Metro-Haul: Towards a High Bandwidth, 5G application-aware optical network

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Metro-Haul
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http://metro-haul.eu

METRO-HAUL: METRO High bandwidth, 5G Application-aware optical network, with edge storage, compute and low Latency

H2020-ICT-2016-2 Metro-Haul Grant No. 761727

Metro-Haul – EU project

Metro-Haul

METRO High bandwidth, 5G Application-aware optical network,
with edge storage, compute and low Latency

- EC-Funded project to design and build a smart optical metro infrastructure able to support traffic originating from heterogeneous 5G access networks
  - Addressing the anticipated capacity increase and its specific characteristics, e.g., mobility, low latency, low jitter etc., for next generation mobile applications
- 5G-PPP Phase 2 EU Project – started 1st June 2017
- Budget of Eight Million Euros
- Project Lead: Andrew Lord, Albert Rafel (BT)
- Comprising of 20 core partners

  BT, Telecom Italia, Centre Tecnològic Telecomunicacions Catalunya (CTTC), Telefónica, University of Bristol, Polytechnical University of Catalonia (UPC), CNIT, NAUDIT, OpenLightComm, Lexden Technologies, Zeetta Networks, Fraunhofer HHI, Technical University Eindhoven, Coriant Portugal, Ericsson, Polytechnical University of Milan, ADVA, Nokia, Old Dog Consulting, SeeTec GmbH

Metro-Haul Objectives

- Architect and design cost-effective, energy-efficient, agile and programmable metro networks
  - Scalable for 5G access and future requirements
  - Design of all-optical metro nodes (including full compute and storage capabilities)
  - Interface with both 5G access and multi-Tbit/s elastic core networks.
- Challenges:
  - Optical challenge, focused on making metro optical transport simultaneously cost effective and agile, involving both the optical architecture and also innovative new optical component technologies.
  - Network management challenge. Metro-Haul will design and implement an SDN/NFV control framework and architecture supporting 5G operational and both end-user and vertical oriented services, including slicing.
  - Monitoring challenge. Both implementation and AI-based tools for interpreting the vast amount of data.
- Commercial Use Cases, including:
  - Use Case 1 - Video Security for Smart Cities
    - Intelligent video security based on automatic object/person identification and tracking.
    - Video-based automated security system relying on stationary and mobile cameras (e.g. body cams, or cameras mounted on drones) with wired and/or wireless access.
    - 5G Berlin testbed coupled with DT's Berlin metro infrastructure.
  - Use Case 2 - Crowdsourced Video Streaming.
    - Simultaneous sourcing of video from different individuals in an event with a large crowd.
    - The different video sources need synchronising and clustering
    - Dynamic and controllable metro network essential

5G Latency, Capacity and Management Dependencies

Latencies

- Underpinned by fibre connections
- Service requirements (e.g. Ultra Reliable Low Latency Connection service)

Capacities

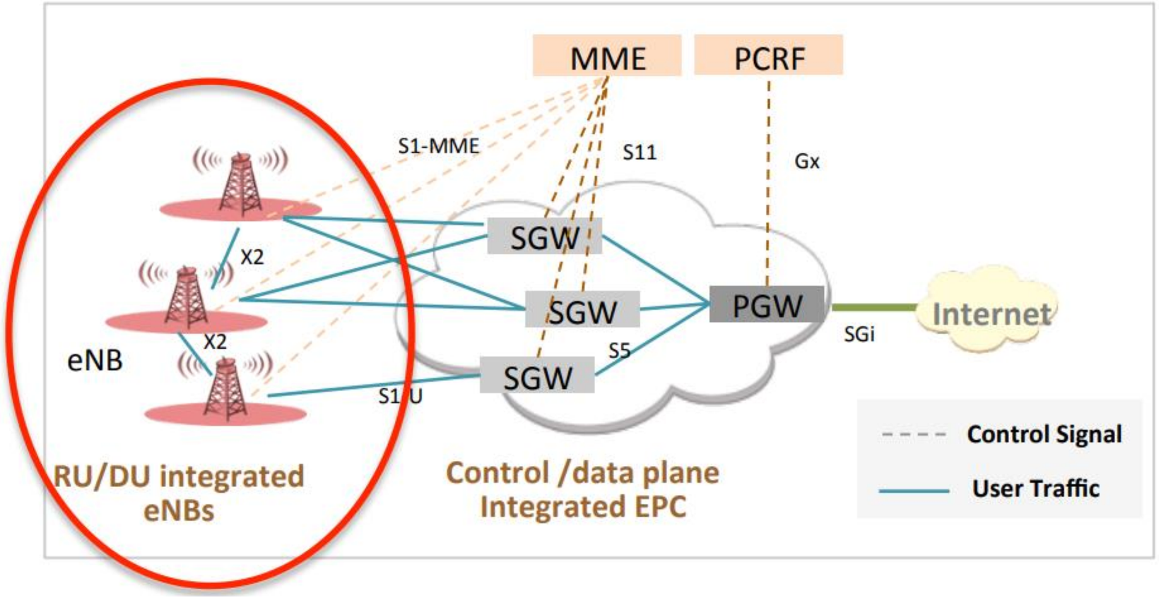
- Wireless Channel Width (20MHz, 100MHz, etc.) & Modulation Order (e.g. 64 QAM, 256 QAM, etc.)
- Varible Bit-rate (Sliceble) Optical Bandwidth

