5G FUNCTIONAL SPLITS

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5G Functional Splits

Overview

Previous RAN architectures (2G, 3G and 4G) were based on a "monolithic" building blocks, where few interactions happened between logical nodes. Since the earliest phases of the New Radio (NR) study, however, it was felt that splitting up the gNB (the NR logical node) between Central Units (CUs) and Distributed Units (DUs) would bring flexibility. Flexible hardware and software implementations allow scalable, cost-effective network deployments – but only if hardware and software components are interoperable and can be mixed and matched from different vendors. A split architecture (between central and distributed units) allows for coordination for performance features, load management, real-time performance optimization and enables adaptation to various use cases and the QoS that needs to be supported (i.e. gaming, voice, video), which have variable latency tolerance and dependency on transport and different deployment scenarios, like rural or urban, that have different access to transport like fiber.

Parallel Wireless's dynamic architecture helps mobile operators to utilize different 3GPP-compliant splits based on architecture and infrastructure availability. While for rural deployment higher splits (i.e. 2, 6) are more desirable, for dense urban areas lower splits (7, 8) will be the optimum solution. While higher level splits can utilize less than perfect fronthaul (FH), lower level splits need to utilize near perfect FHs. Parallel Wireless's dynamic solution will enable mobile operators to pick and choose any RAN splits based on the same hardware and network components by using different software implementations. These splits will be also software upgradeable if network conditions change. Different protocol layers will reside in different components based on FH availability and system design. This approach will dramatically reduce the overall TCO for mobile operators.

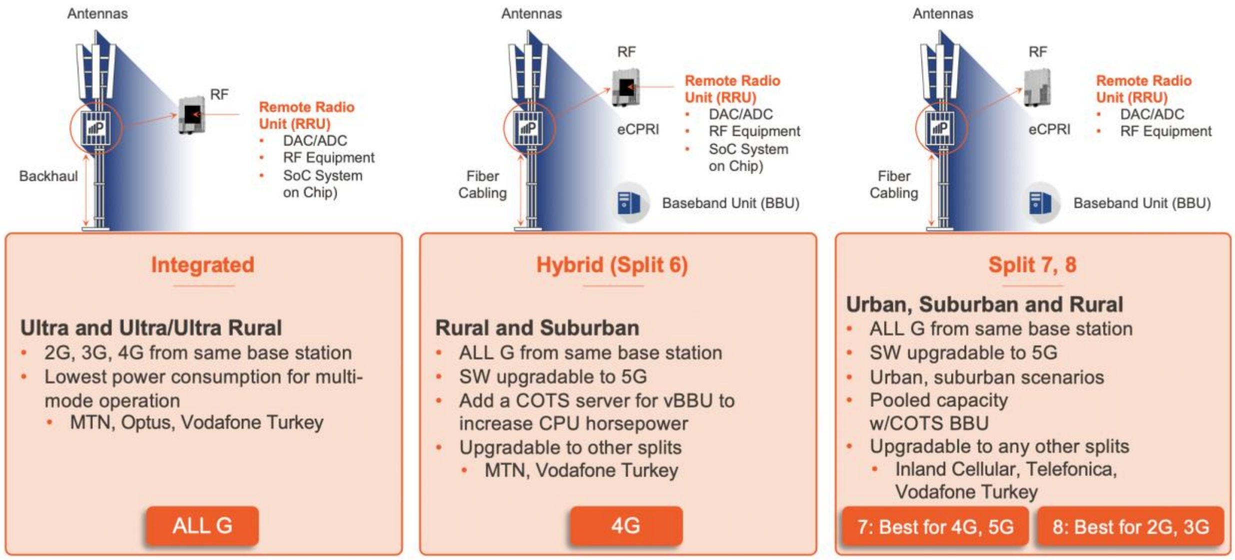
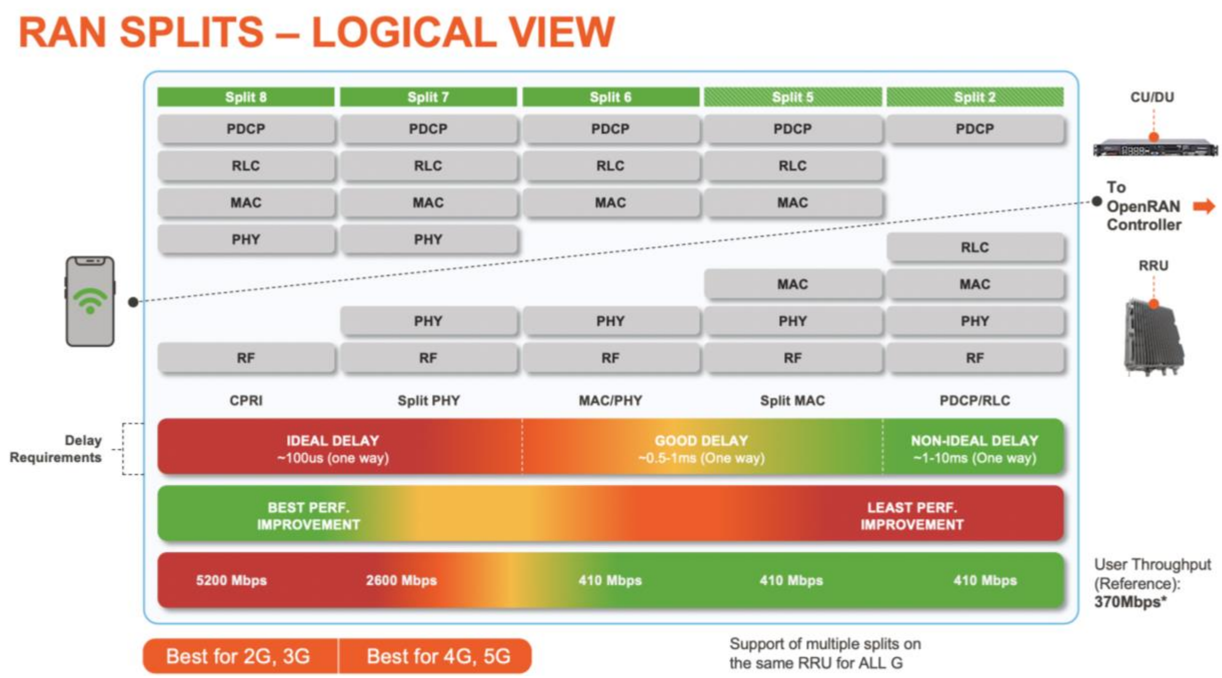


