



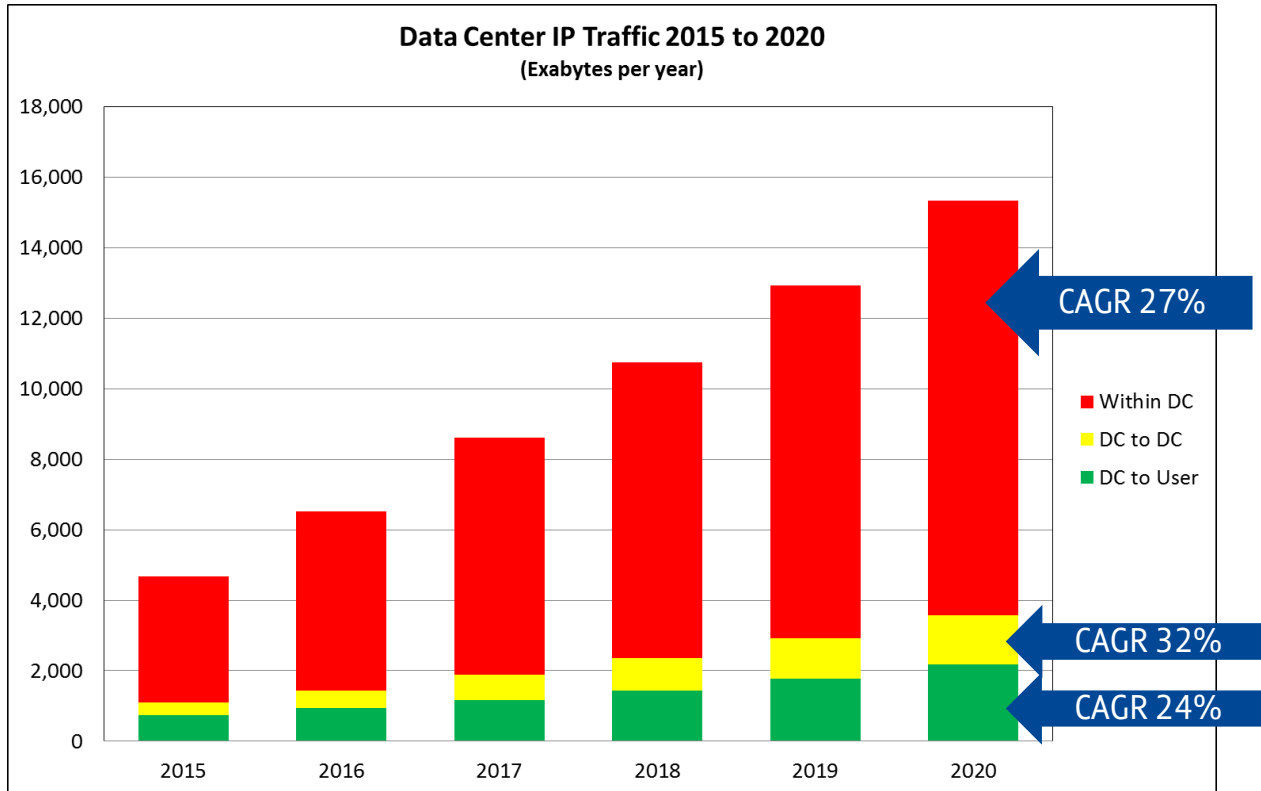
Optical Metro Networks in a 5G world

Andrew Lord (Head of BT Optical Research)





