

# Scaling for Ultrafast, G.FAST, FTTP, 5G and the Cloud

Neil J. McRae  
Chief Architect  
BT



# Agenda

- BT Core network
- Traffic growth and trends
- Scaling the core
  - new router introduction
  - scaling the optical layer
- Readyng the network for 5G
- Network Cloud
- Telemetry and AI
- Whitebox

# Investing in Research & Development

**3rd**

largest investor in R&D in the UK over past ten years\*

**2nd**

largest investor in R&D in the fixed line telecoms sector over past ten years

**30+**

Direct university research relationships

**102**

Number of inventions filed in 2016/17

**3rd**

highest number of patents filed with the European Patent Office of UK-based companies

**£2.5 billion**

spent on R&D over the last five years

**1025**

Graduates and Apprentices recruited by BT in 2016

**4900**

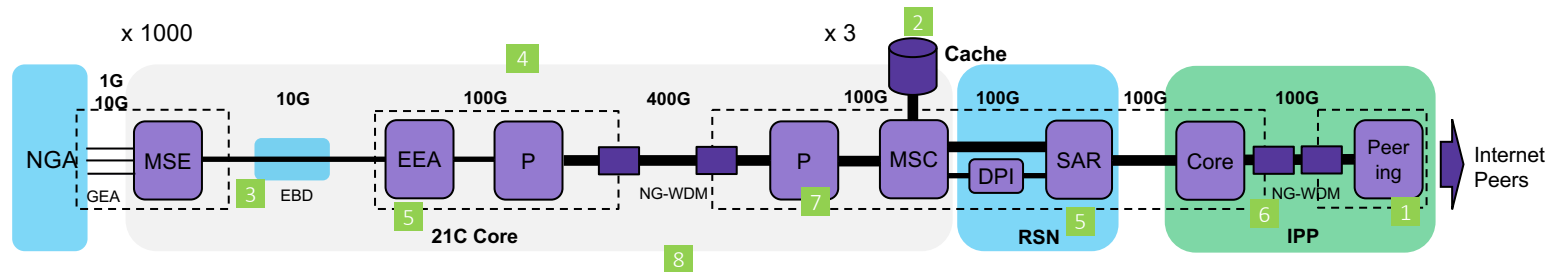
patents in our portfolio



# Research Initiatives

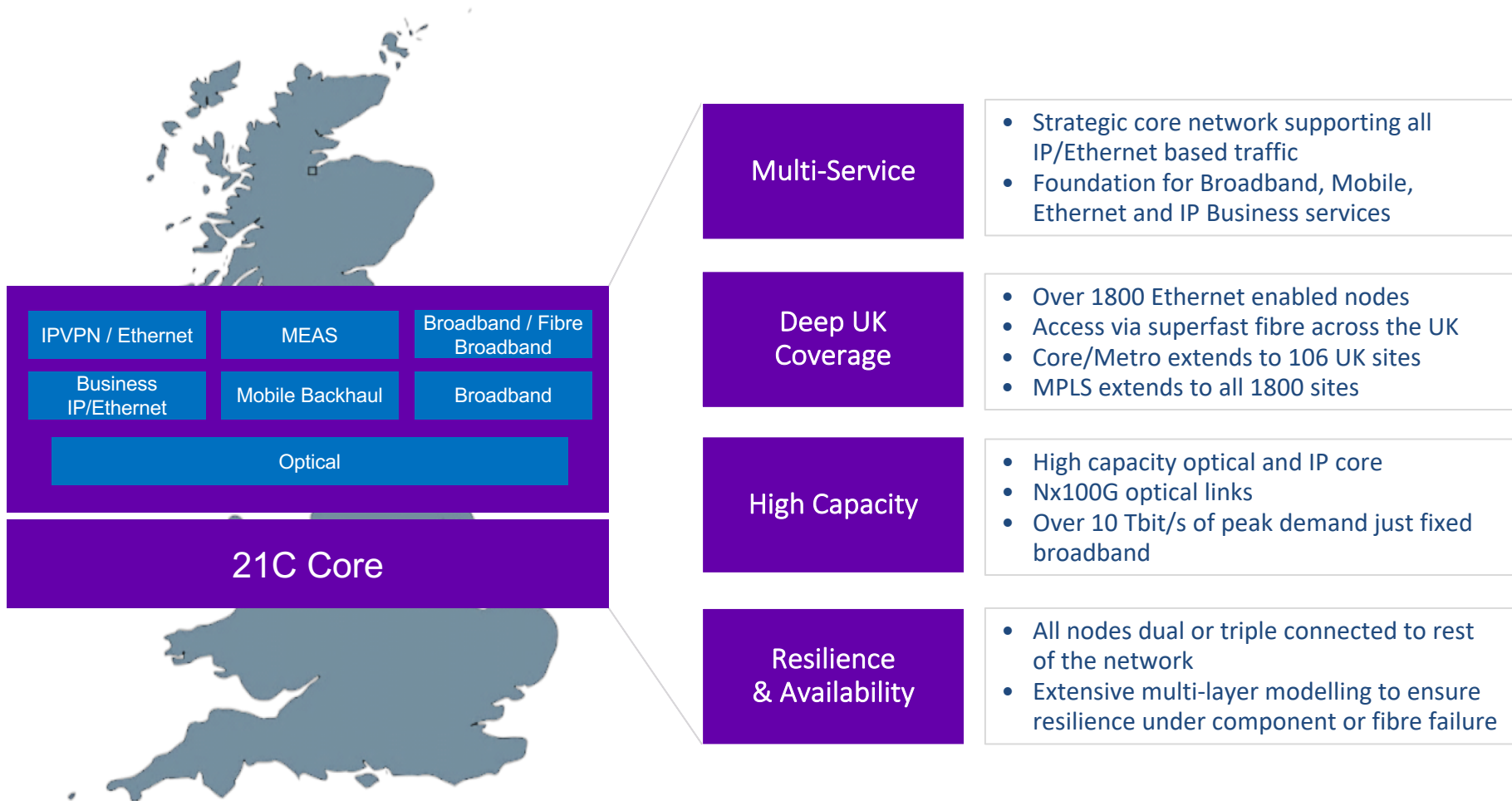
## Principles

- Working with partners to improve the solution.



