Beyond 5G
towards a converged network

Paul Crane
Director
Converged Network Research

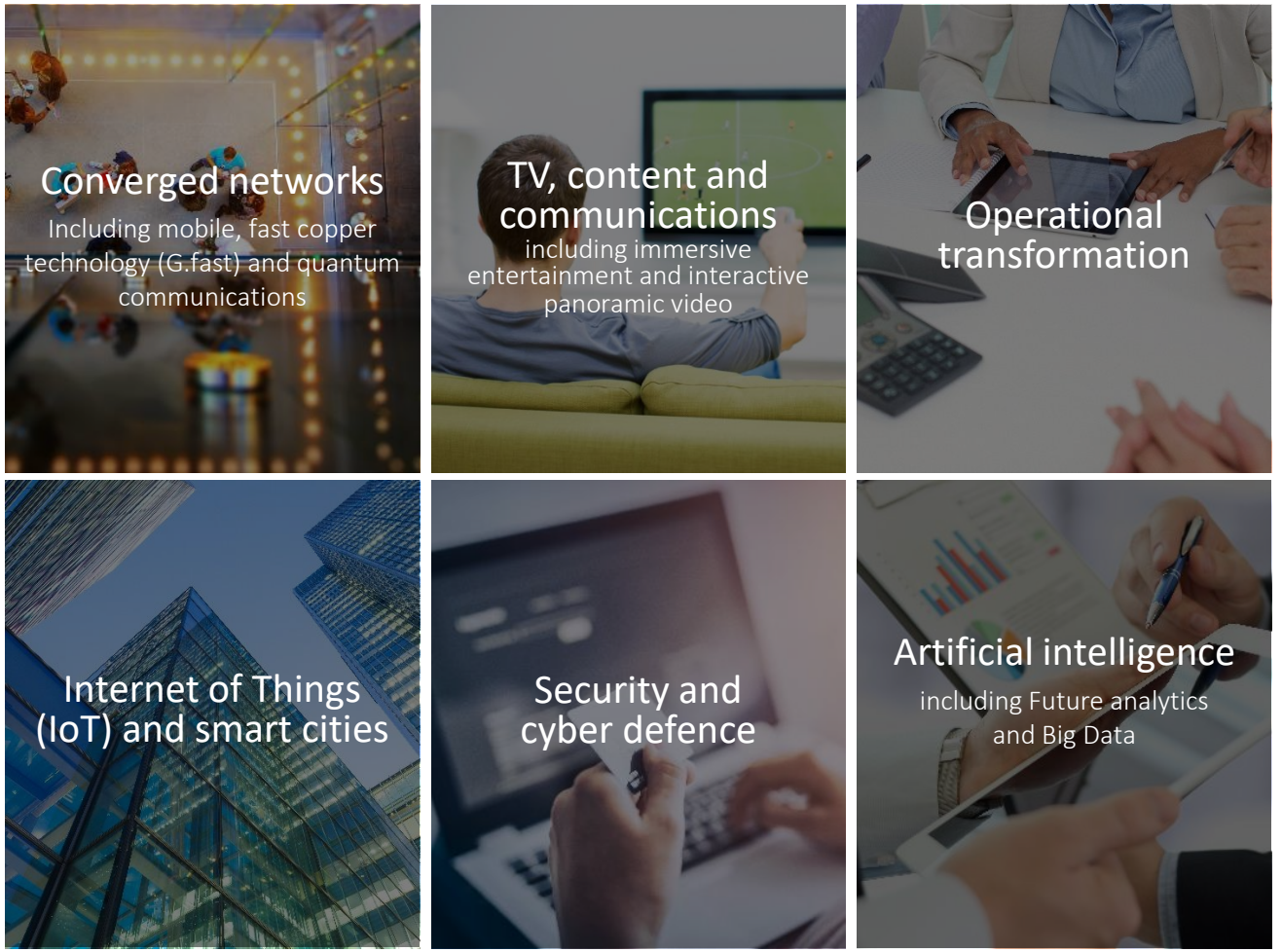
BT Applied research
18th February 2019

(1) Background

(2) Industry Landscape

(3) Network requirements

BT Applied research priorities

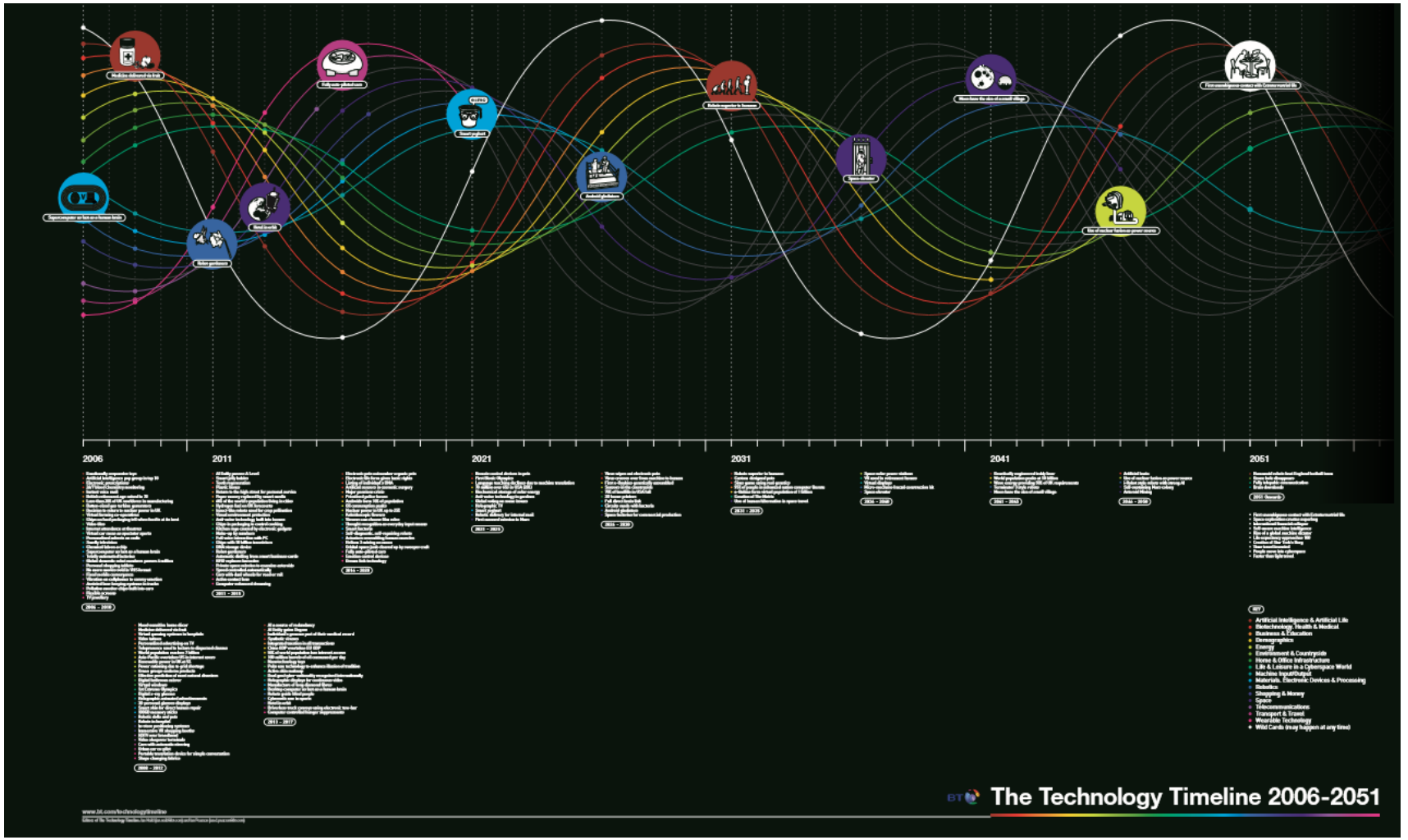


What the 2019 looked like in 2006

AI Entity gain a degree
Hotel in orbit
Helium mining on the moon
Fully auto-piloted cars

