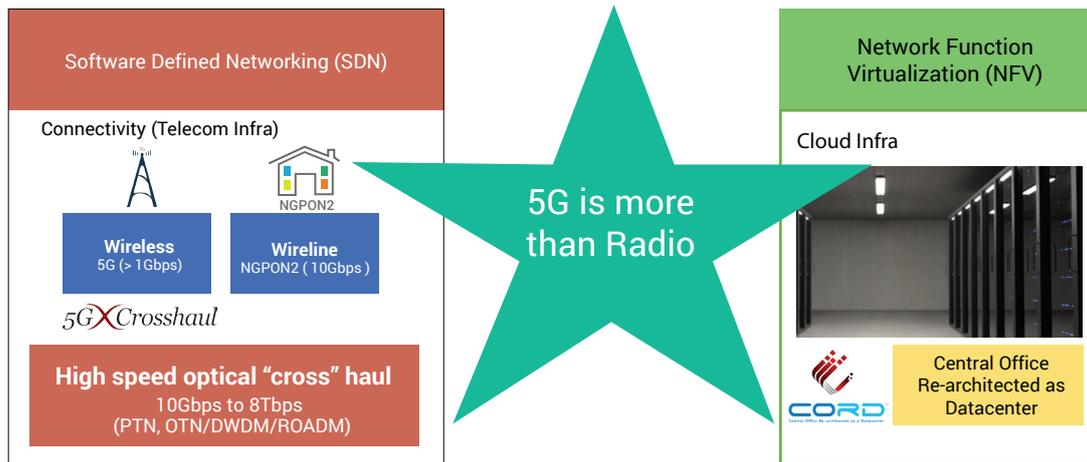
- Increased fiberisation, denser base stations, higher capacities
- An intelligent edge network that supports the new cloud RAN architecture
- Converged delivery of enterprise, backhaul and residential services
- Need for scalable and modular platforms with high-speed interfaces
- Flexible, "software-defined" networks with app-like simplicity in service creation and provisioning
- Increased adoption of open source hardware and software frameworks
- Cloudification of exchange offices as data centers (CORD)
- Virtualization of CPEs and network functions

5G (IMT2020) Network Architecture

Functional view³ of the vision for 5G calls for service-based architecture and functions interaction, separation between control plane (CP) and user plane (UP), network slicing, flexible user plane and fixed mobile convergence (through converged control plane and simplified user plane). This is made possible through softwarization embedded across all network layers by leveraging SDN, NFV, Edge and Cloud computing.

² https://www.itu.int/en/ITU-D/Documents/ITU_5G_REPORT-2018.pdf

³ IMT2020-presentation-Marco-Carugi-final-reduced.pdf



Source : NGMN

Softwarization in 5G Networks – SDN/NFV

SDN is a network architecture framework that allows the network to be centrally controlled through software applications. NFV provides the necessary software abstraction for the devices in the network. This architecture facilitates provisioning of newer services such as usage-based charging models, granular service capabilities and enhanced security. Network operators are moving to cloud to cater to the customer demands of service flexibility and operational efficiency. The benefits of SDN/NFV for 5G are:

- Flow-based and policy-based routing will improve speeds and latency in 5G networks
- Massive content caching closer to users on a large scale using the back-end intelligence provided by SDN
- SDN routing decisions are vastly more intelligent, compared with traditional dynamic routing protocols. SDN can overcome previously catastrophic outages by intelligently recalculating data flow routes on the fly
- SDN/NFV allows for tremendous scalability and dynamic provisioning. SDN automates network expansion into new regions, and capacity addition in existing areas