- |   |   |   |
|---|---|---|
| <p><b>1</b> Research with Cambridge University on autonomous healing.</p> <p><b>2</b> Research with Cambridge University on cache optimisation, Research with MIT Media Lab on content optimisation (codec etc)</p> <p><b>3</b> Research with Cambridge on access, passive gearing, (coherent, Waveguide Cu, Beamforming)</p> | <p><b>4</b> Research with Cambridge, Southampton Huawei and Ciena on future optical</p> <p><b>5</b> Research with Bell Labs on future Ethernet and network topology and edge compute<br/>Research with Oxford on Quantum Compute</p> <p><b>6</b> Research with Cambridge, Bristol and others on alternatives to optical fibre<br/>Research with Surrey on 5G core and radio</p> | <p><b>7</b> Research on Network Chaining with Kings</p> <p><b>8</b> KQD research with various</p> |
|---|---|---|

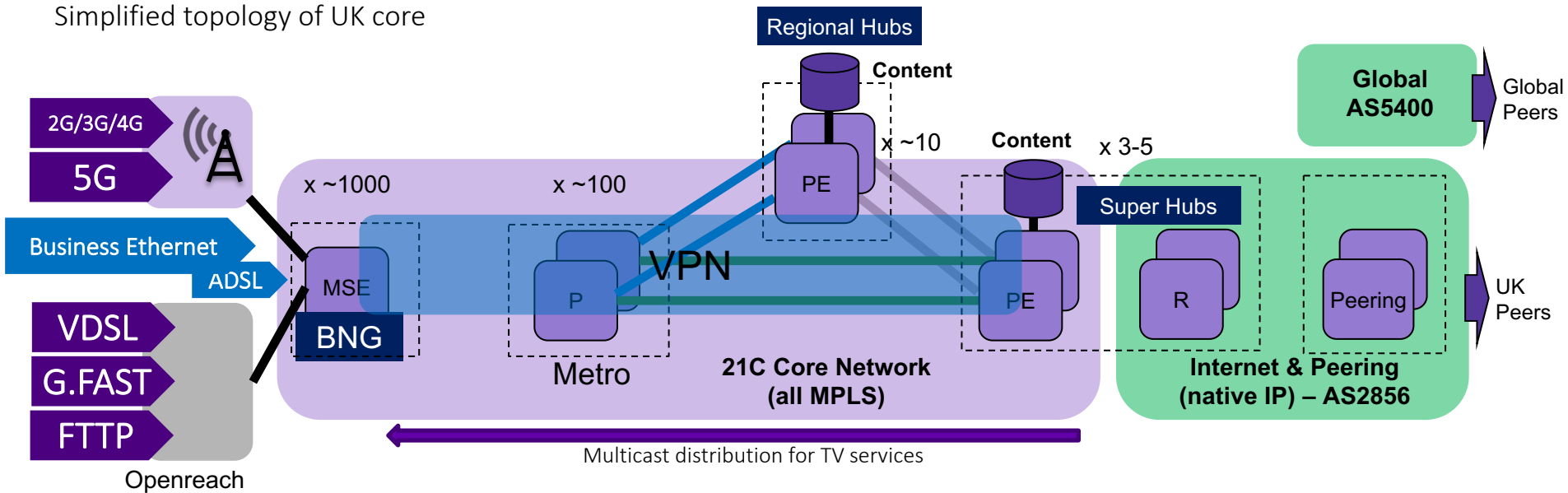
# BT Core network



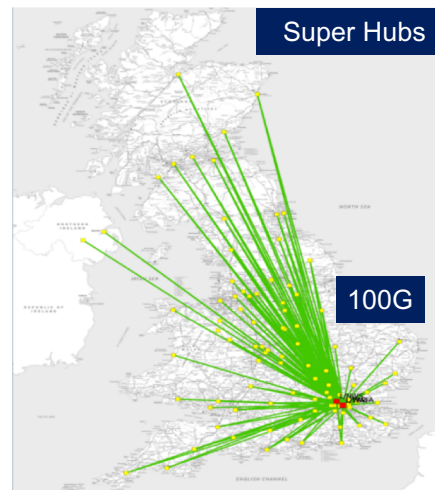
- **One network which carries all consumer and business demands**
- **Scaled to meet peak demands across all services, with resilience to efficiently meet demands of most critical services**

# Core network topology

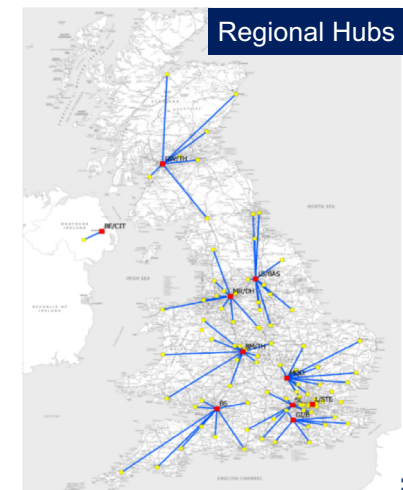
Simplified topology of UK core



- MPLS core platform extends to ~1000 sites to connect to Openreach NGA
- Aggregates 5000 ADSL nodes and 10,000s of cell sites
- BNG function distributed to edge to enable early decision on traffic routing
- Express routes to London based Super Hubs for Peering/Transit bound traffic
- Regional Hubs for CDN content delivery

