# Evolution of Fixed Services for wireless backhaul of IMT 2020 / 5G

- **Wireless Backhaul for IMT 2020 / 5G - Overview and introduction**
  by Renato Lombardi, Huawei

- **Wireless X-Haul Requirements**
  by Nader Zein, NEC

- **Microwave and millimeter-wave technology overview and evolution**
  by Mario Frecassetti, Nokia

- **Operator's view on frequency use related challenges for microwave and millimeter-wave in IMT 2020/ 5G backhaul/X-Haul**
  by Paolo Agabio, Vodafone

- **Panel discussion:**
  Economics on deployment and operational aspects of microwave and millimeter-wave technology in IMT 2020 / 5G mobile backhaul/X-Haul network

5G REQUIREMENTS TO WIRELESS BACKHAUL

New Challenges	5G Impact on Wireless-BH/XH

5G Use Cases

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5G RAN
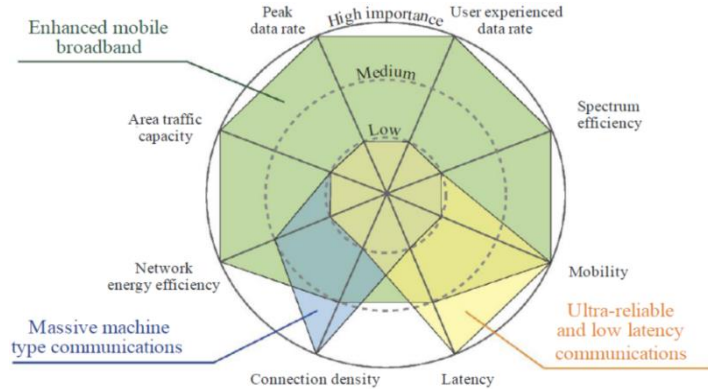
Increased Density
Network Coordination

OPS

Operational Simplification
Services Setup Acceleration

| Capacity |
|---|
| Latency |
| Link Density (W-BH/XH) |
| Synchronization |
| Advanced Packet Networking |
| Automated Network Management |

5G ACCESS SITES CONFIGURATIONS

Based on 3GPP, TR 38.913, V14.3.0, 2017-06, "Study on scenarios and requirements for next generation access technologies" and ETSI ISG mWT view.

| Area Type	Sites Configurations (indicative)	Cell Type
Dense Urban ('DU')	• 5G 100 MHz 16L MIMO ~4 GHz • 5G ≤ 800 MHz 4L MIMO ~30 GHz	• Small-cell
Urban ('U')	• LTE 50-100 MHz • 5G 100 MHz 16L MIMO ~4 GHz • 5G ≤ 800 MHz 4L MIMO ~30 GHz	• Macro-cell
Sub-Urban ('SU') Semi-Rural ('SR')	• LTE 50-100 MHz • 5G 100 MHz 8L MIMO ~4 GHz	• Macro-cell
Rural ('R')	• LTE 50-100 MHz • 5G 50 MHz 4L MIMO ~2 GHz • 5G 20 MHz 4L MIMO ~700 MHz	• Macro-cell

Each macro-cell site consists of three (3) sectors, serving 5G and 4G services, whilst small-cells, namely, outdoor pico-cell sites, are assumed as single-sector 5G NR only
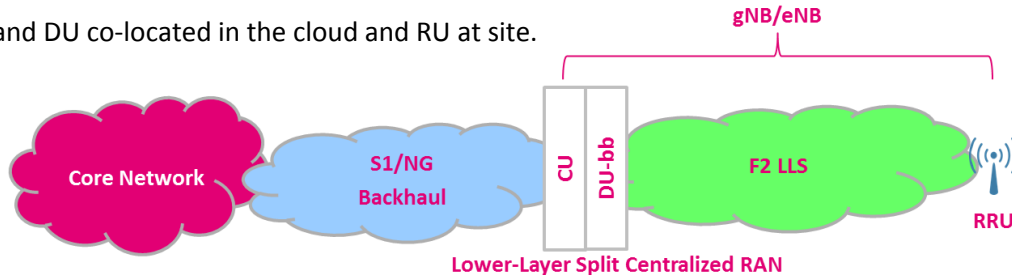
5G RAN Architecture Options and X-haul