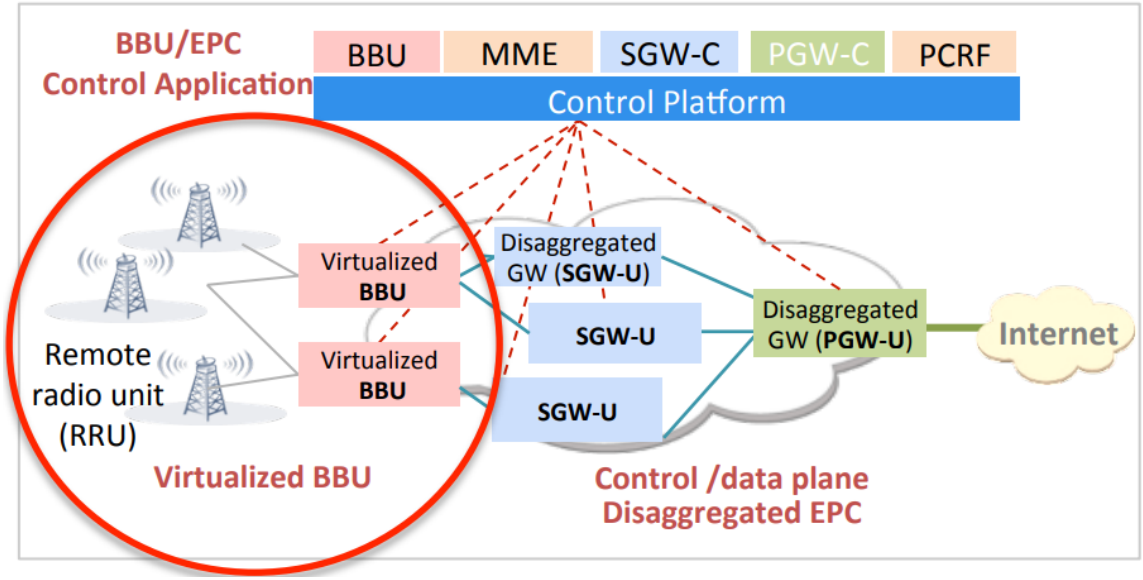
Management

- Hierarchical Orchestration across Domain/Resource Controllers
- Automated end-to-end management
- Services delivered over resource slicing

5G Requirements have significantly lower latencies and much greater capacity than 4G

Evolving Radio Access Network Architectures



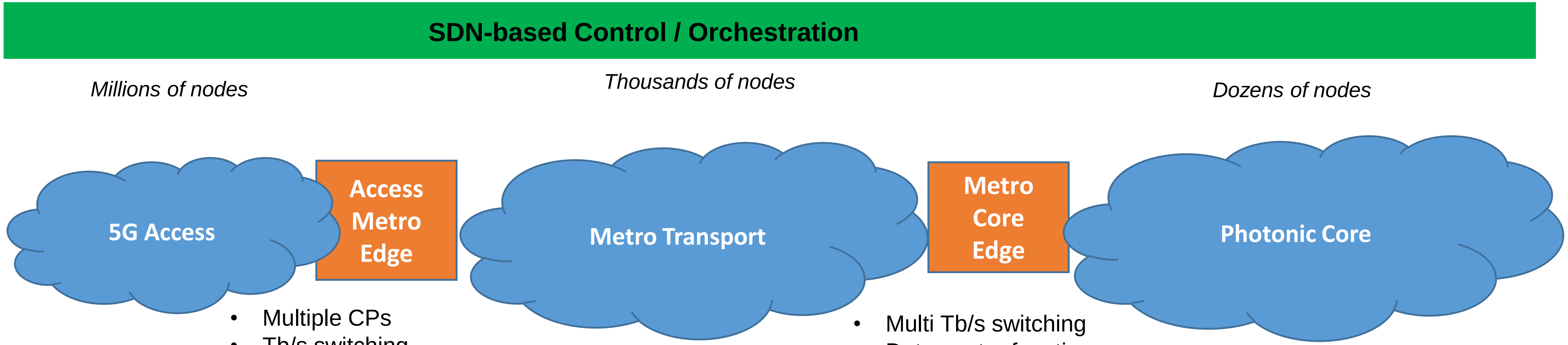


Traditional architecture
- Limited Scalability
- Inefficient coordination of resources
- Sub-optimal spectrum usage
- Latency and bandwidth limitations

Metro-Haul Architecture
- Disaggregated & Virtualized RAN
- High Flexibility & Scalability
- Centralised Coordination of resources
- Spectrum usage optimisation
- Managed slicing of network and resources

UE: User Equipment

What are the Network Research Challenges?



