



Distributed multi-tenant cloud/fog and heterogeneous SDN/NFV orchestration for 5G services

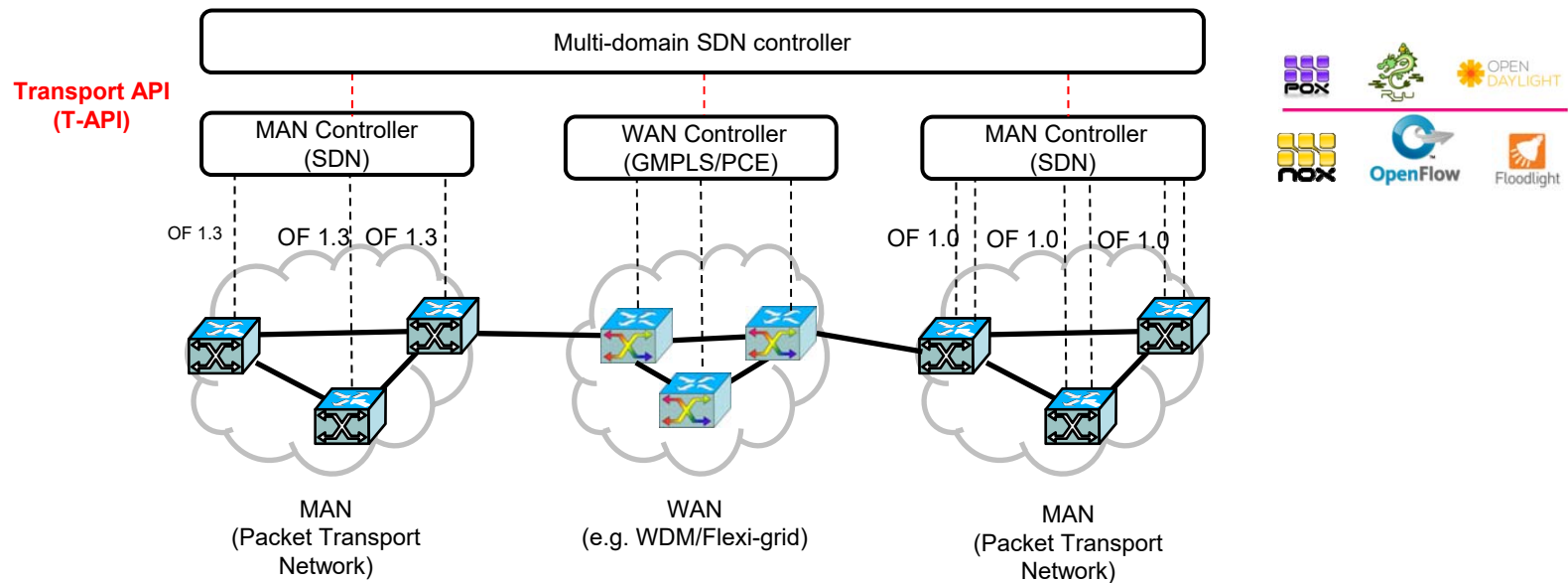
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The need for generic control functions and a Transport API

- The NBI of the domain controllers are typically technology and vendor dependent.
 - The multi-domain SDN orchestrator shall implement different plugins for each of the controller's NBI.
- The ONF Transport API defines a generic functional model of a control plane that can be used regardless of a particular vendor, and defines the associated protocol.