Full voice interaction with PC
Private space missions
Viewers can choose film roles
Major pensions crisis

No mention of social media



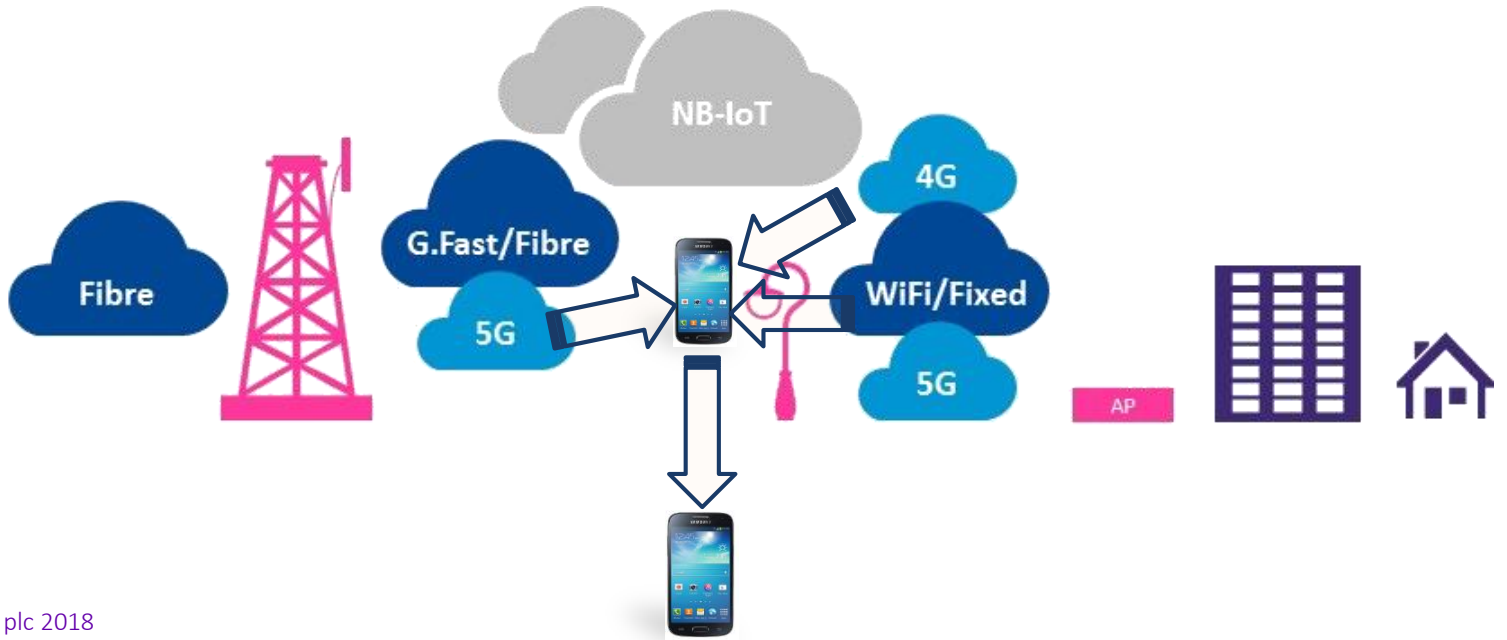
Industry Landscape

Baseline: The journey towards 5G

2018

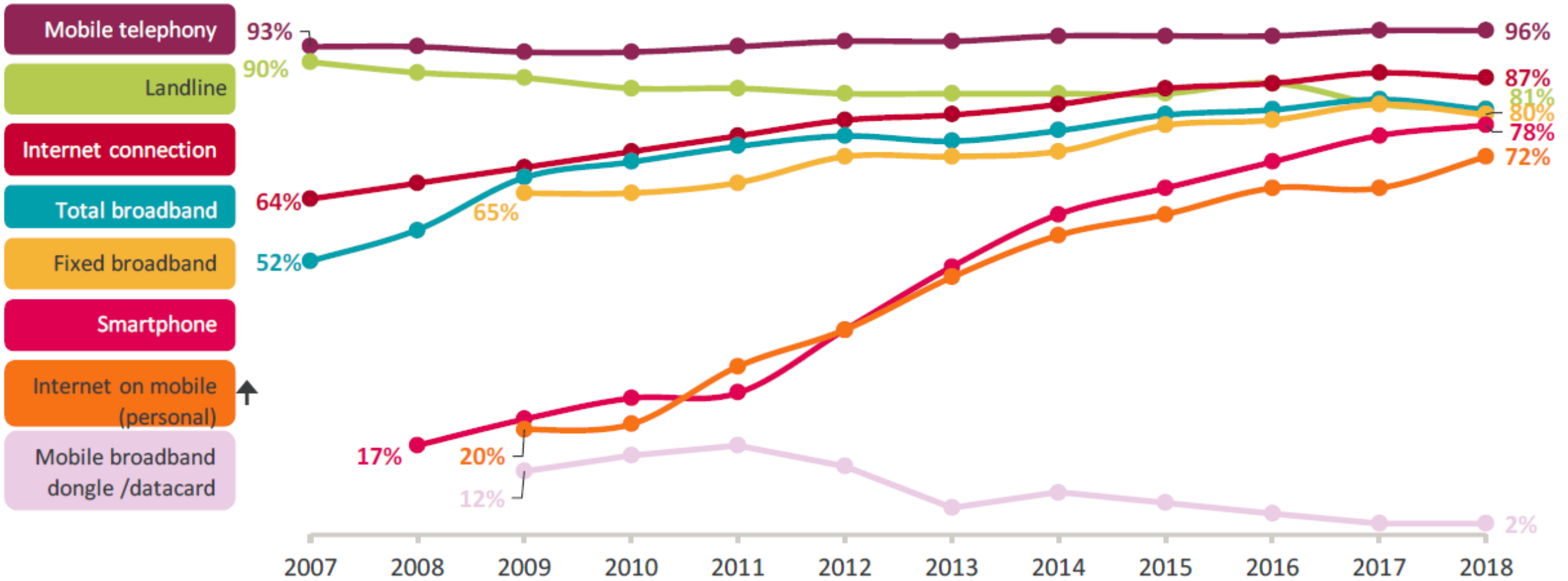
Increase mobile 'Time on 4G' to 99%	Switch on the first 5G network in the UK	Create a seamless experience for public WiFi	Build new core – one, smart, digital network
Extend IMS capabilities to all our BT & EE customers	Launch a converged hardware portfolio	Introduce IP Voice for our customers	Move from 3G to 5G

2022



Industry Economics: A look back at the communications market

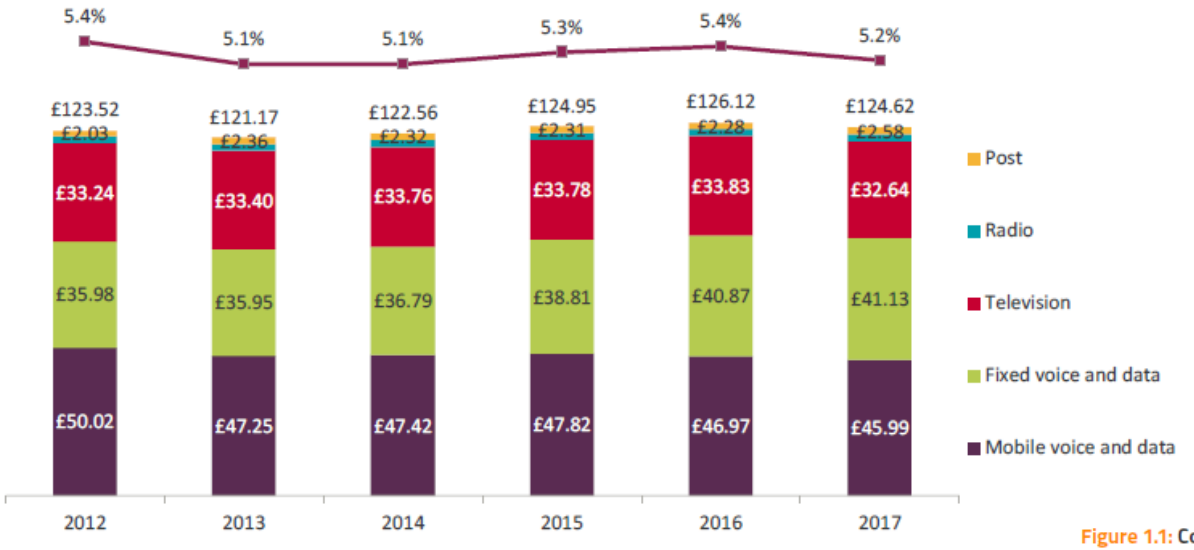
Figure 1.3: Take-up of communications services



Source: Ofcom Technology Tracker. Data from Quarter 1 of each year 2007-2014, then Half 1 2015-2018.