Distributed RAN
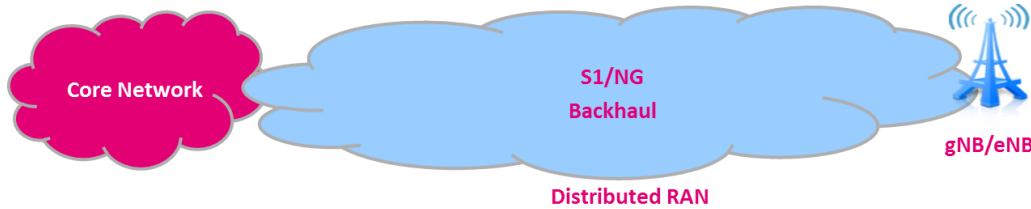
CU in the cloud and DU/RU are co-located

Higher-Layer Split Centralized RAN
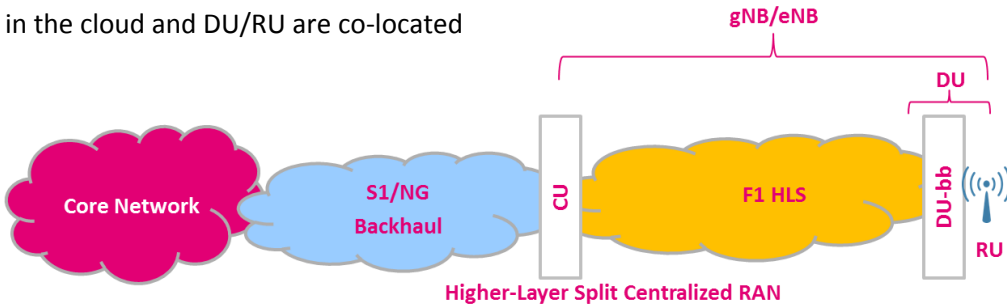
CU and DU co-located in the cloud and RU at site.

Lower-Layer Split Centralized RAN

- In D-RAN architecture, gNB/eNB is/are located at the RF site and connected to core network (EPC, NGC) via S1/NG interfaces.
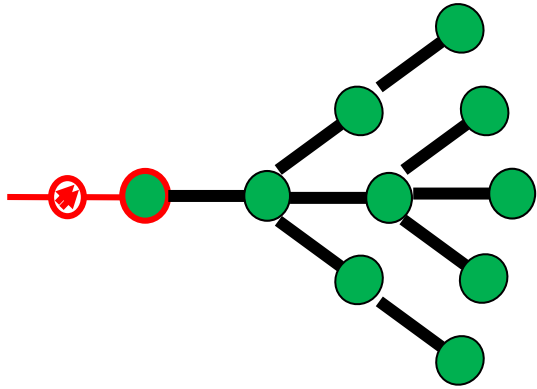
- In the concept of Centralized RAN architecture, the decomposition of conventional RAN functions disaggregates gNB functions with two new entities, CU and DU.

- CU to be placed in a (more) central location to enable optimal radio network coordination and to realize the benefits of virtualisation.

- New X-Haul interfaces between CU and DU (i.e. F1 HLS) and between DU and CU (i.e. F2 LLS) are under discussion, whilst S1/NG interfaces are still employed for the connection between CU and core network.

- Another possible deployment architecture, in which CU in the cloud, DU at the Edge and the RU at site.