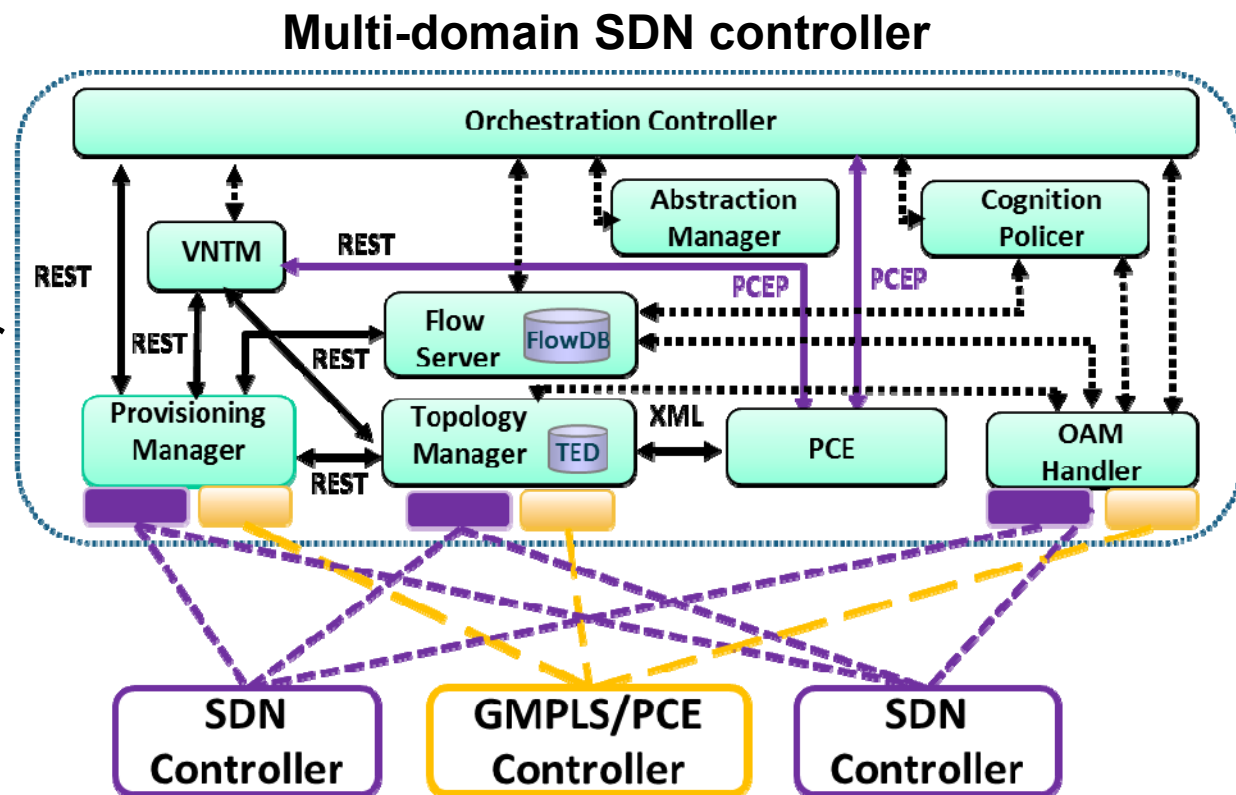
ONF Transport API Overview

- Objective – realize the software-centric approach to standardization
 - Purpose-specific API to facilitate **SDN control of Transport** networks
 - Focus is on **functional aspects** of transport network control/mgmt
 - Target is **YANG & JSON** API libraries
 - Demonstrable code
- Activity scoped based on use case contributions and discussions. Examples include
 - Bandwidth on Demand
 - E2E Connectivity Service
 - Multi-layer Resource Optimization and Restoration
 - Multi-Domain Topology and Monitoring
 - Network Slicing and Virtualization
- **Topology Service**
 - Retrieve Topology, Node, Link & Edge-Point details
- **Connectivity Service**
 - Retrieve & Request P2P, P2MP, MP2MP connectivity
 - Across (L0/L1/L2) layers
- **Path Computation Service**
 - Request for Computation & Optimization of paths
- **Virtual network Service**
 - Create, Update, Delete Virtual Network topologies
- **Notification Framework**
 - Subscription and filtering
 - Autonomous mechanism

Multi-domain SDN controller for handling network complexity

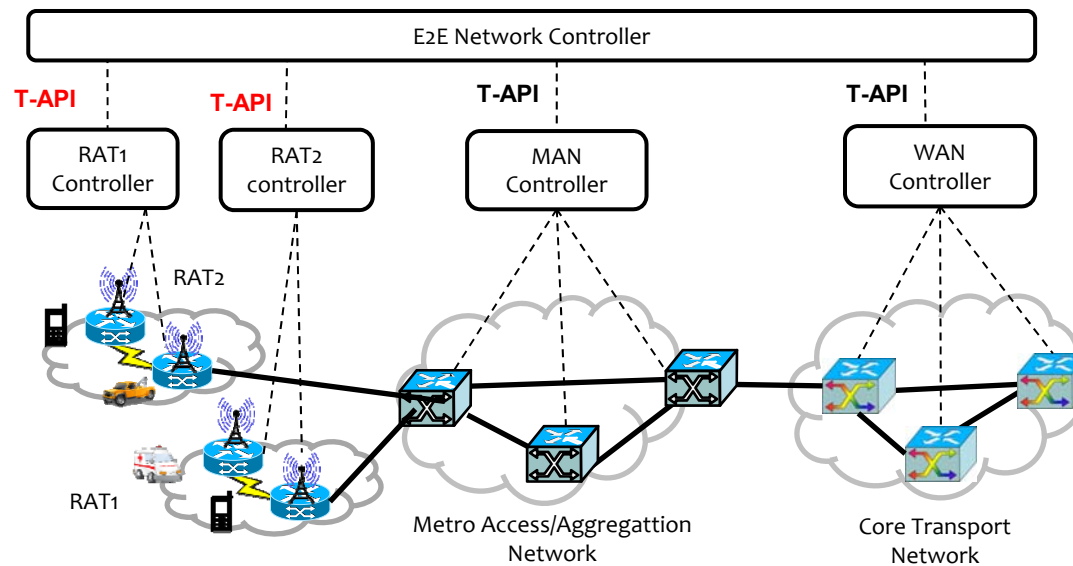
Architecture includes:

- PCE
- Topology Manager
- Provisioning Manager
- VNTM
- Flow Server
- OAM Handler
- Abstraction Manager
- Cognition Policer



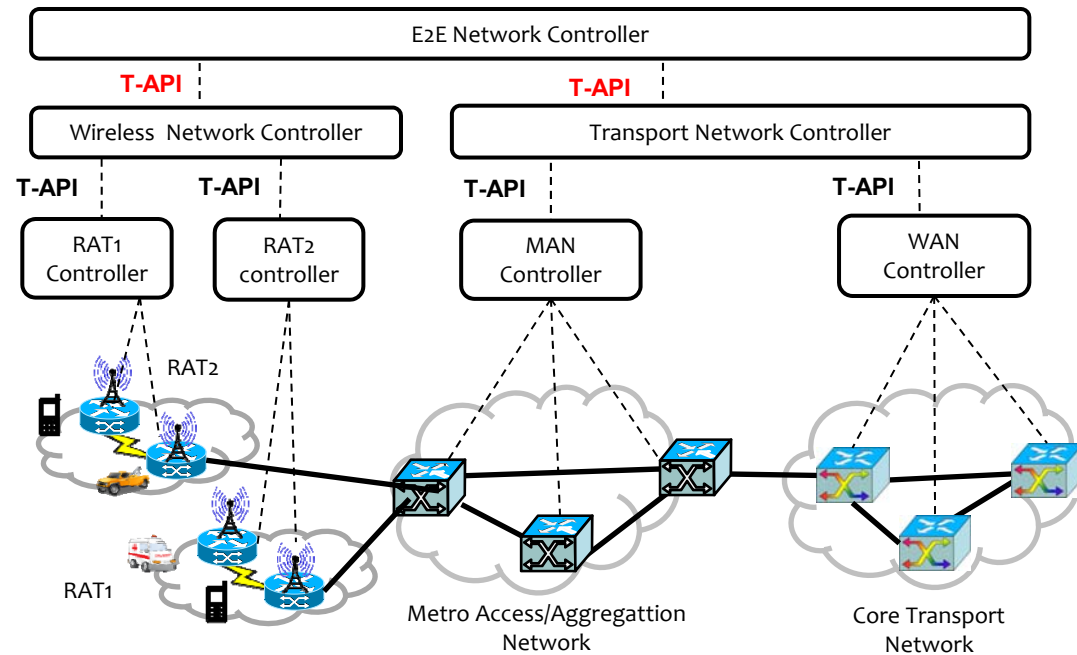
T-API enables integration of heterogeneous wireless and transport networks

- 5G services requires the integration of all network segments (radio/fixed access, metro and core) with heterogeneous wireless and optical technologies.
- T-API enables the integration of multiple Radio Access Technologies (RAT) with heterogeneous control planes and technologies (5G, mmWave, LTE/LTE-A, Wi-Fi, etc.)



