# NITOS testbed: a platform for flexible experimentation with 4G/5G resources

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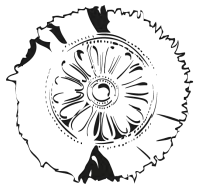

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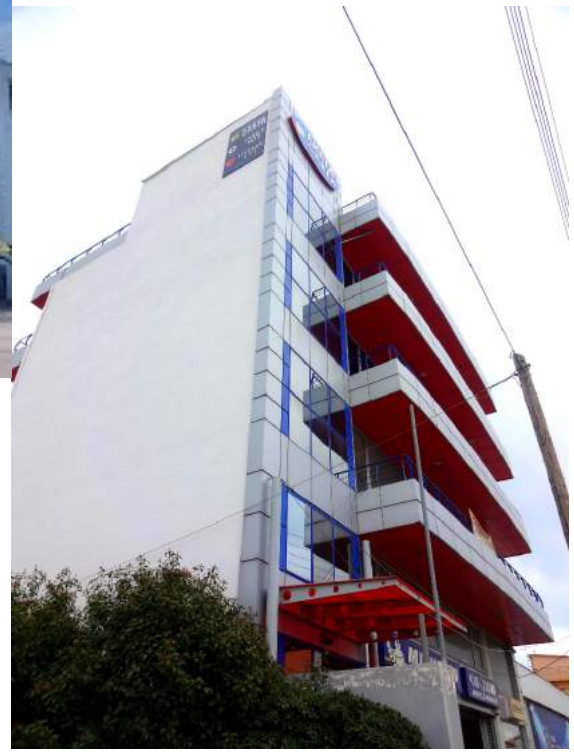
# Network Implementation Testbed Laboratory (NITLab)

- ✓ Affiliated with CERTH and UTH
- ✓ 5 faculty members
- ✓ 25 researchers (research engineers, postdocs, PhD students, master students)
- ✓ Research activities in the field of wired and wireless networking, cloud, smart cities
- ✓ Strong participation in EU projects
- ✓ Website: nitlab.inf.uth.gr



# Outline

- ✓ Brief Presentation of the NITOS Wireless Testbed
- ✓ 5G Applications developed over the testbed
  - ✓ Development of disaggregated heterogeneous base station functionality
  - ✓ Development of Multi-Access Edge Computing (MEC) mechanisms
  - ✓ Orchestration tools for the heterogeneous 5G infrastructure

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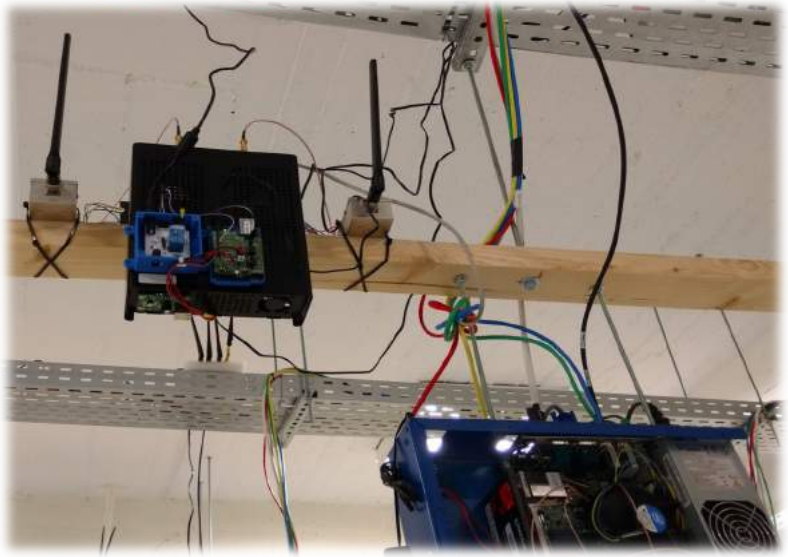
# NITOS Wireless Testbed (1/3)

- ✓ NitLab developed and operates NITOS, a research experimental facility that supports the research activity of the lab in EU level
- ✓ NITOS stands for "Network Implementation Testbed using Open Source tools"
- ✓ NITOS supports multiple technologies like wireless (Wi-Fi, 4G, mmWave, SDR), wired networks, SDN/NFV, cloud, sensors.



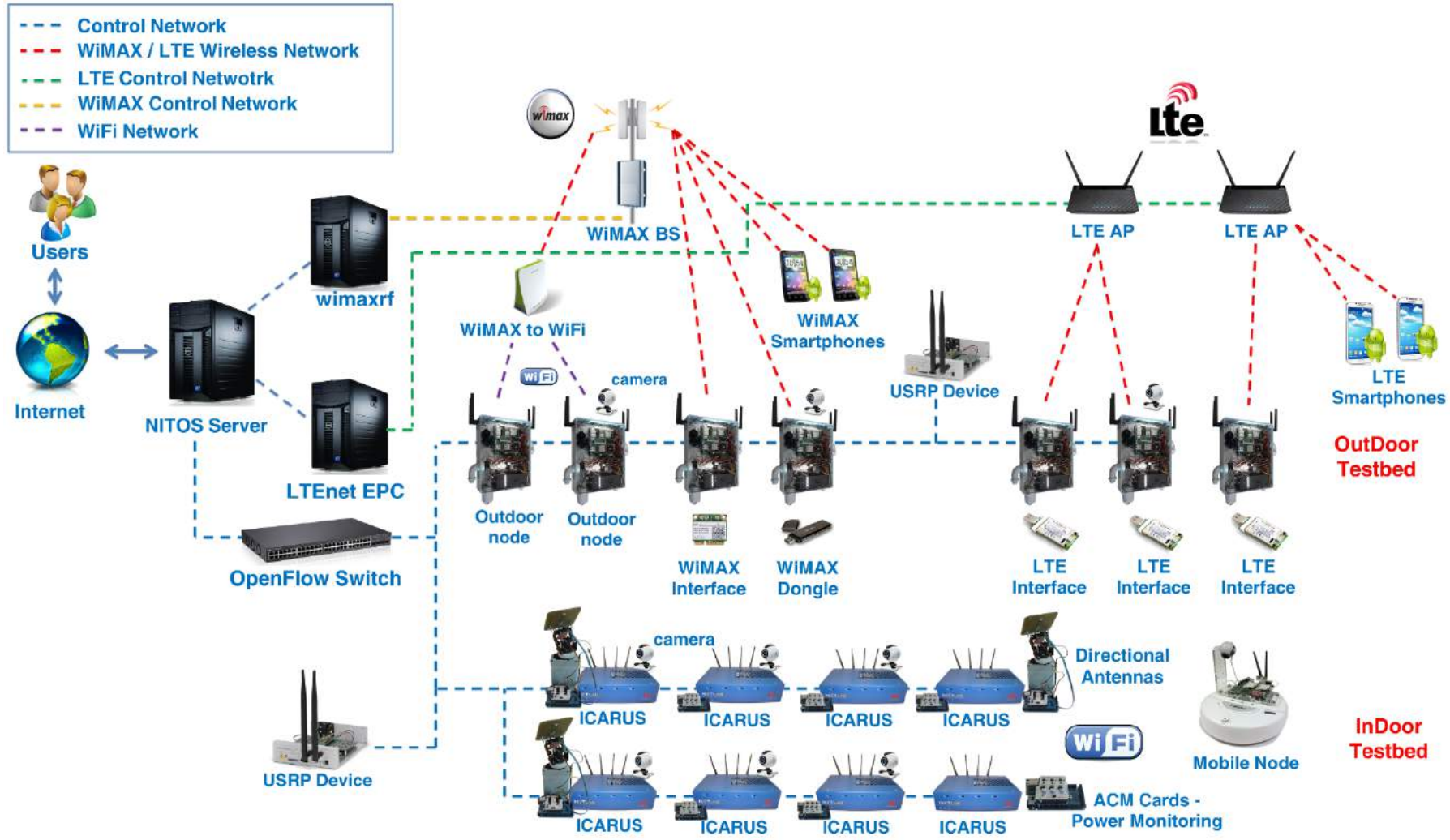
# NITOS Wireless Testbed (2/3)