- Multiple CPs
- Tb/s switching
- Remote storage / compute
- NfV
- Dynamic config
- **Whitebox**

- Multi Tb/s switching
- Data centre functions
- Multi layer 1-3
- ROADM
- **Sliceable spectrum**

- Gb/s access
- Wireless femtocells
- Deep fibre
- 5G KPIs?
- **Infrastructure cost**

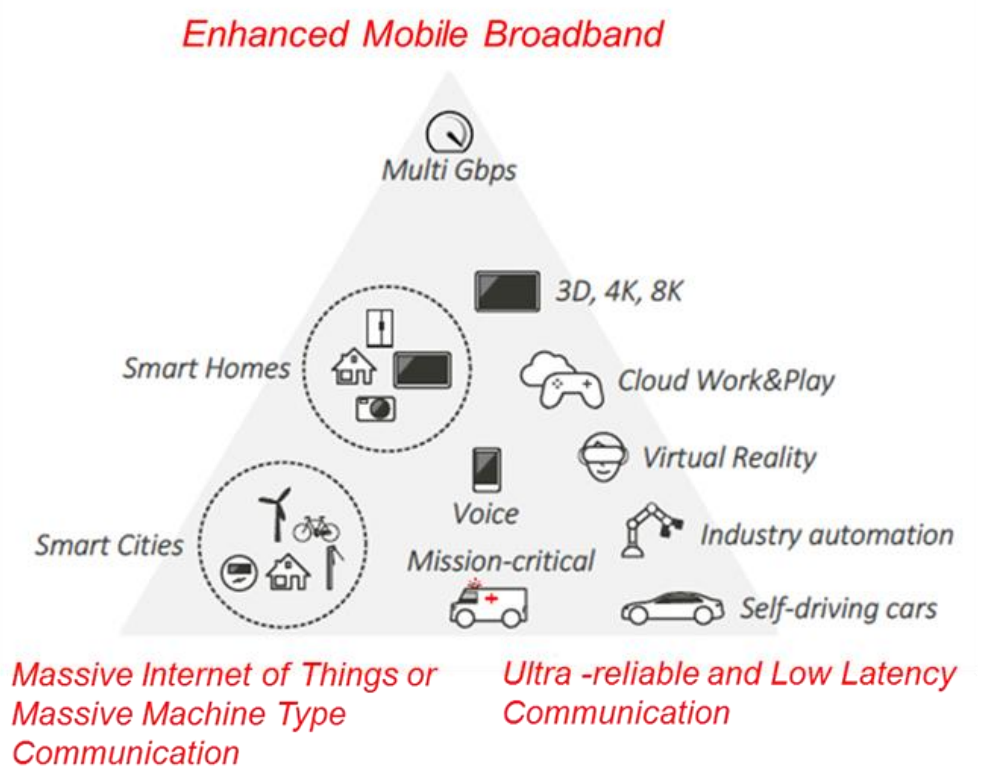
- 10-25G transport
- Many wavelengths
- Limited flexibility
- **Cheap 10G over 50km**

- > 1Tb/s per fibre
- Increased flexibility
- Cost less critical
- **Elastic Optical Networks**

Resiliency and Security

Service Use Case Categories

end user (mass or vertical) oriented	eMBB	**enhanced Mobile BroadBand** - Handling of 5G enhanced Mobile broadband, useful, but not limited to the general consumer space mobile broadband applications including streaming of High Quality Video, Fast large file transfers etc.
	mIoT	**massive Internet of Things** - Allowing the support of a large number and high density of IoT devices efficiently and cost effectively.
	CriC/URLLC	**Critical Connections/ Ultra Reliable Low Latency Connections.** Supporting low latency ultra-reliable communications for allocations including augmented (virtual) reality, advanced gaming, industrial automation, tactile interaction, (remote) control systems. Public safety and Critical Communication are included in this category
Network/Service Operator oriented	NEO	**Network Operation**. Use cases and their consolidated potential requirements, to enable network operators to support the needs of new scenarios and markets related to network operation. Include use cases with network resources (connectivity, storage, computation) as a service, network slicing and similar.



