Slicing and orchestration in service-oriented 5G architecture

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Plenary keynote at IEEE/IFIP WONS 2018
6-8 February 2018, Isola 2000, France

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Connected, Controlled, and Flexible

Digital Society

Value Creation  Consistent experience

Sustainable business model

What is 5G?
V2X is a critical component to our vision
Giving vehicles the ability to communicate with each other and beyond

Technical Requirements
- 1ms Latency
- Up to 10Gbps Throughput
- Up to 1M Connections/Km²
- 500Km/h High Speed

Long Tail Use Cases will be Key Driving Force of 5G

Not a one-size fits all
Turn physical infrastructure into multiple logical networks

Service-Oriented 5G
Today’s 4G is designed for limited number of UCs

Throughput-optimized
Fixed
Rigid

Communication-oriented 4G
Mindful about 3GPPP facts and figures

514 Companies from 45 Countries
50,000 delegate days per year
40,000 meeting documents per year
1,200 specifications per Release
10,000 change requests per year

Communication-oriented 4G
Future mobile network will look fundamentally different.

There will be no “one-size-fits-all” architecture.

Like it or not.
Flexible and Customizable for each use-cases

Service-oriented 5G
Trends

Softwarization
Virtualization
Disaggregation

Service-oriented architecture

Service-oriented 5G
Why will it happen?

Extreme network flexibility and modularity

Service-oriented 5G
## 3GPP re-architects mobile networks

<table>
<thead>
<tr>
<th></th>
<th>3G</th>
<th>4G</th>
<th>5G</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Downlink waveform</strong></td>
<td>CDMA</td>
<td>OFDM</td>
<td>OFDM, SCFDMA</td>
</tr>
<tr>
<td><strong>Uplink waveform</strong></td>
<td>CDMA</td>
<td>SCFDMA</td>
<td>OFDMA, SCFDMA</td>
</tr>
<tr>
<td><strong>Channel coding</strong></td>
<td>Turbo</td>
<td>Turbo</td>
<td>LDPC (data) / Polar (L1 contr.)</td>
</tr>
<tr>
<td><strong>Beamforming</strong></td>
<td>No</td>
<td>Only data</td>
<td>Full support</td>
</tr>
<tr>
<td><strong>Spectrum</strong></td>
<td>0.8 – 2.1 GHz</td>
<td>0.4 – 6 GHz</td>
<td>0.4 – 90 GHz</td>
</tr>
<tr>
<td><strong>Bandwidth</strong></td>
<td>5 MHz</td>
<td>1.4 – 20 MHz</td>
<td>Up to 100 MHz (400MHz for &gt;6GHz)</td>
</tr>
<tr>
<td><strong>Network slicing</strong></td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>QoS</strong></td>
<td>Bearer based</td>
<td>Bearer based</td>
<td>Flow based</td>
</tr>
<tr>
<td><strong>Small packet support</strong></td>
<td>No</td>
<td>No</td>
<td>Connectionless</td>
</tr>
<tr>
<td><strong>In-built cloud support</strong></td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Service-oriented 5G
3GPP re-architects mobile networks

Service-oriented 5G
3GPP Role Model

E.g.: End user, Small & Medium Enterprise, Large enterprise, Vertical, Other CSP, etc.

Service-oriented 5G
Shared Resources?
Isolated Resources?
Automation - Orchestration
the phase change of modern software

Software cost

Operation cost

Free software is becoming expensive

Automation-Orchestration
LifeCycle Management (Encapsulate operation)

Automation-Orchestration
LifeCycle Management (Encapsulate operation)

Installation → configuration → connections → upgrades and updates → scale-out and scale-back → health checks → operational actions → benchmarks

https://jujucharms.com/q/oai

Automation-Orchestration
Disaggregation

Radio Resources

BS1

BS2

BS3

Services

S1 S2 S3

S1 S2 S3

S1 S2 S3

S1 S2 S3

vBS1 vBS2 vBS3

40% of resources are not used

Multiplexing gain
Multiplexing Gain
Network Slicing Concept
Turn physical infrastructure into multiple logical networks on top of a partially shared network infrastructure.

Each instance of a network slice represents an independent end-to-end network.
Enabling Technologies
Service provider: owner of data with isolated and customized services

Runtime: multi-service execution environment allowing to monitor and control the behavior of the underlying RAN resources, states, and functions

Infrastructure: including RAN module, physical infrastructure, and radio spectrum

RAN Slicing System
Inter-Slice Resource Partitioning

![Graph showing goodput (kB/s) over time (ms) for three slices: Slice 1, Slice 2, and Slice 3.](chart)

- **Slice 1**: Blue line with a peak goodput of approximately 7000 kB/s around 2.5 ms.
- **Slice 2**: Red line with a goodput range of 1800 to 2200 kB/s.
- **Slice 3**: Orange line with a goodput range of 1200 to 1400 kB/s.

**Time (ms)**: 0.0 to 5.5 × 10^4
Function customization in Monolithic BS

RAN Slicing Example
Benefit of Slicing

Maximize the multiplexing gain

Isolate tenants resources

customize tenant resources
What is the typical number of slices?

What is the typical lifetime of a slice?

Two numbers in Slicing
Why such a big complexity to support slicing?

Is the net neutrality principles retained?
Realtime control and coordination in RAN and CN

Tradeoff between slice isolation and resource sharing

Security control across many logical networks and abnormally detection

Pattern recognition and correlation to support QoS-QoE

Predict network behavior if a given control logic is applied

Automate failover and network health monitoring and prediction

Dynamic guarantees as a function of cost /adaptive/probabilities
Need for agile network service delivery platforms and use-cases for 4G-5G R&D

- 5G-SaaS
  - Consume 5G service
- 5G-PaaS
  - Build 5G service and open APIs
- 5G-IaaS
  - Host 5G service

Opensource Platforms
Agile network service delivery platforms

A Flexible & Programmable SD-RAN Platform

A Low Latency SDN-based MEC Platform

An event-driven juju-based service orchestrator core

A Flexible & Programmable SD-CN Platform

Network function & application distribution Repository

Remotely accessible experimentation testbed

Mosaic5G.io Ecosystem
Agile network service delivery platforms

Open5G Lab

Net Store

JOX Orchestrator

LowLatency-MEC

FlexRAN Controller

FlexCN Controller

OpenAirInterface RAN

OpenAirInterface CN

Mosaic5G.io Ecosystem
Mosaic5G.io Objectives

- Software-Defined Network
- Network Delivery Platform
- Network Intelligent
- Network Applications
- Custom Use-Case

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Mosaic5G.io
Success Stories

- MWC 2016, 2017
- ITU, FG-13, 2016, 2017
- ETSI 2016, 2017
- EUCNS 2015, 2016, 2017
- OPNFV 2016
- Mobicom 2014, 2016, 2017
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