Extending Network Slicing to the RAN

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Outline

• Cloud-Computing-As-An-Analogy
• Cellular Network Evolution Towards Network Slicing
• Network Slicing – What is it?
• Network Slicing in 3GPP
  • Only focusing on the core
• Where are we with the RAN?
  • SD-RAN driving RAN Slicing?
Evolution to Cloud Computing

- Evolution to Cloud Computing
- HORIZONTAL DISAGGREGATION
- VERTICALLY INTEGRATED

- Open Interface
- Adobe
- Mac OS
- Open Interface
- Open Interface
Evolution to Cloud Computing
Evolution to Cloud Computing
Evolution to Cloud Computing

Physical Resources

RESOURCES: SEEMINGLY INFINITE
Evolution to Cloud Computing

Services Resources

RESOURCES: SEEMINGLY INFINITE

CLOUD

HARDWARE

HYPERVERSOR

OS

APP

Networking

Storage

Compute

PLATFORM

CLOUD AUTOMATION, OA&M

Software
Cloud Computing...

is a style of computing where **scalable** and **elastic** IT-related **capabilities** are provided as-a-service to **external customers** using Internet technologies.

**elasticity**: ability to grow or shrink infrastructure resources (compute and storage) dynamically as needed to adapt to workload changes in an autonomic manner, maximizing the use of resources.

**scalability**: ability to increase workload size within existing infrastructure (hardware and software) without impacting performance.
Cellular Networks Today

3GPP CORE

eNB/gNB

UEs

3GPP RAN

3GPP CORE

IMS

APPS

PUBLIC CLOUD

OTT APPS
Horizontal Disaggregation

3GPP CUPS (Release 14)

- USER PLANE
- CONTROL PLANE
- APPS
Virtualization

RESOURCES: NOT ALWAYS INFINITE!
RAN Virtualization

New Resources: Connectivity Service VNFs
RAN Virtualization

New Resources: Time-Frequency Resource Blocks

RESOURCES: PHYSICALLY LIMITED

Wireless Time-Frequency Resource-Blocks

RAN Connectivity VNF

Edge Cloud
Virtualized Mobile Networks
Virtualized Mobile Networks

With Distributed Network Resources
Virtualized Mobile Networks

With Distributed Network & Services Resources
Network Slicing…

is a mobile networking platform using which elastic and scalable access & connectivity related capabilities are provided as-a-service to customers in a given geography using 3GPP-standardized technologies

**elasticity:** ability to grow or shrink networking resources (spectrum, compute, storage, xhaul) dynamically as needed to adapt to supported use case changes in an autonomic manner, maximizing the use of resources

**scalability:** ability to increase allocated networking capacity size within existing network resources (spectrum, hardware and software) without impacting own or other slices’ performance
## Network Slicing Lifecycle

### Slice Request Attributes

<table>
<thead>
<tr>
<th>Attribute</th>
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<tbody>
<tr>
<td>Latency</td>
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<tr>
<td>Throughput</td>
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<tr>
<td>Reliability</td>
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<tr>
<td>Mobility</td>
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<td>Geography</td>
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<td>Security</td>
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<tr>
<td>Analytics</td>
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<tr>
<td>Cost Profile</td>
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### Composable Network & Service Resources

### Automated Composition and Life-Cycle Management

### Localized, Personalized Delivery
Network Slicing aims to transform a mobile network to a network cloud with distributed physical and services resources.
Network Slicing & 3GPP

Descriptions

**Network Function**: A 3GPP adopted or 3GPP defined processing function in a network, which has defined functional behavior and 3GPP defined interfaces.

**Network Slice**: A logical network that provides specific network capabilities and network characteristics.

**Network Slice Instance**: A set of Network Function instances and the required resources (e.g. compute, storage and networking resources) which form a deployed Network Slice.
Network Slicing & 3GPP
Network Slicing & 3GPP

NSI 1

CN

AN

NSI 2
Network Slicing & 3GPP

S-NSSAI: [SST, SD]
Network Slicing & 3GPP

NSSAI: [S-NSSAI 1, S-NSSI 2,...]]

S-NSSAI: [SST, SD]
Q: Which Slice Instance for S-NSSAI 1 and PLMN x?
A: NSI 1

S-NSSAI: [SST, SD]
Q: Where are the Slice Instance components for NSI 1?
A: IPs

S-NSSAI: [SST, SD]
What About the RAN?

O-RAN calls this Near Real-Time

SD-RAN Controller

PHY
Scheduling
MAC
RLC
PDCP
RRC

PHY-LO
PHY-HI
Scheduling
MAC
RLC
PDCP-U
SDAP
PDCP-U
RRC

CU-U
CU-C

Let's call this Real-Time

Packet & Signal Processing  Radio Resource Management Control
RAN Controller

Base Station Near-Real Time Control (Radio Resource Control - RRC)

- R-NIB: Time Averaged QCI Values
- R-NIB: Device Configuration, Session Info

Base Station Real Time Control (MAC Scheduler)

- R-NIB: Instantaneous QCI Values

- Handover Control
- Base Station Wireless Resources Usage
- Load Balancing
- Interference Management
- Dual Transmission Decision
- Cipher Key Assignment
- Semi-Persistent Scheduling
- RF Configuration
- RAN Slicing
Real-Time Control

User Buffers

SCHEDULER

QCI Feedback
Every 1ms
Real-Time Control

STEP 1: Decide on which users to serve

User Buffers

SCHEDULER

QCI Feedback Every 1ms
Real-Time Control

STEP 2: Decide on how many RBs to allocate to each selected user and get PHY to populate packets

SCHEDULER

QCI Feedback Every 1ms

User Buffers

5 4 12 9
STEP 3: Map PHY packets to RBs

Real-Time Control

User Buffers

QCI Feedback Every 1ms

SCHEDULER
Disaggregate and Virtualize Real-Time Control

User Buffers

Virtual RB to Physical RB Mapping

Virtual RBs
Assign Resources Elastically

Virtual RBs

Virtual RB to Physical RB Mapping

SCHEDULER
WIRELESS HYPERVISOR

SCHEDULER
WIRELESS HYPERVISOR
Configure Slices

RAN Near-Real Time Control

RAN Real Time Control

SCHEDULER
WIRELESS HYPERVISOR

SCHEDULER
WIRELESS HYPERVISOR
Challenges

- Telco Transformation: Mindset shift from appliance-based thinking to cloud-based thinking
- Killer use cases enabling new revenue streams
- Where is the Edge?
- Telco Transformation: Cloud-Native
- Workload Placement
- Telco Transformation: Multi-Tenancy
- Orchestration, Automation, Network Cloud Management
- RAN Virtualization and Slicing
Network Slicing and the Edge

With 5G - Edge is where Public Cloud meets the Network Cloud
Network Slicing and the Edge

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Diagram showing the relationship between Public Cloud, Mobile Network Cloud, and various network slicing instances (NSIs) with Microservices connected.
Two Clouds: Let’s Talk

Public Cloud

Mobile Network Cloud

End-to-End Management
THANK YOU