Inter/Intra data centre traffic

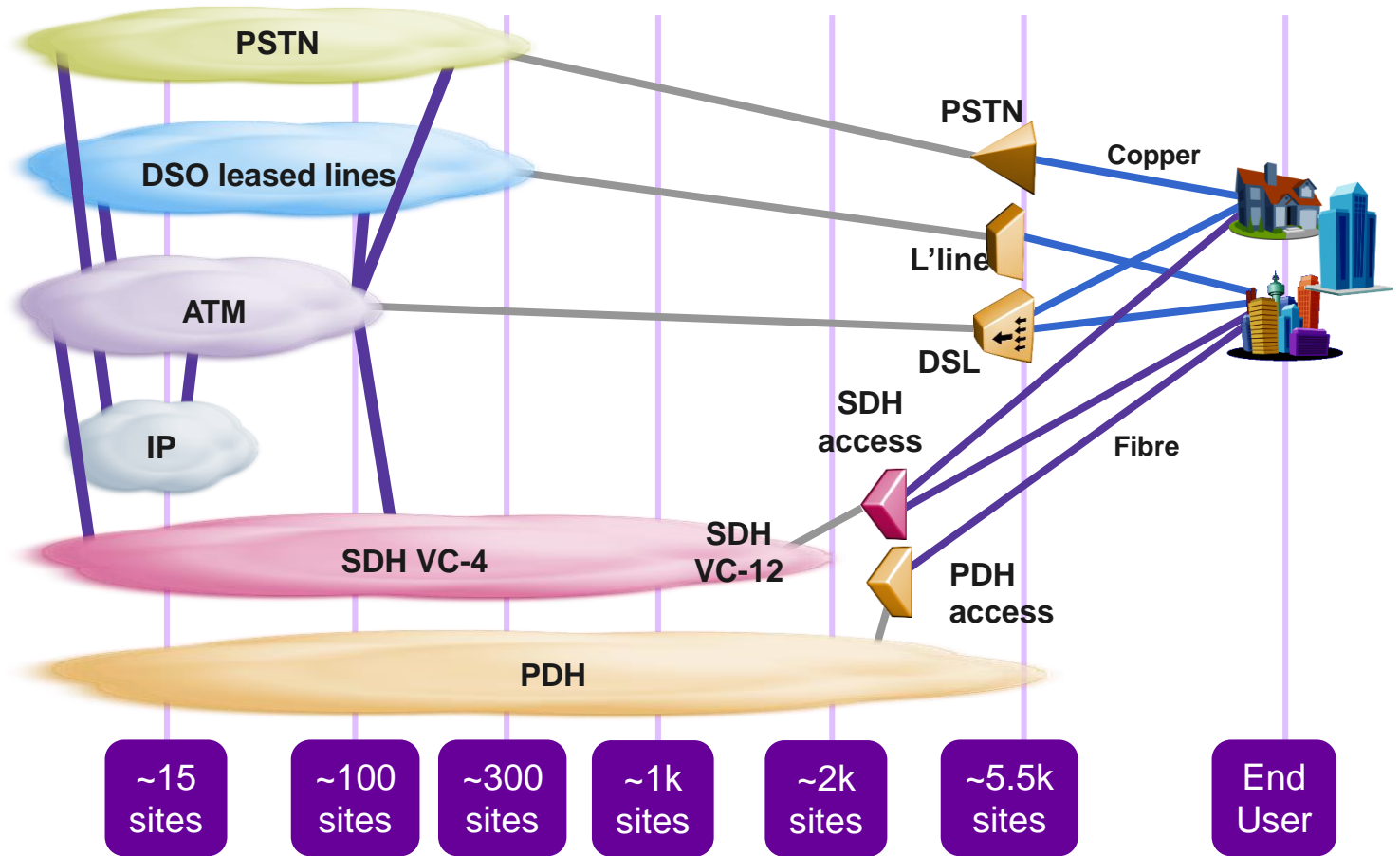


Source: Cisco CGI, 2015-2020

BT still reporting 40%+ traffic growth

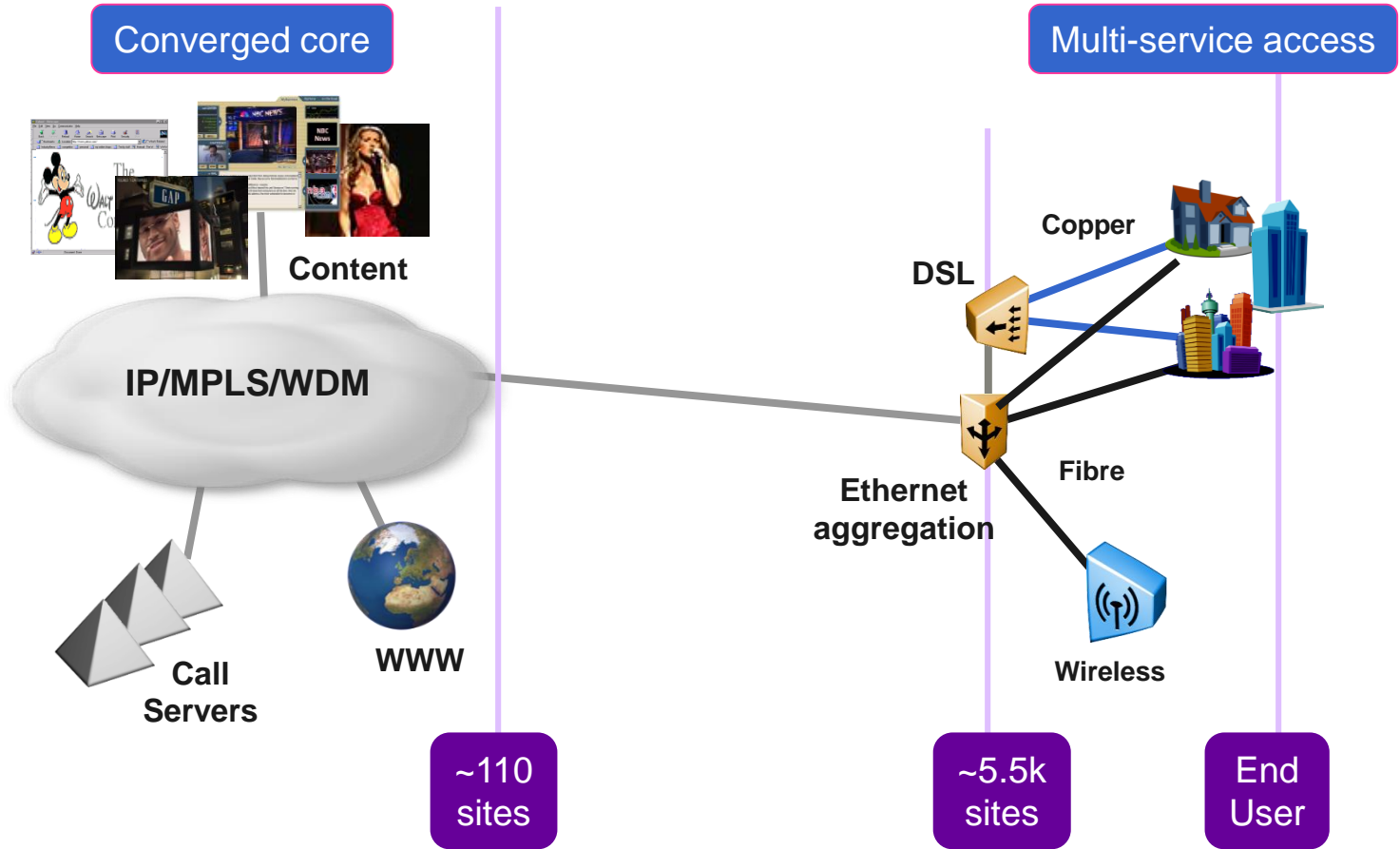


BT Network (2004)





BT 21CN Network (2017)

