5G System Requirements and Architecture

Performance
• 1000x higher mobile data volumes
• 10x - 100x higher number of connected devices
• 10x - 100x typical end-user data rates
• 5x lower latency
• 10x longer battery life

Flexibility
• Network programmability
• Agile service deployment
• Affordable and sustainable

5G Architecture from NGMN White Paper
## 5G Use cases

### 4 White papers 5G scenarios are covering massive IoT, low latency, high reliability, flexibility, cost-efficiency, etc

**IMT-2020 whitepaper - 4 scenarios**
- Seamless wide-area coverage
- High-capacity hot-spot
- Low-power massive-connections
- Low-latency high-reliability

**NGMN whitepaper - 8 scenarios**
- Broadband access in dense areas
- Broadband access everywhere
- Higher user mobility
- Massive internet of things
- Extreme real-time communications
- Lifeline communications
- Ultra-reliable communications
- Broadcast-like services

**3GPP whitepaper - 6 scenarios**
- Ultra-reliable
- Mobile broadband
- Flexible and scalable
- Wide-area
- Virtual presence
- Real-time

**IMT-2020 whitepaper - 3 scenarios**
- Enhanced mobile broadband
- Ultra-reliable and low latency communications
- Massive machine type communications

### Very distinct use cases with different requirements to be supported over the same BH infrastructure

<table>
<thead>
<tr>
<th>Phone</th>
<th>Wireless</th>
<th>Transport Network</th>
<th>Internet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity</td>
<td>150–300Mbps</td>
<td>Access 150Mbps</td>
<td>10–40Gbps</td>
</tr>
<tr>
<td>Delay</td>
<td>10ms</td>
<td>4–10ms</td>
<td>10ms</td>
</tr>
</tbody>
</table>

**Transport Network**
- Microwave
- Fiber

**Internet**
- Cloud
- Internet
- 3rd CDN
Software Defined Wireless Network concept

Mobile backhaul

Mobile service provided over

- Multi-technology network
  - Optical, microwave, Ethernet
- Multi-topology architecture
  - Ring, star

Source: NGMN, “LTE Backhauling Deployment Scenarios”
Mobile backhaul

Exemplary case - QoS

Need for providing homogeneous QoS over heterogeneous transport networks

Need for dynamically controlling network resources according to radio conditions

✓ For instance, adaptive modulation in a wireless backhaul path could impact the network resources for a flow both in the radio access and the aggregation switches in backhaul

Source: NGMN, “Integrated QoS Management”
Software Networks and Economic Efficiency

Some other cases

- The higher granularity of the access networks make them subject of higher investments
- Sharing network infrastructures with other operators reduce that investments
- Agile and flexible mechanisms for sharing network resources are needed
- Variations on traffic load, network status, or service node location could lead to flow redirection over vacant infrastructure

- New models for network resource management (including sharing)
  - Multi-tenancy at any level
  - Reducing CAPEX and OPEX
  - Help building the case for addressing 5G
  - Address the long tail when and wherever necessary
    - Following the users
  - A new converged architecture
  - The “last yard” rather than the “last mile”
Mobile backhaul

SDN control will allow the orchestration of the network resources

Separate, independent layers do not allow overall optimization
  • Multilayer approach for performing combined optimization

Separated domains complicate the service provisioning and network adaptation
  • Interconnection of controllers for e2e optimization

Separated control and management mechanisms require multiple interventions
  • Standard interfaces simplify heterogeneous device management
SDN challenges for 5G

- **Fine-grained management of network flows**
  - New possibilities arise for a richer management of traffic flows to provide advanced functionalities (e.g., offloading, caching, etc.)
  - Opportunity for achieving a better network utilization
  - Fixed/Mobile mix of traffics with distinct QoS and different impact in terms of network costs and revenue

- **SDN-based control mechanisms**
  - Scalability of the decoupled control elements
  - Reliability of a logically centralized system

- **Co-existence with fixed and mobile legacy infrastructure**
  - Put in value the control plane in current network equipment already deployed e.g. E2E MPLS (integration vs. substitution)
  - Interoperability with conventional equipment in the field (IP routing, MPLS signaling, OAM mechanisms, etc.)