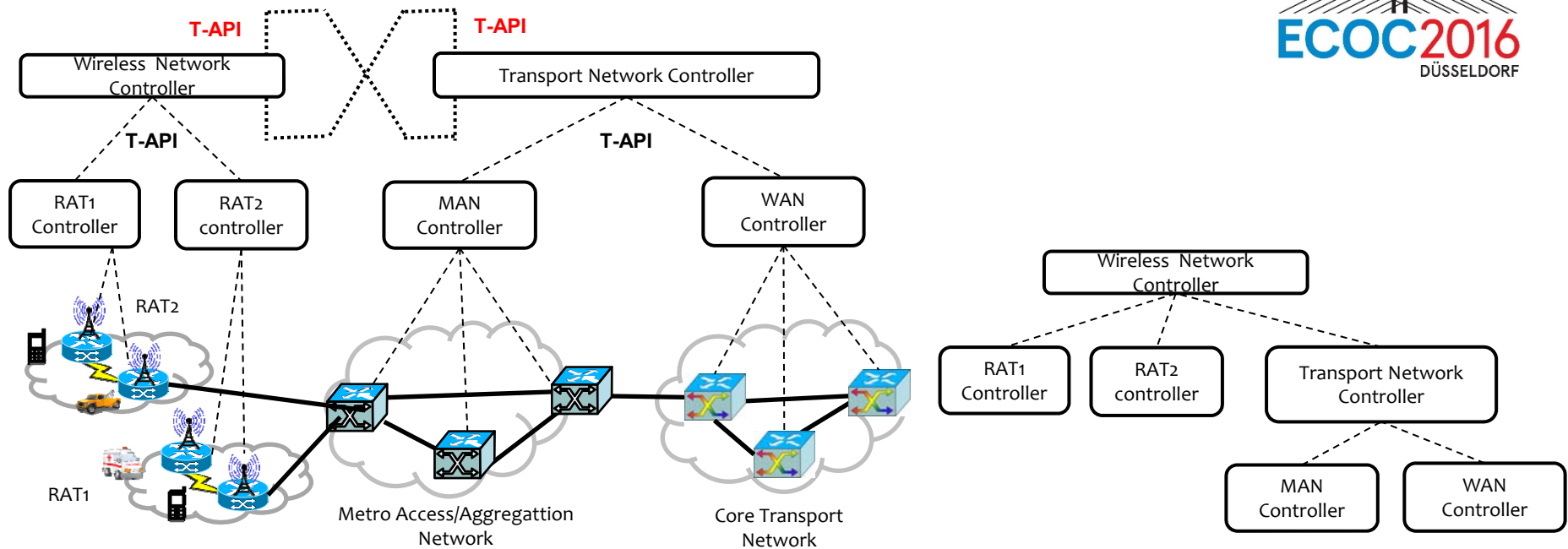
Hierarchical SDN Control using T-API

- We have proposed a hierarchical control approach with different levels of hierarchy (parent/child architecture) for scalability, modularity, and security purposes in multi-technology multi-domain heterogeneous wireless/optical networks
- Each successively higher level has the potential for greater abstraction and broader scope, and each level may exist in a different trust domain.
- T-API can be used as the NBI of the child SDN controller and as SouthBound Interface (SBI) of a parent SDN controller in order to provision E2E services