- ✓ NITOS is the main testbed facility of multiple EU projects (currently in two 5GPPP - 5G-PICTURE, 5G-VICTORY).
- ✓ NITOS is constantly upgraded with state-of-the-art hardware and software.

# NITOS Wireless Testbed (3/3)

- ✓ Wide offering of resources for Wireless/Wired/IoT/Cloud experimentation
- ✓ Organized in three different setups, to cover different experimental settings
  - ✓ Indoor RF-isolated setup
  - ✓ Outdoor, prone to external uncontrolled interference
  - ✓ Office setup, with low external interference
- ✓ Over 100 physical machines as testbed nodes that can be reserved with the testbed's tools, offering different technologies (COTS LTE, Open Source LTE, WiFi, WiMAX, SDRs, mmWave Units, OpenFlow switches, ZigBee/LoRa/LoRaWAN sensors and cloud infrastructure)

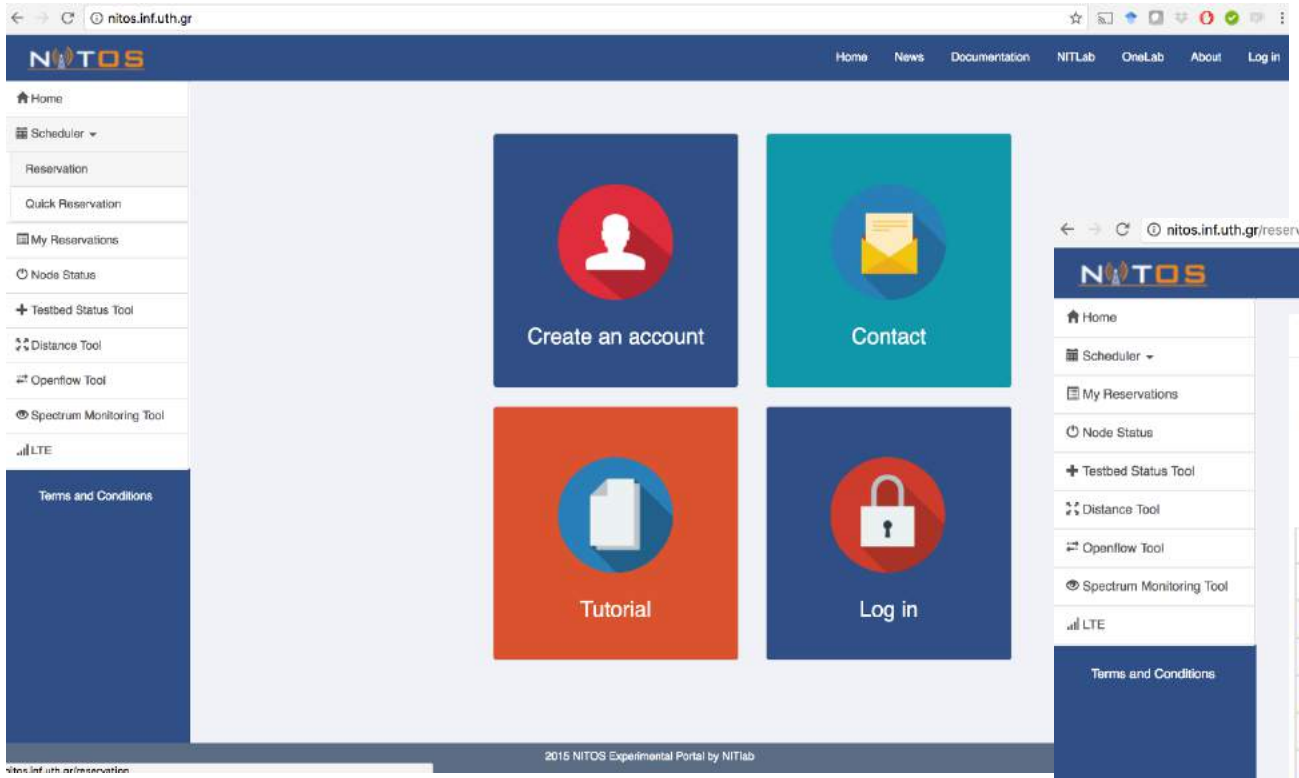
# NITOS Overall Architecture

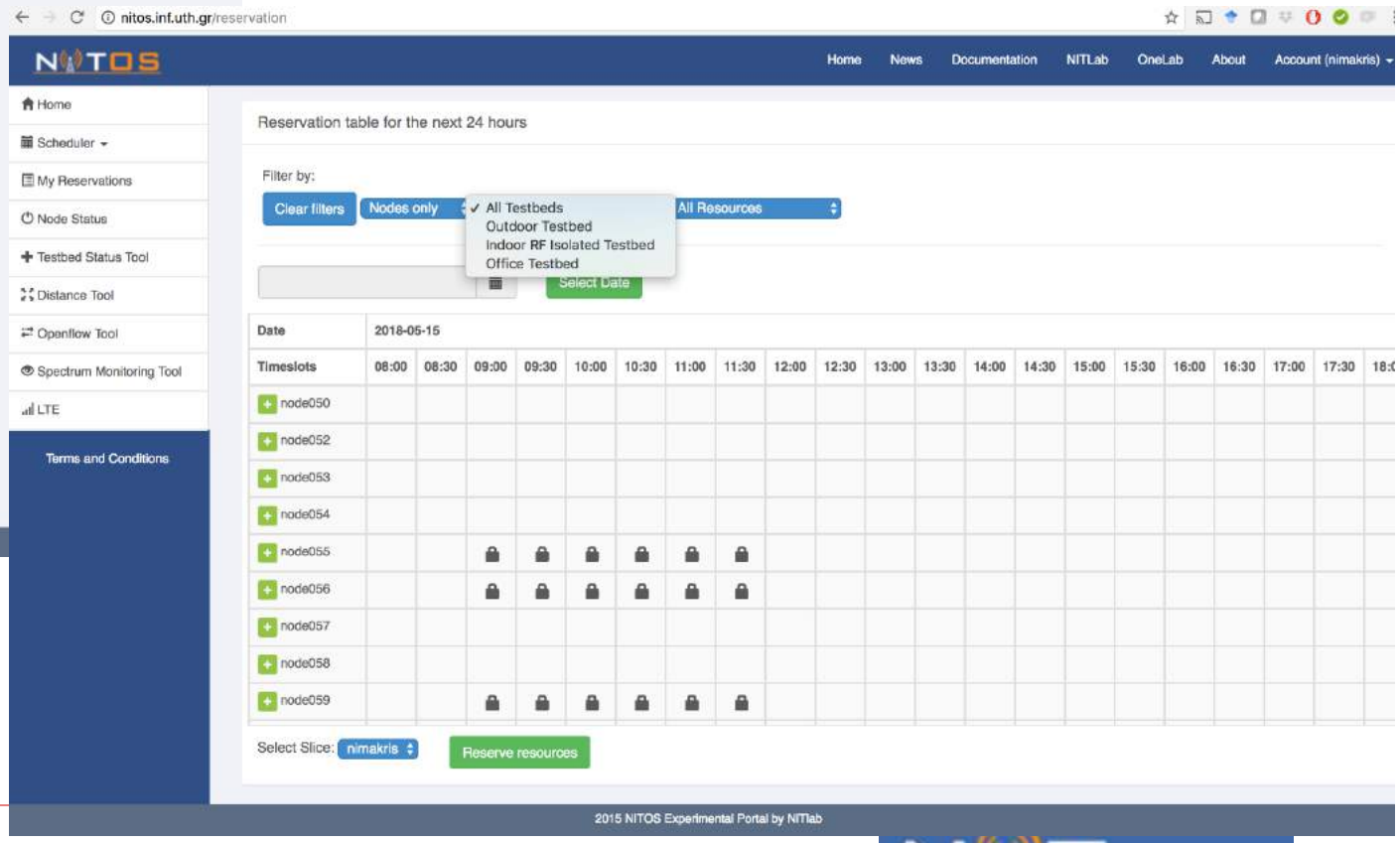


# NITOS Testbed Provisioning

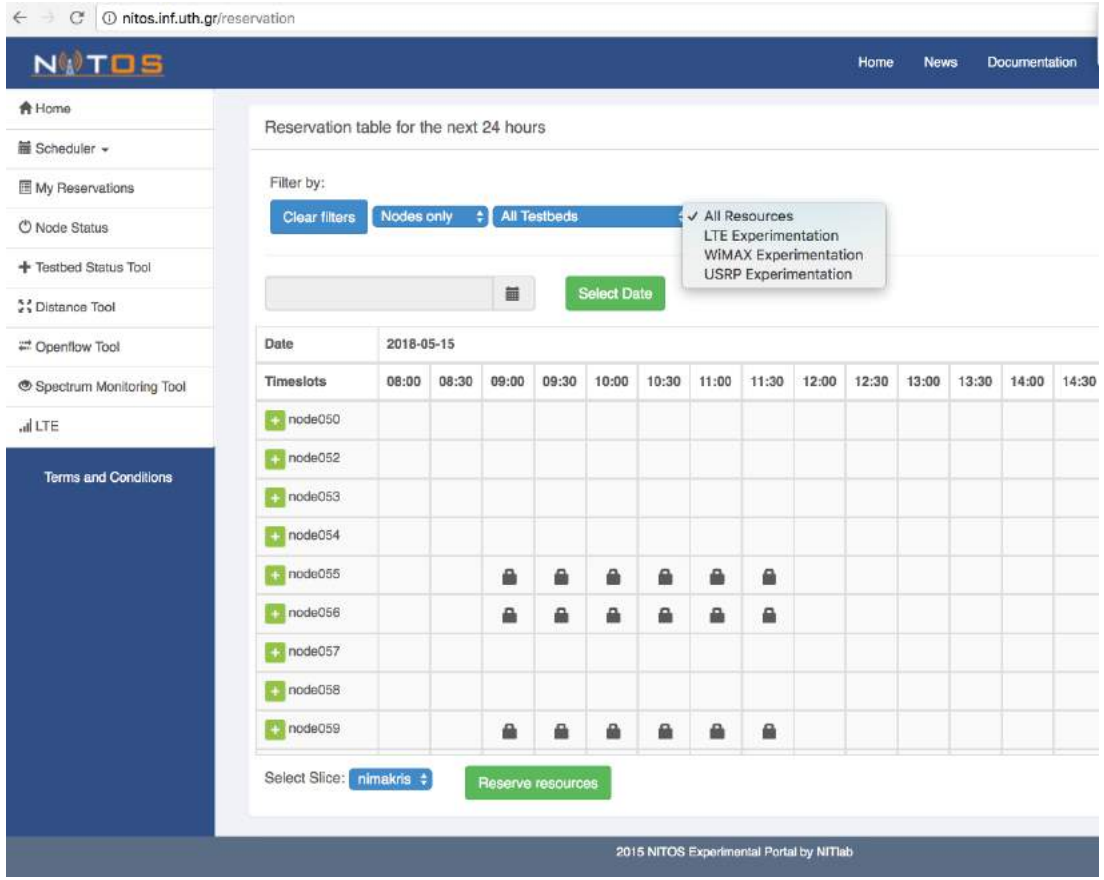
- ✓ A number of different tools are available for facilitating the provisioning of equipment remotely:
  - ✓ NITOS portal for listing the available resources
  - ✓ Experimenter reserves a “slice” of the testbed
  - ✓ Images are available for loading on the nodes
  - ✓ Experimenter gets full root access on the node over ssh
  - ✓ Tools available for automatic experiment setup and measurement collection (OMF)

