



# 5G-Infrastructure PPP Information Day 17<sup>th</sup> March 2016, Bologna

#### View point: 5G Networks are

- *"Faster, Stronger"* An extremely flexible and highly programmable e2e compute & connect infrastructure which is application & service aware as well as time, location and context aware
- "Higher Level Flexibility" in all segments of te network: Radio-networks, Front / Back Haul Network & Access Network, Aggregation Network, Core networks & Software-defined clouds & Mobile edge computing → High / ever higher performant connectivity & compute environments
- Natively leveraging Network Virtualisation / Slicing/ Network Function Virtualisation, Programmability and Softwarization technologies:
- Support on demand composition of network functions and capabilities
- Enforce required capability/capacity/security/elasticity/ adaptability/ flexibility "where and when needed"
- Management and Control are becoming part of the dynamic design of the software architecture
- Services are executed in one (or more) Slices (i.e. a slice is made of a set of VMs)
- Significant reduction in management complexity and in costs of operations (i.e. OPEX)



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## **Some Competences and Interests**

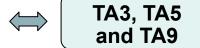
UCL is the top-rated university in the UK for research strength (REF2014).

UCL is ranked fourth in the world's top universities by the QS World University Rankings (2014) and number 21 in the Shanghai Ranking of World Universities (2014)

 New potential transmission standards based on Spectrally Efficient Frequency Division Multiplexing (SEFDM) where up to 40% bandwidth saving (relative to OFDM) may be achieved at the expense of receiver complexity.



- Large Scale Antenna Systems, topologies studies and efficient waveform and receiver design through analog-digital processing
- Spectral sensing systems for wireless energy and bandwidth efficiency
- Massive MIMO and MIMO systems
- Radio over Fibre systems (RoF) operating in the mm-wave region; system, sub-system and circuit level design.



mmWave communications, beamspace MIMO, antenna topologies



TA3

 From energy efficient to energy neutral networks through energy harvesting and balancing



TA4

Data-aided waveform design for energy efficiency in the C-RAN



TA5

Secure self-configurable and self-sustainable networks though energy neutrality



**TA8, TA13** 

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- Information, context, knowledge & monitoring systems for slices for all 5G network segments
- Unified Autonomic Management & Orchestration
- Unified Service & Network management & orchestration single & multiple domain
- Management Capability layer & manifests & APIs
- Self-X functionality & control loops for bundle of service mapped to slices
- Abstraction and virtualisation of heterogeneous transport resources
- Functional Migration & Control methods for relocating network functions to the edge
- Network functions optimisation & orchestrations (control, conflicts, integrity)
- Integrated virtual networking environment : networking, computation, storage resources & slices)
- Network Hypervisor & OS facilities
- Execution environments & management for applications that define the software components and network functions of a network service together with their configuration parameters
- Full lifecycle of the application related virtual machines and virtual routers in the network and the allocation of the applications running on the virtual nodes
- Programmability in networks and services
- Multi tenant network-based clouds and management
- Uniform Programmability in networks and services
- Multi tenant network-based clouds and management
- Slices as a Service functionality
- Context-aware on demand virtualisation and relocation of slices as-a-service across domains
- On demand configuration of a control plane that allows effective use of slices & elasticity capability layer of the slices
- Information, context, knowledge & monitoring systems for slices for all 5G network segments
- Management & Operation Capability layer & manifests & APIs
- Uniform Programmability in networks and services
- Uniform Network Softwarisation

Participation in a full study project of seamless integration of satellites network with network clouds and 5 G networks – European Space Agency (ESA) project INSTICT



TA11: Converged 5G Network

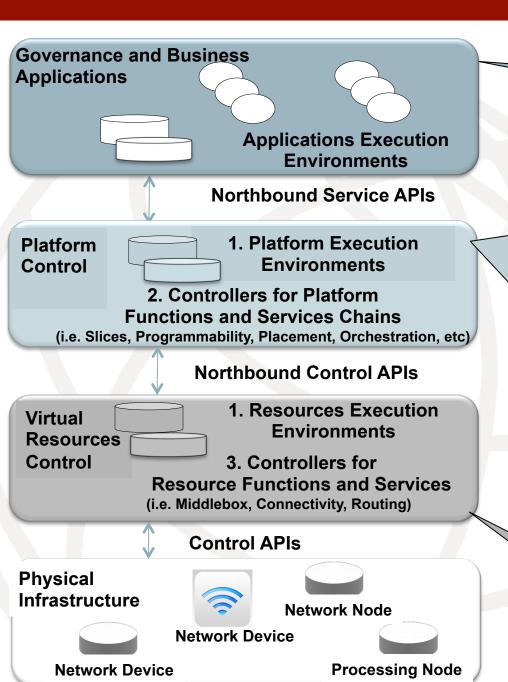
TA12: Foundations for Software Networks



TA19: E2E NFV / SDN Holistic Operational Model

TA6: Seamless Integration of Satellites Networks and Air Platforms into 5G

#### 5G Network Softwarisation Model (S/W stack model)



Governance, Service Orchestration, Deployment, execution, global manifest

- Dynamic networked environments that combine virtual networks with virtual compute nodes within the same topology
- Control Elements for Resources & Integrated Virtualisation, Networked hypervisors
- Rapid VMs movements, Virtual networks
   Control Elements for VMs
- Creation of groups of VMs, Orchestration, multi goal optimisation, Resources Virtualisation Functions, Virtual Machines management (QoS, rapid movement, monitoring, federation), VMs Information Base, Service-awareness Enablers, Execution Environments Management, Network Services, Self-management Functions, VPEX Management

- Control Elements for Resources & Integrated Virtualisation,
- Networked hypervisors
- Rapid VMs movements, Virtual networks

## **Concluding Remarks**

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  - Support on demand composition of network functions and capabilities
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  - Management and Control are becoming part of the dynamic design of the software architecture
  - Services are executed in one (or more) Slices (i.e. a slice is made of a set of VMs)
- Significant reduction in management complexity and in costs of operations (i.e. OPEX)
- "Software Networks" → Softwarization and in particular (Self) Management and Control would represent nearly 99% of the new 5G Networks & Services functionality !!!
- "Low Operational Costs" → Significant reduction in management complexity and in costs of operations (i.e. OPEX)