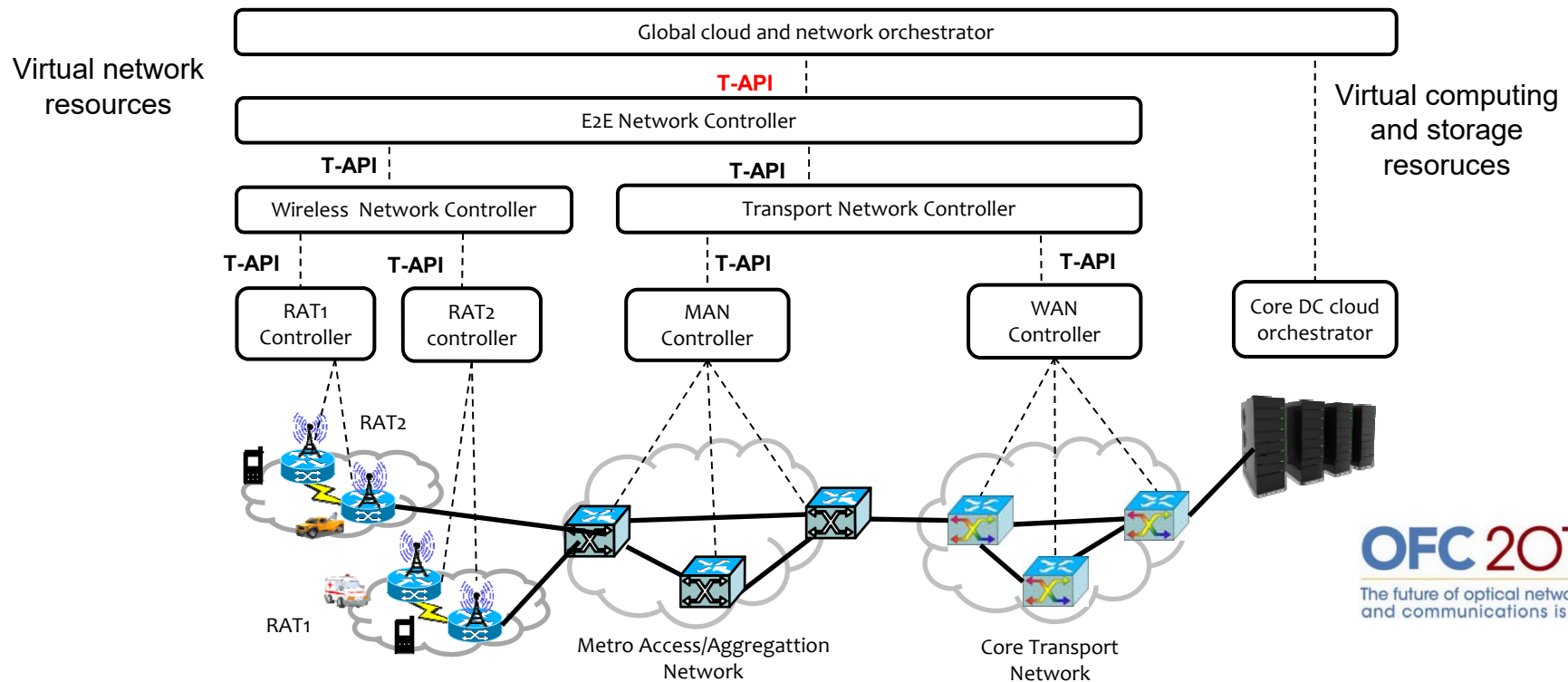
Peer SDN Control using T-API

- In a multi-carrier scenario there's no hierarchy, no cross-domain control, no cross-domain visibility. It is reasonable that a peer interconnection model is needed.
- The Peer SDN model corresponds to a set of controllers, interconnected in an arbitrary mesh, which cooperate to provision end-to-end services.
- The controllers hide the internal control technology and synchronize state using East/West interfaces. T-API can be used as the East/West interface.



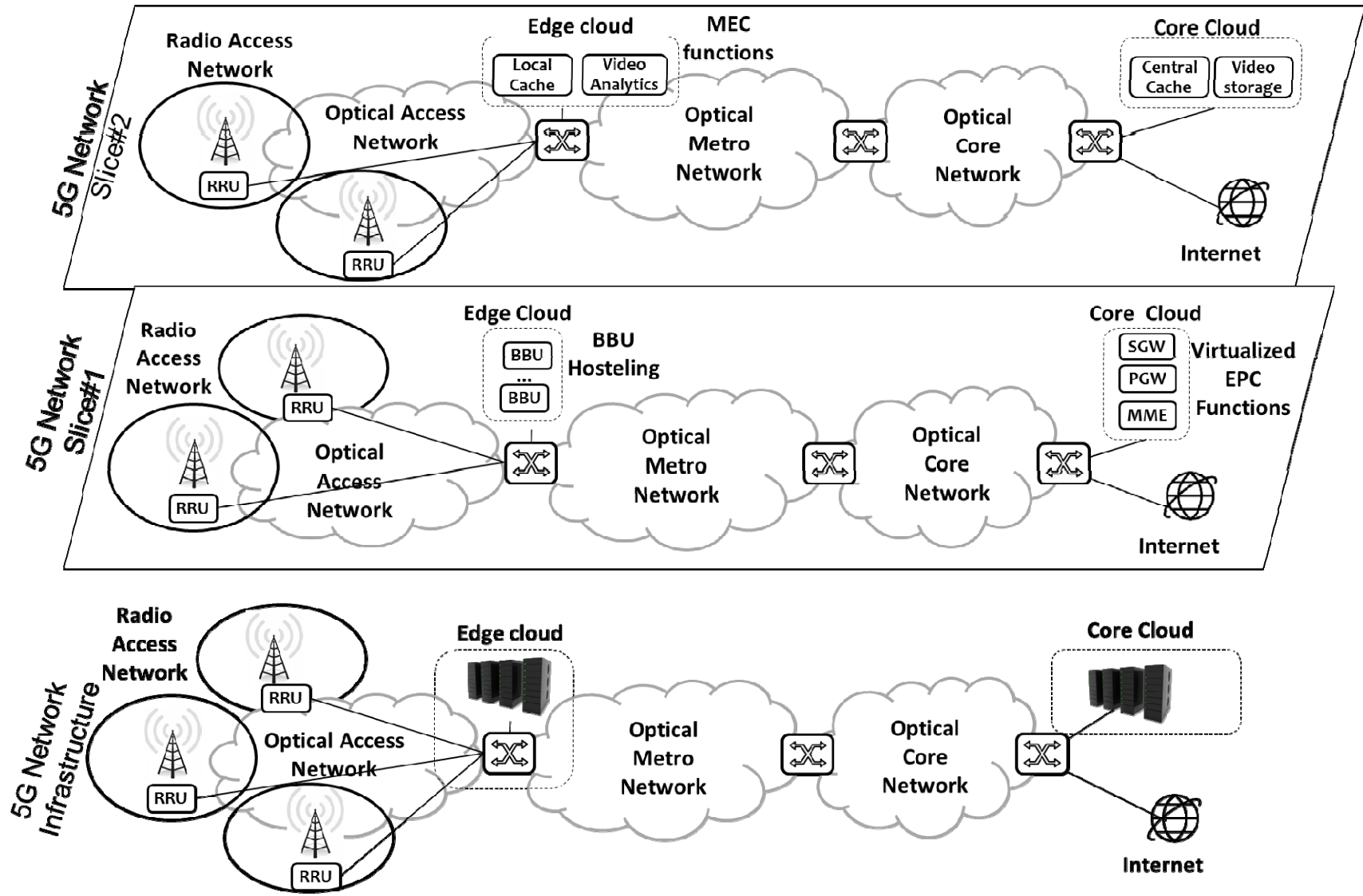
T-API enables global orchestration of cloud and network resources