Industry Economics: Very competitive market

Figure 1.2: Average household spend on communications services

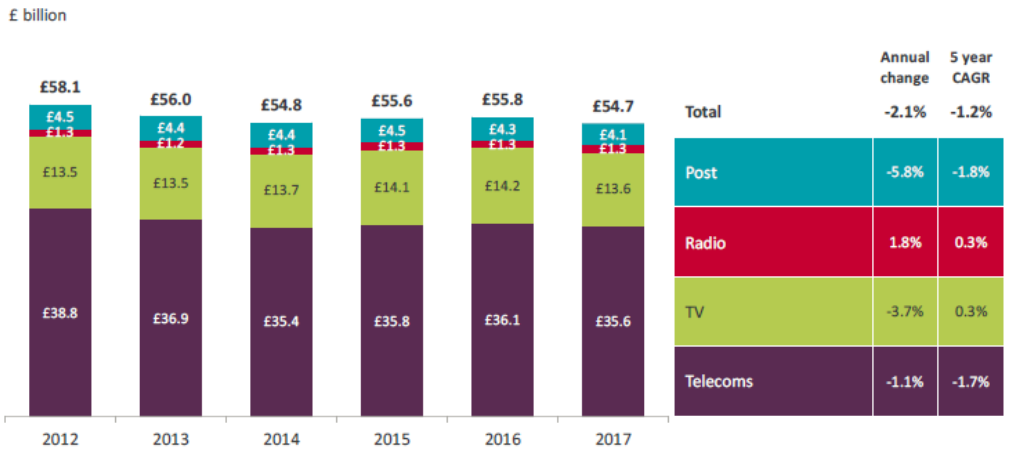


Source: Ofcom / operators / ONS

In the UK market, average monthly spend on communications services fell 1.2% in 2016/17

Total UK communications revenue last year declined to £54.7bn, the lowest level in the last five years

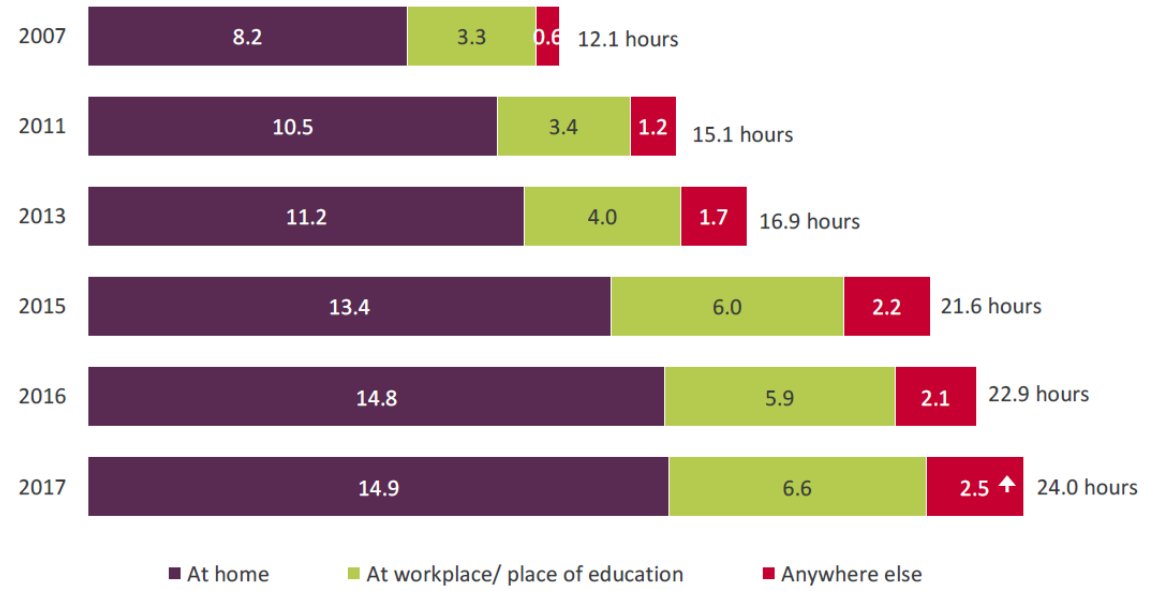
Figure 1.1: Communications industry revenue: telecoms, TV, radio and post (£bn)



Source: Ofcom/ operators.

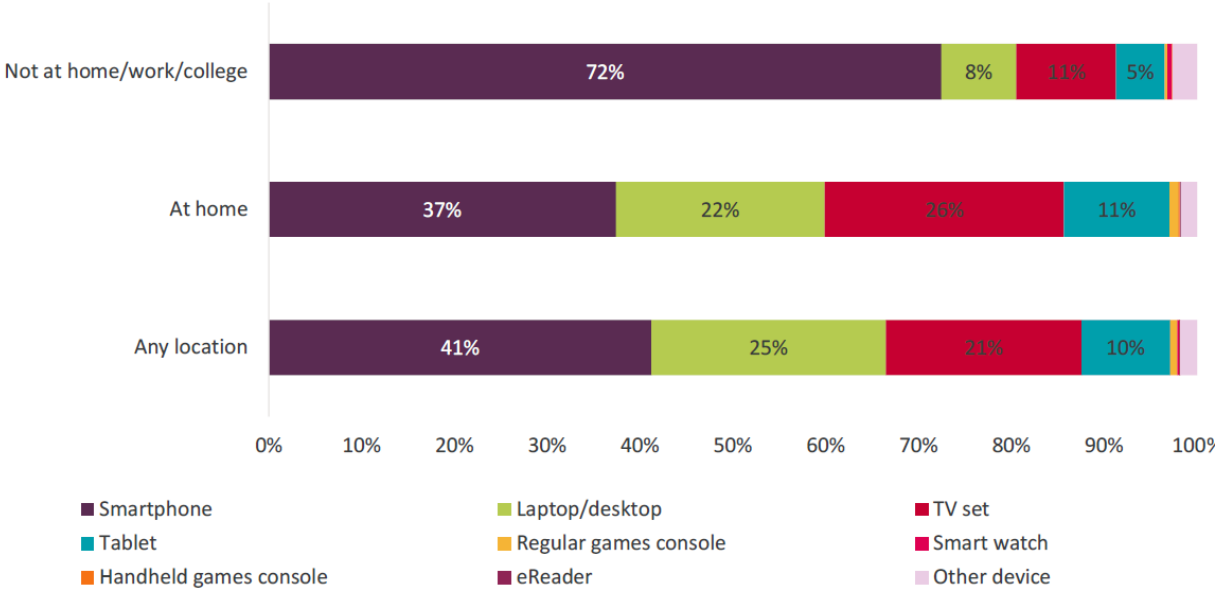
Industry Economics: essential for todays society