Figure 1: Open RAN Use Cases

The choice of how to split New Radio (NR) functions in the architecture depends on some factors related to radio network deployment scenarios, constraints and intended supported use cases. Three key ones are: 1. A need to support specific QoS per offered services (e.g. low latency, high throughput for urban areas) and real/non-real time applications. 2. Support of specific user density and load demand per given geographical area. 3. Available transport networks with different performance levels, from ideal to non-ideal.

Mobile operators need the flexibility to pick and choose different splits based on the same COTS-based hardware and network components by using different software implementations. Different protocol layers will reside in different components based on fronthaul availability and deployment scenarios. This approach will reduce the cost of operations and TCO for mobile operators.

Higher functional splits are more desirable for capacity use cases in dense urban areas while lower functional splits will be the optimum solutions for coverage use cases. So, while lower functional splits utilize less than perfect fronthauls, there is a greater dependence on fronthaul performance for higher functional splits.



Source: Parallel Wireless

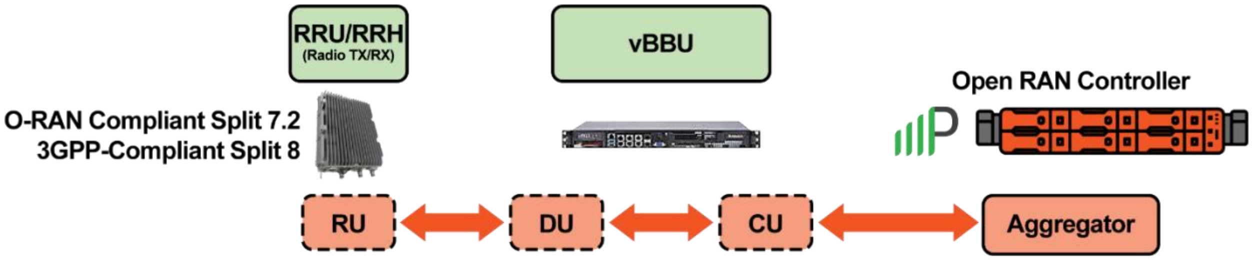
To take full benefit of split architecture that can deliver interoperability, ability to select best-of-breed components and scalability, any solution needs support 2G, 3G, 4G, 5G baseband functions. For the best latency support requirement, baseband functions decoupled from hardware should be deployed on NFVI or as containers. An MNO can use any VM requirements and/or any orchestration to enable these functional splits.

Open RAN Components

The Parallel Wireless Open RAN solution includes an Open RAN controller, edge core and analytics software, and an ecosystem of hardware radios and servers supporting majority of 3GPP and O-RAN compliant CU/DU splits.

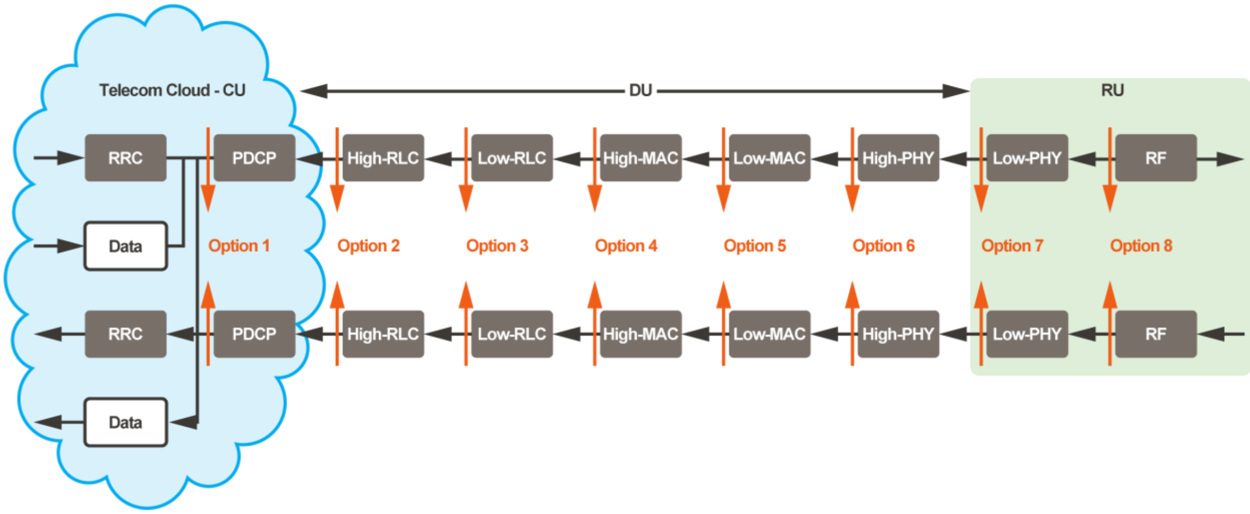
Remote Radio Head (RRH) or RU

RU: this is the radio unit that handles the digital front end (DFE) and the parts of the PHY layer, as well as the digital beamforming functionality. 5G RU designs are supposed to be “inherently” intelligent, but the key considerations of RU design are size, weight, and power consumption. Parallel Wireless solution utilizes standard off the shelf RRHs from different Open RAN hardware OEMs. Because of our open software-based solution most of commercially available RRHs can be integrated into our solution with minimum integration effort and reducing the overall cost of ownership for mobile operators. Software-defined Remote Radio Head (vRRH) allows 2G, 3G, or 4G implementation, but as 5G grows in popularity, the radio hardware can be reconfigured to support All Gs, including combinations of 2G + 4G + 5G or 3G + 4G + 5G (if operated in the same frequency), eventually, a pure 5G implementation—all without new hardware with a simple software upgrade.