- A Global orchestrator acts as a unified cloud and network operating system enabling the dynamic management of the virtual cloud and network resources allocated to the specific tenants (slices)
- T-API is a key enabler for the integration of cloud and network resources

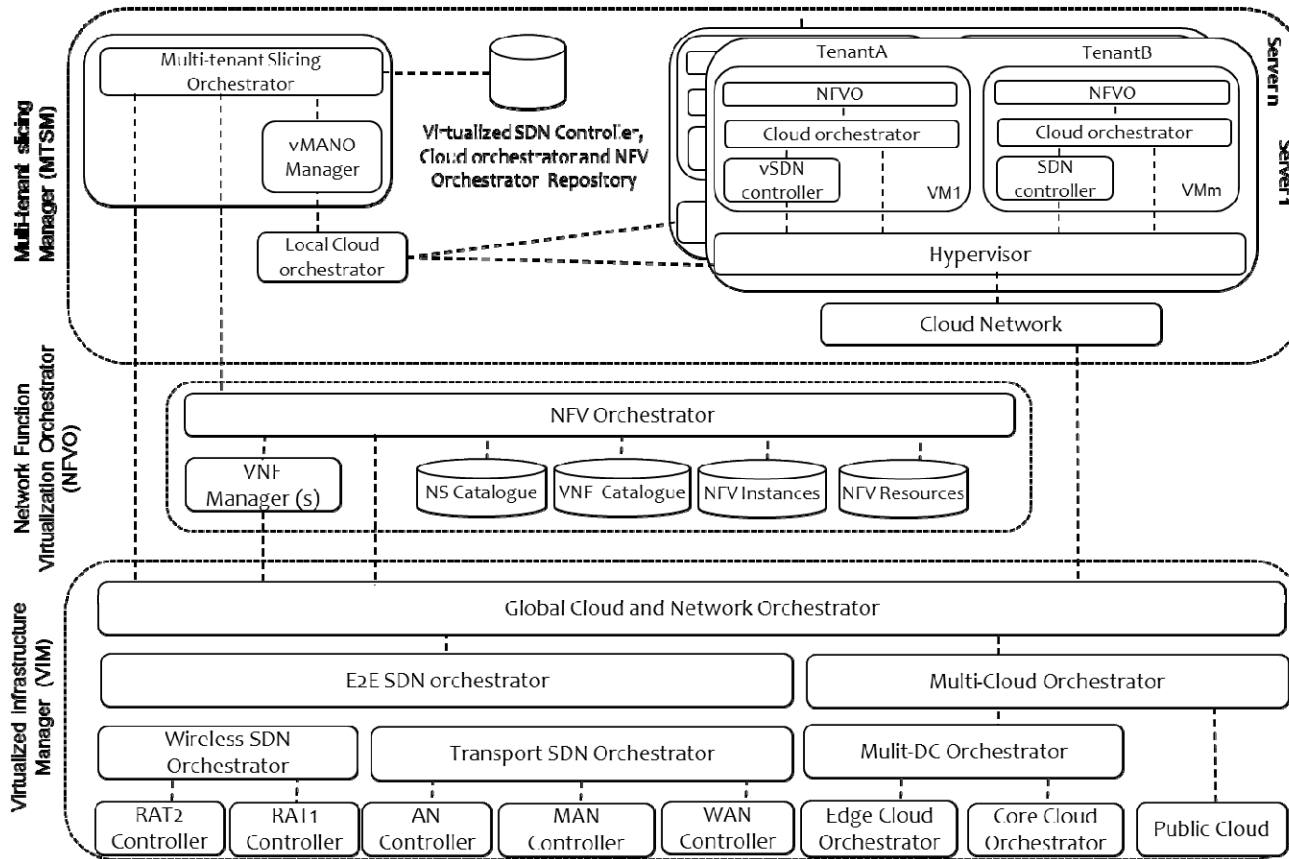


OFC 2016
The future of optical networking
and communications is here.