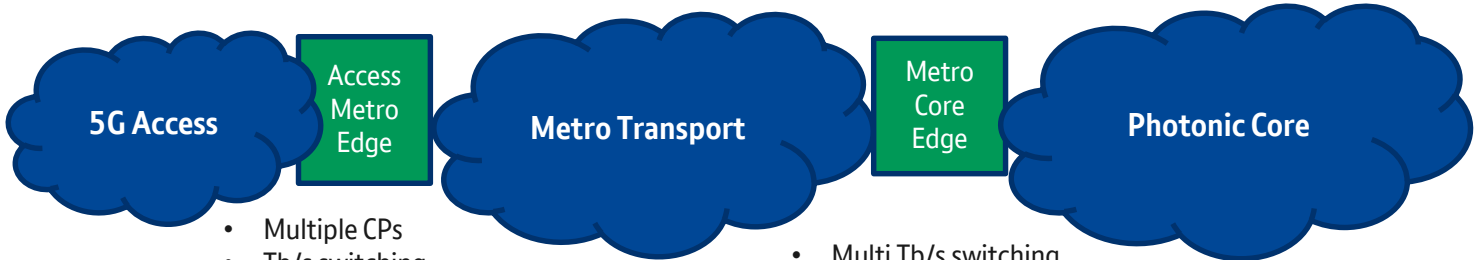


SDN-based Control / Orchestration

Millions of nodes

100s / 1000 nodes

Dozens of nodes



- Multiple CPs
- Tb/s switching
- Remote storage / compute
- NfV
- Dynamic config
- Whitebox
- **Cost, power, space premium**

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

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

- 10-25G or coherent? transport
- Many wavelengths
- Cost-effective flexibility
- 20km – 50km – 100km
- **Cost, power, space premium**

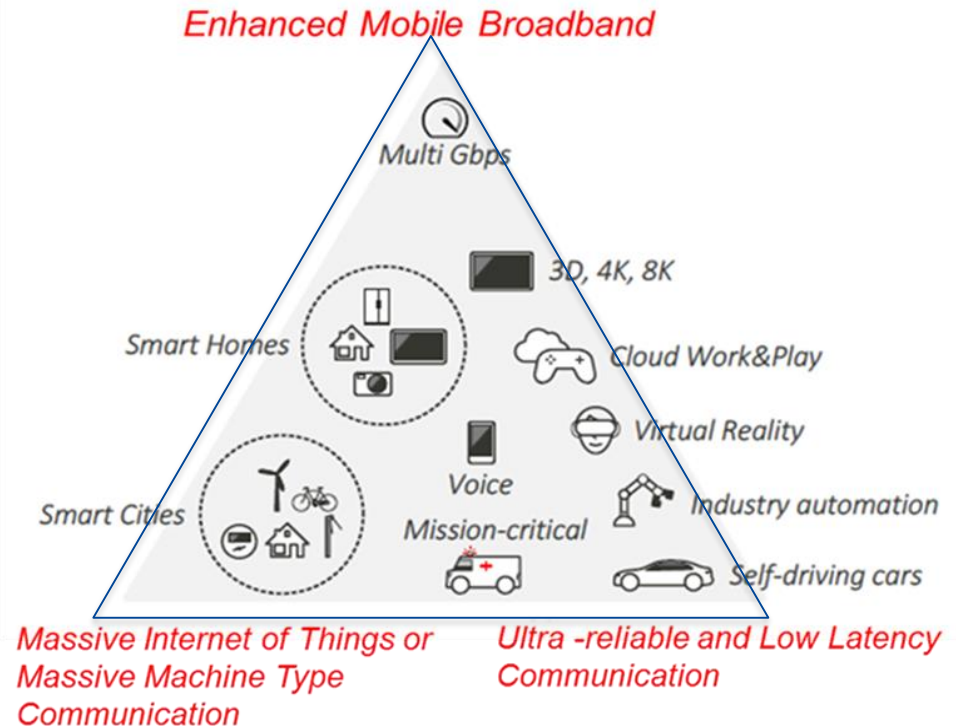
- > 1Tb/s per fibre – multiple bands / fibres / SDM
- Increased flexibility
- Cost less critical
- Elastic Optical Networks