Virtual Baseband Unit (vBBU)

In a 5G RAN architecture, the BBU functionality is split into two functional units: a distributed unit (DU), responsible for real time L1 and L2 scheduling functions, and a centralized unit (CU) responsible for non-real time, higher L2 and L3. In a 5G cloud RAN, the DU's server and relevant software could be hosted on a site itself or can be hosted in an edge cloud (datacenter or central office) depending on transport availability and fronthaul interface. The CU's server and relevant software can be co-located with the DU or hosted in a regional cloud data center. The actual split between DU and RU may be different depending on the specific use-case and implementation (although the O-RAN Alliance definition is Option-7.2 and Small Cell Forum is Option-6).



DU: this is the distributed unit that sits close to the RU and runs the RLC, MAC, and parts of the PHY layer. This logical node includes a subset of the eNB/gNB functions, depending on the functional split option, and its operation is controlled by the CU.

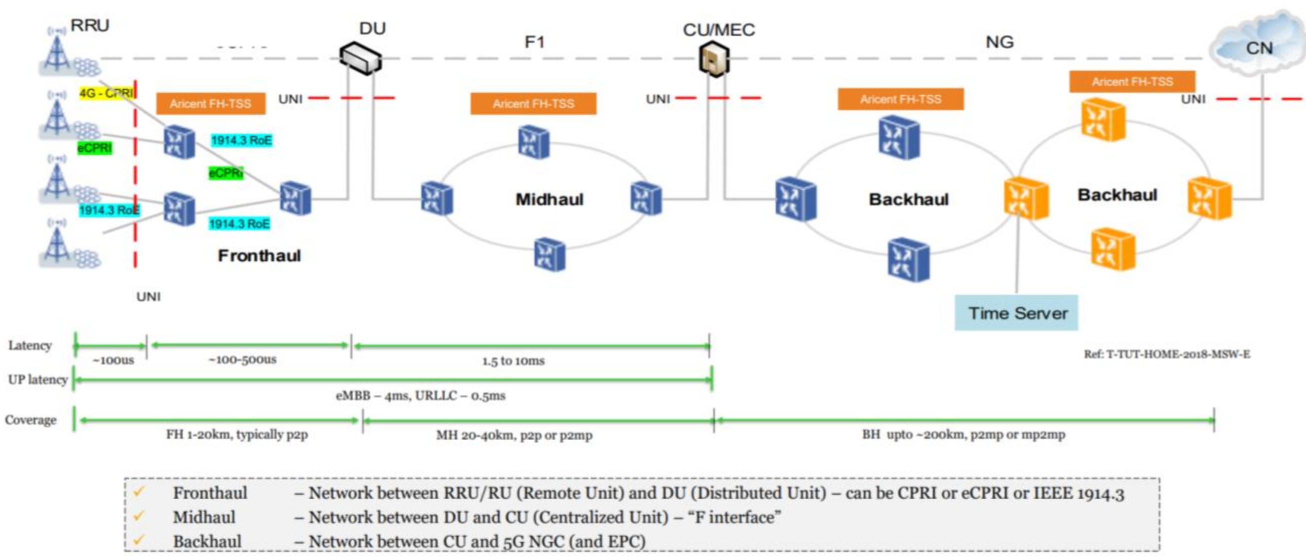
CU: this is the centralized unit that runs the RRC and PDCP layers. The gNB consists of a CU and one DU connected to the CU via Fs-C and Fs-U interfaces for CP and UP respectively. A CU with multiple DUs will support multiple gNBs. The split architecture enables a 5G network to utilize different distribution of protocol stacks between CU and DUs depending on midhaul availability and network design. It is a logical node that includes the gNB functions like transfer of user data, mobility control, RAN sharing (MORAN), positioning, session management etc., with the exception of functions that are allocated exclusively to the DU. The CU controls the operation of several DUs over the midhaul interface.

The centralized baseband deployment allows load-balancing between different RUs. That is why, in most cases, the DU will be collocated with RUs on-site to conduct all intense processing tasks such as fast Fourier transform/inverse fast Fourier transform (FFT/IFFT). Edge-centric baseband processing delivers low latency, local breakout, seamless mobility with real-time interference management, and optimal resource optimization. There are three purposes of separating DU from RU: 1. To reduce cost – less intelligent RU costs less, 2. Ability to look at a sector of RUs at once and not just an individual RU – this will help to enable features like CoMP, and 3. As processing is done in the DU, resources can be pooled resulting in pooling gains.