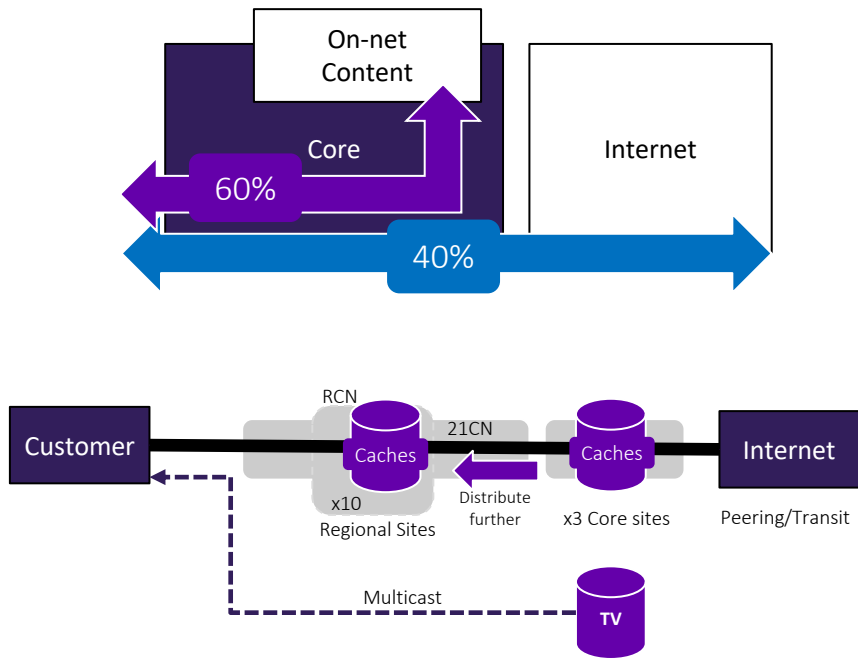


Express routes to super hubs



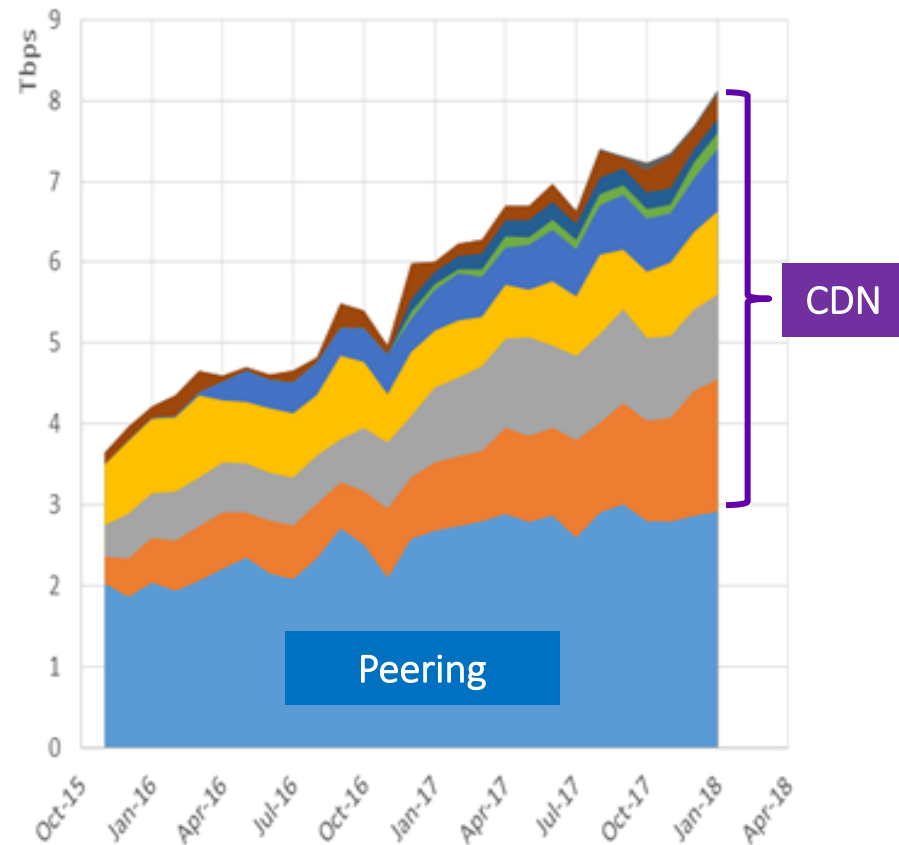
Regional hub connectivity

# Content delivery by CDNs



- Caching content deeper in the network offloads c 60% of core capacity – caches currently at ~13 locations, with potential to deploy more deeply to optimise further
- We also serve BT TV content over multicast – which avoids an additional 1Tbps of traffic on the CDNs

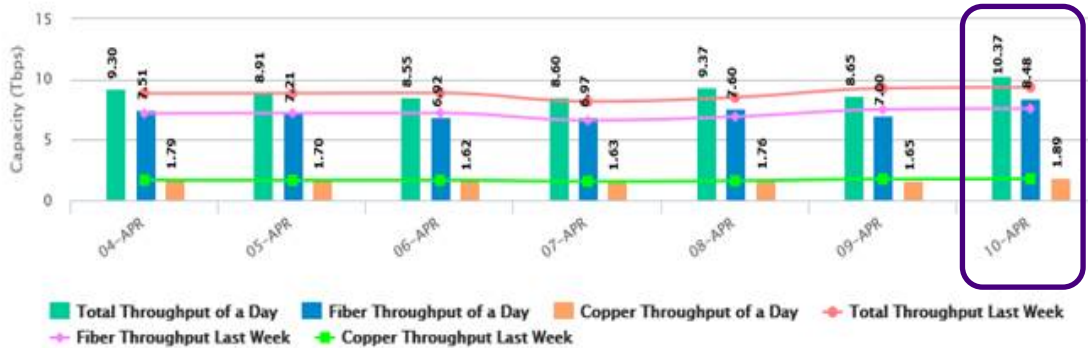
Proportion of peak time traffic offloaded via caching (up to 14-Jan-18)



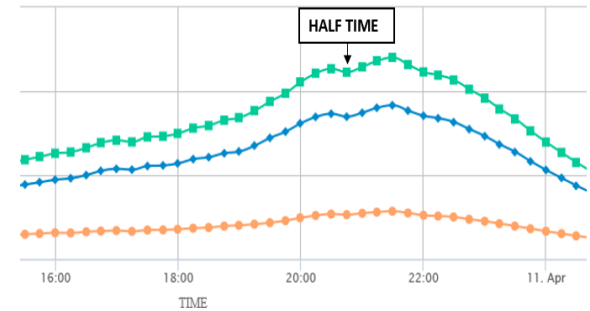
# Demand peaks are driven by sporting events...



