MEF 3.0 & The Road to 5G:
Transport, Network Slicing, Orchestration, and Fixed-Mobile Convergence

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What is new in 5G?
5G Is Use-Case Driven

Massive MTC
- SMART AGRICULTURE
- FLEET MANAGEMENT
- TRADING
- SMART METER

LOW COST, LOW ENERGY
SMALL DATA VOLUMES MASSIVE NUMBERS

Enhanced Mobile Broadband
- ENTERPRISE
- HOME
- VENUES
- NON-SIM DEVICES
- Mobile/Wireless/Fixed

Critical MTC
- TRAFFIC SAFETY & CONTROL
- REMOTE MANUFACTURING
- REMOTE TRAINING
- REMOTE SURGERY

ULTRA RELIABLE VERY LOW LATENCY
VERY HIGH AVAILABILITY

- INDUSTRIAL APPLICATION & CONTROL
- VR/AR
- 4K/8K UHD
- BROADCASTING
## Technical Expectations of 5G

<table>
<thead>
<tr>
<th>Specification</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Data Rate</td>
<td>1 - 20 Gbps</td>
</tr>
<tr>
<td>User Experienced Data Rate</td>
<td>10 - 100 Mbps</td>
</tr>
<tr>
<td>Spectral Efficiency</td>
<td>×1 - ×3</td>
</tr>
<tr>
<td>Mobility</td>
<td>350 - 500 km/h</td>
</tr>
<tr>
<td>Latency</td>
<td>1 - 10 ms</td>
</tr>
<tr>
<td>Connection Density</td>
<td>10k - 1m devices / km²</td>
</tr>
<tr>
<td>Network Energy Efficiency</td>
<td>×1 - ×100</td>
</tr>
<tr>
<td>Area Traffic Capacity</td>
<td>0.1 - 10 Mbps / m²</td>
</tr>
<tr>
<td>Mobility</td>
<td>350 - 500 km/h</td>
</tr>
<tr>
<td>Latency</td>
<td>1 - 10 ms</td>
</tr>
<tr>
<td>Reliability</td>
<td>99.999% (of packets)</td>
</tr>
<tr>
<td>Position accuracy</td>
<td>10m - &lt;1m</td>
</tr>
<tr>
<td>Security</td>
<td>Strong subscriber authentication, user privacy and network security</td>
</tr>
<tr>
<td>Availability</td>
<td>99.999% (of time)</td>
</tr>
<tr>
<td>Battery life</td>
<td>10 years*</td>
</tr>
</tbody>
</table>

*For low power IoT devices

Source: ITU-R, NGMN, 3GPP
Critical MTC: Communications Distance vs. Latency

Latency

Communication distance

- Tele-surgery
  - Remote handling w/o haptic feedback
    - Substation-internal comm.
    - Wind turbine-inter
    - High speed motion control
- Remote handling with haptic feedback (e.g., remote mining)
  - Drive Control (packaging, printing)
  - Autonomous driving
  - Automated guided vehicle
  - Hot rolling mill control
  - Process automation
- Inter-substation comm.
- Substation-internal comm.
- Robot manufacturing cell/roundtable
- Wind turbine-inter
- High speed motion control

- 2 m
- 10 m
- 100 m
- 1 km
- 10 km
- 100 km
### 5G-Enabled Digitalization Revenues for ICT Players

**Revenues generated by new industry digitalization value-producing opportunities that are created or enhanced by the introduction of 5G networks.**

<table>
<thead>
<tr>
<th>Year</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
<th>2023</th>
<th>2024</th>
<th>2025</th>
<th>2026</th>
</tr>
</thead>
<tbody>
<tr>
<td>$US Billions</td>
<td>0</td>
<td>4</td>
<td>28</td>
<td>97</td>
<td>259</td>
<td>595</td>
<td>879</td>
<td>1,130</td>
</tr>
</tbody>
</table>

- **Agriculture**
- **Retail**
- **Financial Services**
- **Automotive**
- **Media & Entertainment**
- **Public transport**
- **Healthcare**
- **Public Safety**
- **Energy & Utilities**

**Source:** Ericsson

- **2019:** $0.0
- **2020:** $4.0
- **2021:** $28.0
- **2022:** $97.0
- **2023:** $259.0
- **2024:** $595.0
- **2025:** $1,130.0
- **2026:** $1,307.0

**Growth:**
- **“Normal market growth”** +22%
- **“Ramp up”** +181%
On the Road to 5G

- **2016**: 3GPP Rel-14
- **2017**: Rel-15
- **2018**: Rel-16
- **2019**: Rel-17
- **2020**: Rel-18