The industry is coming to a consensus that the lower level interface that connects RU and DU (fronthaul) should be eCPRI to deliver the lowest latency. Fronthaul latency is constrained to 100 microseconds. A single DU may be serving RUs up to many kilometers away.

It is important to note that the DU/CU split is hardly impacted by the type of infrastructure. The primary new interface is the F1 interface between the DU and CU, and they need to be interopearble across different vendors to deliver the true promise of Open RAN. Midhaul connects the CU with the DU. And while in theory there can be different splits, the only one being considered de-facto between DU and CU is Option-2. There's also very little difference on the midhaul interface between the different splits (1-5). The latency on the link should be around 1 millisecond. A centralized CU can control DUs in an 80 km radius.

Backhaul connects the 4G/5G core to the CU. The 5G core may be up to 200 km away from the CU.



Source: Altran (Aricent)

RAN vendors that started with CPRI and now are trying to sell the solution of converting CPRI to eCPRI in their architecture, should not try to justify this approach as it creates unnecessary complexity and latency.

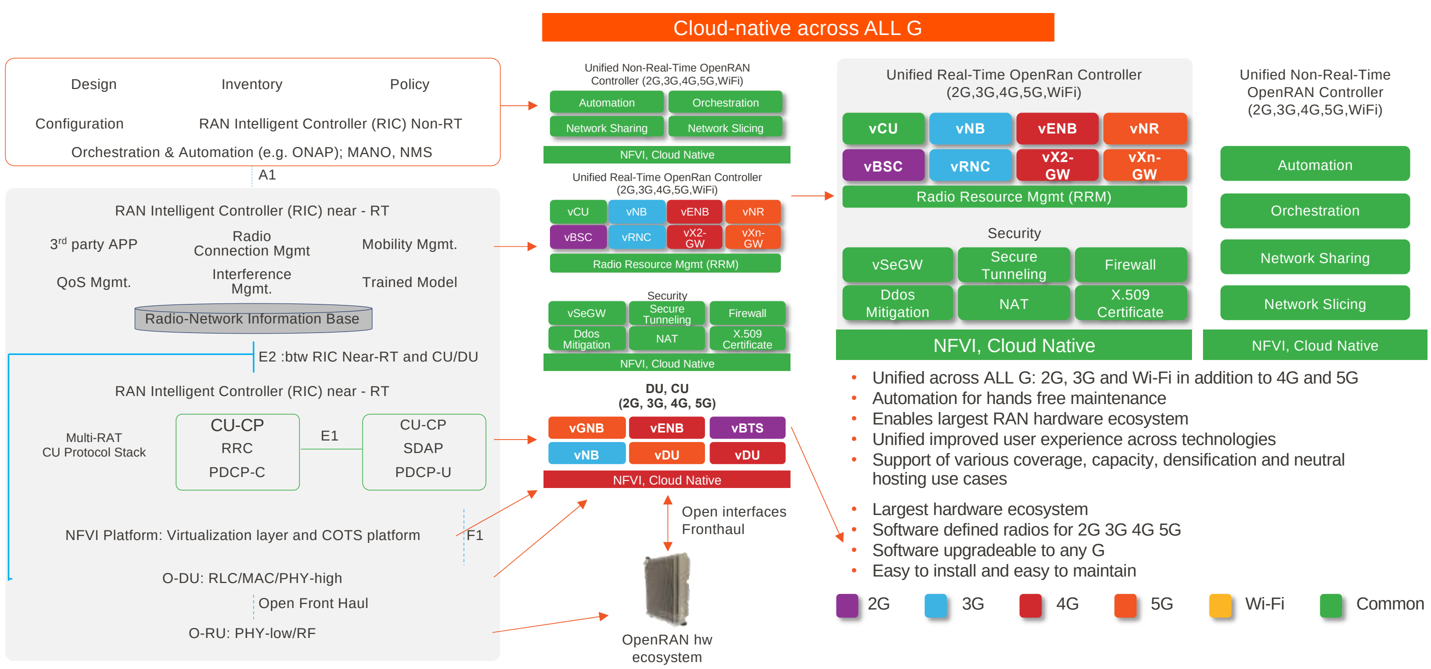
Based on Intel-based COTS hardware, this component can provide different type of functionality based on different splits; Low-PHY, High-PHY, MAC, RLC and PDCP functionality in a central fashion. It communicates to a cluster of RRHs (which contains RF and lower PHY) and supports multiple carriers based on the RRH cluster's load. The interface between vBBU and RRHs is based on Ethernet-based eCPRI. Virtualized Baseband Unit (vBBU) brings the future-ready architecture of a DU and a CU, deployed at the network's edge. The vBBU resources can be shared among multiple remote radio units (RRUs) on site in a multi-carrier 1-sector, 3-sector, or 6-sector configuration to achieve optimal resource pooling for low cost of operation. The BBU function is split between the CU and DU for 5G. This depends on which path the mobile operator is taking toward 5G, as there are many options that accommodate incumbent 2G, 3G, and 4G networks, as well as the level of integration between the current network and a new 5G network.