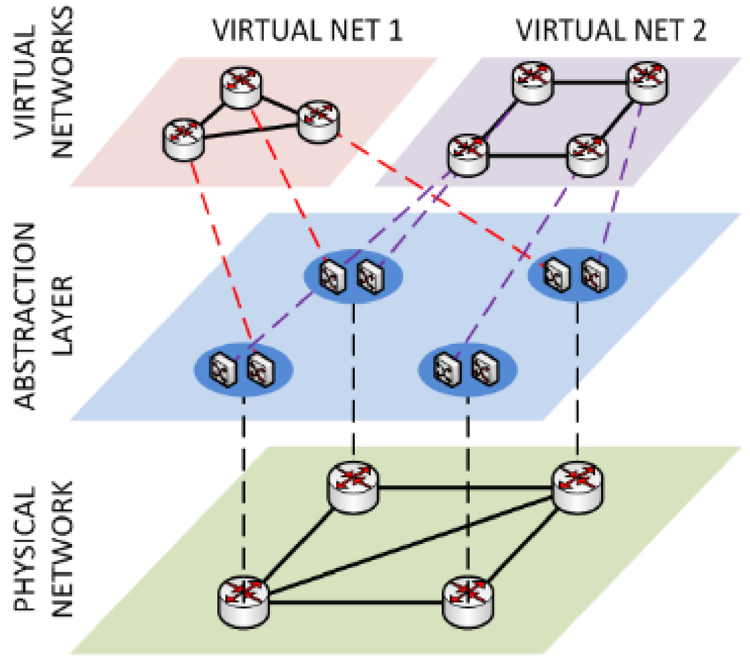
Source: 3GPP

Using Communication Service Connected Templates

	Key Performance Indicators	Short definition
1	Bandwidth (data rate) [Mbs]	Peak and Average values of data rates
2	Latency [ms]	The time it takes to transfer a given piece of information from a source to a destination.
3	Jitter [ms]	Variation in latency as measured in the variability over time of the packet latency across a network.
4	Reliability [%]	Percentage value of the amount of sent network layer packets successfully delivered to a given node within the time constraint required by the targeted service, divided by the total number of sent network layer packets.
5	Availability [%]	Percentage value of the amount of time the end-to-end communication service is delivered according to an agreed QoS, divided by the amount of time the system is expected to deliver the end-to-end service according to the specification in a specific area.
6	Mobility - UE speed [km/h]	Fixed (no mobility: office, home) or max speed in movement (Pedestrian or on a transportation mean: train, road veichle, airplane, drone, …)
7	Area Traffic Capacity [Gbs/km^2]	Traffic collected per area. (Relevant for hotspots and crowded area scenarios.)
8	Rely on Sensor Network [Yes/No]	A use case/service relying on sensor network
9	Massive Type [Yes/No]	High density sensor (i.e. millions of sensors per km^2)
10	Device Direct [Yes/No]	The connection between two UEs without any network entity in the middle.
11	Coverage Requirement [Standard/Extended]	Full Network, Office and residential, confined area (crowd), downtown, along roads, along railways, …
12	Energy Consumption critical [Yes/No]	Regards consumptions of sensors with autonomous battery (not connected to the energy mains network)
13	Type of User Equipment (UE) [Conventional/Special purpose]	Conventional (tablets, smartphones, laptops) or special purpose (e.g. devices installed on robots or drones)

Defining Methods for Resource Control and Flexibility

- Software Defined Networks (SDN) provide this flexibility
- Partly an abstraction layer
- Separates the control plane from the data plane allowing software-defined control of:
  - The current configuration / settings of the network elements
  - Orchestration of new network services
- Open interfaces/APIs:
  - For controlling the network elements
  - Allow network service orchestration



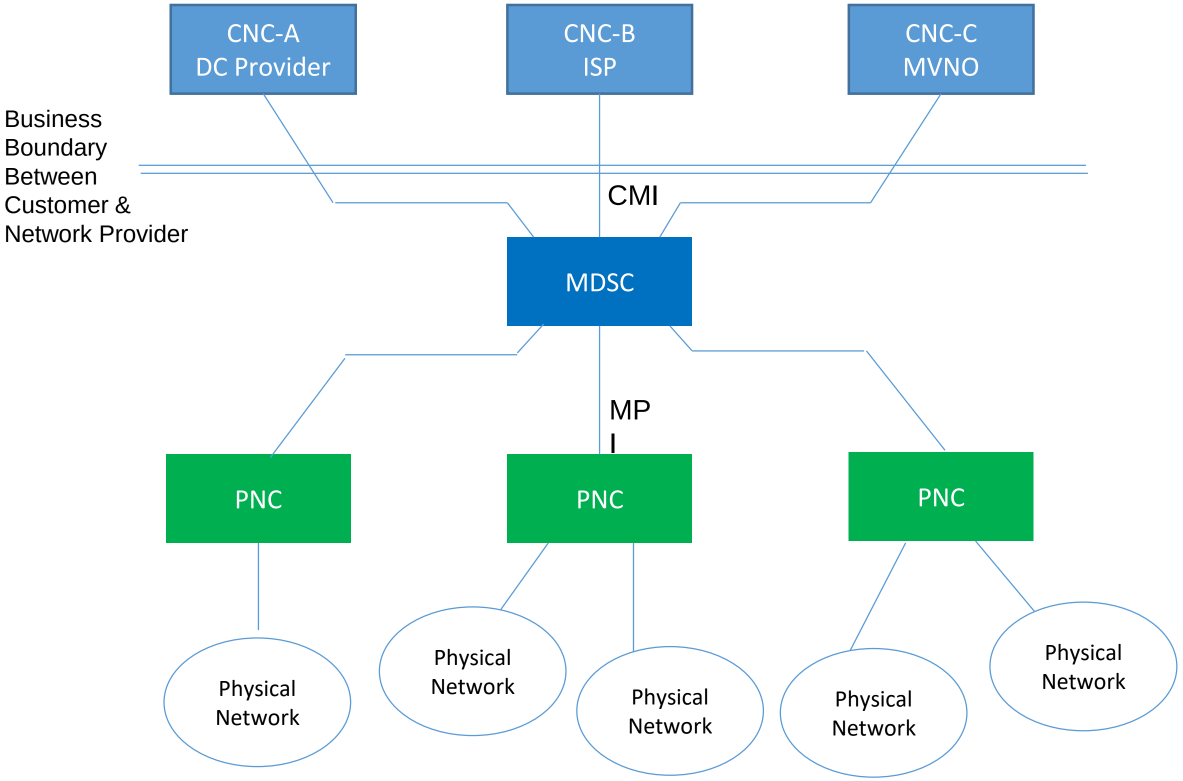
Main benefits –
- **Automated, multi domain, fast provisioning**
- **Bandwidth flexibility**
- **Customer network control via API**