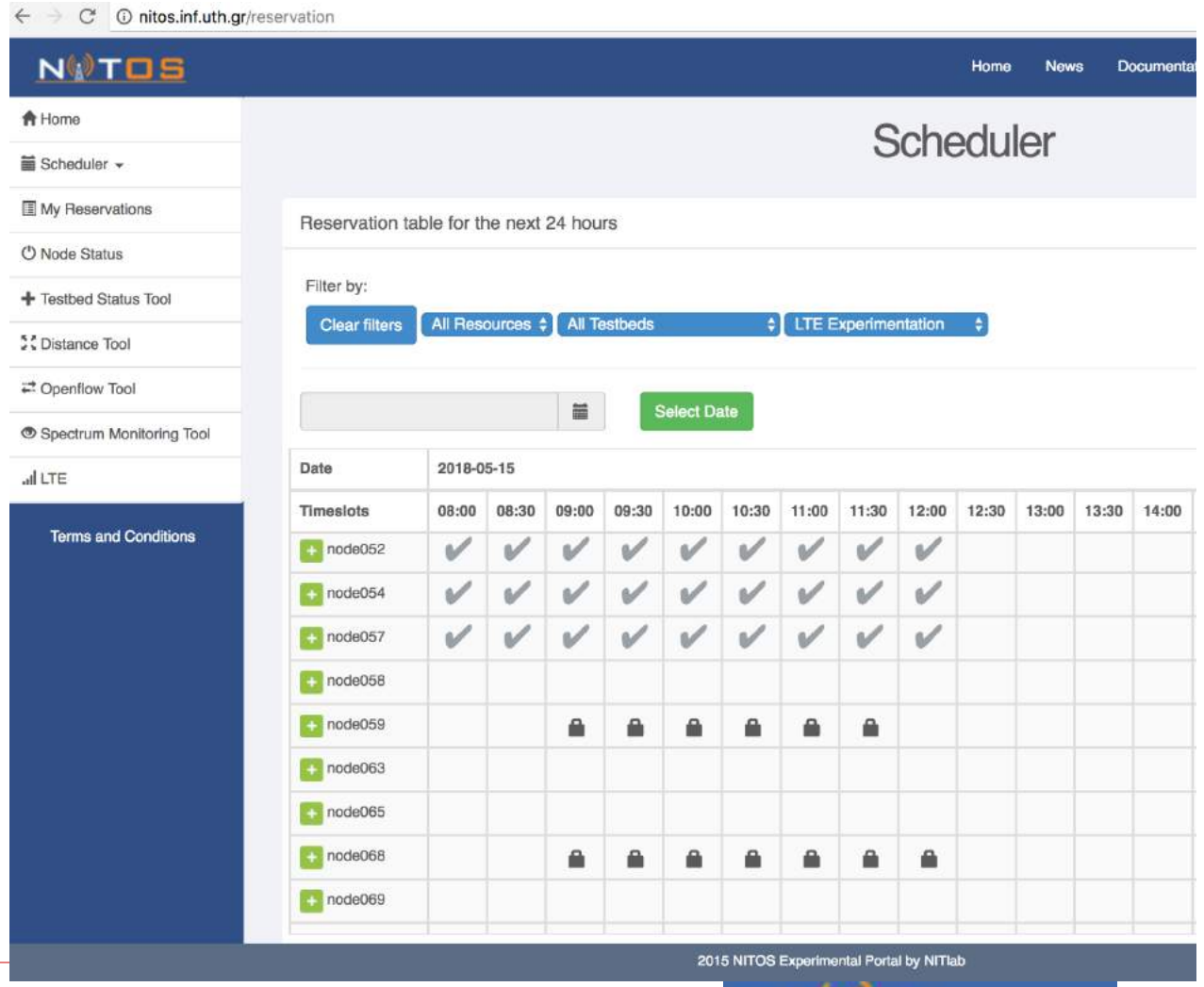
# Providing access to experimenters



# Providing access to experimenters



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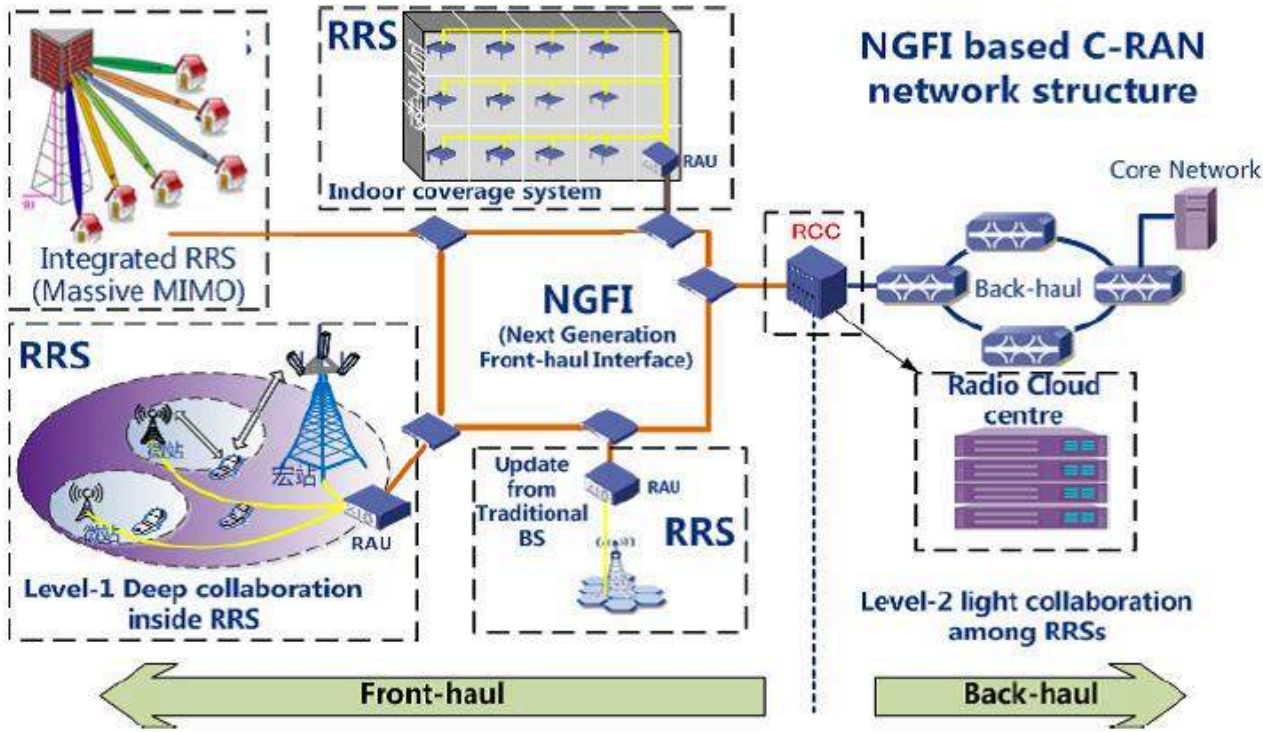
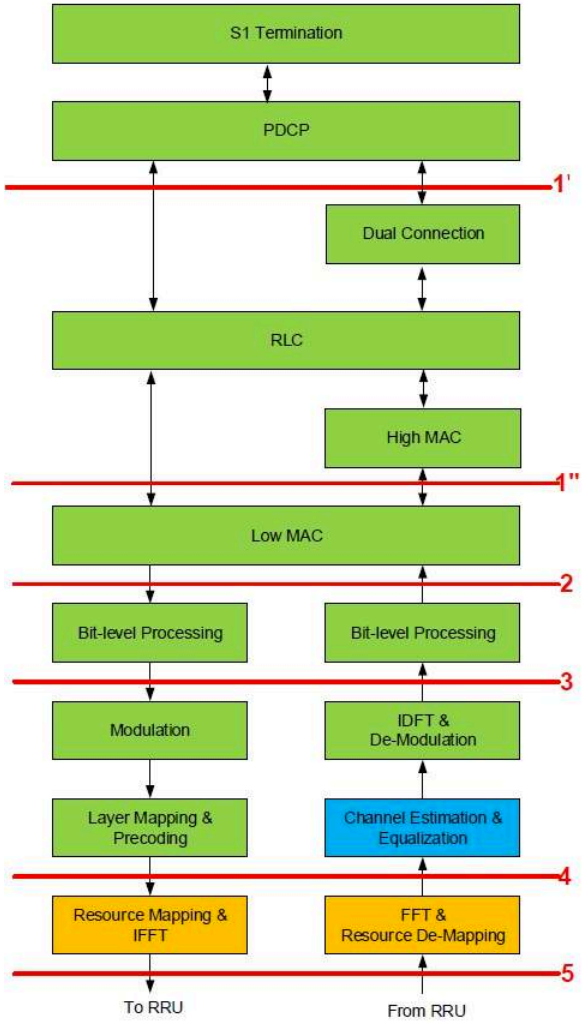
# Next Generation Fronthaul Interface (NGFI)

- ✓ Remote Radio Heads (RRH): Simple passive elements, instructed by the Cloud for their operation.
- ✓ Ideally even the baseband processing is taking place in the Cloud.
- ✓ Fiber interface between the Cloud and the RRHs.
- ✓ Minimize equipment cost, deploying much simpler units on the network, dynamically turning on/off RRHs, instantiating new base stations on the Cloud