Key Technologies:

- **Massive MIMO**
- **LTE Advanced**
- **Massive IoT**
- **RAN Virtualization**
- **Low latency**
- **Early deployments**
- **5G new Carrier Type, NR**
3GPP R15 – 2 Architecture Tracks for New Radio

- **5G Enabled EPC**
  - S1-based
  - Options: Option 1, Option 3
  - Interfaces: LTE, NR

- **3GPP Target Q4 17**

- **NextGen Core**
  - Options: Option 2, Option 4, Option 5, Option 7
  - Interfaces: LTE, NR

- **LTE**
- **NR**

- **LTE**
- **LTE NR/EPC**
- **LTE NR/NXGC**
5G RAN Network

- Multiple Functional Splits between RRH and BBU based on Transport and RAN efficiency tradeoff
- Different Functional Split has different KPIs
5G Transport – Dimensioning Examples

5G D-RAN
- Radio (e)CPRI 10-25G/sector < 75µs
- gNB (e)S1 1-10G < 10ms
- (v)EPC

5G C-RAN
- Radio (e)CPRI 10-25G/sector < 75µs
- gNB (e)S1 10-40G < 10ms
- (v)EPC

eMBB with V-RAN
- Radio (e)CPRI 10-25G/sector < 75µs
- DU F1 1-10G < 5ms
- CU (e)S1 10-40G < 10ms
- (v)EPC

C-MTC with V-RAN
- Radio (e)CPRI < 30µs (indicative)
- DU CU (v)EPC
- Antenna
- Hub
- Central Office
- Switching/Aggr

Example dimensions are traffic model based
All latency numbers in the slide are one way
Throughput is related to carrier bandwidth and MIMO layers
5G Main Components & Their Evolution

- **Wireless Access**
  - LTE evolution
  - NB-IoT
  - NR
  - Massive MIMO

- **Transport**
  - Fronthaul
  - Backhaul
  - Resource Differentiation
  - RAN Transport Interaction

- **Cloud**
  - NFV
  - SDN
  - Virtual Data Center
  - PaaS

- **Network Applications**
  - Cloud Enabled
  - Scalability
  - Distributed Deployment
  - Cloud Native

- **Management**
  - Orchestration
  - Analytics
  - Automation
  - Security

Source: Ericsson
MEF Work Areas

1. Transport for 5G
2. Network Slicing
3. Orchestrating 5G Services
4. MEF Services over 5G
Transport for 5G
Transport Evolution – Backhaul & Fronthaul Considerations

- Sites
- Coordination
- Synchronization

- Radio Access Network
- Evolved Packet Network

- Capacity
- Latency
- Security
- Slicing

- Thousands
- Hundreds

# sites
RAN Coordination Requirements

Transport capacity and **one-way** latency  

**Fronthaul:** 2.5/5/10/25/(50) Gbps \leq 75 \mu s

**Inter-site:** 10/40 Gbps  
<== 23-30 \mu s

**Inter-site:** BH dimensioning*  
<== 5 ms

**Inter-site:** BH dimensioning*  
<== 30 ms

Radio coordination opportunities

**Optimal coordination with co-located basebands**

**Optimal coordination with dedicated fiber transport**

**Tight coordination with high performance transport**

**Loose coordination with any transport**

*Capacity based on backhaul dimensioning

**Optional**

High capacity sites

Capacity sites

Network wide coverage

**C-RAN**

**Virtualized RAN** **C-RAN**

**Distributed RAN**

Fronthaul:

- 2.5/5/10/25/(50) Gbps
  - \leq 75 \mu s

Inter-site:

- 10/40 Gbps
  - \leq 23-30 \mu s

Inter-site:

- BH dimensioning*
  - \leq 5 ms

Inter-site:

- BH dimensioning*
  - \leq 30 ms

**Virtualized RAN**

- Capacity based on backhaul dimensioning

**Distributed RAN**

- **Optional**
MEF 22.2 Terminology

**Backhaul** – macro/small cell to core

**Midhaul** – small cell to macro

**Fronthaul** – remote radio to baseband unit
MEF 22 Phase 4 - Transport for 5G

- Functional Splits can be in 1 or 2 stages (RRH-DU-CU)
- Three types of Fronthaul Networks
- Each has its own KPIs

- RRH, CU, DU, and Core distributed based on Services KPIs
- Multiple configurations can be co-located
- Transport Network can provide support for all