What do we mean by Network Slicing?

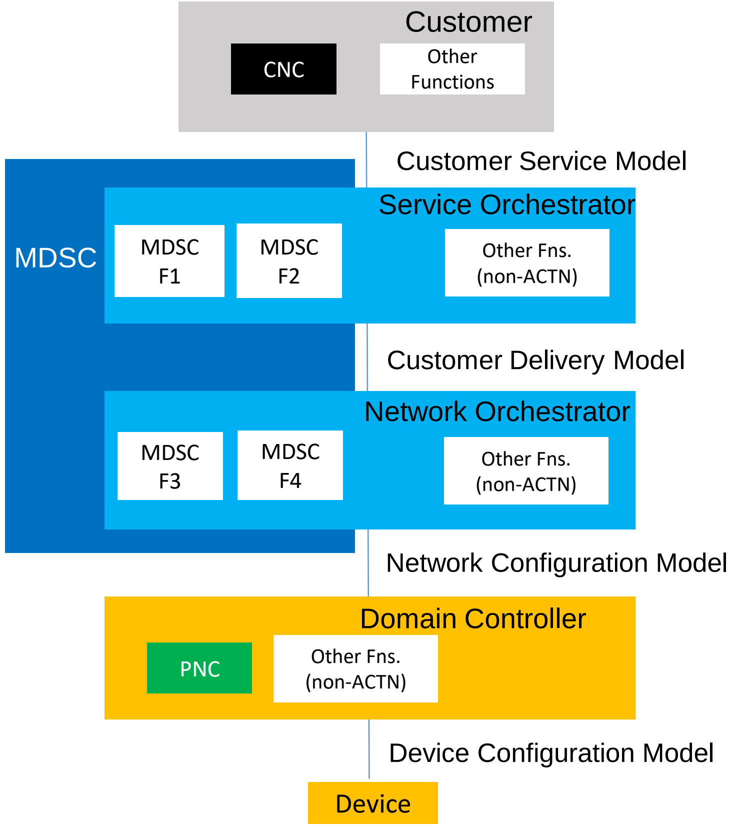
- Network slicing (in the context of Metro-Haul) provides Traffic Engineered connectivity and function to serve customers with a wide variety of different service needs, which may include:
  - Latency, reliability, capacity, and service function specific capabilities
- Requirements for Network Slicing
  - **Resource Slicing**: provide a flexible range of services both by partitioning (slicing) the available network resources and provide specific Service Functions with correct chaining logic
  - **Network and Function Virtualization:** The resources to be virtualized can be physical or already virtualized, supporting a recursive pattern with different abstraction layers
  - **Resource Isolation: O**perate concurrent network slices across a common shared underlying infrastructure
    - **Performance**: Each slice is defined to meet specific service requirements, usually expressed in the form of Key Performance Indicators (KPIs)
    - **Security**: Attacks or faults occurring in one slice must not have an impact on other slices, or customer flows are not only isolated on network edge, but multiple customer traffic is not mixed across the core of the network
    - **Management**: Each slice must be independently viewed, utilised and managed as a separate network
  - **Control and Orchestration:** Orchestration is the overriding control method for network slicing
    - **Multi-domain Orchestration**: Managing connectivity setup of the transport service, across multiple administrative domains;
    - **End-to-end Orchestration**: Combining resources for an "end-to-end service (e.g., transport connectivity with firewalling and guaranteed bandwidth and minimum delay for premium radio users (spanning multiple domains).