- ✓ Fronthaul link needs up to 40Gbps of throughput.
- ✓ Next Generation Fronthaul Interface (NGFI) splits the functionality at a higher layer, allowing this fronthaul interface to be realized over a plain Ethernet connection.
- ✓ RRH stops being a passive element - becomes the Remote Radio Unit, incorporating parts of the PHY or MAC layer.



# NGFI Possible split alternatives

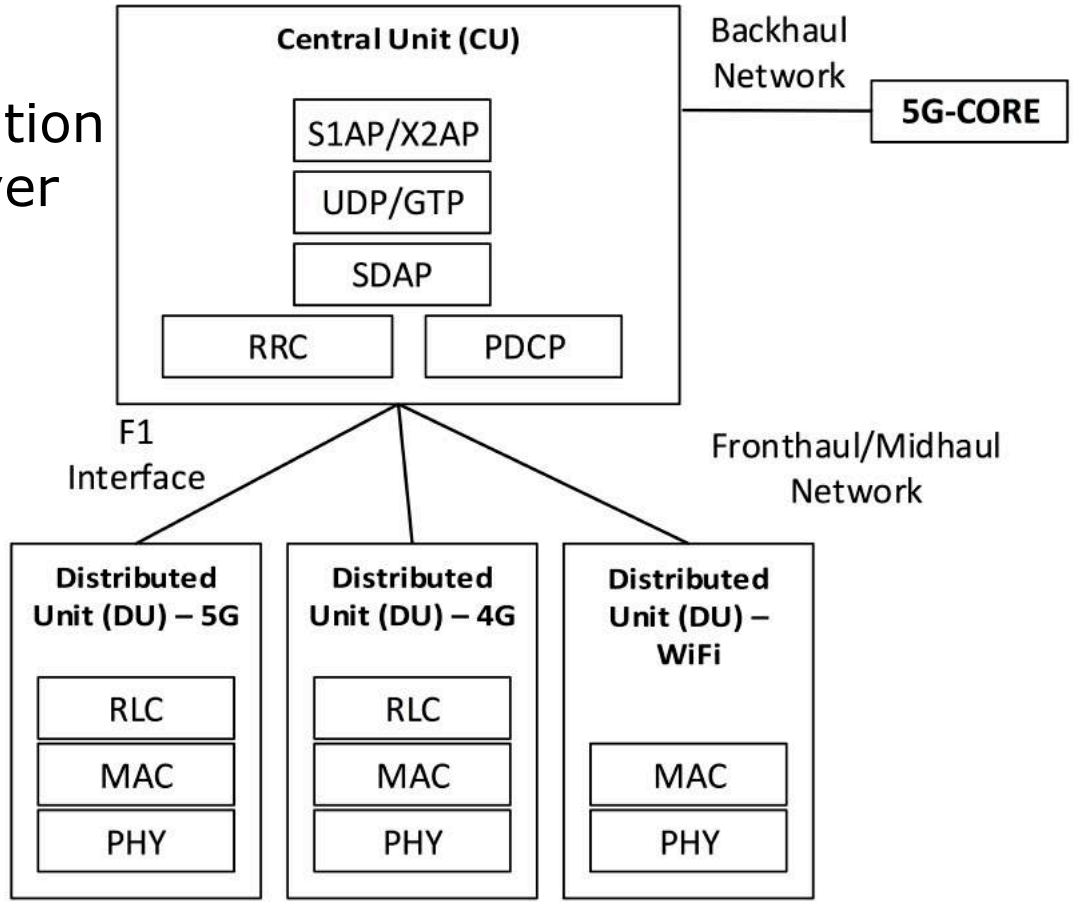
- ✓ Six different splits of the base station functionality have been proposed.
- ✓ Depending on the point of where the split takes place, different requirements are posed for the fronthaul interface