Backhaul Network Topology Evolution

- **Network topology change**
  - Network densification
  - RAN sharing and operators consolidation
  - Fiber penetration from core to edge

- **''Shorter networks'' and shorter hops**
  - Shortening of microwave chains
  - **Star topologies** from the fiber PoP

90% of distances is less than 10km

46%
24%
20%
10%

■ 0-3km ■ 3-5km ■ 5-10km ■ >10km

● Radio site connected with fiber
● Radio site connected with microwave
● New Radio site connected with microwave
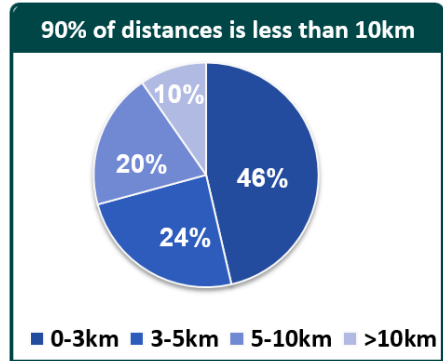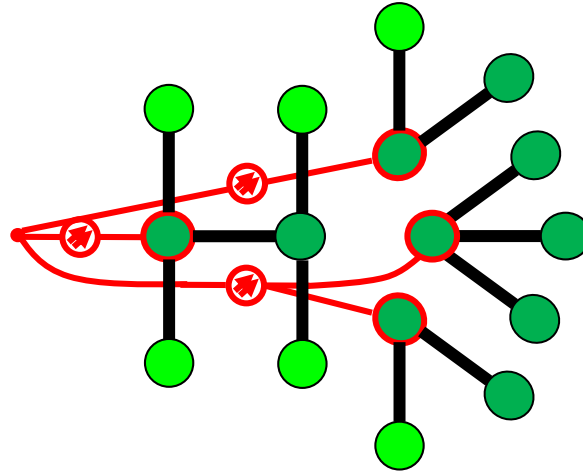
5G Access Sites Configurations and Network Segments

	RURAL	SUB-URBAN	URBAN	DENSE URBAN
Transmission Distance	>7 km	<7 km	<3 km	<1 km
Capacity — Initial phase	<1 Gbps	<2 Gbps	<5 Gbps	<5 Gbps
Mature phase	<2 Gbps	<5 Gbps	<10 Gbps	≥25 Gbps
Site distribution by segment	>40%	>25%	>30%	5%