5G Network Slicing



5G Network Slicing Proof-of-Concept

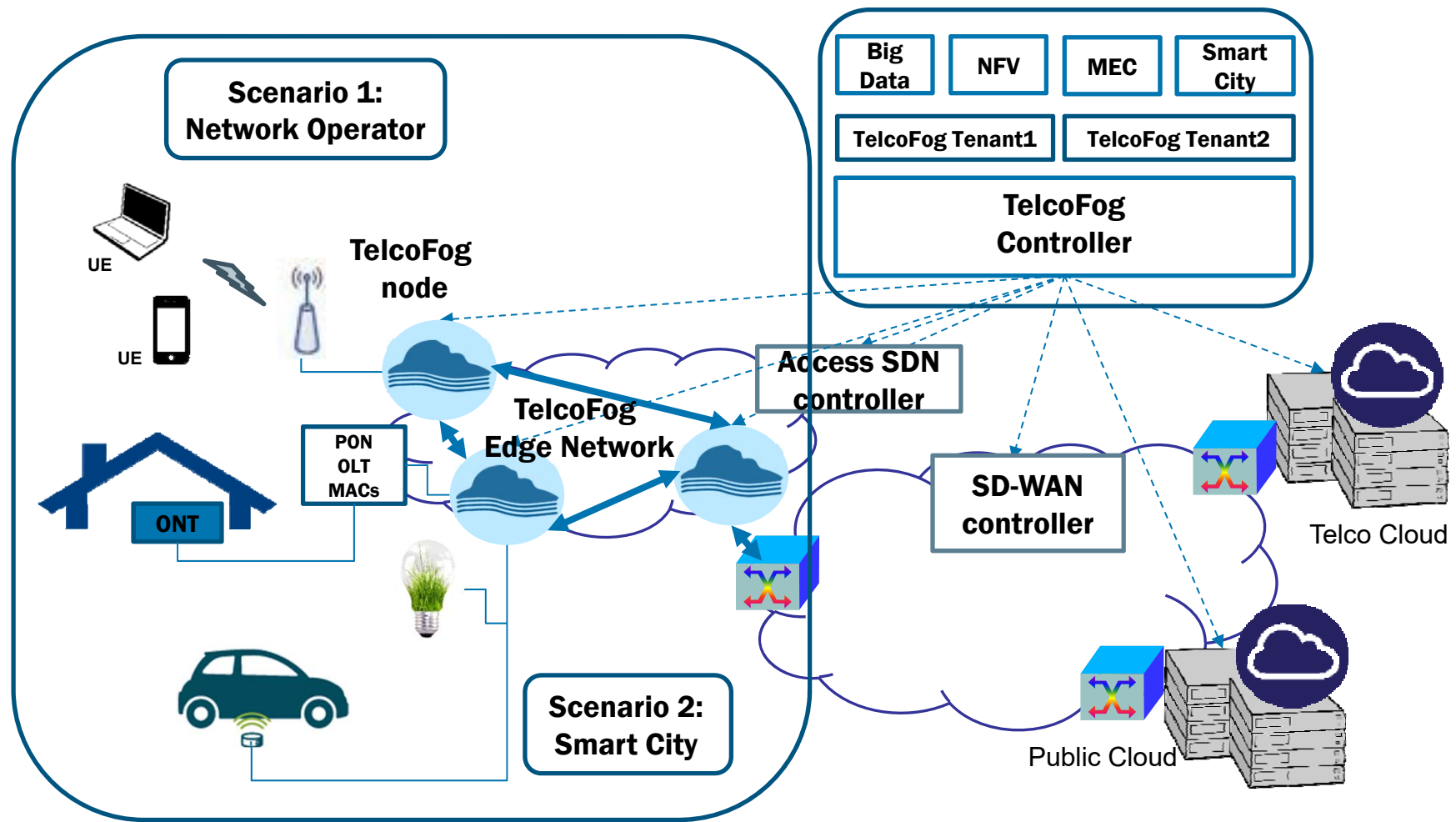


Multi-tenant 5G Network Slicing Architecture with Dynamic Deployment of Virtualized Tenant Management and Orchestration (MANO) Instances, A. Mayoral et al., submitted at ECOC 2016.