- MEF Ethernet Service Types – Mobile Fronthaul 1,2,3, Mobile Backhaul, Ethernet Backhaul
- Multiple Ethernet Service Types can co-exist
Network Slicing
Three Alternative Network Scenarios Modeled

1. One big network
2. Separate networks
3. Network slicing

This study was restricted to evaluating the impacts of network slicing in the core network only.
Benefits of Network Slicing

- Better customer experience
- Shorter time-to-market
- Scalability through design and verification
- Simpler resource management
- Increased automation
- Flexible network
Overall Economic Impact of Network Slicing

Network slicing enables:
- New revenue generation
- Lower opex
- Greater capex efficiency

**Result:**
Significantly increased economic benefit through new service launches.

*Contribution: revenue minus impacted opex and capex
**Subset of opex that can be influenced by network slicing*
**Transport Network Slicing – System View**

- MEF Ethernet Service based on EVCs
- Ethernet Service Slice is a group of Ethernet Services (EVC)
- A new Group of Ethernet Service is now introduced
Transport Network Slicing Representation

**Slice Representation Examples** - A Group of EVCs

- Single S-Tag = EVC, Enhanced MEF tools (e.g., Trunk/OVC+, Envelope+) to represent Slice ID
- Single S-Tag – Higher order bits=Slice ID, Lower order bits=EVC
- Double S-Tag – Inner Tag=EVC, Outer Tag=Slice ID
- PBB – S-Tag=EVC, B-Tag+I-Tag=Slice ID
- MPLS – S-Tag=EVC, MPLS Label=Slice ID
Fronthaul is inside the RAN Slice between RRH and BBU or between RRH & DU and DU and CU(BBU)

Backhaul is between RAN and Mobile Core Network or between RAN and Wireline Network for Wireline Services

There is an East-West association between RAN, Core, and Transport
Orchestrating 5G Services
5G Network End-to-End Orchestration

- E-2-E LSO = Mobile LSO + Transport LSO
- MEF LSO -> Transport LSO
- MEF LSO extends to E-2-E LSO and/or Mobile LSO
Data-Driven Orchestration

Network Slice Catalogue:
- Mobile Broadband
- Nomadic Broadband
- Industry Automation

Network Slice Resources:
- Access/Mobility
- Service Provider Core
- Service Provider IT Cloud

Network Service Composition

Logical Networks
- MBB Basic
- Media
- Premium Communication
- Robotic communication
- Health

Physical Resources (Access, Connectivity, Computing, Storage, ..)

Data-Driven Orchestration
Orchestrating 5G Services

Ensuring 5G-based services are orchestratable through SDN controllers as part of:

- Heterogeneous connectivity service
  - Multi-Operator
  - Multi-Technology
- Full service lifecycle
  - Network resource provisioning
  - Service OAM and SAT
  - Service assurance (e.g. Zero touch telemetry, closed loopback control)
  - OpenCS 5G project
- Defining use cases, epics and user stories
- Use case -> Information Model -> Data Model -> standardized open northbound APIs for 5G environments
5G Ready Core

MEF LSO - Management & Orchestration & Analytics & Exposure

Virtualization

Software Defined Networking (SDN)

Distributed Cloud CORE & RAN

Network Slicing

Multi-access with new 5G RAT, Fixed Wireless Broadband, Wi-Fi and FTTx
SDN based Transport with options for white label switches/routers
Local and Private Core Networks
User-Plane(s) for various use cases and deployment options (e.g. low latency)
MEF Services over 5G
MEF Services Over 5G – Why?

- More and more traffic is now terminated on mobile devices
- Customers would like the same SLA
  - at the office, home, or traveling
- Fiber availability is limited
- Copper plants are old and deteriorating
  - Optimized for low bandwidth
  - T1/E1 replacement
- Low CAPEX (FedEx vs. Technician)
Advantages of MEF Services Over 5G

- Service on demand (Time to deliver = Revenue)
- Fast activation
- Out-of-band management for SDN networks
- Supporting IoT use case
MEF Services Over 5G

- MEF services
  - Carrier Ethernet
  - IP
- Network slicing allows customer separation for EVC end-to-end
- 5G adds native support for IP or Ethernet frames/service at the UE
Summary

1. 5G is much more than a new wireless technology
2. Multiple transport options can support 5G interfaces
3. Application driven networks calls for network slicing
4. LSO can facilitate orchestration of mobile and fixed networks
5. MEF Services can run fully/partially over 5G
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