21CN Broadband Capacity - Weekly Baseline



21CN Real Time Broadband Utilisation

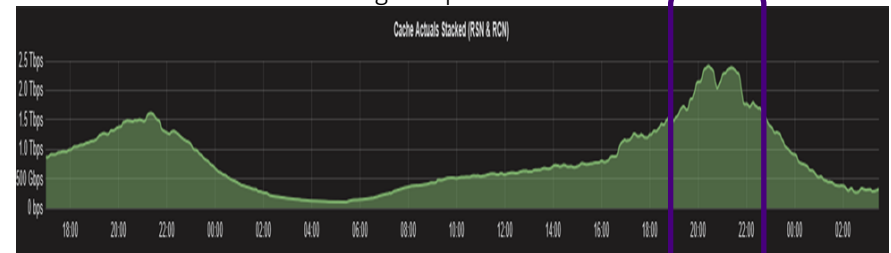


Peak demand is driven from major sporting events. Man City vs Liverpool game on 10<sup>th</sup> April drove highest peak of traffic on our network - 10.37Tbps.

Traffic generated from content CDNs hosted within our network.

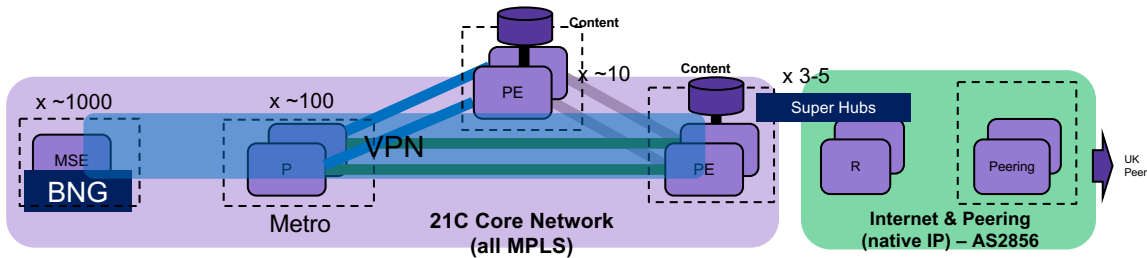
In addition multicast delivered live streams to our devices without loading CDN.

Traffic served from CDN serving BT Sport

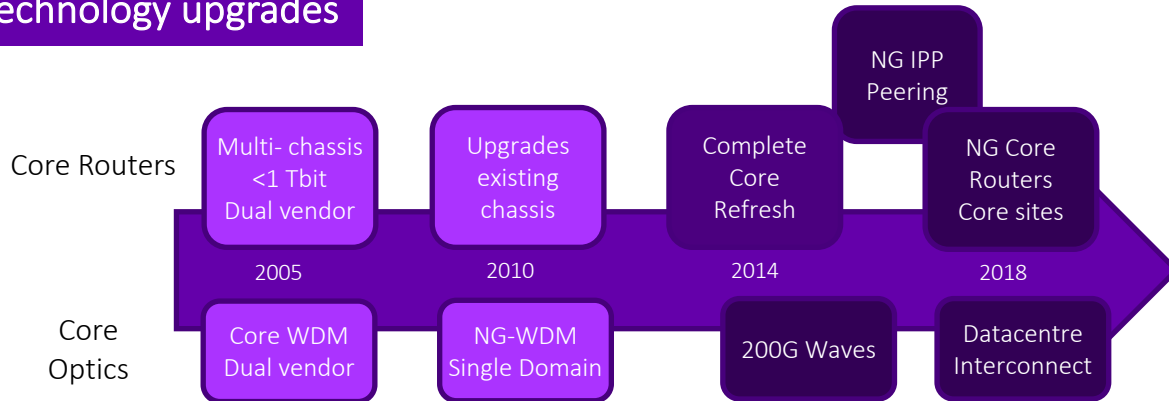




# Dollars less – bandwidth more.

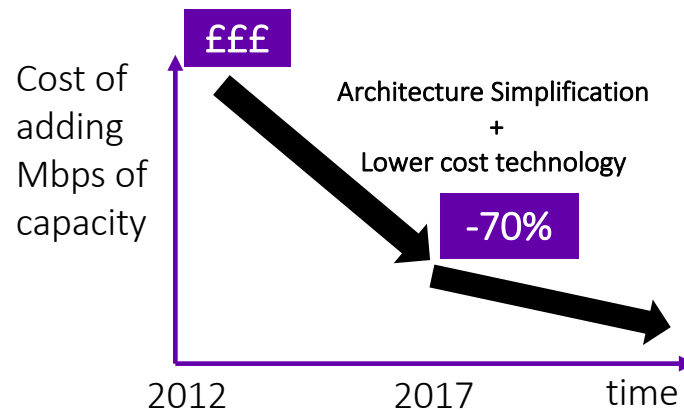


## Technology upgrades



- Traffic growth drives constant equipment refresh to deploy devices with higher switching capacity and drive down unit cost
- Our 21C strategic network is about to introduce its 4<sup>th</sup> generation of core routers

## Unit Cost £/Mbps



- Since 2012 we have reduced unit cost of capacity by over 70%
- Achieved by halving the number of electronics in the path carrying broadband and driving technology cost reduction
- Now targeting more reduction

# Next gen routing platform

Current generation:  
Nokia 7950 XRS



Current generation devices support 16Tbps per routing node  
Example shown is deployed as one of a set of resilient devices in one of our Super Hub nodes

But demand for traffic growth requires us to grow capacity on of routers at our hub sites

Growth driving investment in next generation core devices



- Next gen router being deployed
- Enables significant increased density of 100G aggregation at our core nodes
- System will support 100s 100GE ports and 400GE.
- 10GE supported via break out cables for legacy device interconnect
- Able to replace multi-chassis device with single footprint core routers due to much higher density
- Petabit scale.