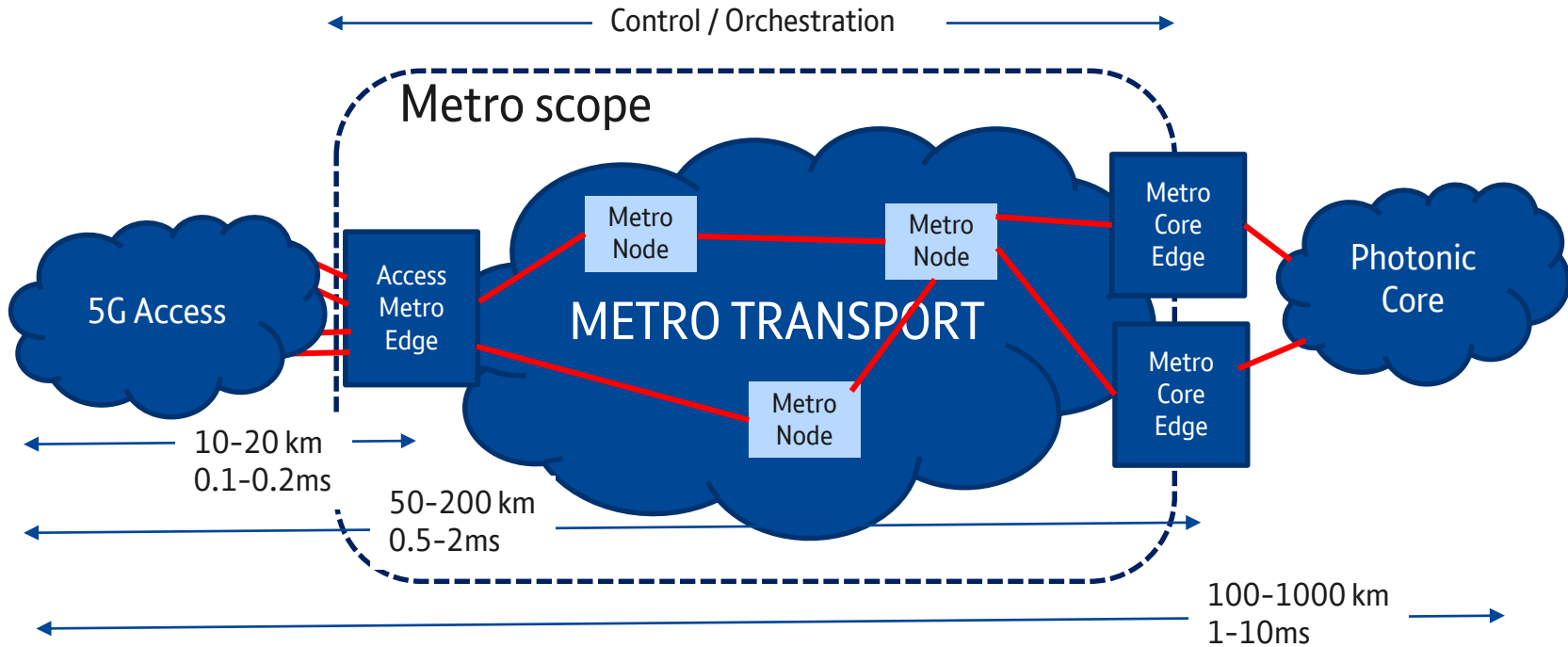


Security, Monitoring, Resilience

- 1000 times higher mobile data volume per geographical area
- 10 to 100 times higher typical user data rate
- 10 times lower energy consumption
- End to end latency < 1ms
- Scalable management framework enabling fast deployment of novel applications
- Reduction of the network management OPEX by at least 20% compared to today

<https://5g-ppp.eu/kpis/>





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

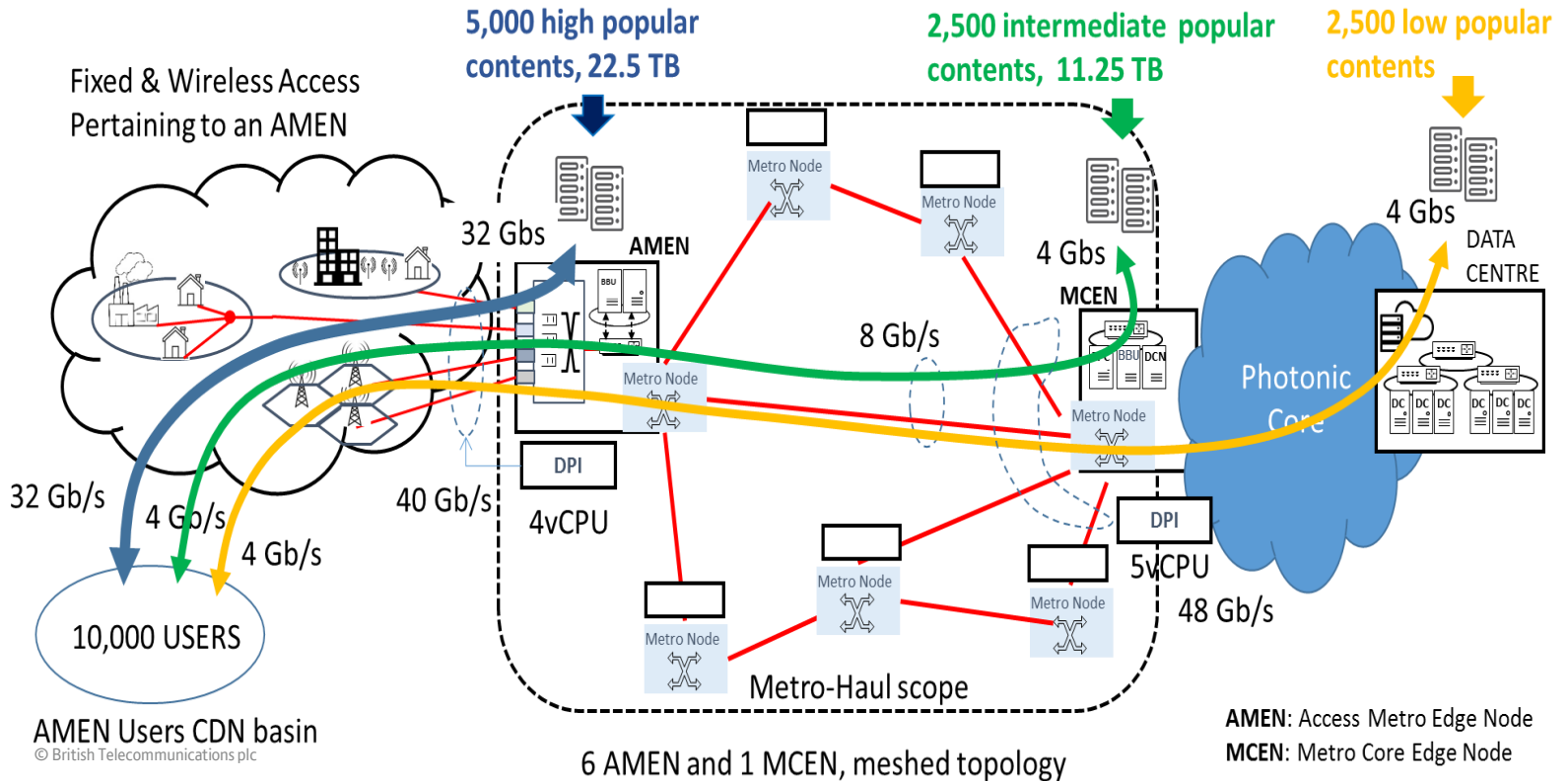
Metro Control Plane – full orchestration

Vertical	Use Case	CoS
Media and Entertainment	Content Delivery Network	eMBB
	Live TV Distribution	eMBB + URLLC
	6DoF Virtual Reality	eMBB + URLLC
	Crowdsourced Video Broadcasts	URLLC
Cloud Services	Service Robotics	eMBB + URLLC
	Enterprise Access with NG Ethernet	BB + URLLC
Utilities	mIoT Utility Metering	mIoT
Automotive	ITS and Autonomous Driving	eMBB + URLLC
Industry 4.0	Smart Factories	eMBB + URLLC + mIoT
Public Safety and Environment	RT LL Object Tracking and Security -	URLLC
Operator orientated	Secure SDN Control. Video Distribution	BB + URLLC

- 3GPP definition is assumed
- Enhanced mobile broad band (eMBB)
- Massive internet of things (mIoT)
- Ultra-reliable low latency connections (URLLC).