Open RAN Controller

Open RAN Controller is a key element of the Parallel Wireless solution. The Parallel Wireless Open RAN software suite completely decouples RAN hardware and software functionality. The solution is anchored by the Parallel Wireless Open RAN Controller that provides RAN services, optimizes the network using analytics, and provides centralized management and intelligence for every generation of wireless network (2G, 3G, 4G, 5G, and Wi-Fi) for seamless mobility. The functionality supported is as identified by O-RAN Alliance: NON-RT and near.

Real-Time Controller

Provides O-RAN defined, near-real-time RAN Intelligent Controller (RIC) functionality and extends it to real-time. It provides complete RAN orchestration and real-time SON including self-configuration, self-optimization, and self-healing. All new radio units are self-configured by the software, reducing the need for manual intervention, which will be key for 5G deployments of massive multiple-input and multiple-output (MIMO) and small cells for densification. The self-optimization is responsible for necessary optimization-related tasks across different RANs, utilizing available RAN data from all RAN types (macros, massive MIMO, small cells) from the



Parallel Wireless Analytics Module. The proactive approach utilized by the Parallel Wireless platform, in contrast to the legacy reactive optimization approach, improves user experience and increases network resource utilization, key for consistent experience on data-intensive 5G networks.

Non-Real-Time Controller

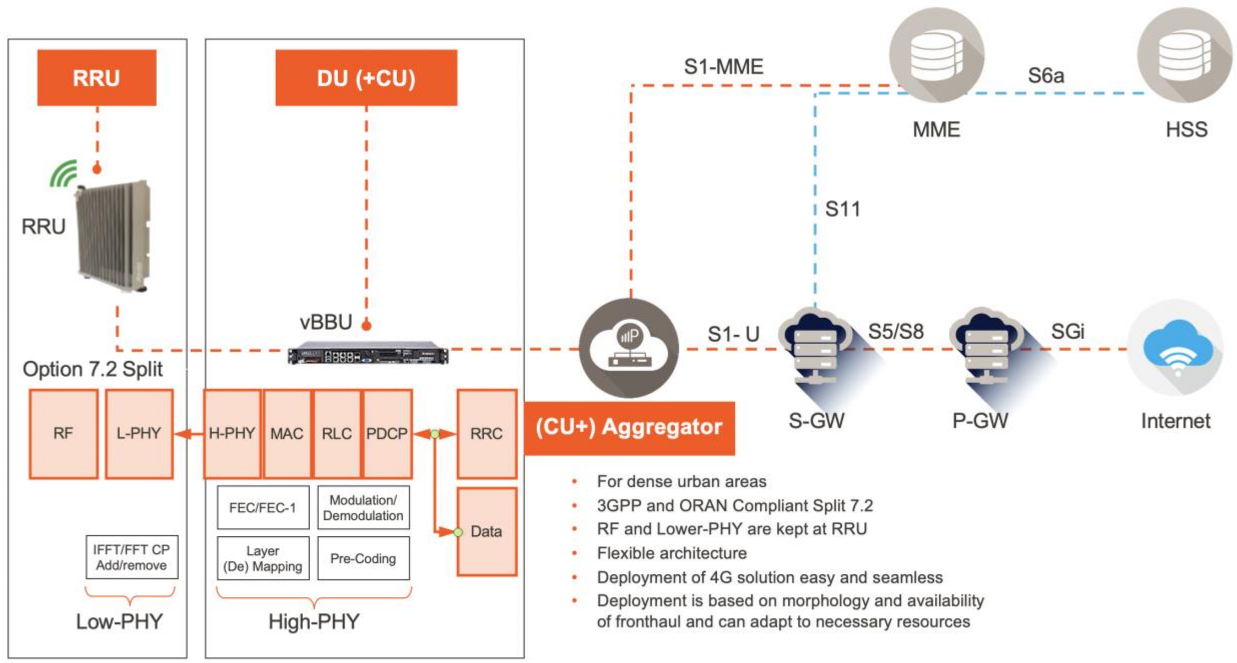
Provides O-RAN defined, non-real-time RIC functionality such as configuration management, device management, fault management, performance management, and lifecycle management for all network elements in the network. Network slicing, security, and role-based access control and RAN sharing are key aspects that are applicable to all the controller functions across the network. This software suite also provides a layer of intelligence that can be realized across the network by using telemetry information gathered from across the network. By providing timely insights into the network operations, operators can use the non-real-time controller to further understand and optimize the network. This controller fully complements the suite of products that Parallel Wireless offers today to realize, deploy, manage, and optimize the entire network with a single pane of glass.