# Low cost optical to 400GE

**We plan to deploy datacentre interconnect platforms to provide high capacity WDM links between key sites this year. The advantage is significant capacity in a small footprint and support for modern Netconf/YANG control**

- Terabit/s capacity optical boxes in a compact, modular form factor (e.g. 1RU or 2RU).
  - Programmable line side modulation formats, 100/200Gbit/s evolving to 400Gbits per single carrier.
  - Simple stackable solution for ease of capacity scaling
  - Lower power consumption (as low as 0.5W/Gbit/s)
- Carrier grade optical performance comparable to traditional optical transponders.
  - High-quality coherent optics
  - Ultra-efficient flexible grid compatible WDM e.g. ~120 channels in C-band
- Supporting simple high-speed Ethernet client connectivity
  - e.g. 100GE evolving to 200/400GE.
- Supporting new Netconf/YANG based management capabilities
  - Enabling near real-time streaming telemetry (not SNMP!)
  - Potential for more openness and disaggregated deployment models

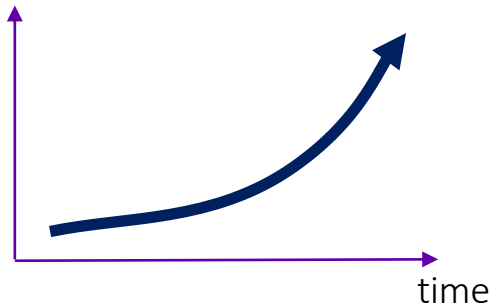


**Also evaluating 400G line side optics and 400GE client ports for connection to NG core routers**

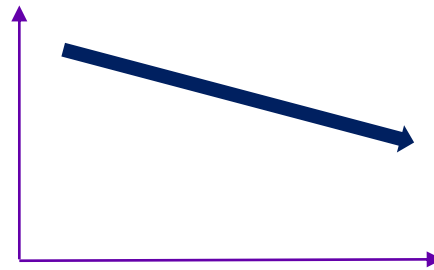


# New devices drives investment in accommodation...

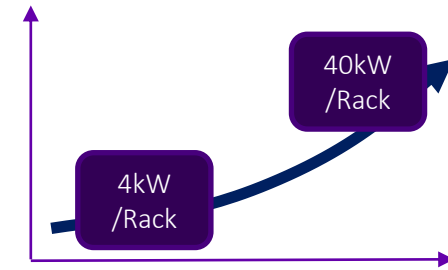
Switching capacity



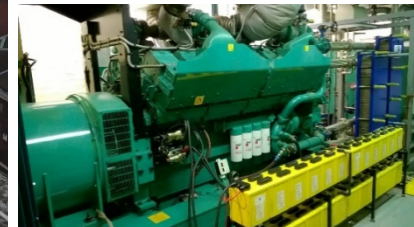
Watt/Gbps



kW/Rack, kW/Node



**Meeting capacity growth is driving investment in cooling and power – as vendors keep pace with switching capacity but are not able to reduce Watt/Gbps as rapidly**



This is driving investment in new air conditioning being deployed at our key sites, back up generators at some nodes

# 5G and demand?

EE hits 2.8Gbps download speeds in UK-first 5G trial

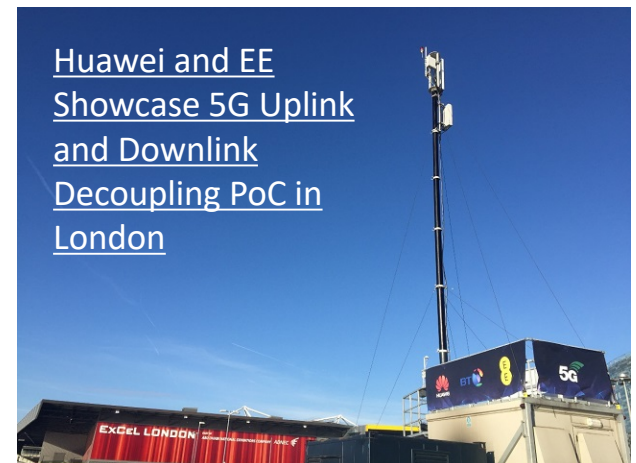
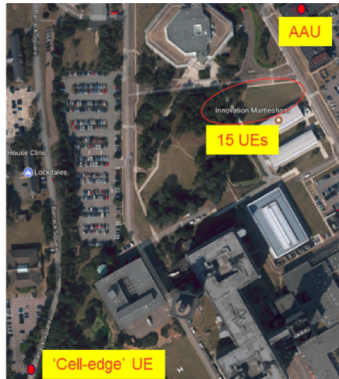


University, BT and Nokia to conduct joint research into 5G mobile networks in Bristol

<http://www.bristol.ac.uk/news/2017/november/5g-mobile-networks.html>

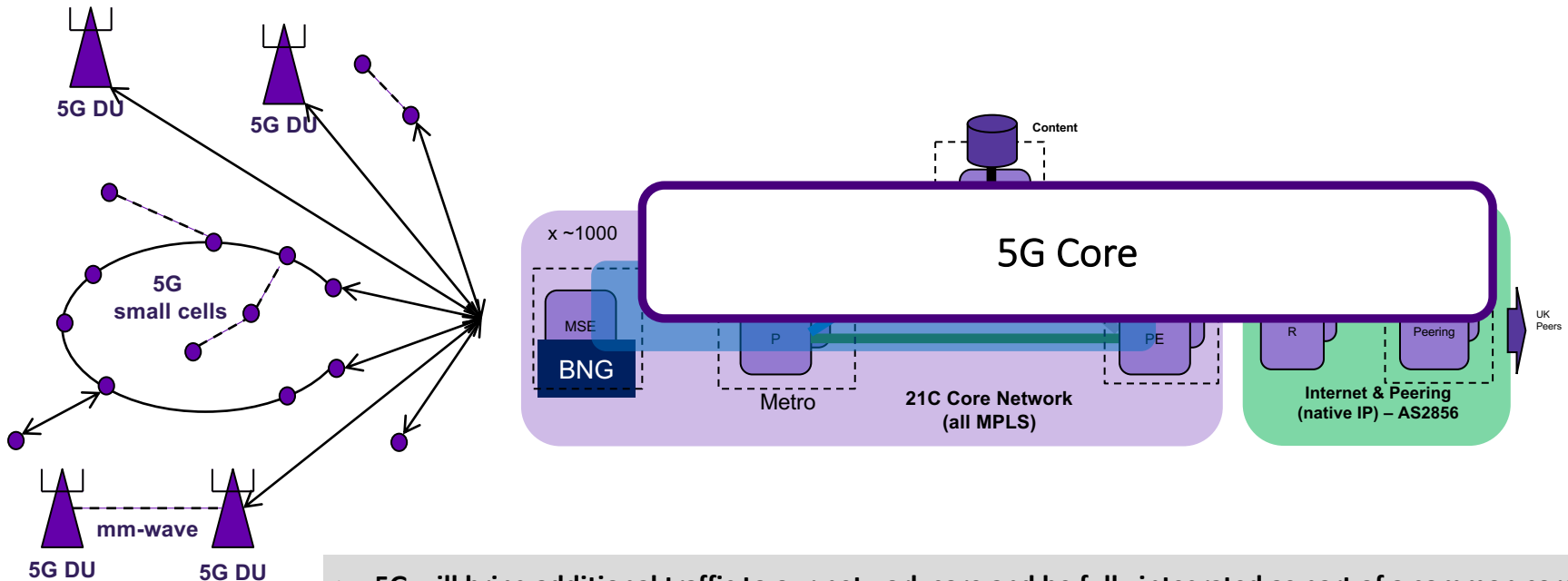
<http://newsroom.ee.co.uk/ee-showcases-end-to-end-5g-network-architecture-with-28gbps-speeds/>