Figure 1.6: Claimed time spent going online each week, by location



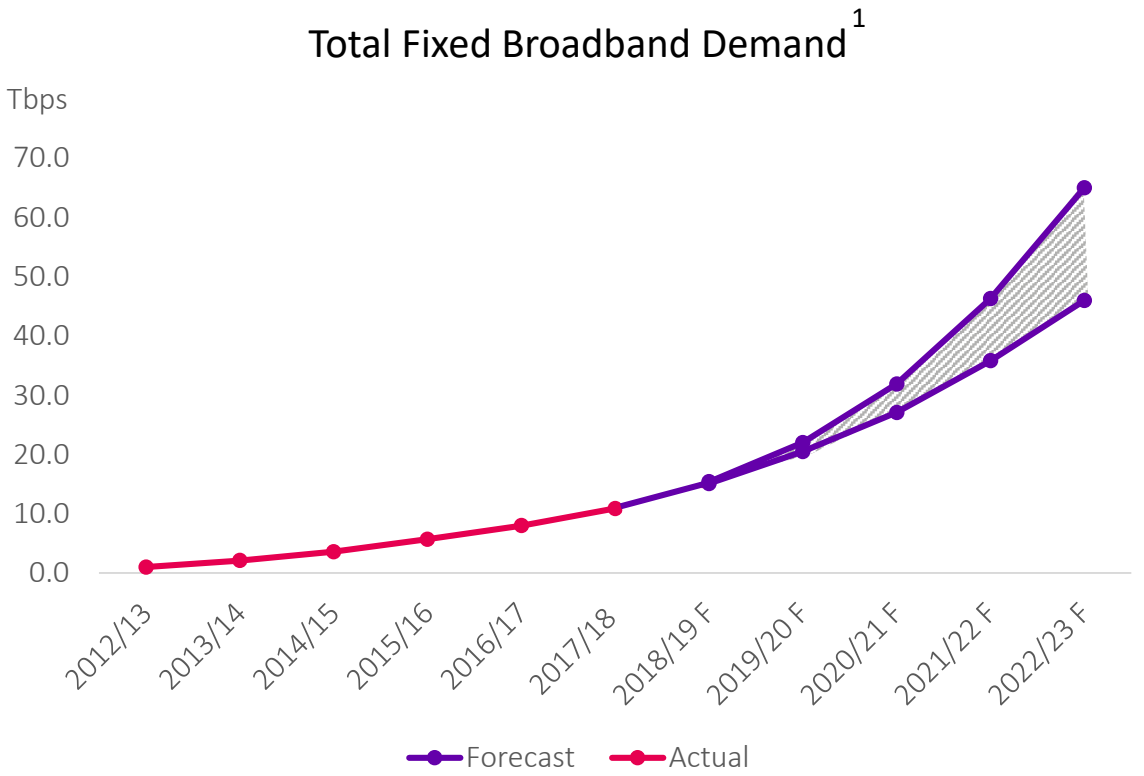
Source: Ofcom Adult Media Literacy Tracker 2017

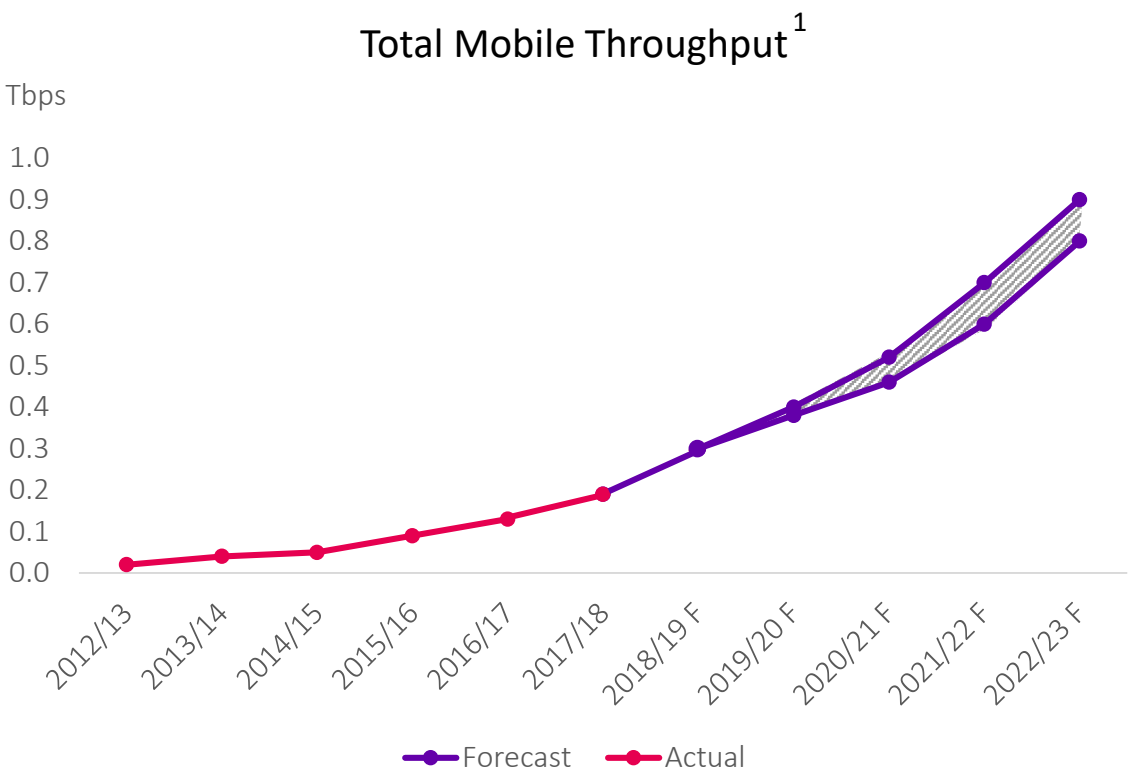
Figure 1.7: Proportion of time spent online, by device and location



Source: TouchPoints 2017

Industry Economics: Exponential growth in data consumption and network capacity requirements





- Government and Ofcom promoting FTTP infrastructure competition
- Multiple ultrafast projects announced across the market

- Mobile data traffic growth continues
- Heavy investments in mobile infrastructure are needed in the mid-term