Wireless Backhaul

Fiber

Small Cells at street level for densification
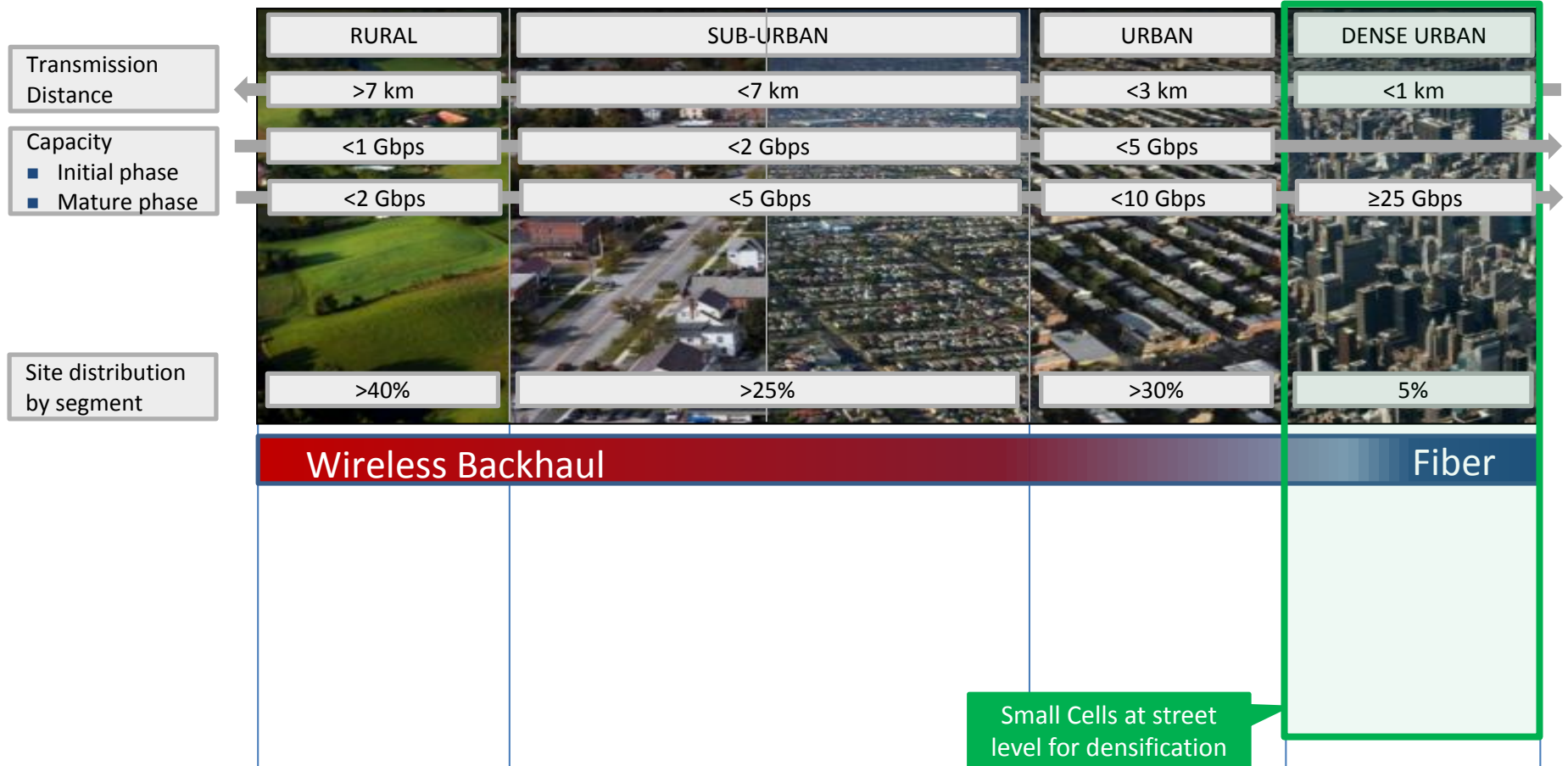
5G Advanced Packet Networking

5G network requirements goes beyond capacity and latency enhancement, and encompass the **provision and management of end-to-end traffic and services delivery** via the access and through the transport networks.

Advanced packet networking could be accomplished by utilising the following **Advanced Networking Functionality:**

- ➢ Ultra-low and deterministic transmission latency (a few tens of us) and jitter
- ➢ Ultra-high precision time/phase packet-based synchronisation
- ➢ 10GE and higher-speed ports
- ➢ SDN automation & advanced packet networking (L3VPN MPLS, RSVP-TE, Segment Routing, etc.)

5G Advanced Packet Networking

Ultra-low and deterministic transmission latency (a few tens of us) and jitter can be achieved by utilising IEEE 802.1 TSN standards and tool box:

TSN Components
Common Standards

- Synchronization
- Reliability
- Latency
- Resource Mgmt

Time synchronization:
Timing and Synchronization (802.1AS) includes a profile of IEEE 1588 (revision ongoing: P802.1AS-Rev)

Bounded low latency:
Credit Based Shaper (802.1Qav)
Frame preemption (802.3br & 802.1Qbu)
Scheduled Traffic (802.1Qbv)
Cyclic Queuing and Forwarding (802.1Qch)
Asynchronous Traffic Shaping (P802.1Qcr)
QoS Provisions (P802.1DC)

Note: P upfront of an ID indicates ongoing Project

Ultra reliability:
Frame Replication and Elimination (802.1CB)
Path Control and Reservation (802.1Qca)
Per-Stream Filtering and Policing (802.1Qci)
Reliability for time sync (P802.1AS-Rev)

Dedicated resources & API
Stream Reservation Protocol (802.1Qat)
TSN configuration (802.1Qcc)
Basic YANG (802.1Qcp)
Link-local Registration Protocol (P802.1CS)
Resource Allocation Protocol (P802.1Qdd)
YANG for CFM (P802.1Qcx)
YANG for LLDP (P802.1ABcu)
YANG for Qbv, Qbu, and Qci (P802.1Qcw)
YANG & MIB for FRER (P802.1CBcv)
Extended Stream Identification (P802.1CBdb)