## Massive MIMO testing @Adastral Park



Huawei and EE Showcase 5G Uplink and Downlink Decoupling PoC in London

# Converged Core network

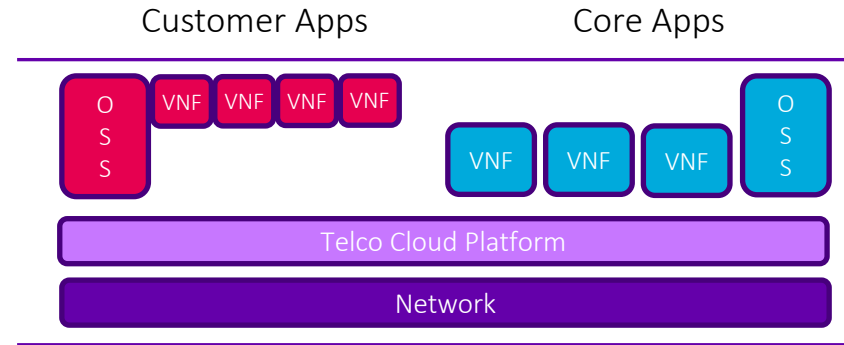
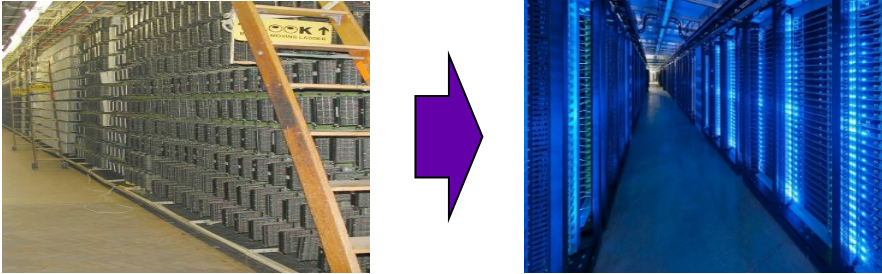


- 5G will bring additional traffic to our network core and be fully integrated as part of a common core platform
- 5G will evolve to be cloud native – we are enhancing our core infrastructure to support network cloud
- 5G services will demand innovation around network slicing, cell site distribution, edge compute and latency reduction
- Combined Network + Network Cloud will be highly automated for fulfilment (orchestration) and assurance (telemetry), to achieve agility and simplicity

# Network Cloud

We are deploying a strategic infrastructure for hosting NFV and cloud based network apps in our exchanges

Our exchanges will be transformed to programmable network nodes

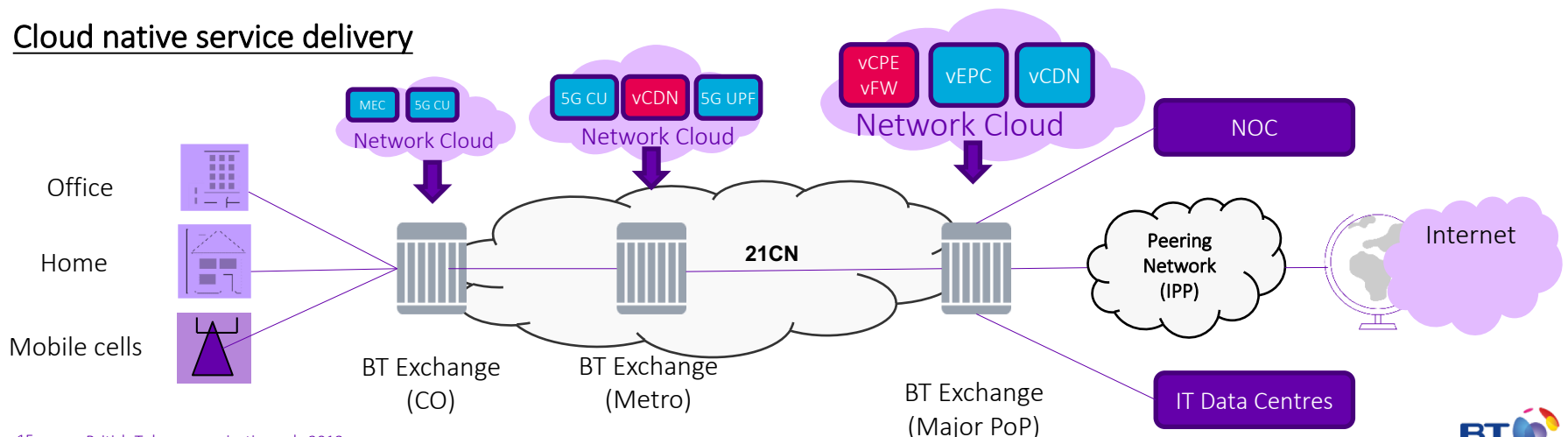


We are building computing capability into our network exchanges to enable virtualised network infrastructure (NFV).