Source: BT

[1] actual and forecast growth on BT networks

Evolving supply chain

Virtualisation is a very radical change to the way we build networks

O-RAN ALLIANCE

NETWORKING AND ORCHESTRATION
OPNFV
pnda
Open Source Networking

CORD

docker
Docker, Containers, and the Future of Application Delivery

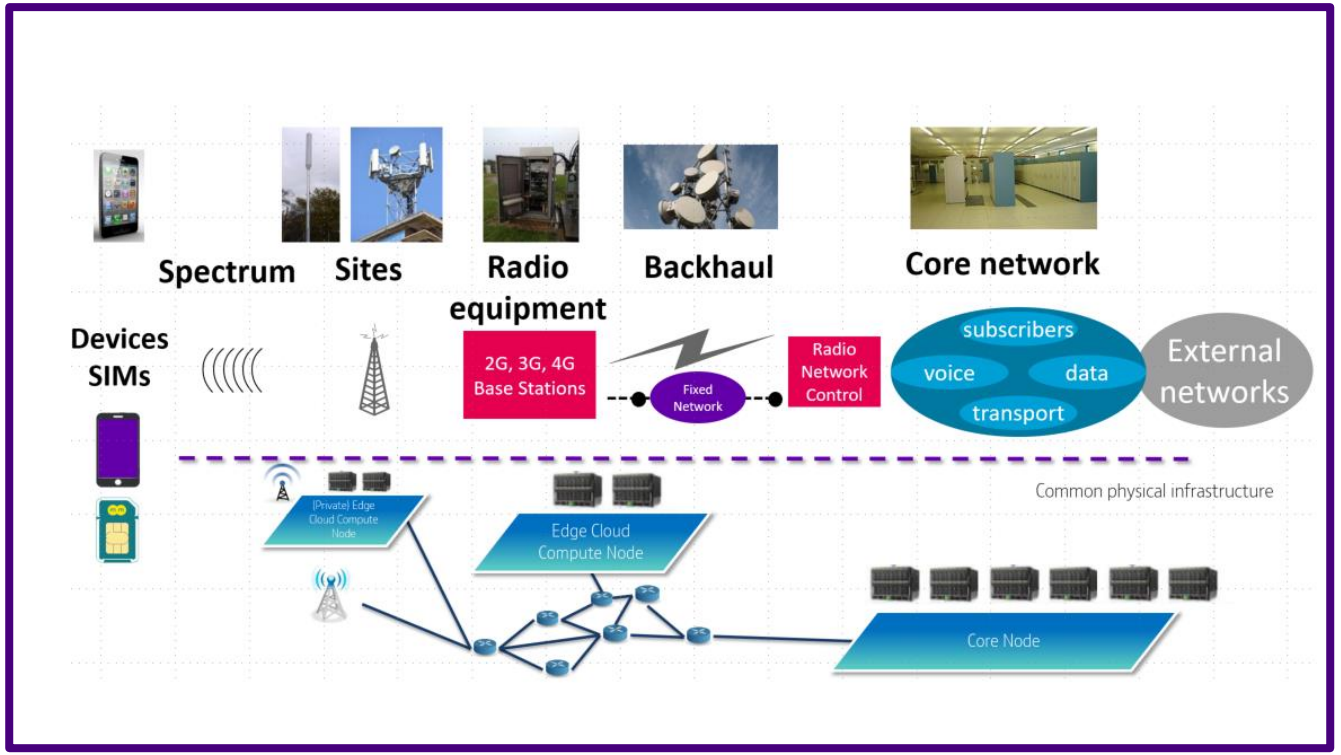
serverless

kubernetes

ARM
Expanding Ecosystem

Whitebox

P4.org
Programmable Hardware



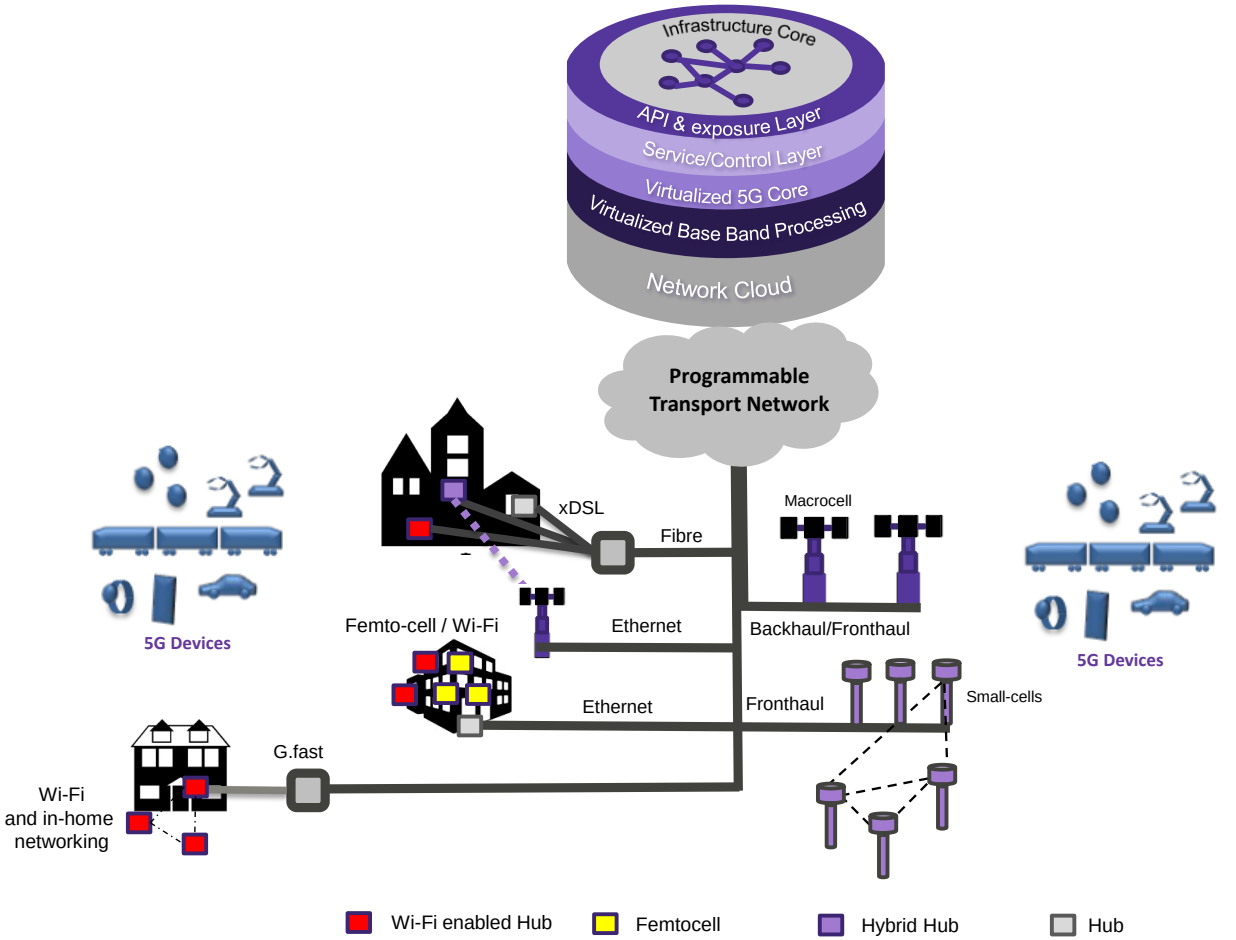
BT

Convergence

Milestone moment for 5G as Broadband Forum delivers recommendations for converged 5G core network to 3GPP

Broadband Forum-orchestrated feedback from major global operators and vendors will open doors for the leveraging of fixed and mobile networks to unlock new service capabilities

Fremont, California, February 14, 2019: A milestone moment in developing a converged 5G core network, addressing both fixed and mobile networks, has been reached after Broadband Forum delivered detailed recommendations to 3GPP.



What will customers want towards 2030?

5G requirements have so far stood the test of time, except coverage.

Expect to see mission critical becoming more prominent

Expect Ultra low latency to enable new forms of collaboration and entertainment

Towards the 'hyper connected society'?

Enhanced Mobile Broadband – UHD Video, Virtual/Assisted Reality, Interactive gaming, Tactile Internet, Fixed Wireless Access

Mission Critical Machine Type Comms – self/assisted driving, traffic safety and control, industry automation, remote surgery

Massive Machine Type Comms– IoT, Smart Home/Building/Factory/Energy, Smart Agriculture, Logistics, Asset Tracking

Assertions for 2030 based on current trajectory

Wireless connectivity will become increasingly essential

Reliability, latency & coverage will be equally important as peak rate and capacity

Security and trust under increasing threat

Economic trajectory will continue

New equipment supply chain players will emerge based on open source & emerging integration models