The need to unify fog and cloud computing for Telcos: The TelcoFog node

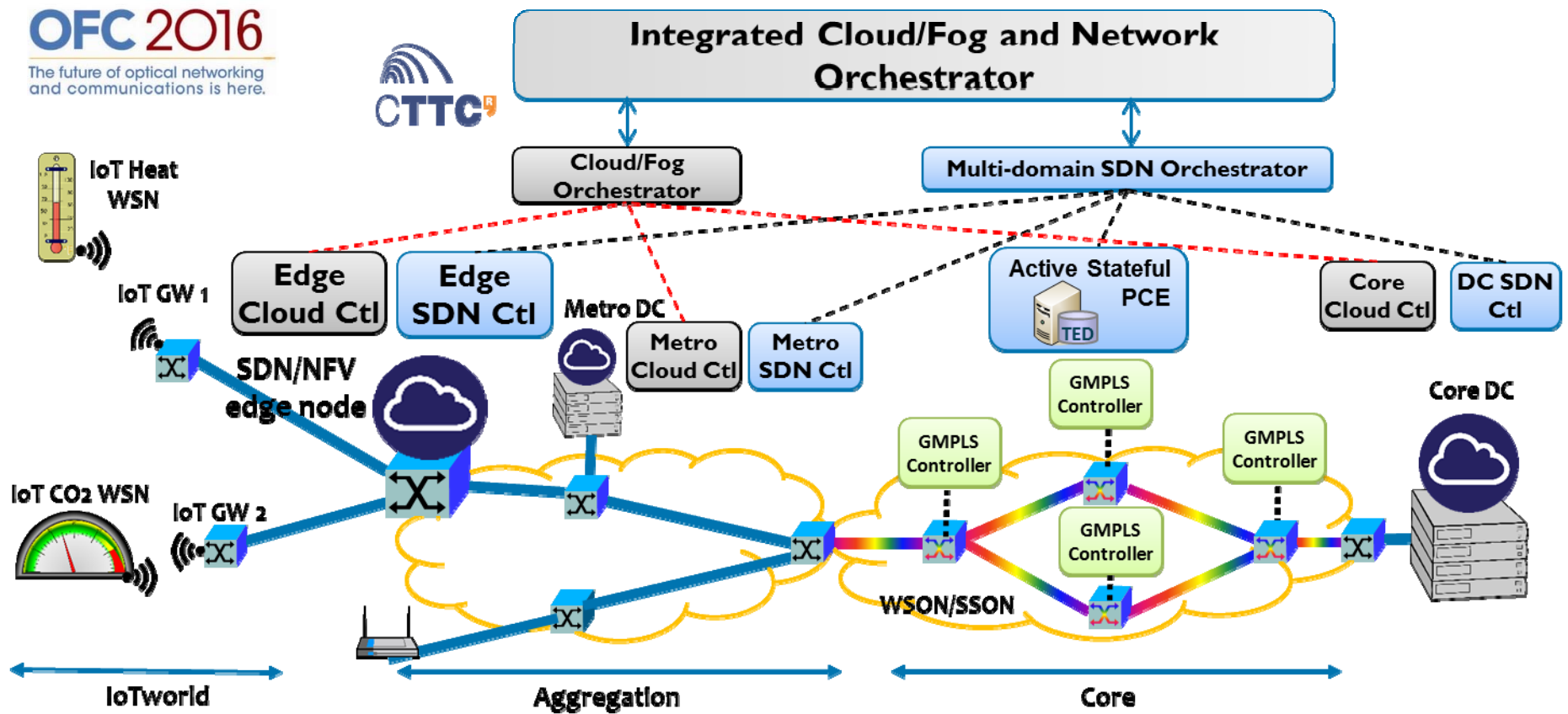
- We propose a highly distributed and ultra-dense fog infrastructure which can be allocated to the extreme edge of the network for a Telecom Operator network to provide services based on NFV, MEC or IoT services.
- The proposed flexible and programmable Fog computing architecture will be based on:
 - containers,
 - software-defined virtual switches and networking,
 - Multi-layer security enabling multi-tenancy, network and service virtualization
 - Smart resource migration and orchestration for mobility support
 - open APIs, and
 - big data and analytics.
- Interoperability between different services, orchestrators, nodes, sensors and actuators will be provided with the extensive and massive usage of YANG information models.

TelcoFog Scenarios



TelcoFog Proof-of-Concept

- End-to-End SDN Orchestration of IoT Services Using an SDN/NFV-enabled Edge Node



Conclusion

- ONF Transport API as an enabler for multi-vendor inter-operability
- Multi-domain SDN controller handles network heterogeneity and complexity
- Hierarchical/Peer SDN control are both sides of the same coin
- IT and SDN joint orchestration in future NFV deployments will be needed
- 5G Network Slicing – Adding new functionalities to Network Virtualization
- TelcoFog: unifying fog and cloud computing for Telcos



Thank you! Questions?

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