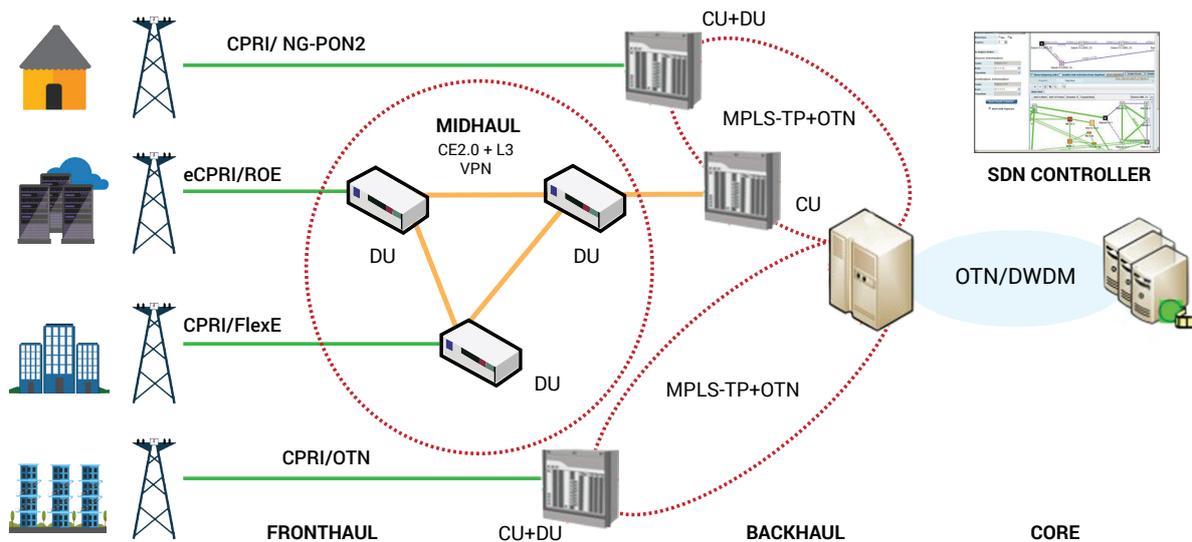
Cloud RAN (C-RAN) Architecture

5G operates at a higher frequency spectrum which results in increased number of base stations while using the traditional architecture. The traditional RAN architecture houses the Base Band Unit (BBU) and Remote Radio Unit (RRU) in each cell site. C-RAN provides a solution to configure the network of densely distributed radio heads by softwarising them to exchange compressed digitized radio samples for cloud-based processing. The C-RAN moves the baseband processing from the individual cell site to a Central Office (CO).

Consequently, the RAN architecture is split into fronthaul, midhaul and backhaul – collectively referred to as Crosshaul⁴.

Mobile backhaul refers to the section of the telecom network that transports cellular traffic from base stations at cell towers to the nearest traffic switching center. While multiple backhaul options are available today (optical fiber, microwave or copper) with the arrival of pre-5G/5G mobile operators are fast gravitating towards optical fiber as the physical medium of choice. 5G also imposes additional demands in terms of latency, jitter, scalability and connection bandwidth on the backhaul. Midhaul is the link between the controllers that feeds the next link. Fronthaul is the link between the controller and the radio head or small cell.

⁴ <http://5g-crosshaul.eu/wp-content/uploads/2015/11/5G-Crosshaul.pdf>



CU: Centralised Unit

DU: Distributed Unit

Deployment scenarios

Various hybrid deployment scenarios of backhaul, midhaul and fronthaul are required for dense deployment of network infrastructure. Some of the deployment scenarios are:

- Independent RRU, CU and DU locations - In this scenario, there are fronthaul, midhaul and backhaul networks. The distance between an RRU and DU is in the range of 0-20 kilometers while the distance between the DU and CU is tens of kilometers.
- Co-located CU and DU - In this scenario, the CU and DU are located together, consequently there is no midhaul.
- RRU and DU integration - In this scenario, an RRU and DU are deployed close to each other, maybe hundreds of meters, for example in the same building. In order to reduce cost, an RRU is connected to a DU just through straight fibre and no transport equipment is needed. In this case, there are midhaul and backhaul networks.
- RRU, DU and CU integration - This network structure may be used for small cell and hot-spot scenarios. There is only backhaul in this case.

Integrated 5G Crosshaul architecture

The integrated 5G Transport Network⁵ is a forward looking concept that is implemented by software-defined transport architecture. The network and radio devices are virtualized using network function virtualization (NFV) and cloud RAN (C-RAN). The hitherto distributed model is now centralized and is controlled by the SDN controller. The single network seamlessly supports functional L3 splits between antenna and packet core.

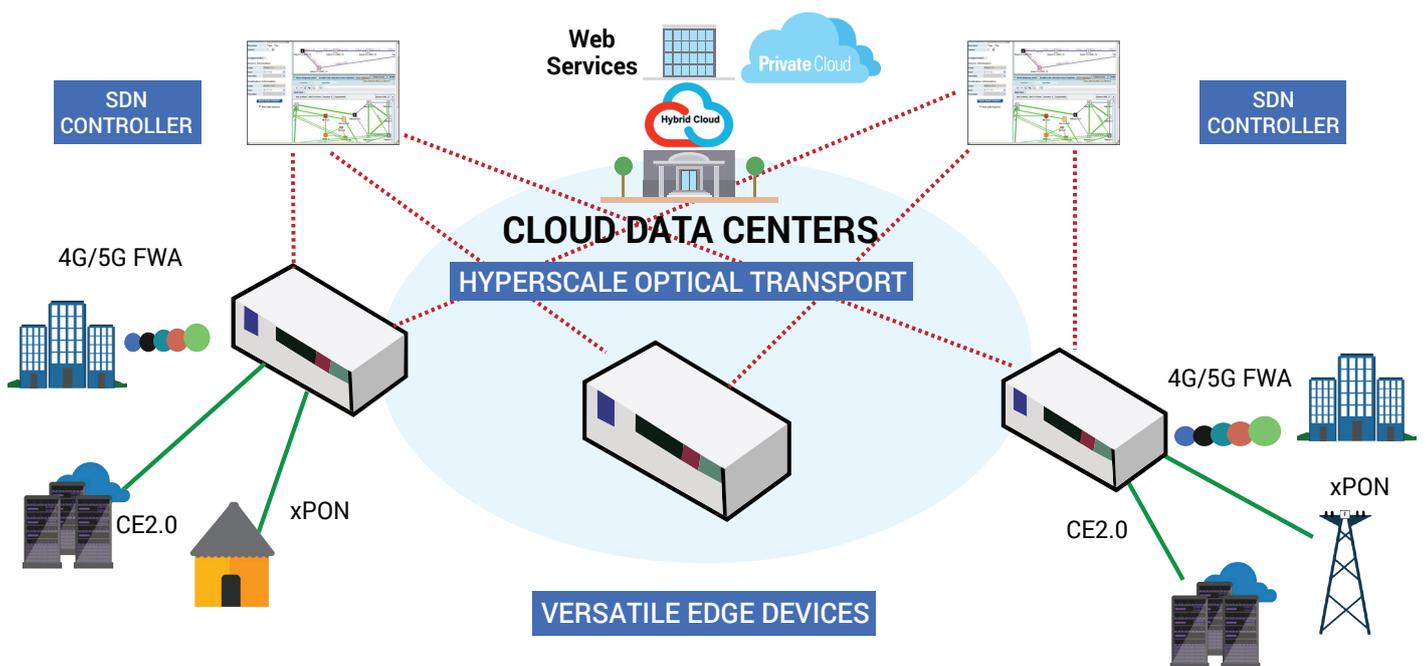
⁵ <https://www.rcrwireless.com/20161115/sponsored/fusion-fronthaul-backhaul-means-5g>

