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Scaling and Sharing Network Slices in 5G Networks CARLA FABIANA CHIASSERINI, POLITECNICO DI TORINO 5GB



Slices

Networks

Scaling

Sharing

Virtualization

NFV

VNF placement

Edge/MEC

KPIs

Vertical services

Scaling in/out (or up/down)

Al-driven networks

Keywords or Buzzwords?



New-generation cellular

What is/was a breakthrough in 5G?

Vertical industries become customers of mobile networks

Verticals **specify** their quality of service requirements (not limited to data rate any longer)



How is this possible to host vertical services?

How is this possible to host vertical services? First, network as a programmable platform

Edge computing: the network as a programmable platform

Network will **process** data, not just transfer it



How is this possible to host vertical services? First, network as a programmable platform

SDN as a key technology

Northbound interface: Network control API





NFV, SDN, MANO: ETSI Architectural view



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How is this possible to host vertical services? First, network as a programmable platform

Edge computing: the network as a programmable platform

Network will **process** data, not just transfer it

Processing and applications within the network to provide mobile users with services

Lower delays and higher efficiency



Edge vs MEC

Edge computing: the cellular network as a programmable platform

Multi-access Edge Computing (MEC): network as a programmable platform at the VERY edge, which also exploits information related to radio link



How is this possible to host vertical services, each with the required quality of service?

Network slicing

Virtualization allows to **slice** the network into virtual subnetworks (separated sets of resources)

Service deployment = Creating a slice hosting the virtual function set



Some examples of vertical services

Automotive use case: the Extended Virtual Sensor Service for Intersection Control

- Vehicles send periodic messages (CAMs) toward the network infrastructure
- CAM: position, speed, heading,...
- A Collision Detection algorithm runs in the Edge parsing the CAMs sent by the vehicles
- If a collision is detected, an alert is sent to the two vehicles on collision course



Automotive Virtual Function Graph: The Extended Virtual Sensor Service



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Industry 4.0: Digital Twin

- Robots periodically send position information
- Central entity processes data and performs rendering
- Human user can visualize the digital twin and input commands
- Central entity performs motion planning and generates commands
- Commands sent back to robots



Digital Twin



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Challenges

Vertical service deployment (VNF placement and resource allocation) – still lots to learn, especially in presence of mobility

Virtualization at the Edge poses a **performance issue**, especially in terms of delay (both the above services have strict delay constraints)

Cost, big concern for Verticals and Mobile Operators

End-to-end slicing

Challenges

Vertical service deployment (VNF placement and resource allocation) – still lots to learn, especially in presence of mobility

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End-to-end slicing



Is VERTICAL service virtualization the only one that matters?





vRAN



Chang et al. RAN Runtime Slicing System for Flexible and Dynamic Service Execution Environment. IEEE Access 6, 34018–34042, and Schmidt et al. Radio Access Network Slicing System, Eurecom



Learning at the Edge for Efficient Virtual Networks

Carla Fabiana Chiasserini, Politecnico di Torino

Heterogeneity

Different actors: Base stations, Pedestrian users, Vehicles, Drones, IoT

Different connectivity: D2I/I2D, D2D, V2X

In general, limited computational / memory capability, and in some cases limitations in terms of power consumption





First challenge: Experiments and measurements from the edge

5G-Transformer & 5Growth architecture



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System implementation in 5G-Transformer



Performance metrics

System level Reliability (depends also on radio) Delay

Application level

Percentage of vehicle collisions detected (in time) Percentage of false positives and corresponding vehicles relative distance

G. Avino, Giuseppe, et al., «A MEC-Based Extended Virtual Sensing for Automotive Services», IEEE Transactions on Network and Service Management, July 2019

Cross-layer SLA Management

Delay performance



Vehicle density =20 vehicles/km: with **Edge** 99.99% of the cases, delay below 50 ms; with **Cloud:** in 98% of the cases above 60 ms

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Application-layer performance

Reliability and delay are intertwined, faster is also more reliable



G. Avino, Giuseppe, et al., «A MEC-Based Extended Virtual Sensing for Automotive Services», IEEE Transactions on Network and Service Management, July 2019

Closer look to delay performance





System implementation in 5G-Transformer



Scale out/in

Measure CPU consumption: if above threshold, then scale out:

A new VM running the Collision Detection algorithm is instantiated, and the area controlled by each instance of the algorithm is reconfigured



Demo at EuCNC 2019, IEEE NFV-SDN 2019, IEEE NFV-SDN 2020 (Best paper award) and X. Li, et al. «Automated Service Provisioning and Hierarchical SLA Management in 5G Systemses,» IEEE Transactions on Network and Service Management, submitted



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If video streaming is provided too, we need to arbitrate between the two services if there are not enough resources at the MEC for the safety service

Demo at EuCNC 2019, IEEE NFV-SDN 2019, IEEE NFV-SDN 2020 (Best paper award) X. Li, et al. «Automated Service Provisioning and Hierarchical SLA Management in 5G Systemses,» IEEE Transactions on Network and Service Management, submitted



5G-Transformer & 5Growth architecture



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Some real-world stuff

To be shown during Q&A session ⁽²⁾