Open RAN Controller is a fully virtualized, ETSI NFVI compliant, cloud-native solution that can be deployed on Intel x86-based COTS Data Center infrastructure. It also supports MEC (Multi-Access Edge Computing) for maximum deployment flexibility within a Mobile Operator's network, to suit its throughput, latency and high availability requirements. Given the breadth of functionality supported by Open RAN Controller, its sizing is dependent on Call Model details, as well as local and geo Redundancy, as well as Data Center needs.

The future evolution of RAN will be toward dynamic functional splits. While the OpenRAN Controller (aggregator) acts as a mediator between the RAN and core network, the functionality of the RAN will be distributed between DUs and CUs as it is defined in 5G, and this software can be co-located with the aggregator. In different scenarios, these elements can collapse together and create a single physical entity with different virtual functionalities.

Parallel Wireless Split 7.2

Parallel Wireless recommends option 7.2 split of 3GPP for the case when high throughput and low latency FH is available between vBBU and the RRH. In case of requirements for more delay-sensitive service, based on appropriate fronthaul availability, the MAC-PHY split will be the preferred solution. Option 7 Split architecture is where the DU handles the RRC/PDCP/RLC/MAC and higher PHY functions, whereas the RU handles the lower PHY and RF functions. CU functionality may be embedded with the DU on the same server, or it can be pushed up the network as a virtualized aggregation entity, along with an OpenRAN Controller or aggregator. Option 7 allows operators to take advantage of sharing or pooling gains while maintaining the lowest processing utilizations on both the DU and RU – leading to a very cost-effective solution with a low TCO and an ideal option for a distributed RAN deployment, including Massive MIMOs.