| | Interface 1 | | Interface 2 | | Interface 3 | | Interface 4 | | Interface 5 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Bandwidth | Ratio | Bandwidth | Ratio | Bandwidth | Ratio | Bandwidth | Ratio | Bandwidth | Ratio |
| Downlink | 174 Mb/s | 1 | 179.2 Mb/s | 1 | 125.2 Mb/s | 1 | 498 Mb/s | 3 | 9,830.4 MB/s | 66 |
| Uplink | 99 Mb/s | 1 | 78.6 Mb/s | 1 | 464.6 Mb/s | 6 | 2,689.2 Mb/s | 36 | 9,830.4 MB/s | 131 |

# Our Work on the PDCP/RLC split

- ✓ PDCP layer to be used as the convergence layer for multiple RAT technologies
- ✓ We developed a protocol for the full communication between the CU and DU units of the network over NITOS and using the OpenAirInterface platform (OAI)
- ✓ Based on the 3GPP TS 38.470-475
- ✓ F1 interface introduced for the communication between CU and DUs
- ✓ Target use cases:
  - ✓ multi-RAT behavior (e.g. 5G/4G/WiFi)
  - ✓ modelling of the midhaul/fronthaul network
  - ✓ multi-tier splits (e.g. CU/DU/RRU)



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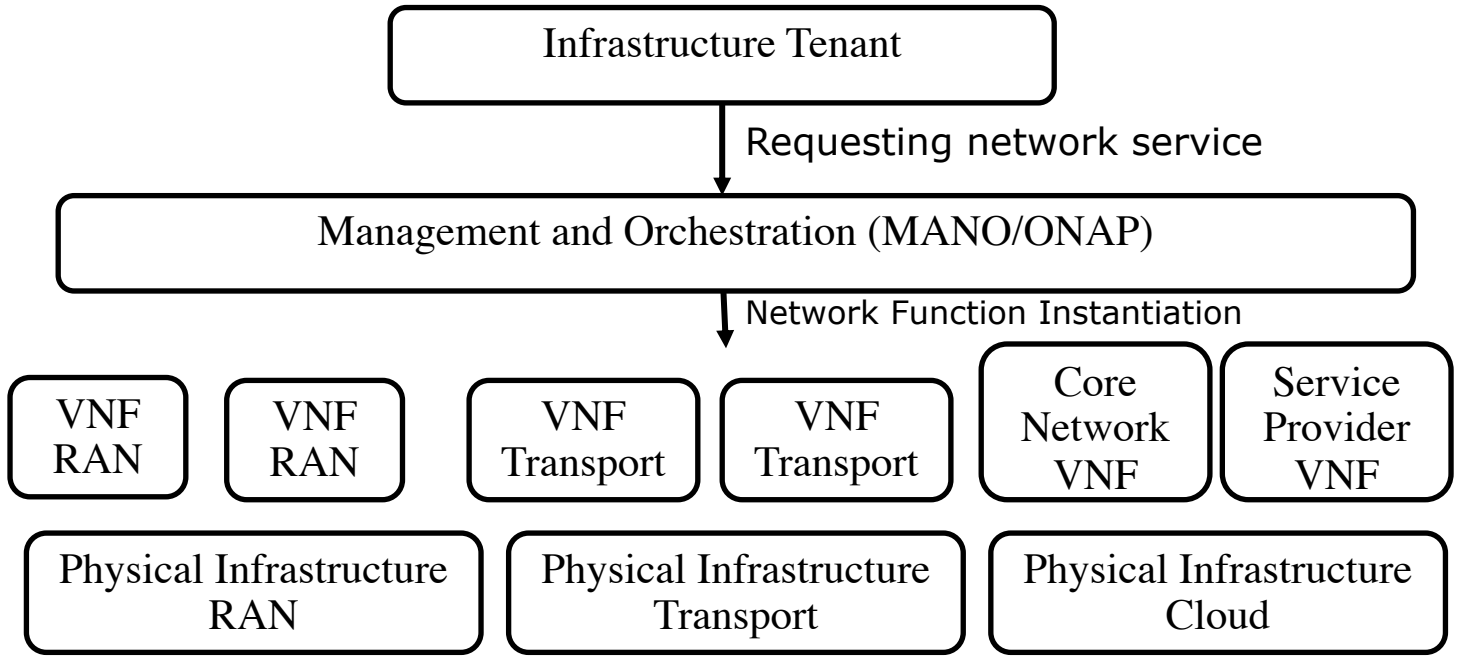
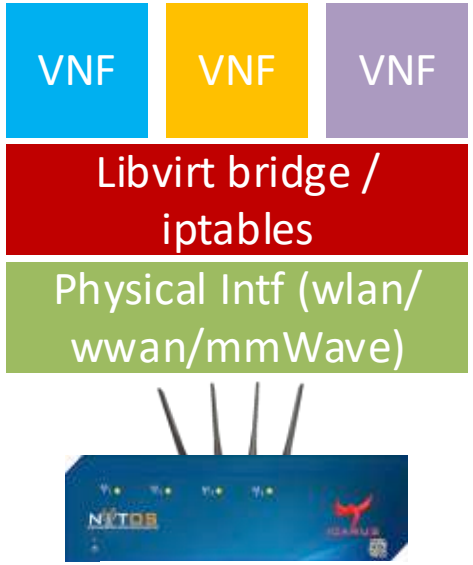
# 5G – A Softwarized Network

- ✓ Abstraction of physical elements
- ✓ Easy software based updates
- ✓ Automatic orchestration of end-to-end network components
- ✓ Flexibility added to the network
  - ✓ Dynamic instantiation of new network elements
  - ✓ Based on demand, network load, user mobility, etc.
  - ✓ Achieve optimality in the RAN as well (spectrum allocation, etc.)