Sustainability, especially energy usage, will be a key purchase decision

Requirements for a future converged network

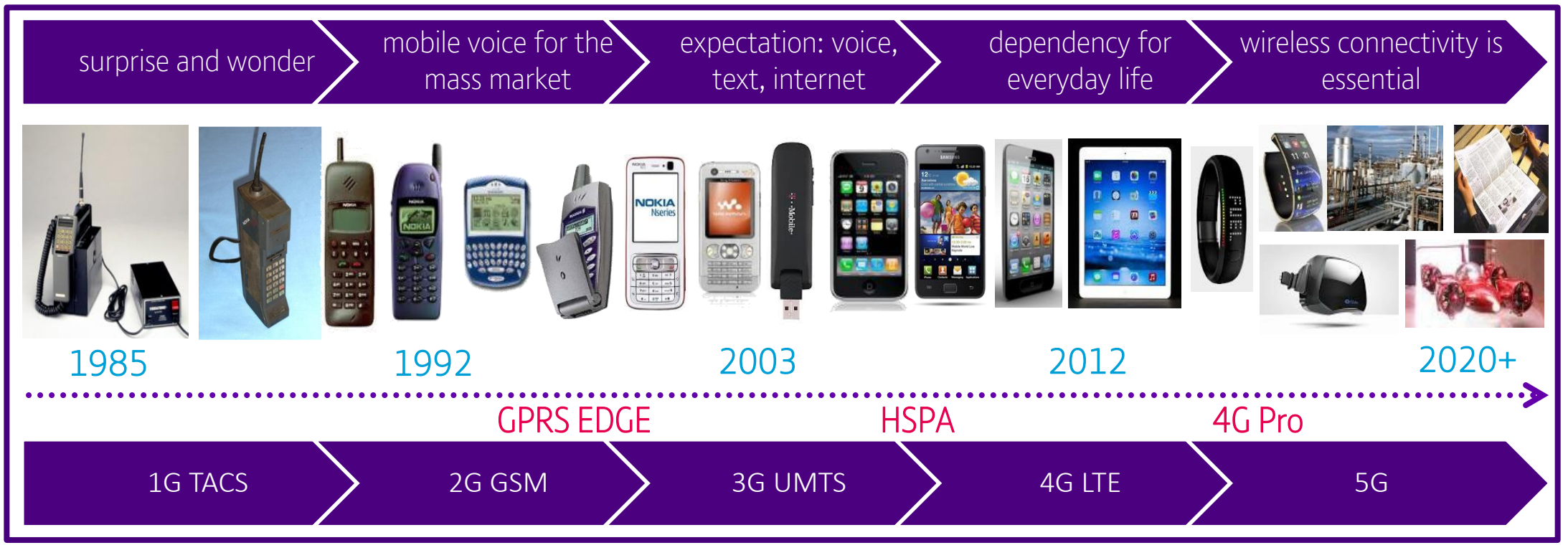
Evolution not generation
Simplification
Capacity
Coverage
Security
Energy

Evolution not generation

Standardisation has been core to the success of telecoms and especially mobile

A generational technology change may no longer be sustainable

Industry should focus on enabling an evolutionary change



Wi-Fi Evolution with backwards compatibility

Wi-Fi avoids spectrum re-farming by ensuring that all generations of Wi-Fi technology can co-exist with each other in the same spectrum.

This means that as new Wi-Fi technologies are introduced, the proportion of traffic of the legacy generation will gradually decline as the prevalence of new devices increases.

In the transition period, however, any client of any generation can still communicate with any access point of any generation.

There is no switch-over day, nor any requirement to reserve greenfield spectrum for the new technology.

Requiring that all new devices can send and receive transmissions from all previous generations.

Standard	Channel	Modulation	Channel BW (MHz)	MIMO
802.11b	2.4GHz only	DSSS	22	No
802.11g	2.4GHz only	OFDM 64 QAM	20	No
802.11n (Wi-Fi 4)	2.4GHz and 5GHz	OFDM 64 QAM	20, 40	4 SU
802.11ac (Wi-Fi 5)	5GHz only	OFDM 256 QAM	20, 40, 80, 160	8 MU
802.11ax (Wi-Fi 6)	2.4GHz and 5GHz	OFDMA 1024 QAM	20, 40, 80, 160	8 MU

BT

Evolution will not be challenge free

Wi-Fi Backwards Compatibility – Pros and Cons

Pros	Cons
• Old devices do not become obsolete – the earliest Wi-Fi device can talk to the latest. • No need to allocate greenfield spectrum to the latest deployment, nor to “refarm” old allocations.	• Greater complexity in transceiver design – new transceivers are supersets of older ones. • Can result in lower efficiency use of spectrum than would be possible with a greenfield approach. • Does not promote the replacement of out-of-date, inefficient equipment.

How do we make future mobile networks backwardly compatible?

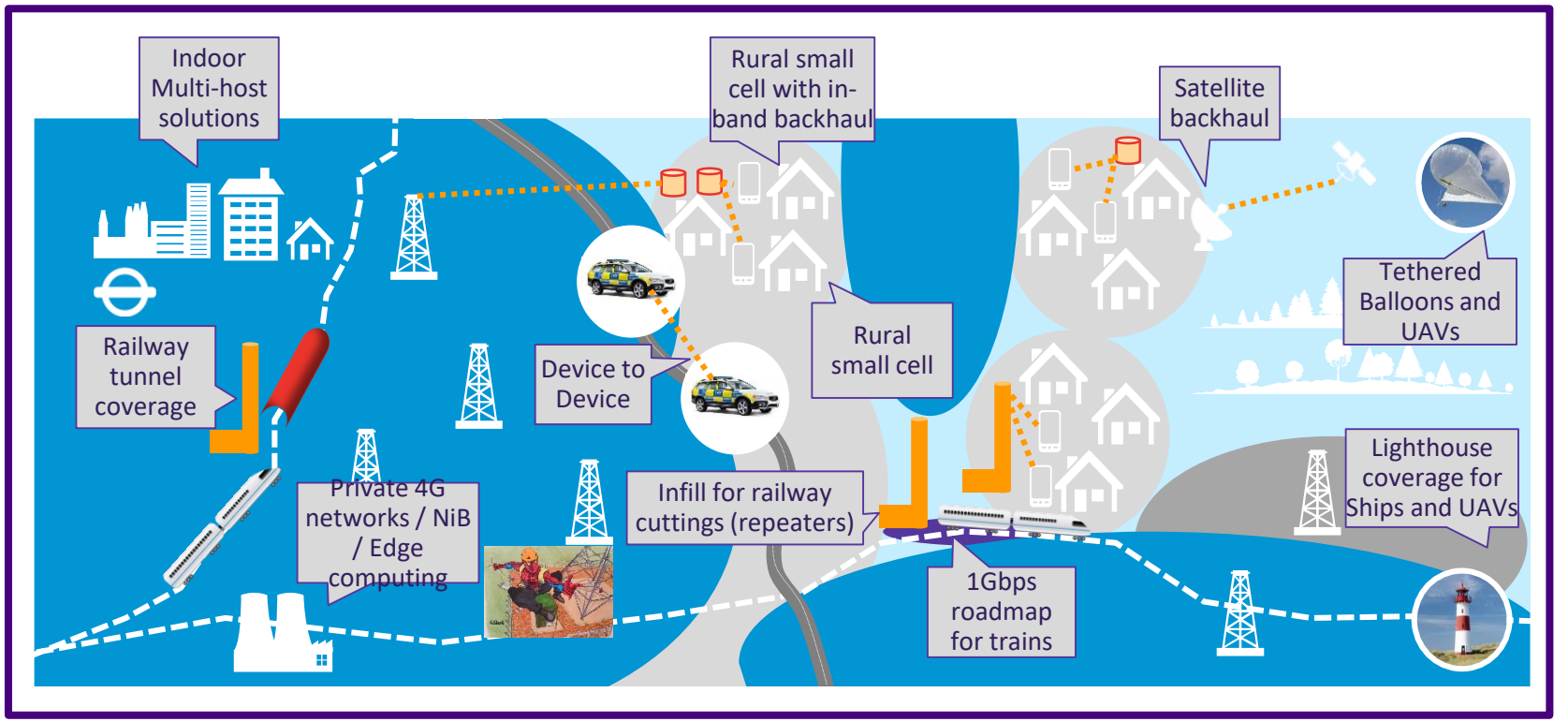
Coverage

Missing driver for 5G, we must avoid future rural / urban digital divide

Some industry activity innovating economic solutions

What else can be done?