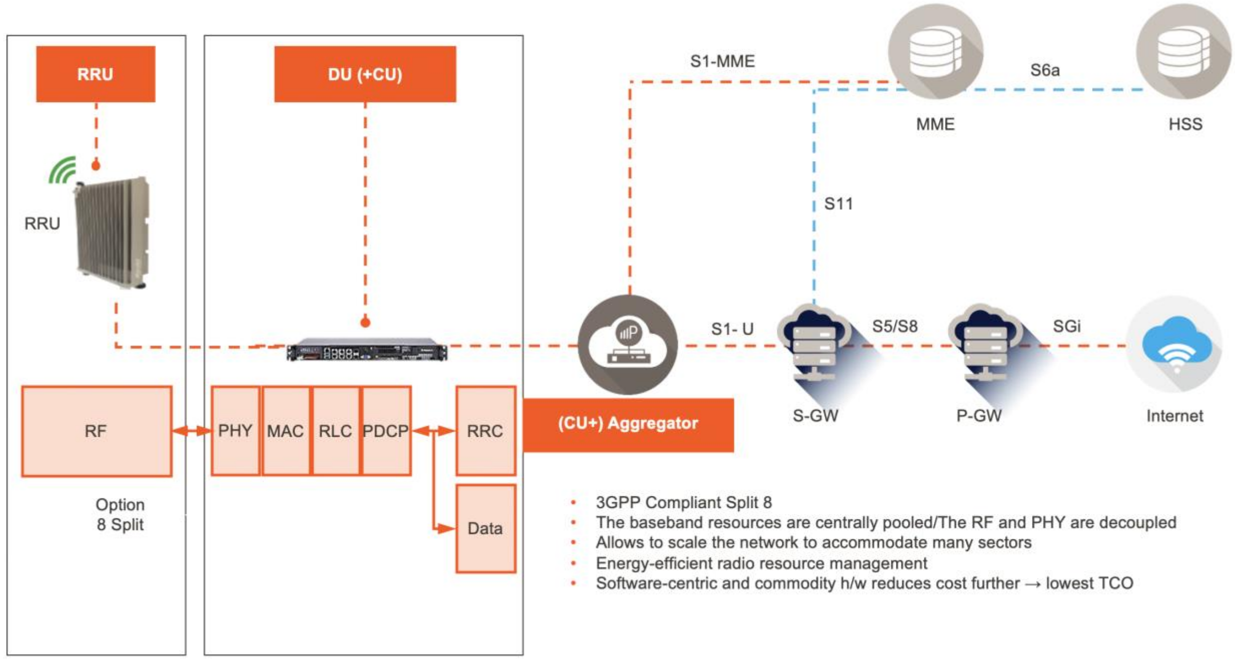
Parallel Wireless Split 8

Split 8 is based on the industry standard CPRI, PW CU and DU are interoperable with third party CUs / DUs / RRUs. Split 8 is based on the industry standard CPRI interface and has been around for a while. With traffic split 8, all functions (from PHY to RRC layers) except for RF are handled by the DU, while the RF layer is located in the radio. But why is this split gaining attention now?

This split is highly effective in 2G and 3G, where traffic rates are much lower (and therefore processing itself is lower, to a certain extent) and can be easily done on an x86 server, while allowing operators to use cost-optimized RUs with minimal logic and processing. The DU and RU should be interoperable with other third party DUs and RUs. The enhancement over the legacy Split-8, is that in order for RUs to run multiple technologies over the same FH interface, they now need to utilize eCPRI instead of the legacy CPRI interface between the RU and DU.

The RAN DU sits between the RU and CU and performs real-time L2 functions, baseband processing. In the O-RAN Alliance working group, the DU is proposed to support multiple layers of RUs. To properly handle the digital signal processing and accelerate network traffic, FPGA can be used. But what is important to understand is that hardware acceleration is considered a requirement for 5G but less so in previous technologies like 2G, 3G, and even 4G.

This approach allows for centralized traffic aggregation from the RUs, which in turn enables a seamless migration path from the traditional LTE ecosystem to the NR ecosystem.



Summary

Parallel Wireless solution can support different functional splits between CUs and DUs not only for 4G and 5G, but also for 2G and 3G. DU software for 2G 3G 4G and 5G will complement RRHs by providing extra processing capabilities thereby increasing the capacity while reducing the fronthaul/midhaul bandwidth requirements. Parallel Wireless has developed its products to accommodate not just one specific split but with options that build in flexibility and the ability to create different splits based on different architectures and deployment scenarios. Parallel Wireless's 5G RAN virtualization will address all these requirements through its Open RAN software suite as an anchoring point.

Our approach can help MNOs unify their cellular network infrastructure to deliver quality end-user experiences for all coverage and/or capacity use cases in rural and urban. This is made possible by virtualization, abstraction and automation to empower them to be profitable despite margin pressure for 2G, 3G, 4G and 5G. Operators that take this approach will be in a leading position to win the race for early 5G commercialization.