How to build high-performance 5G networks with vRAN and O-RAN?

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@QCOMResearch
For better coordination, scalable capacity, faster deployments, lower latency, and new use cases

**Traditional RAN**
Combined baseband processing unit + Radio unit

**Centralized RAN (C-RAN)**
Centralized baseband processing unit

**Virtual RAN (vRAN) + MEC**
Virtualized baseband processing unit with disaggregation

BBU: Baseband unit; DU: Distributed unit; vBBU: Virtual baseband unit; vCore: Virtual core network; vCU: Virtual central unit; MEC: Multi-access Edge Computing
Disaggregation can create a more open and interoperable virtual RAN

BBU: Baseband unit; COTS: Commercial off-the-shelf; CP: Control plane; CU: Central unit; DU: Distributed unit; UP: User plane; vCore: Virtual core network; vCU: Virtual central unit
Disaggregate layers of the protocol stack

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Disaggregate RAN hardware and software with COTS HW

Disaggregation can create a more open and interoperable virtual RAN
Disaggregate layers of the protocol stack

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Disaggregate control plane and user plane functions

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5G vRAN

Designed for unprecedented flexibility and cost-effective network deployments

Virtual Central Unit
Control and user plane separation

Core Network

Distributed Unit

Radio

Active antenna systems

User plane

Control plane

E1

Allows for interoperability between the CU and DU

Remote radio head w/ centralized baseband

Remote radio head + PHY with centralized baseband

3GPP TR 38.801

CU: Central unit; DU: Distributed unit; MAC: Medium access control; PDCP: Packet data convergence protocol; PHY: Physical layer; RF: Radio frequency; RLC: Radio link control; RRC: Radio resource control; SDAP: Service data adaptation protocol
Designed for unprecedented flexibility and cost-effective network deployments

SON: Self-optimizing networks; nFAPI: Network functional application platform interface
Broaden the interoperable ecosystem with standardized open interfaces

CUS: Control, User and Synchronization plane
nFAPI: Network functional application platform interface

O-RAN Alliance
Small Cell Forum
Third Generation Partnership Project

5G vRAN
Disaggregate RAN hardware and software with COTS HW

Disaggregate layers of the protocol stack

Disaggregate control plane and user plane functions

5G vRAN

Support different deployment scenarios

Improve resource scalability and utilization

Efficiently deploy new services

Build denser networks

Ride the innovation wave

Disaggregate to maximize the benefits of virtual RAN
Efficiently deploy new services

Support different deployment scenarios

Place processing and analytics where it is needed
Simplify orchestration

Improve resource scalability and utilization

Improve cost and energy effectiveness with trunking gains from resource pooling
Rapidly scale virtual resources for additional capacity

Simplify orchestration

Support lower end-to-end latency
Evolve and upgrade components separately
Tailor dimensioning and features to suit the use case with 5G private networks

Rapidly scale virtual resources for additional capacity

Build denser networks

Reduce cell-site footprint by relocating disaggregated functions to data centers
Build a denser network by accessing more locations with compact installations

Select best-of-breed network components

Ride the innovation wave

Broaden the ecosystem for competition
Spur innovation with vendor diversity

Deploy networks faster with vRAN and disaggregation
Accelerate 5G innovation with modular components and standardized open interfaces

O-RAN architecture

- Drive distributed development and operations (DevOps) with modular network components
- Set the foundation for interoperability by design with standardized open interfaces
- Leverage a broader ecosystem for high-performance 5G with best-in-class functionality
- Accelerate feature development, problem resolution and product differentiation
- Build a common platform for public networks and the growing private network market
Optimize architecture for application with O-RAN

Application-specific constraints influence network topology

O-RAN offers a comprehensive set of network architectures for different application constraints

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**One-way distance and delay constraints**

<table>
<thead>
<tr>
<th></th>
<th>O-CU to O-DU</th>
<th>O-DU to O-RU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enhanced mobile broadband (eMBB)</td>
<td>625 μs (125 km)</td>
<td>100 μs (20 km)</td>
</tr>
<tr>
<td>Massive IoT (mMTC)</td>
<td>625 μs (125 km)</td>
<td>100 μs (20 km)</td>
</tr>
<tr>
<td>URLLC control plane</td>
<td>625 μs (125 km)</td>
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</tr>
<tr>
<td>URLLC user plane</td>
<td>100 μs (20 km)</td>
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</tbody>
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**Physical topologies**

CU: Central unit; DU: Digital unit; eMBB: Enhanced mobile broadband; NF: Network function; mMTC: Massive machine type communications; O-RAN; RIC: RAN intelligent controller; RU: Radio unit
RAN Intelligent Controllers (RIC) unlock new capabilities for the intelligent RAN

Non-Real Time RIC

- Robust RAN analytics for wide area networks
- Train machine learning models at scale
- Enforce intelligent policy control

Near-Real Time RIC

- Deep learning with fine-resolution data
- Drive AI/ML-based performance optimization for complex, interdependent RAN algorithms

Scale intelligence securely with the network

- Add RAN Intelligent Controllers to the vRAN COTS platform
- Dimension network intelligence with network capacity
- Ensure secure access to training data
AAL: Acceleration abstraction layer; NF: Network function; O-Cloud: O-RAN cloud; OFH: Open fronthaul

Drive vRAN performance and efficiency with hardware accelerators

O-RAN architecture
Reduce DU SWaP with HW-accelerated real-time functions

- Modularize with nFAPI for L2 on COTS HW and a fully-accelerated inline PHY
- Optimize physical parameters for PHY layer efficiency with HW accelerators
- Efficiently handle multiple functions with inline accelerators

Digital Unit (DU)

DU without HW acceleration
DU with HW acceleration

Size
Weight

COTS: Commercial off-the-shelf; CUS: Control, User and Synchronization plane; L1: Layer 1 - PHY; L2: Layer 2 - MAC and RLC; MAC: Medium access control; nFAPI: Network functional application platform interface; RLC: Radio link control; SWaP: Size, weight and power
Digital intelligence in the cloud will drive the enterprise of the future


55% embedded AI functions in their business-critical workloads
75% cloud-native architectures for core business applications
60% automated digital infrastructure for business resiliency and security

Enterprises in 2024

Source: https://www.idc.com/events/futurescape
Transform industry and enterprise with 5G, vRAN and MEC

**Reduce end-to-end latency**
with 5G and MEC for industrial IoT and delay-sensitive applications, e.g. Boundless XR

**Support multiple services**
by deploying network and compute resources opportunistically for various latency, throughput and reliability needs

**Increase data security and privacy**
by keeping data local and physically secure

**Increase availability and scalability**
• by using common edge compute resources for both vRAN and MEC
• by independently scaling resources for control plane and user plane traffic
Advance 5G with network slicing

- Protect end-to-end QoS between services and sandbox new services
- Tailor network architecture to service-specific latency needs
- Position resources to suit deployment constraints
- Build one private network with an on-prem edge for multiple use cases
Advance 5G with network slicing

Protect end-to-end QoS between services and sandbox new services

Tailor network architecture to service-specific latency needs

Position resources to suit deployment constraints

Build one private network with an on-prem edge for multiple use cases
Drive new efficiencies and innovation with an integrated 5G private network and edge

5G network APIs open interfaces with the private edge to facilitate:
- Responsive interactivity
- Distributed AI
- Cloud processing

API: Application programming interface
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Integrated mmWave & Sub-6 GHz solution with Global band Support

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High performance Modem-RF
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From Macro to Small Cells
Integrated Sub-6 and mmWave solution