TELECOM INFRA PROJECT



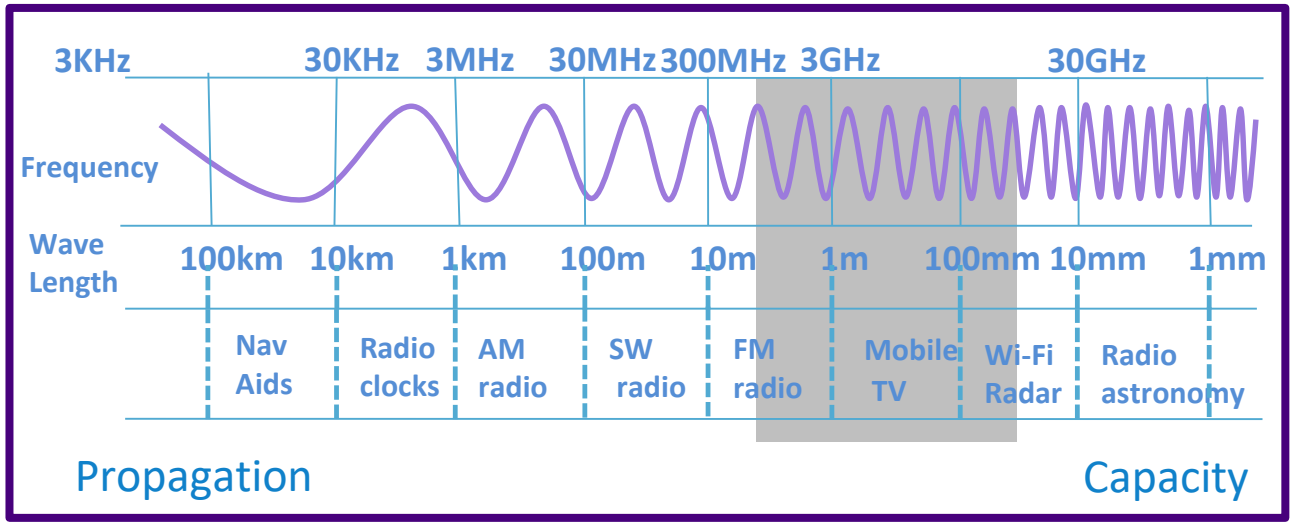
Achieving capacity growth

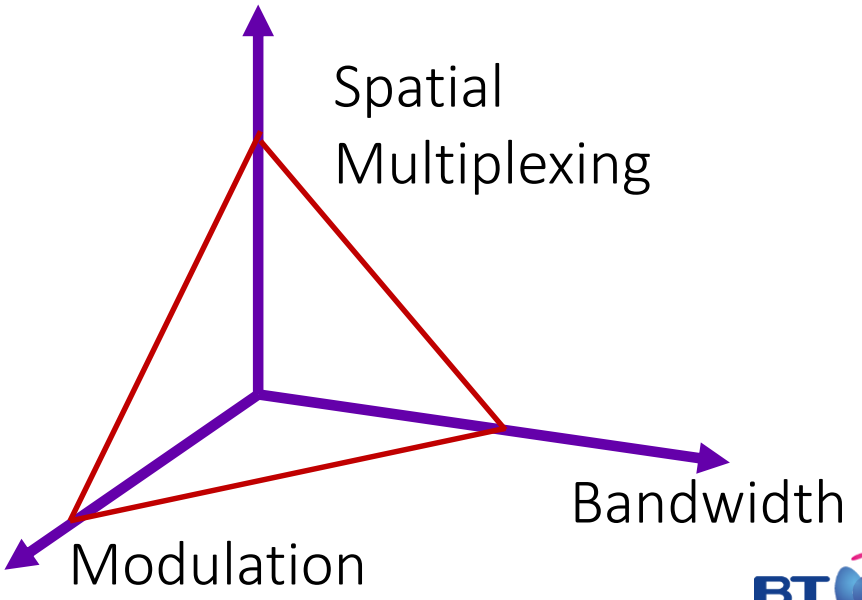
Use more spectrum – expensive or difficult to use in a mobile system

Building more sites - expensive

Increase modulation rates
– near Shannon limit for current technology?

Spatial multiplexing – M-MIMO demonstrates massive potential





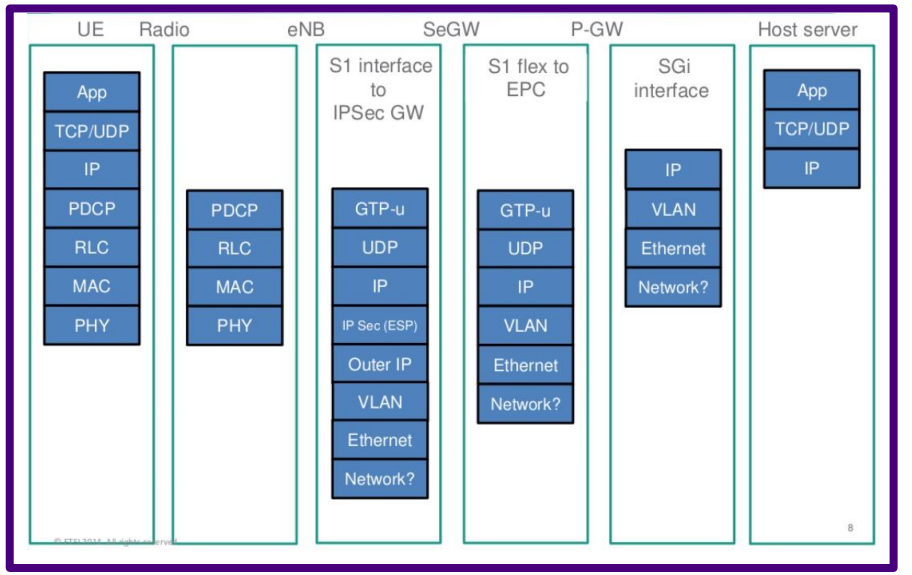
Simplification

Networks today are highly structured to make them understandable, predictable and manageable by people.

Complexity introduced to solve specific problems.

Self Organising Networks, AI/ML, web scale technologies and autonomics will remove the constraints of human understanding and structure, resulting in a network that is paradoxically simpler, more efficient & agile.

Can AI transform how we construct networks?

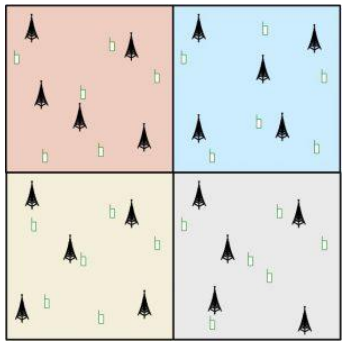


BT

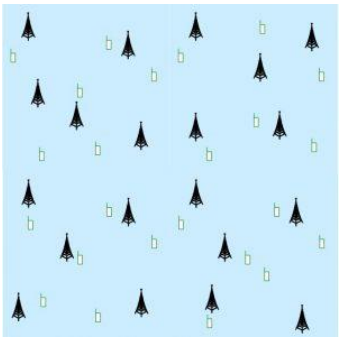
Physical simplification

Advances in electronics, signal processing and compute infrastructure gives us the opportunity to revisit some basic assumptions about how networks are built