Zero congestion loss

Relevant IEEE 802.1 Profiles (utilising TSN components from above):
➤ IEEE Std802.1CM TSN for Fronthaul (for cellular networks)
➤ P802.1DF TSN Profile for Service Provider Networks

Ultra-high precision time/phase packet-based synchronisation are accomplished based on the IEEE Std 1588^{TM} and The relevant parts of the ITU-T G8262/G.8271/G.8272/G.8273/G.8275 Recommendations

5G Network Management Automation Requirement

Mobile networks are evolving to a more complex topology mix and dense network elements deployment.
Transport SDN management based systems are becoming a necessity to meet the emerging requirements for support of variety of services, and efficient utilization of network resources while ensuring high level of reliability, robustness, fault predictability and preventions by dynamically configuring and reconfiguring network elements and managing end to end traffics delivery and routing.

Examples of applications and tools enabled by Transport SDN :
➢ Connection and configuration of new microwave devices
➢ **Closed Loop automation**
➢ Synchronisation management of PTP-capable devices
➢ Management of Ethernet-capable devices (setup and management of Ethernet services etc.)
➢ Congestion management and avoidance by Path re-routing
   Plus many more new emerging applications …
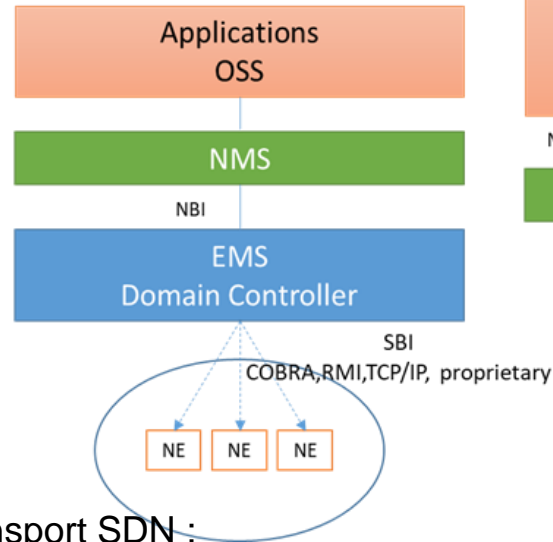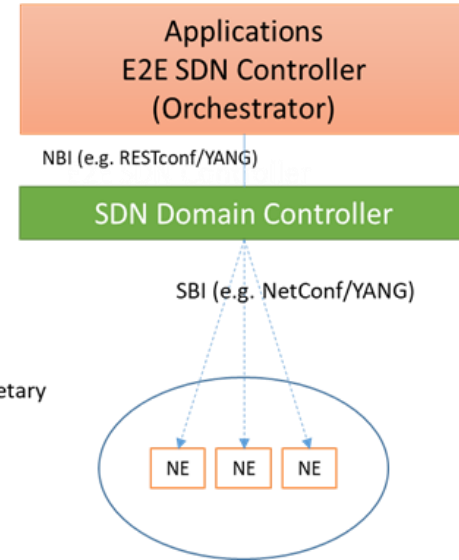
Conclusions

- **5G evolution will have significant impact on wireless backhaul/x-haul.**

- **Various developments in the domains of technology, regulation and standardisation are in progress, including respective activities on the wireless backhaul/X-haul domain.**

  - ➤ **microwave and millimetre wave transmission technologies satisfy 5G "Early Stage" requirements.**

- **To satisfy 5G "Mature Stage" requirements, innovations on wireless backhaul/X-haul technologies will continue towards 5G, focusing on capacity, latency, spectral efficiency, higher transmission distances, synchronization and networking functionalities.**

- **Wireless backhaul/X-Haul technologies will continue to be an essential solution pillar, since they will be able to address the most stringent future requirements of 5G access efficiently and timely.**