This will support two application types:

- **Core network functions** - a significant portion of the 5G core network is expected to be supported in this manner and will drive rollout of computing equipment into the top 10-100 exchange locations
- **Customer network applications** – virtualised network functions hosted on behalf of individual external customers e.g. vFW and vCPEs.

## Cloud native service delivery



# Network Cloud

Orchestrated, high-performance forwarding for Network Functions

OSS Plane  
(Fulfilment &  
Assurance)

## Network Cloud

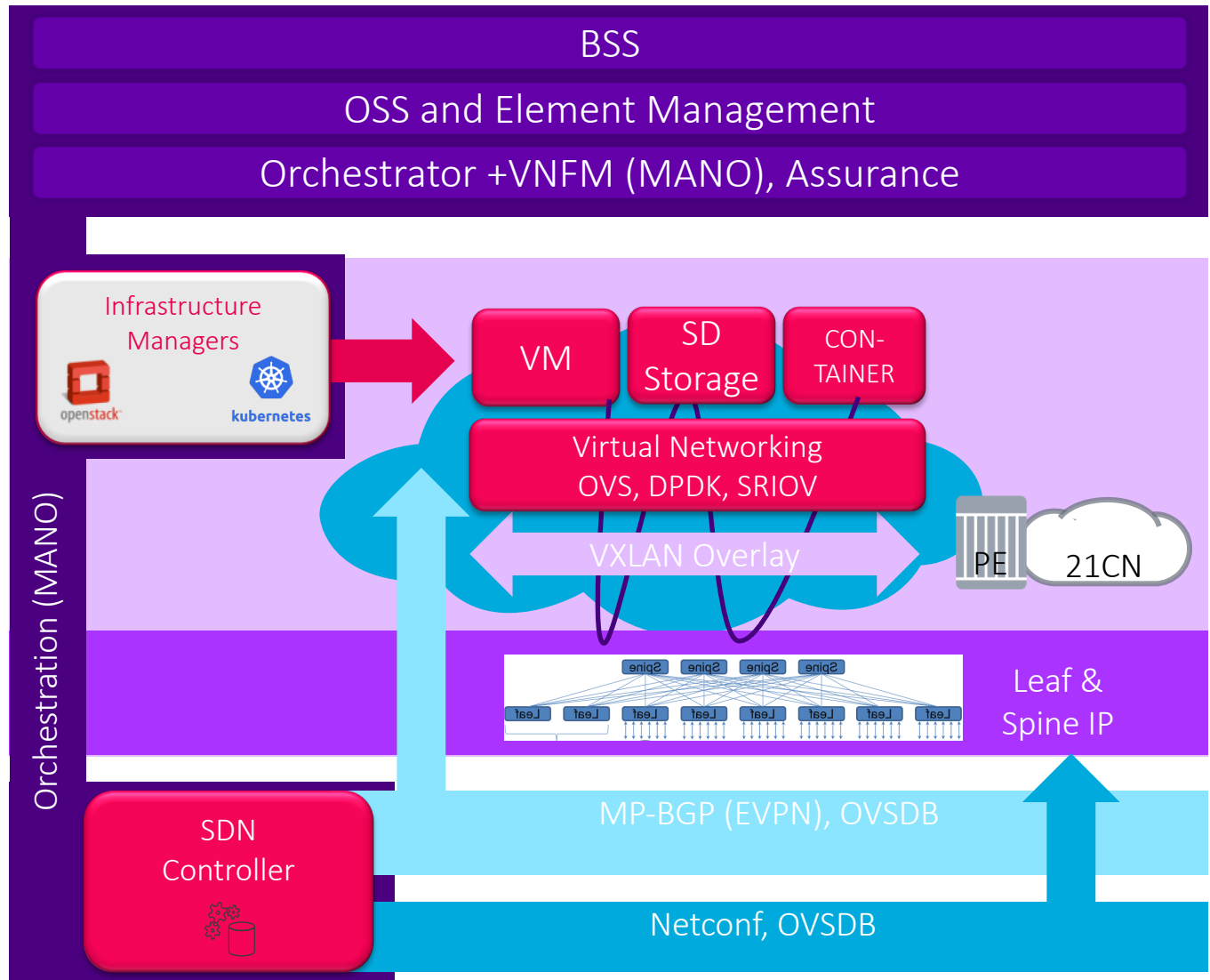
Compute, Storage  
Network:

Overlay  
Forwarding

Underlay  
Forwarding

Control Plane

Config Plane





# Network Cloud

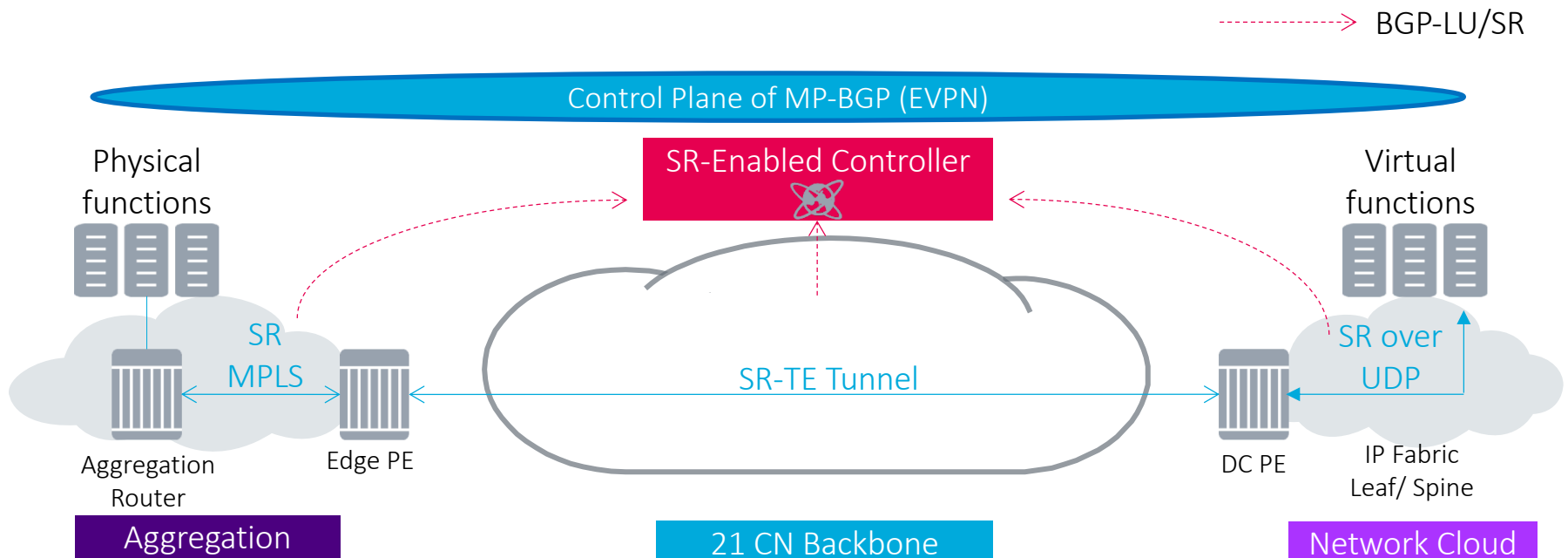
Evolving to support E2E traffic engineering across Network Cloud and 21CN