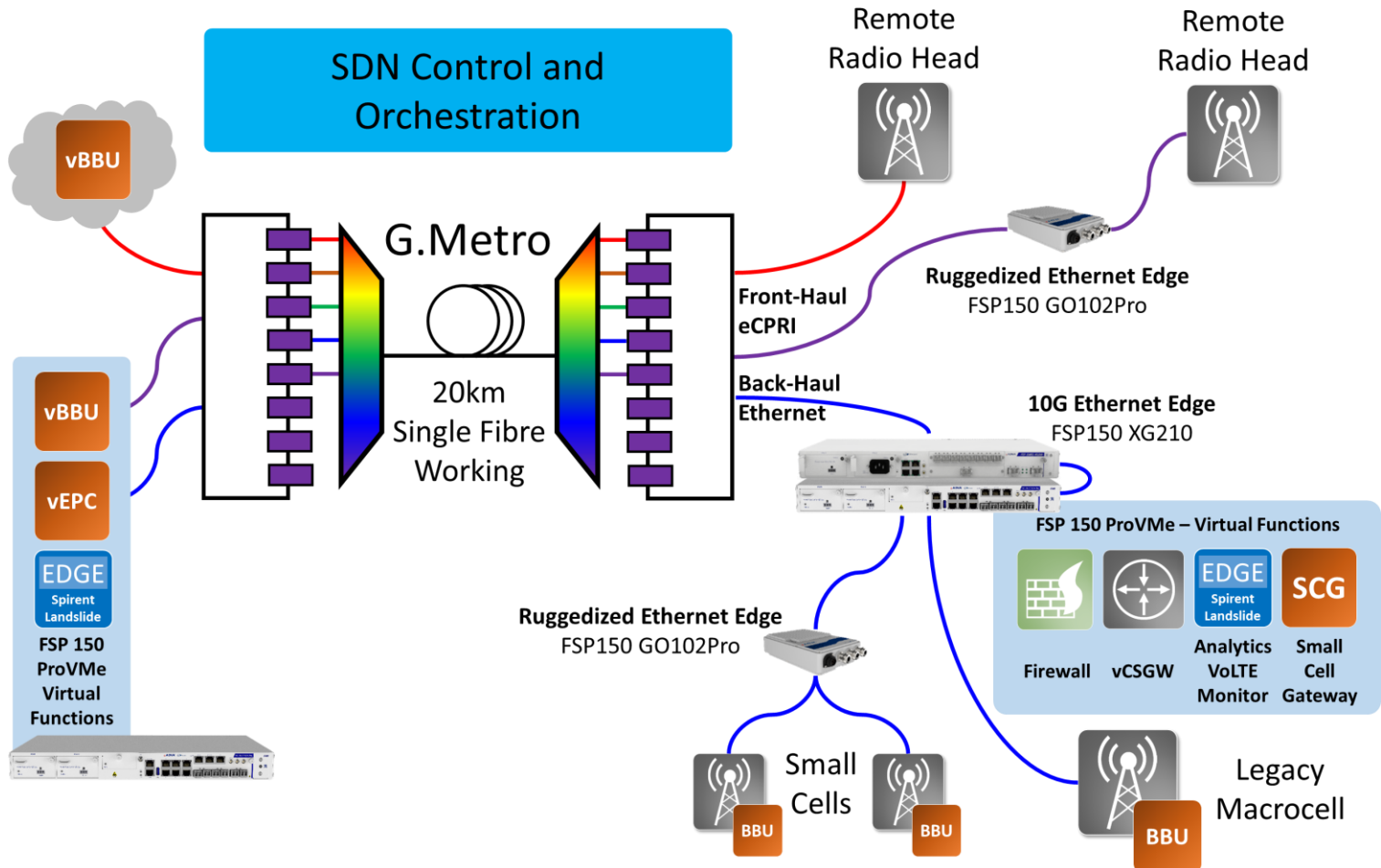


- In the vision of Metro-Haul network architecture
 - CDN caches popular video contents at AMENs and MCENs.
 - Main functions located at AMENs and MCENs to enable efficient video caching and delivery are Storage capacity, Video interfaces to deliver video contents and Traffic inspection capabilities.



Task	Throughput			Storage		Computing capacity	
	AMEN	MCEN	Optical	AMEN	MCEN	AMEN	MCEN
UHD/4K/8K video streaming	32Gb/s	24Gb/s	Nx10Gb/s	22.5TB	11.25TB	-	-
Video traffic inspection, analysis and cache reconfiguration	40Gb/s	48Gb/s	10Gb/s	-	-	4 vCPU	5 vCPU
Peak-hours/Flash crowd phenomenon	32Gb/s	24Gb/s		-	-	-	-

Task	Monitoring and Data analytics	Management, Control and e2e Orchestration
UHD/4K/8K video streaming		Fast recovery mechanisms (protection and restoration)
Video traffic inspection, analysis and cache reconfiguration	Traffic monitoring for early detection of new popular videos	Local and Global reconfiguration of virtual cache
Peak-hours/Flash crowd phenomenon	Traffic monitoring for fast detection of a flash crowd phenomenon	Local and global reconfiguration of virtual cache

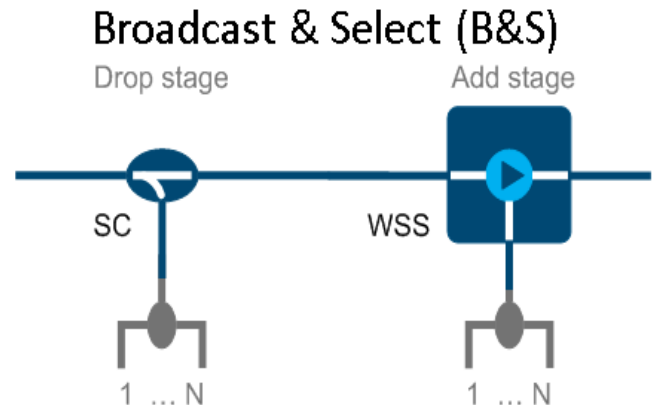
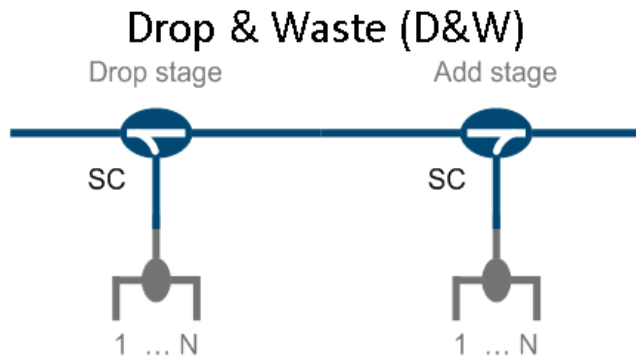


