

Software and Virtualization Technologies in Mobile Communication Networks.

→ Network Functions Virtualization

Simulate hardware platform (high portability, high scalability, more cost-effective)

Virtualized networks: logical software-based routers, easy to deploy network services, physical part only handles packet forwarding.

↳ Virtualized Network Functions (VNF)

- Network Functions in a virtual way.
- Economy of scale and flexibility: less investments in infrastructure, lower costs in infrastructure.
- Flexibility: VNF lifecycle management
 - VNFs are deployed after a service request is done via north bound interface.
 - Onboarding → deploying → monitoring → healing → updating → undeploy.

↳ Network Services

Chained VNFs, interconnected to communicate, can connect to physical functions.

1. VNF concept summary

↳ NFV - concept, terminology

- Standard-based approach to manage network services, which are built from **UNF** aggregation.
- There is need for management and orchestration of the network services

UNF Descriptor: tool used by the UNF Manager, specifies:

- how UNF is instantiated
- how many VFs the UNF has
- ...

NS Descriptor: how the NS is composed

↳ Management and orchestration

Virtualized network services need an entity to manage and coordinate resources → **NFV coordinator**

Allows flexible on-boarding of network services and handle components spin-up.

→ Software defined networks (SDN)

Tool to enable higher degree of control over network devices and traffic flow.

↳ SDN switch

OpenFlow agent that's able to communicate with the controller, processing commands received by it.

Flows contain sets of modifiers and actions which are applied to each packet it matches. Each flow table entry contains match, action and priority.

↳ How to 'direct' the controller? North bound

North bound interface allows for northbound protocols, allowing apps and systems to program network and request services.

Northbound Protocol examples: Rest API, Web Browser, Web Sockets, OSGi framework.

↳ Openflow Problems

Only controls flow tables, not switch pipeline.
Fragmentation adoption (protocol evolves slowly),
limited tunnel support, telemetry.

↳ Programming Protocol-Independent Packet Processors (P4)

Objectives: reconfigurable, protocol-independence, switch/vendor independence, consistent control plane interface.

Benefits:

- new features: add new protocols
- reduce complexity (remove unused protocols)
- efficient use of resources
- greater visibility
- software style development

P4 program is a high-level program that configures forwarding behaviour. The compiler generates the low level code to be executed. OpenFlow and

still be used to install and query rules.

P4 Runtime: Framework for runtime control of a P4-defined data planes

P4

• Programming language used to define how a switch processes packets.

• Specify switch pipeline
• " " behaviour of existing device.

• logical abstraction for the device

vs

P4 runtime

• API to control switches whose behaviour has already been specified in P4 lang.

→ **Open RAN**

Open RAN aims to define interfaces for split RAN architecture.

OpenRAN aims to disintegrate mobile network RAN architecture.

Benefits:

- avoid vendor lock-in
- reduce cost
- quick time to market
- best of breed
- spur innovation
- participate in HW/SW development.

↳ logical Open RAN Architecture.

RIC: RAN Intelligent Controller

— distributed unit

O-DU: Open distributed unit

O-CU-CP
and O-CU-UP: O-RAN central unit

O-RU: O-RAN radio unit

O-Cloud: generic cloud infrastructure.

→ Network Automation

AI accelerates service provisioning, reduces probability of human errors, predict and rectify faults, improves efficiency on detecting threats.

↳ Self-driving network, how?

Telemetry, multidimensional views, automation, declarative intent, decision making.

Telemetry: obtain info from the network, data, etc. Real-time vs statistical.

Multidimensional views: what is useful info? To act, to react, to account...

Decision making: - Rule-based learning

(straightforward, easy to predict, **but** slow work, hard to manage at scale).

- Machine learning

(creative, fast way to learn complex behaviour **but**

can come to strange conclusions, hard to know what it knows.)

Idea is to remove humans from low-level painful tasks. Networks adapt, react, anticipate. Security becomes good guy bot vs bad guy bot.