## Introducing MPLS SR:

- Unified traffic engineering with high scale and low complexity
- With SR, Fast Re-Route (FRR) “for free”
- On demand, in addition to e.g. LDP
- Implement in regions or overlay islands

## Evolution with MPLS-SR over UDP:

- Provides opportunity for tighter coupling between network functions and transport
- Metadata signalled beyond MPLS backbone, into cloud
- End applications signalling TE policy e.g. Cloud native 5G

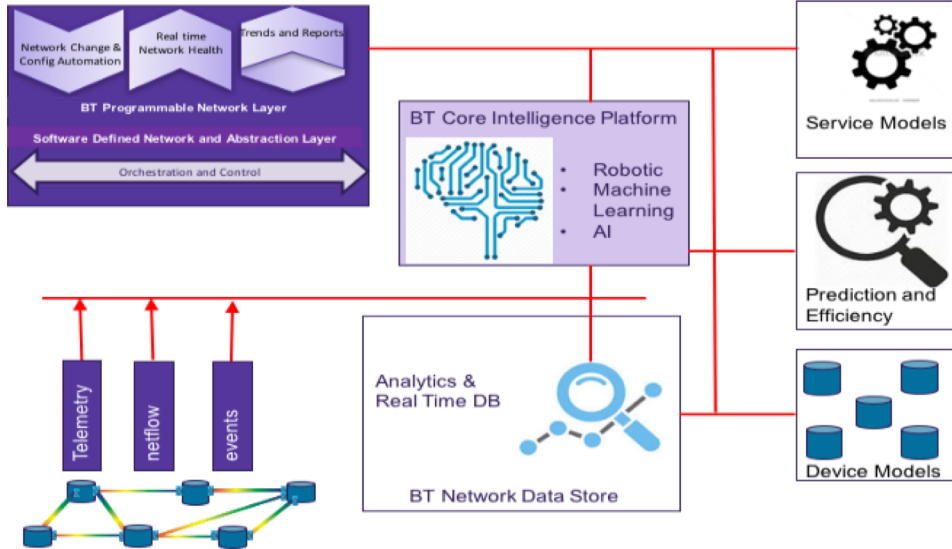


## Telemetry – things of interest may only last a few seconds



- 100m final of 2012 Olympics lasted less than 10 seconds – potentially leading to very short term surge in demand for our network
- Current knowledge of network performance gives us performance reports every few minutes – we need to know about performance every second and in real time to allow us to act and optimise service

# Telemetry is enabling new levels of network analysis and optimisation



## Elapsed Time Analytics

- Detailed trend analysis based on per second rather than per 15 minute data; rich analysis of time of day and volatility between different user profiles
- Analytics of customer experience taking account of new metrics such as latency in each router hop

## Real Time Optimisation

- Warnings of demand surges in real time
- Ability to steer traffic onto different paths under localised congestion
- Ability to move workloads between locations based on network demand – for example serve video from a different cache

Enabling Technology	Device Modelling Languages	YANG
	Common protocols	Netconf / gRPC
	Standardised Models	OPENCONFIG
	Standard Software Frameworks	APACHE kafka A distributed streaming platform



“Diveboard” display in Aadastral operations centre



# Whitebox switching

## Whitebox technology

- We are evaluating the role of whitebox switching deploy as aggregation components in our central offices
- Whitebox leverages generic hardware appliances (“whitebox”) – Software is completely de-coupled from Hardware

## Whitebox technology

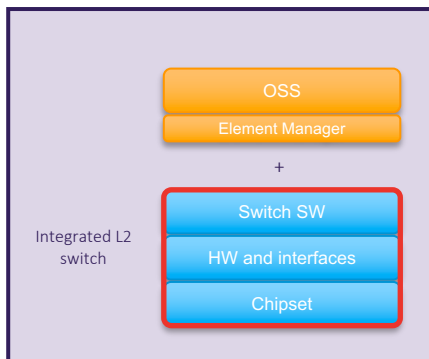
- Whitebox switch disaggregates hardware and software: the software is logically separated from the hardware (different vendors)
- Therefore the hardware becomes generic (low-priced), and all features are implemented in software (more agile and programmable)



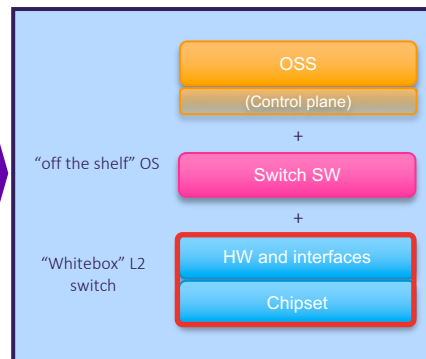
## Benefits

- Economies of a data centre → infrastructure built on generic hardware + switch SW, targeting the highest cost savings
- Agility of a Cloud Provider → platform enables the rapid creation of new programmable services

## Current integrated architecture



## Whitebox-based architecture



## Applicability

We are evaluating whitebox switching to play a role in several parts of our programmable network:

- Broadband Access aggregation / BNG
- Business line aggregation
- Network cloud infrastructure