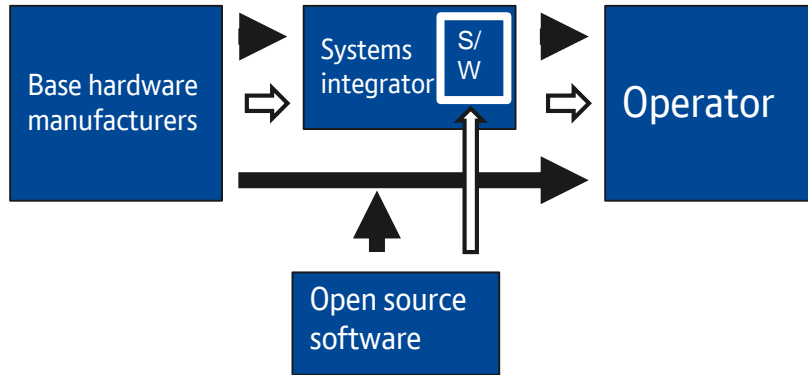
Demo'd at MWC'18



Types of metro optical network

- Main requirement here is **very low cost** 10G-25G WDM with limited reach (<50km) and some switching. Low cost coherent 100G transport also needs deep research.
- Architecture
 - Meshed, chains, horse shoes...
 - Traffic flows expected to be hubbed from the Access Metro Nodes to the Metro Core node
 - Resilience – increased streamed traffic likely to mean increased resilience requirements
- Flexibility – optical switching technology
 - Considerable attention to filterless network architectures – requiring coherent transmission
 - Fixed filter approaches AWG etc) or cost effective WSS filters with some flexibility
- C+L band

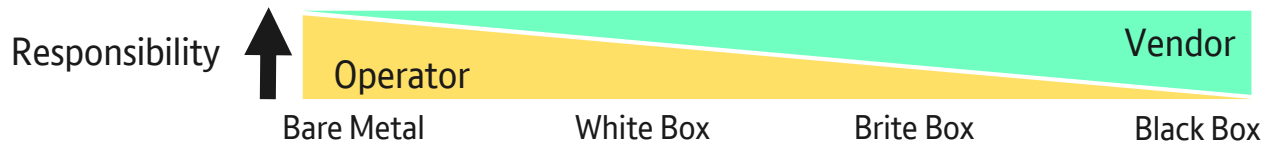




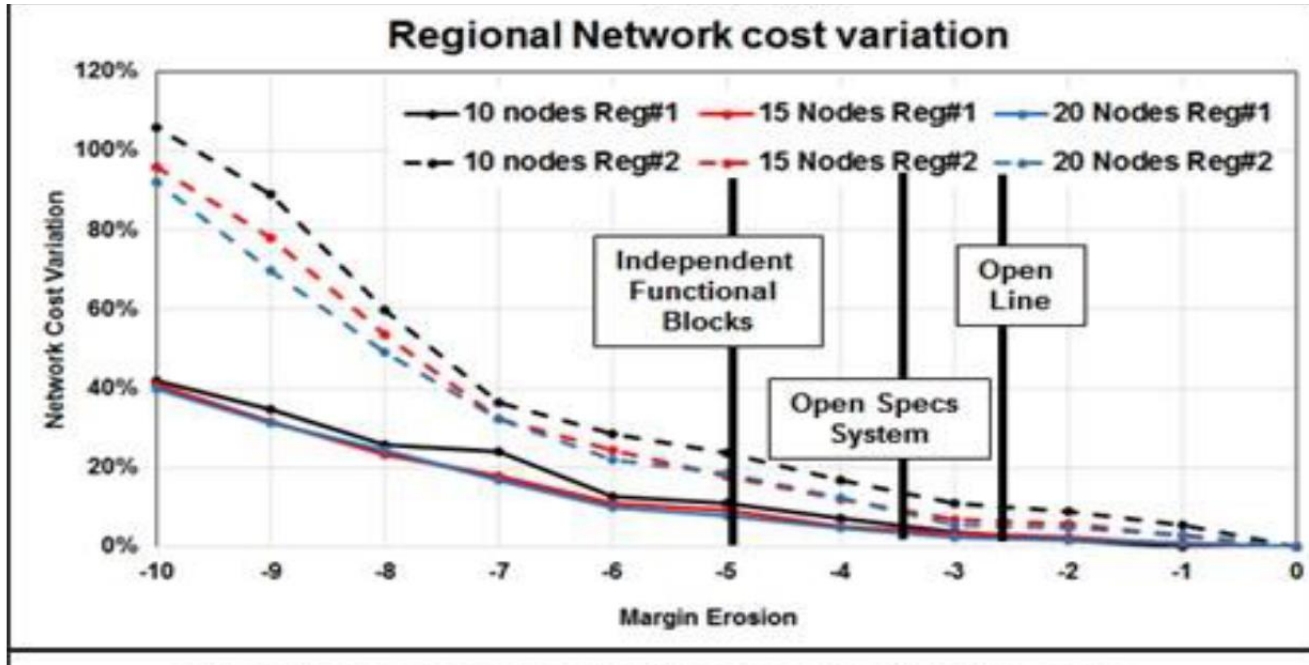
- Traditional approach: single vendor contract
 - Design, deliver and manage for entire solution
 - Be responsible throughout entire life cycle
- Disaggregation divides up this one stop shop
 - Cost savings (hardware and / control software)
 - Benefit from discrete technology developments
 - Operator more involved from initial design stage