Cell-less mobile



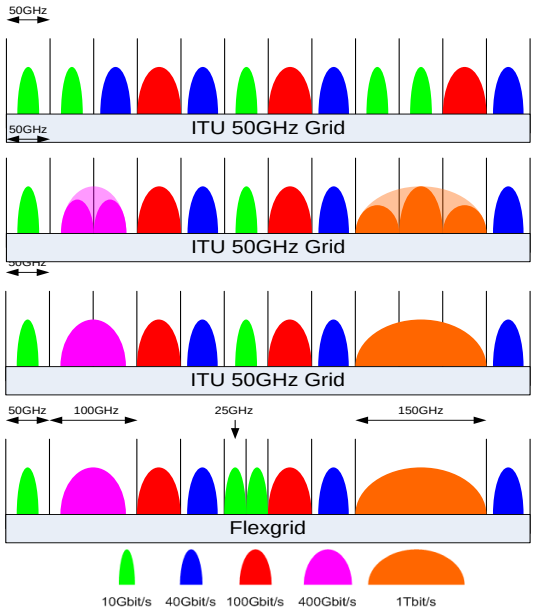
Distributed Massive MIMO



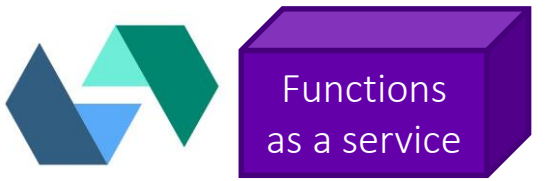
Cell-Free Massive MIMO

Source; http://massive-mimo.net/

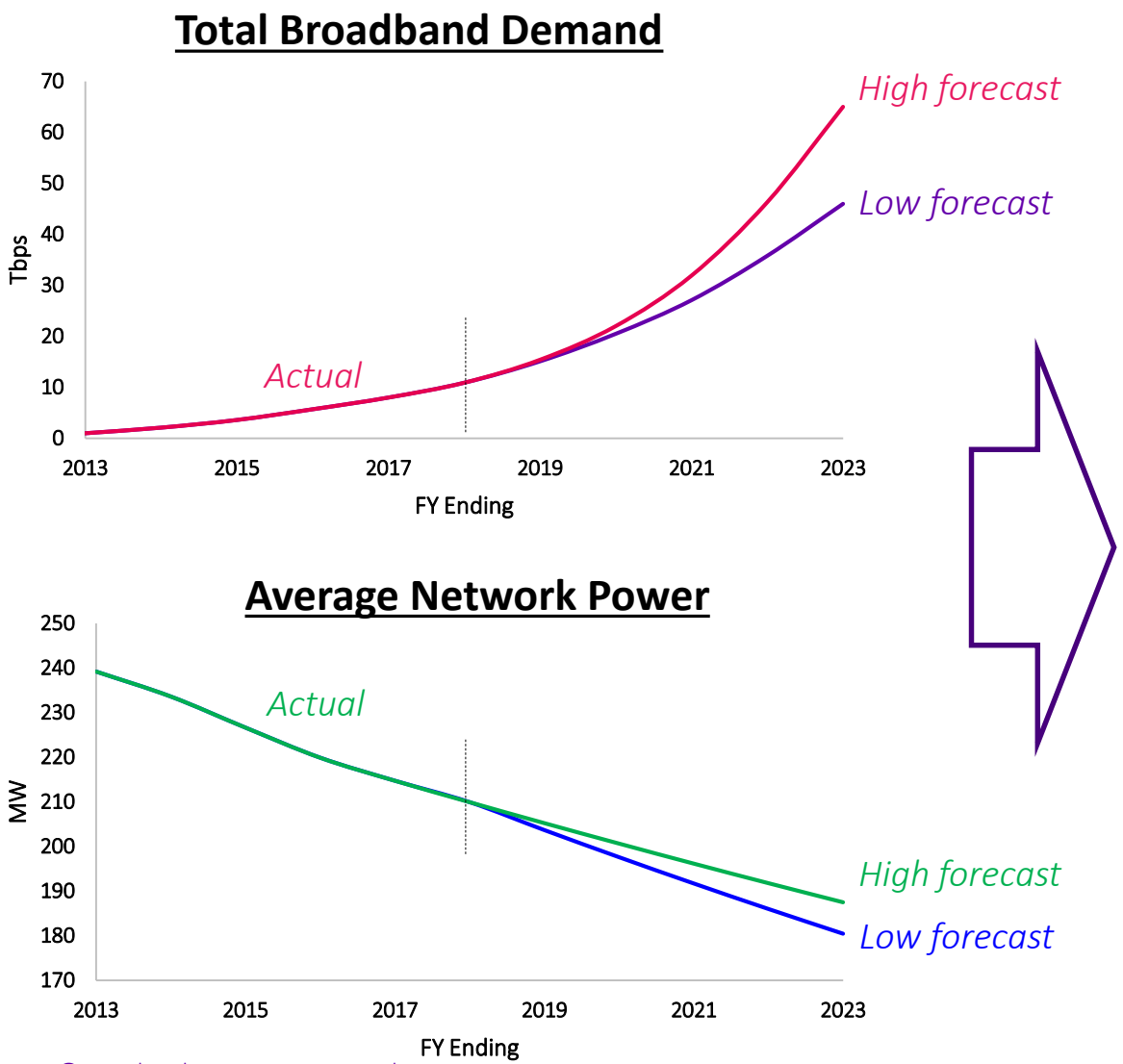
Grid-less Optical

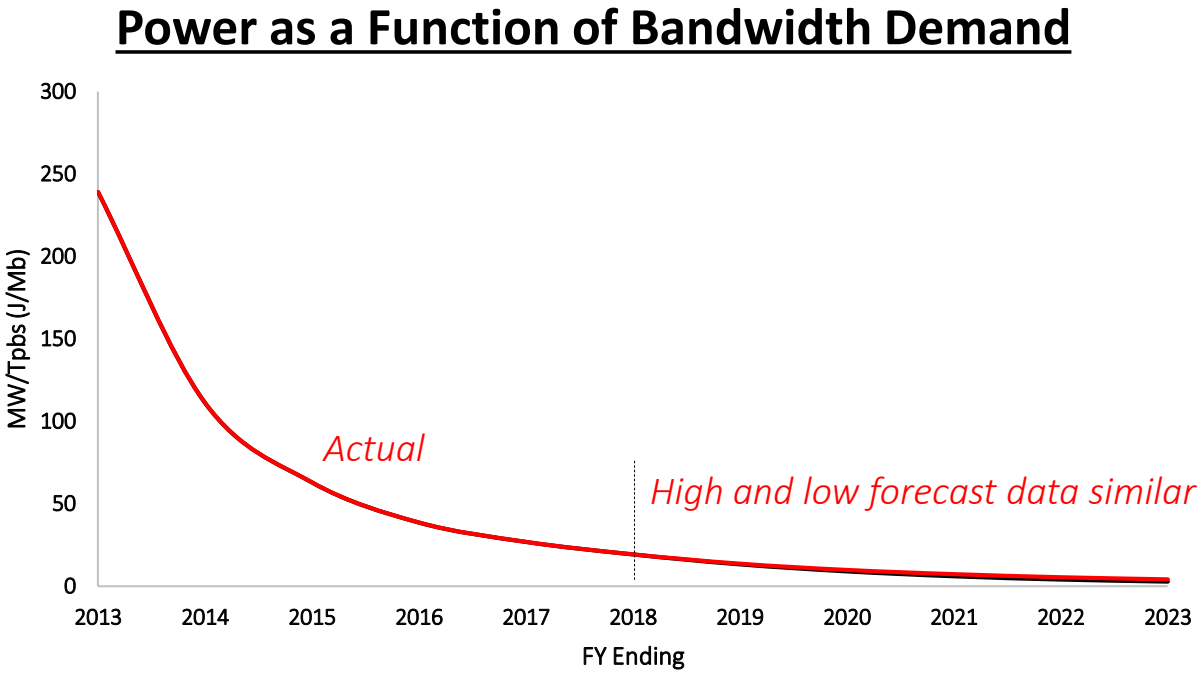


Server-less networks



Energy – Continuing major energy savings





Summary

Evolution not generation

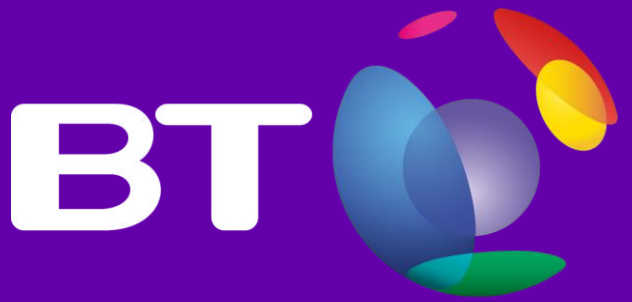
Coverage

Capacity

Simplification

Security

Energy


BT