- **Enabler for network virtualized functions**
  - Rapid programmatic re-configuration to support de-localized network functions from fixed and mobile (even moving network functions to the cloud)

- **New forms of operating the network**
  - Organizational changes and new skills are required
• Xhaul aims at developing an adaptive, sharable, cost-efficient 5G transport network solution integrating the fronthaul and backhaul segments of the network.

• This transport network will flexibly interconnect distributed 5G radio access and core network functions, hosted on in-network cloud nodes, through the implementation of novel building blocks:
  
  • A control infrastructure using a unified, abstract network model for control plane integration (Xhaul Control Infrastructure, XCI);

  • A unified data plane encompassing innovative high-capacity transmission technologies and novel deterministic-latency switch architectures (Xhaul Packet Forwarding Element, XFE).

  • A set of computing capabilities distributed across the network (Xhaul Processing Units, XPUs)

• Xhaul will greatly simplify network operations despite growing technological diversity. It will hence enable system-wide optimisation of Quality of Service (QoS) and energy usage as well as network-aware application development.
The middle layer represents one of the key concepts associated to Xhaul: the integration of the different technologies (including fronthaul and backhaul) in a common packet network based on technology abstraction, unified framing and common data, control and management planes.

Finally, the upper layer presents a selection of the features offered by the Xhaul infrastructure.
Taking Action - First-ever SDN PoC for MW

Motivation

- No common way of controlling and managing Wireless Transport Networks (e.g., Microwaves)
  - Road to simplification
- No advance control plane features for rich functionalities nor multilayer coordination (SDN as an enabler)
  - Road to automation

Framework

- OpenFlow extensions defined within Wireless Transport Project within Open Networking Foundation (ONF)
- First attempt to define a (unified and standard) control plane for Microwave systems
- Multi-vendor interworking, multi-layer control, network-wide coordination

Use cases tested

- **capacity-driven air interface**: network’s ability to adapt to traffic demand and to efficiently optimize wireless resources for a more energy efficient operation of the transport network
- **flow-based shaping**: network’s ability to adapt and respond to changing conditions such as the weather impacting wireless transport networks.

Wireless Transport SDN PoC White Paper
Taking Action - 5TONIC

5TONIC is an open research and innovation ecosystem in the area of 5G Products and Services

- Based on the direct collaboration between Telefónica and IMDEA Networks
- Make industry and academia come together
- Boost technology and innovative business models

With the goal of becoming a central hub for knowledge sharing and industry collaboration in the area of 5G technologies

- Across Europe, associated with the European 5G initiatives
- Across the global Telefónica footprint

Initially focused on two main technology areas

- 5G Virtual Software Network Area
- 5G Wireless System Area

http://saladeprensa.telefonica.es/documentos/nprensa/5TONIC_TEF_EN29_10_2015_DEF.pdf
### Main challenges

<table>
<thead>
<tr>
<th>Key Benefits</th>
<th>Key Challenges</th>
</tr>
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<tbody>
<tr>
<td>Easier deployment of new services</td>
<td>Specification of the interfaces</td>
</tr>
<tr>
<td>Reduced management and operational costs of heterogeneous technologies</td>
<td>Need to integrate scheduled-based and contention-based systems</td>
</tr>
<tr>
<td>Efficient operation of multi-vendor infrastructures</td>
<td>Harmonization of the standardization efforts</td>
</tr>
<tr>
<td>Increased accountability and service differentiation</td>
<td>Verifiable security and privacy architecture</td>
</tr>
<tr>
<td>Continuous and transparent enhancement of network operation</td>
<td>Operation and management of wireless networks is more complex</td>
</tr>
</tbody>
</table>
This work has been (partially) funded by the EU H2020 Xhaul Project (grant no. 671598)

**Xhaul: the 5G Integrated fronthaul/backhaul**

**Telefónica**

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High level setup - SDN PoC for MW