Four options

- Bare metal
 - Operator to install software and take full responsibility
- White box
 - Vendor provides some support
- Brite box
 - Systems integrator installs software and offers some in-life support
- Black box
 - Traditional approach

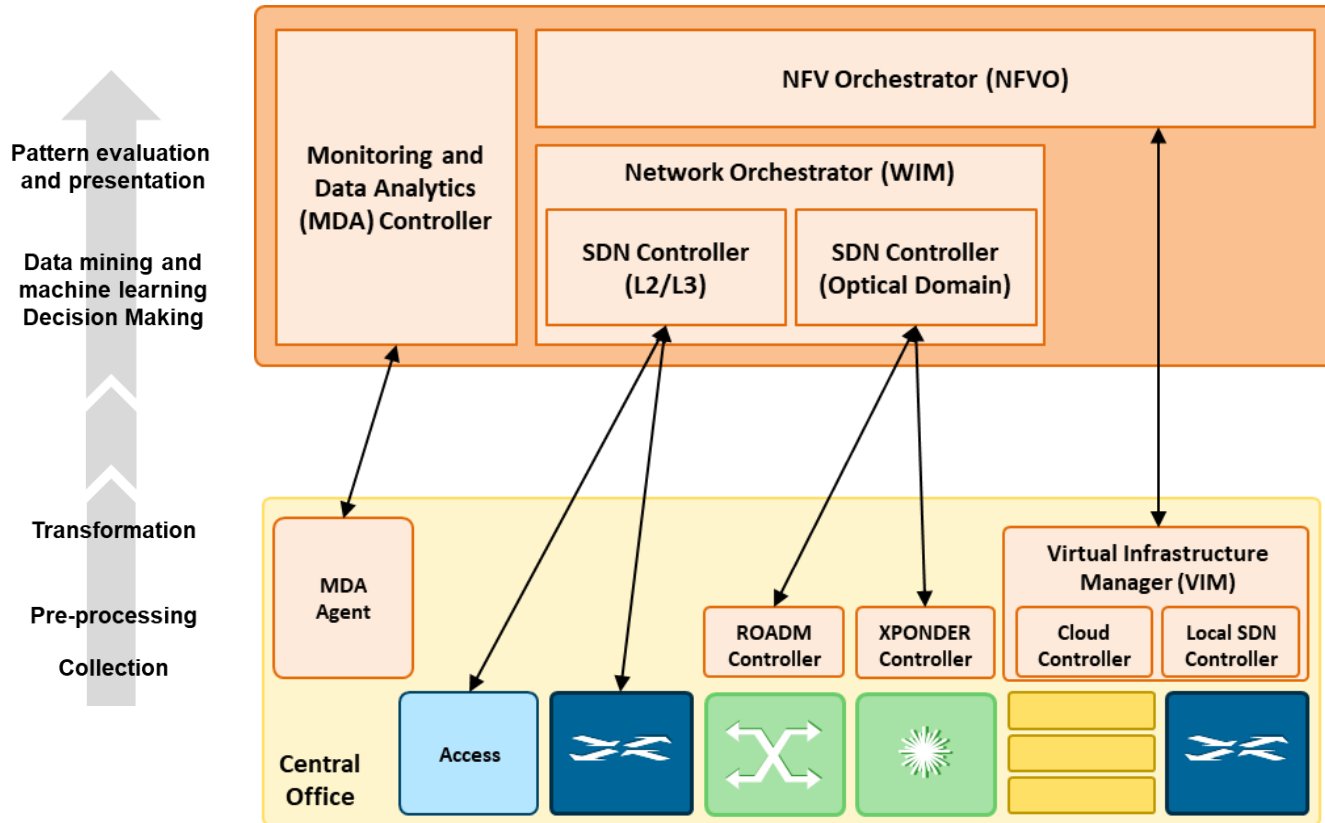


Disaggregation penalty not significant in metro

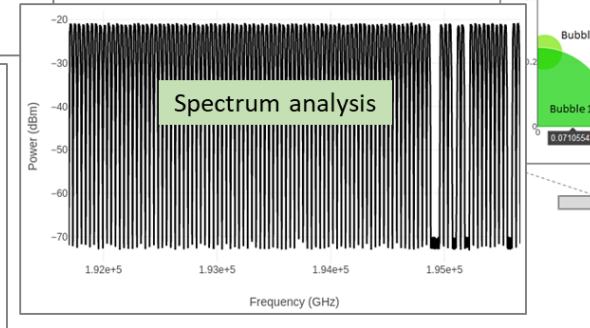
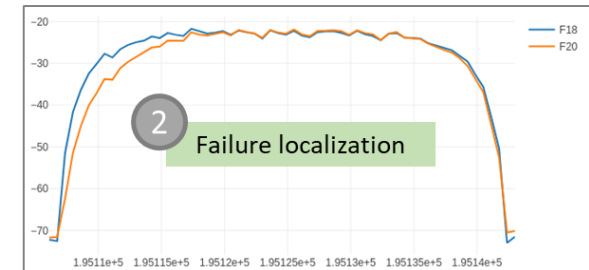
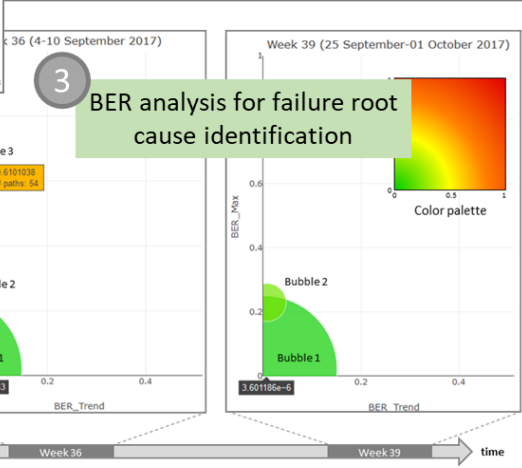
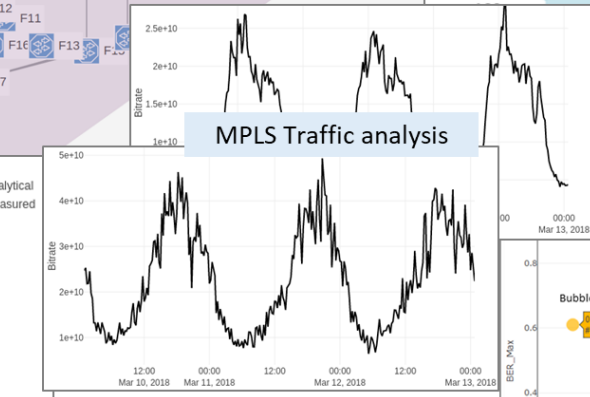
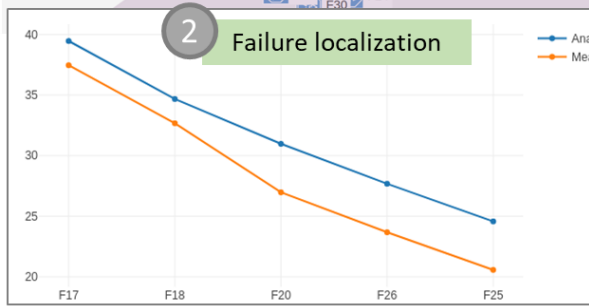
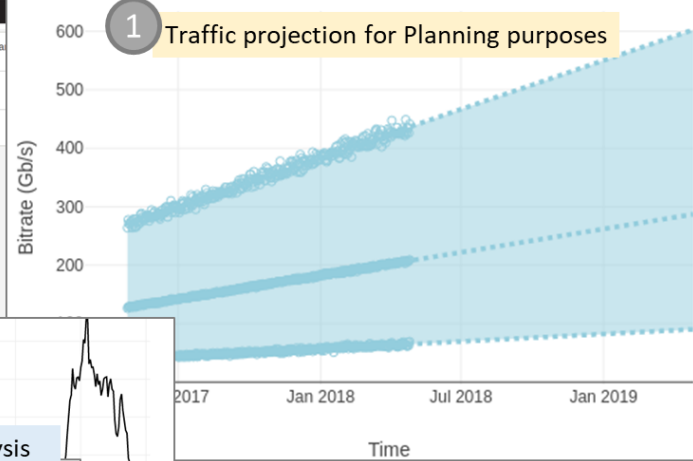
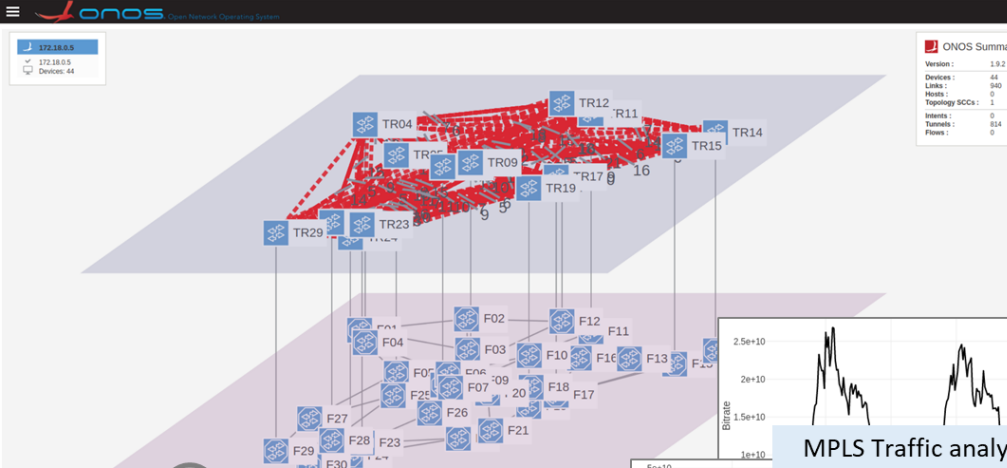


M1E.2 OFC 2018 'Margin requirement of disaggregating the DWDM transport system and its consequence on application economics' Ciena

- Management of complex systems requires appropriate monitoring
- In 5G networks, KPI assurance is required, and so monitoring takes on an even more critical role
- Wide range of resources need monitoring
 - Optical layer, Packet layer (L2, 3)
 - 5G clients
 - Data Center functions
- Monitoring requirement becomes real time
- Fast decisions need to be made to respond to dynamic situations (new services or performance variations)
- Monitoring needs to be incorporated into the overall Control architecture



- **MDA agent** collects monitoring data from all the different sources, process them locally and conveys data to the **MDA controller**.
- **COM** = Control, Orchestration and Management





Machine Learning?

- Huge current hype around this subject
- Concept relates to huge, unpredictable data sets
- Networks have potentially hundreds of nodes, each generating a huge amount of monitoring data
 - Every optical and electrical component on every board
 - Every sub-system, transceiver, EDFA, WSS...
 - Every network component, equipment card, rack, shelf...
- Can all this data be harnessed together to analyse and predict overall network performance
- Potentially TOO much data for a 'linear' analysis?
- Machine Learning could assist in optimising performance and providing warnings of future problems
- Issues –
 - Is there sufficient data for the ML algorithm to learn?
 - Is the data available from the DCN control that manages the network
 - If the algorithm makes a wrong prediction, that might be catastrophic for a Carrier Class network
 - Vendors don't have networks to trial the algorithms they have developed
 - There is no explanation 'why' a specific decision is arrived at

Area needs some careful analysis to see if conventional 'linear' analysis isn't sufficient





Conclusions

- Continued bandwidth growth means continued pressure on optical networks
- Focus moved discernibly from core to metro – though both need attention
- 5G requires radical changes to metro networks
 - Intelligence to handle KPIs
 - Dynamic capability
 - Extended monitoring
 - Deep fibre – cost effective transport
 - Power and space challenges are huge
 - Whitebox could definitely have a role in the metro
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THANK YOU