Abstraction and Control of Transport Networks (ACTN)

Base ACTN Architecture

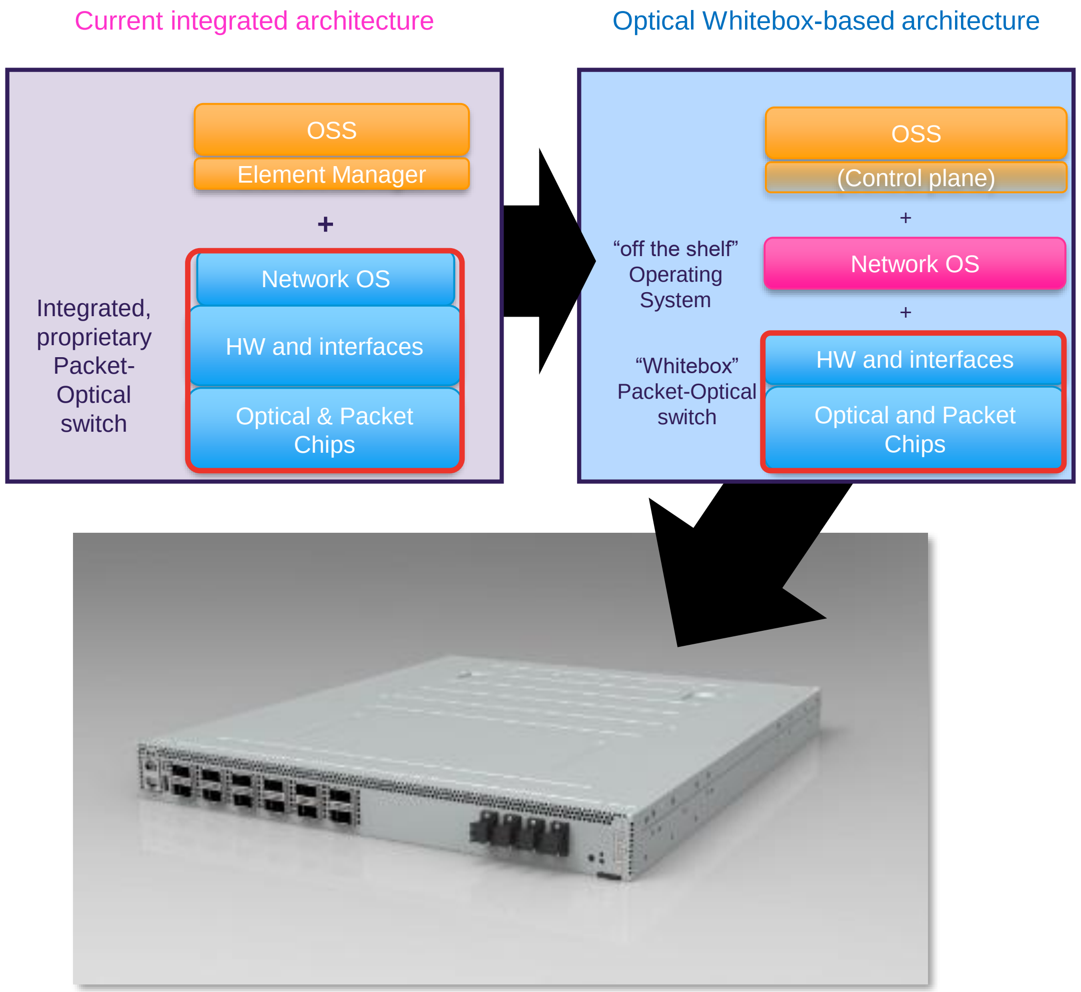


Functional Split of MDSC Functions in Orchestrators

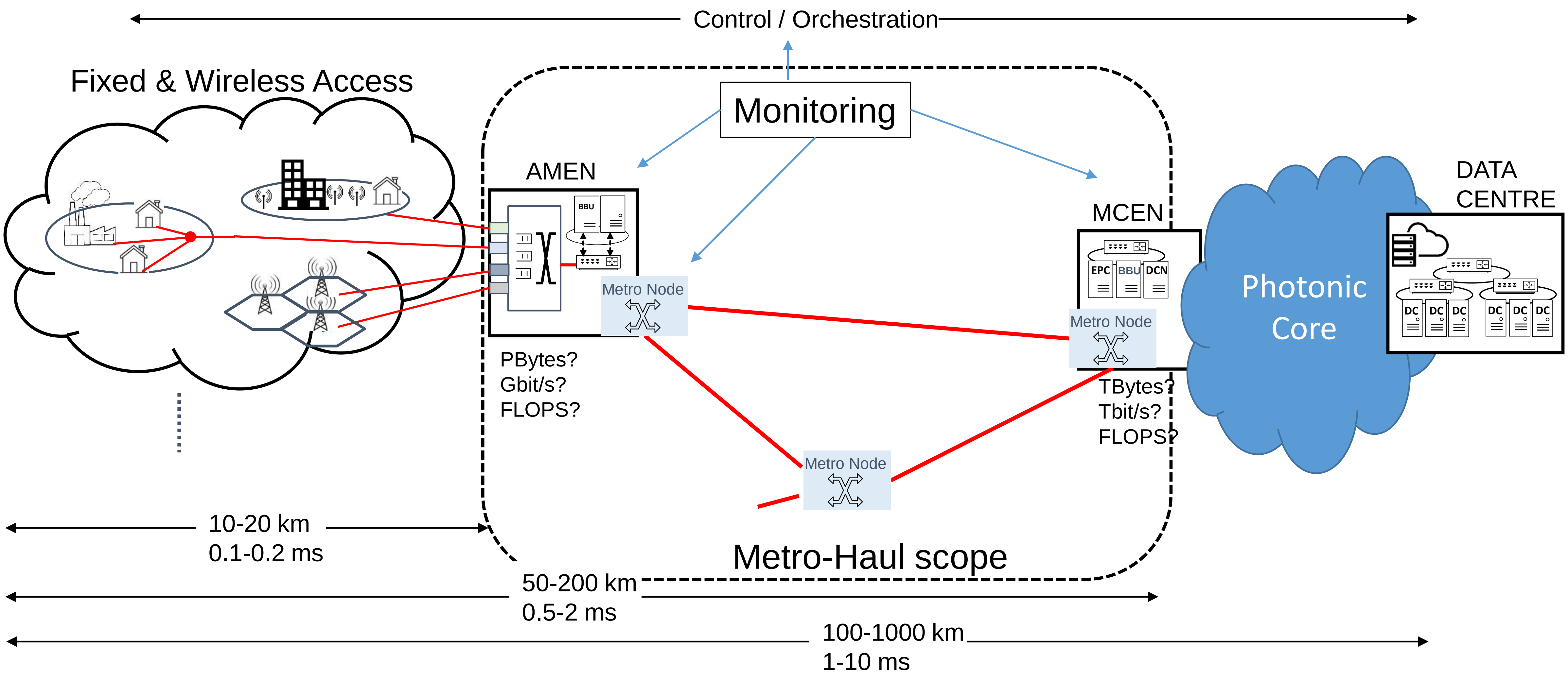


Leveraging Whitebox Optical Transport

- Leveraging OpenSource and Open Platforms
- Building on the Telecom Infrastructure Project (TIP) 'Open' Voyager developed by
  - Facebook
  - Adva Optical Networks
- Software logical separation from hardware (different vendors)
- Hardware is commodity (low-priced)
- Control and forwarding features implemented and accessible in software (agile and programmable)
- What is Unique?
  - Completely new way of developing hardware solutions
  - Disaggregation of Software and hardware
  - Open, published specification



Developing Metro-Haul Architecture



- Access Metro Edge Node (AMEN) – multiple ubiquitous access technologies, cloud enabled (storage, compute)
- Metro Transport Network – metro node: pure transport
- Metro Core Edge Node (MCEN) – larger cloud capabilities
- Metro Control Plane – full orchestration