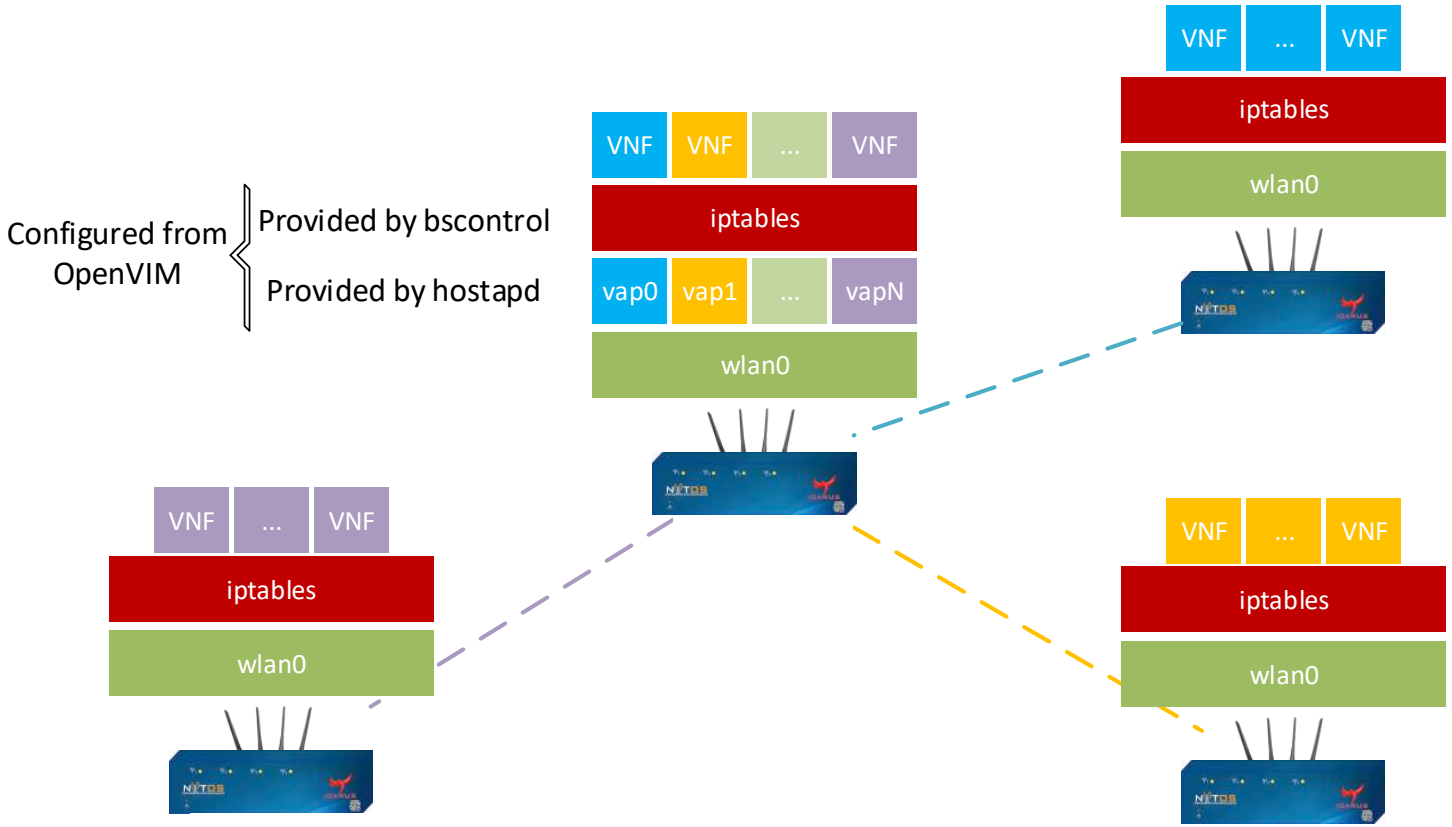
# VNFs running on top of NITOS nodes

- ✓ Provide VNF experimentation services to users through a single entry point to the infrastructure
- ✓ The experimenters select and deploy their VNFs over one or multiple "datacenters"
  - ✓ Each datacenter is a selection of testbed nodes that is added to the VIM of the testbed
  - ✓ Different datacenters for:
    - ✓ Nodes with SDRs
    - ✓ Nodes with LTE dongles
    - ✓ Rest of the nodes
- ✓ Using OpenSourceMANO as the orchestration framework