Transport Choices for 5G Fronthaul

	<p>NGPON</p>	<ul style="list-style-type: none"> • Client support for CPRI • 40Gbps DS/10Gbps US • Multivendor interop through Open OMCI
	<p>OTN</p>	<ul style="list-style-type: none"> • Scalable to 100G and beyond • Ultra low-latency support • Synchronization traffic support • CPRI/eCPRI client support
	<p>FlexE</p>	<ul style="list-style-type: none"> • OIF standard • Advanced "LAG" at sub-PHY rates • Delay and Jitter issues remain • Limitations for SyncE/1588v2 traffic
	<p>RoE/NGFI</p>	<ul style="list-style-type: none"> • IEEE standards to overcome limitations • Pre-emption for Express frames • Time Sensitive Networking

Tejas 5G solutions

Tejas Networks offers comprehensive solutions catering to the newest 5G wireless network trends. Our solutions are in line with network requirements such as - need for larger fabric (Switch/XC), higher density with compactness (small form-factor) and a convergence of DWDM, OTN and packet all in one platform.



The key features offered by Tejas products are:

Edge Networks

- Universal platform for 2G/3G/4G/5G backhaul
- CPRI, OTN for C-RAN/MFH applications
- CE2.0, MPLS-TP, IP-VPN for enterprise services and packet transport
- Support for both xPON OLT and 4G/LTE eNodeB as blades
- Upgradable to support NG-PON and 5G gNB fixed wireless access

Hyperscale Optical Transport in the Metro

- Disaggregated architecture for unlimited scaling
- Support for higher bandwidth 200G/400G interfaces
- Terabit-scale, multilayer switching in small footprint
- Proven 100G alien wavelength deployments in complex third-party networks

Open and Programmable Networks

- SDN-ready network management software
- Open-source domain controllers with standards-based northbound and southbound interfaces
- Virtualized CPEs for OLT/ONT, firewall, IP and common functions
- White-box routers with MEF LSO compliant SD-WAN controllers

Benefits of Tejas 5G Transport Solutions

- Converged, programmable platforms that can simultaneously serve a mix of legacy circuit and new packet needs for a seamless network transformation. Compatibility with traditional transport-style operations lowers retraining costs without sacrificing network/service capabilities
- Reuse of existing investments in L2 transport; selective introduction of L3 functionality (e.g., L3 VPN) to meet specific service needs without requiring expensive network overhaul
- Unique integrated edge product for broadband access (xPON, LTE) and packet optical transport (PTN, OTN, CE2.0) services; upgradable to next-generation technologies (NG-PON, 5G) through simple software upgrades
- Novel disaggregated architecture for “pay-as-you-grow” scalability in hyper-scale Metro and Core optical networks
- Best positioned to tap into India’s software, R&D and design strengths to create software-centric SDN/NFV networks with large-scale virtualization of services

Conclusion

5G will represent a significant advance over previous mobile technology generations due to an explosion in the number of network-enabled IoT devices, greater fiberisation and densification of cell sites and a “cloudified” RAN architecture. The magnitude of these changes is such that it is likely to have a transformational impact on the 5G optical network architecture extending right from the access to the metro and core segments. The emerging cloud architecture with its software-centric network paradigm also presents opportunities for telecom vendors and service providers to evolve innovative products and services that can contribute to the overall growth of the global telecom industry.

Tejas Networks is paving the way to provide 5G solutions using a software-defined hardware approach and a central Network Management System (TejNMS). Tejas’ carrier-grade products are proven across various installations around the world. Our products have a “pay-as-you-grow” architecture that enables telecom operators investing in 3G and/or 4G networks today to select optical products that can smoothly evolve and effectively meet the disruptive requirements of 5G in the near future. Tejas has evolved an optimized Crosshaul architecture for 5G-ready transport with seamless evolution to SDN/NFV/C-RAN architecture.



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