Use Cases being analysed

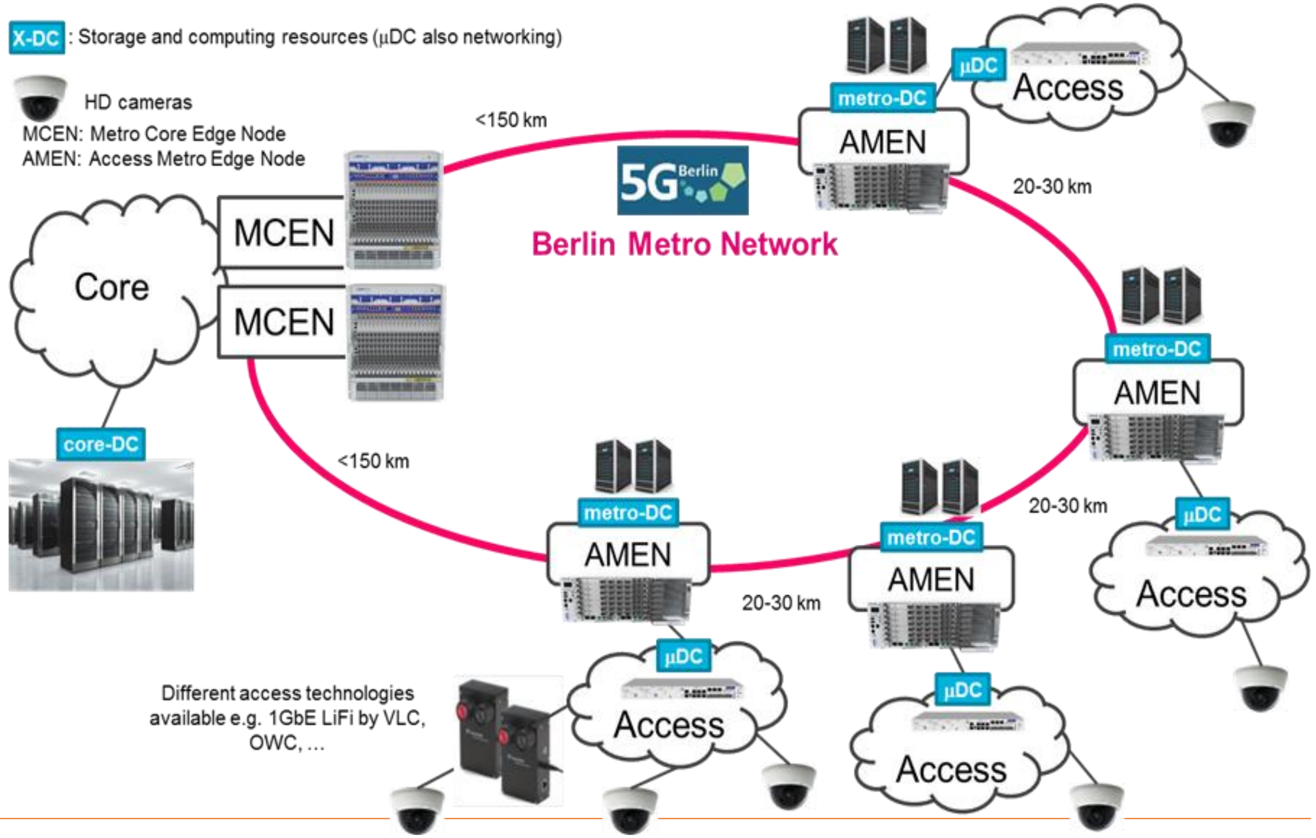
- A small selection of Service Use Cases are being analysed to understand its requirements and mapping on the requirements for the optical Metro-Haul network
- The Service Use Cases include
  - Smart Factory
  - 6DoF Virtual Reality
  - Robotics and Drones
  - Live-TV
  - CDN
  - Utility Metering
  - Crowdsource Video broadcast (included in final demos)
  - Video Security for Smart Cities (included in final demos)
- There are other two Use Cases in the category of Network Operators being analysed
  - 5G NR architectures
  - Secure links using QKD to address DDoS
- Finally a top-down approach is also being investigated

Video Distribution and Security for Smart Cities

- Simultaneous real-time access to the data of several fixed and mobile cameras allows tracking of objects and individuals as well as the automatic recognition of critical events encompassing areas larger than a camera's field of view.
- The number of cameras and their data rate can be flexibly adapted to the situation and resource availability. Individual cameras can provide tracking of anonymous objects; their combination with other data sources could potentially enable simultaneous recognition and identification

Service requirements

- Optical infrastructure for RT video security enabling applications such as RT object tracking, automated face recognition and handover between multiple flexible camera devices
- Low-latency connectivity between fixed and mobile cameras assigned to different AMEN and MCEN with their associated DC storage and computing resources
- Enable flexible distributed cloud computing capabilities for real-time dynamic object tracking applications
- Comprehensive SDN-based network and DC control utilizing standardized open APIs



Metro Haul: A need for Specifications and Standards

- Standardisation for a purpose
  - Reduce development and operational costs
  - Increase interoperability
- Leverage existing work, but develop solution(s) where gaps exists
  - Optical physical layer mainly done (thanks ITU-T)
  - Optical physical interworking in hand (thanks OIF)
  - Optical Control Plane (thanks IETF)
  - NFVI Compute and Storage (thanks ETSI)
- Work already started:
  - Optical Transport Development
    - GMPLS Routing and Signaling Framework for B100G
      - https://tools.ietf.org/html/draft-merge-ccamp-otn-b100g-fwk
  - Optical SDN to NFVI Internetworking
    - Transport Northbound Interface Use Cases
      - https://tools.ietf.org/html/draft-tnbidt-ccamp-transport-nbi-use-cases
  - Network Slicing
    - Applicability of Abstraction and Control of Traffic Engineered Networks (ACTN) to Network Slicing
      - https://tools.ietf.org/html/draft-king-teas-applicability-actn-slicing

Optical Resource Modeling

- Objectives
  - To provide automated interfaces (models) of optical and transport resources to controllers and orchestration layers (including the Metro-Haul platform)
- Effort so far
  - Define requirements of Metro-Haul architecture for optical transport resource modeling
  - Survey of existing work in IETF and other industry groups for transport service modeling
  - Coordinate proposals with leading vendors to adopt ideas and suggestions from TOUCAN into IETF for industry Standardisation
  - Proposed a new service model for connection-orientated SDN transport, being discussed in the Traffic Engineering and Signaling (TEAS) Working Group
- Success so far
  - WSON Model, which has been accepted by the IETF
    - Wavelength Selective Optical Networking YANG Model https://tools.ietf.org/html/draft-ietf-ccamp-wson-yang
  - Flexi-Grid Model, under consideration by the IETF
    - Flexi-Grid YANG Model https://tools.ietf.org/html/draft-vergara-ccamp-flexigrid-yang

THANK YOU

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