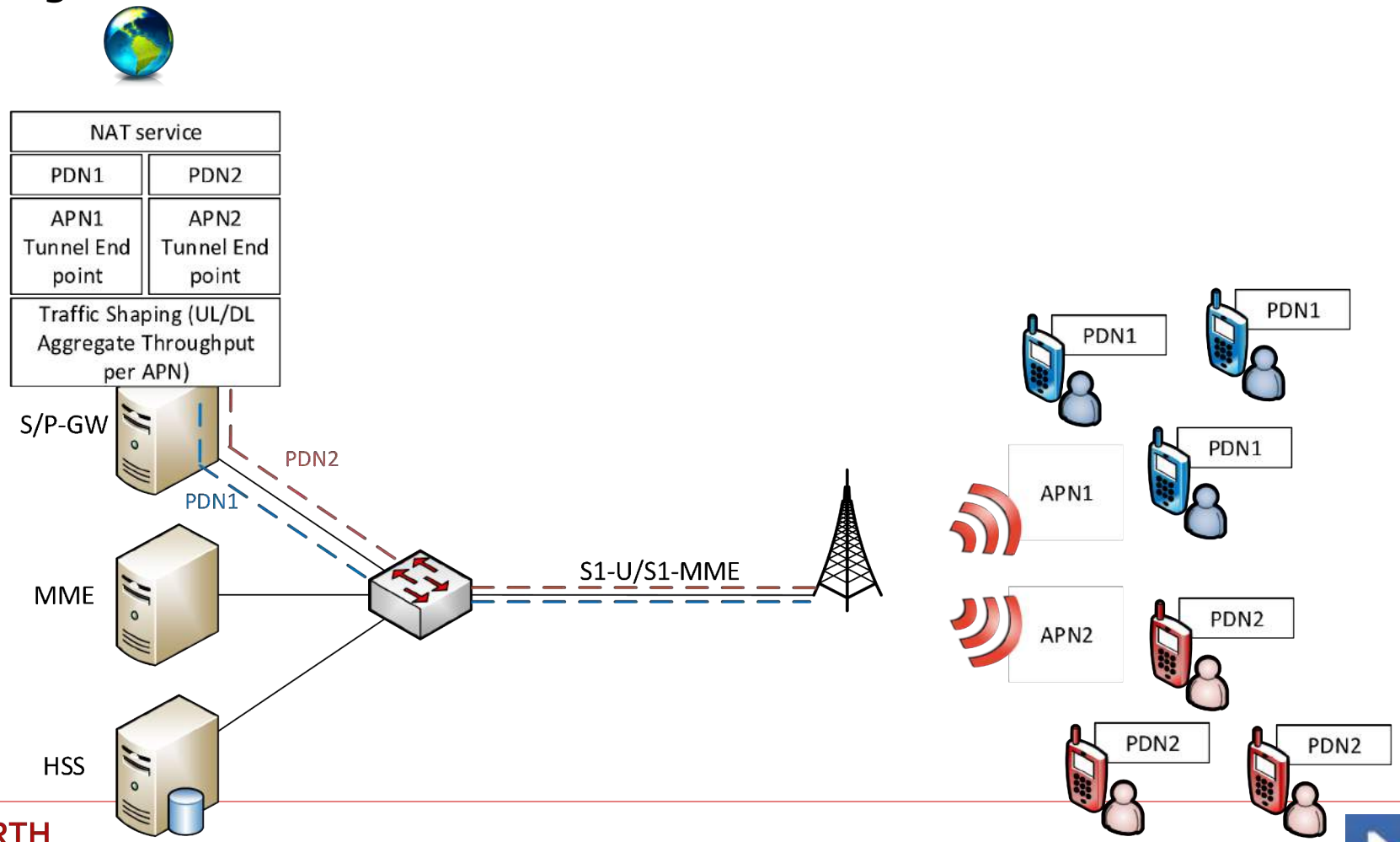

Baseline Host Image

# WiFi case – deployment of VNFs over the NITOS nodes

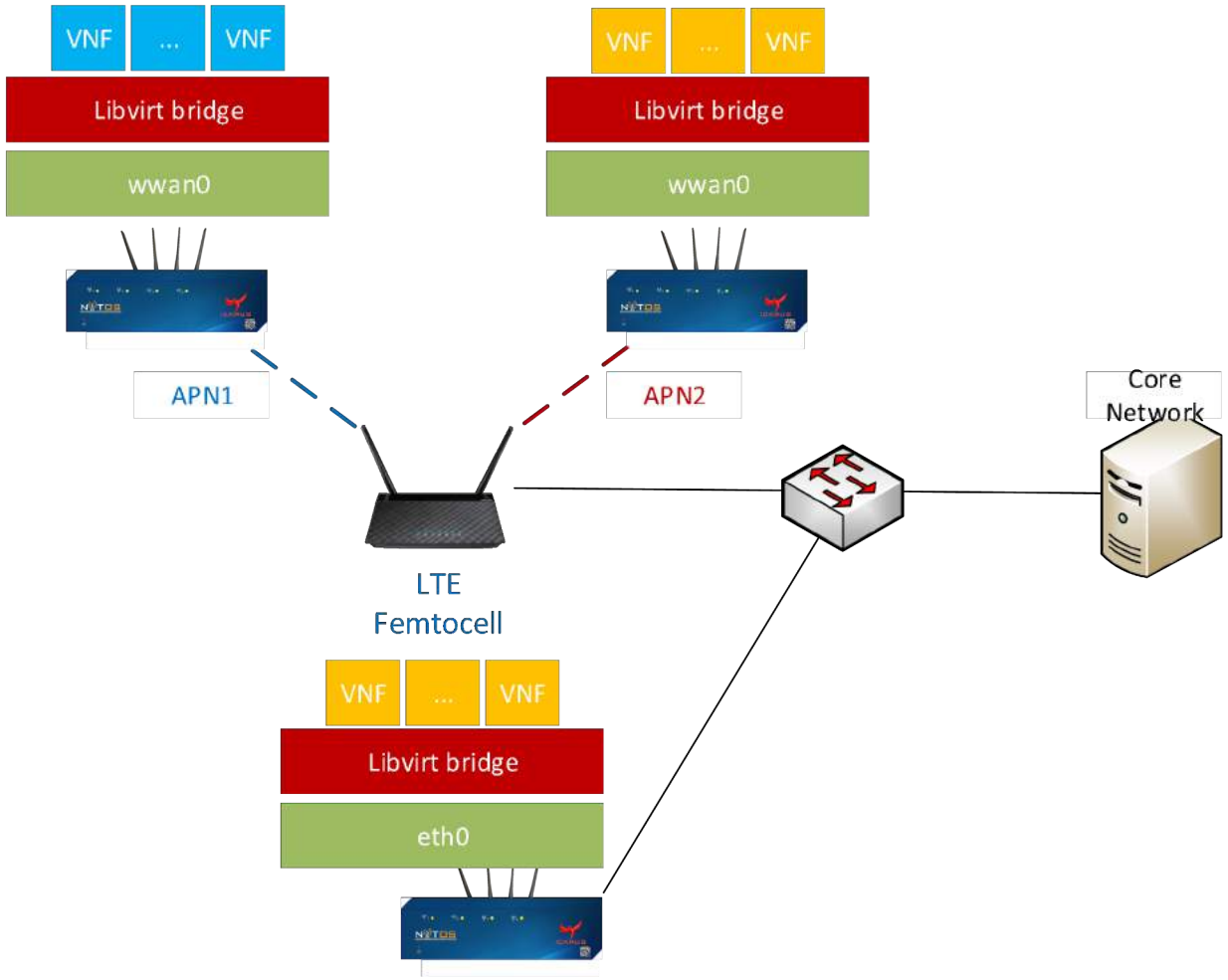


# LTE case – slicing of the infrastructure

- ✓ Slicing the LTE infrastructure based on different PDNs



# LTE case – deployment of VNFs over the NITOS nodes



Thank you for your attention!

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