IPv6 Network Architecture
EE-BT Status and Outlook

Nick Heatley
Network Architect
Architecture &   Strategy, TSO
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Agenda

Status

1. BT and EE IPv6 capability
2. Take-up of IPv6
3. IPv6 Drivers

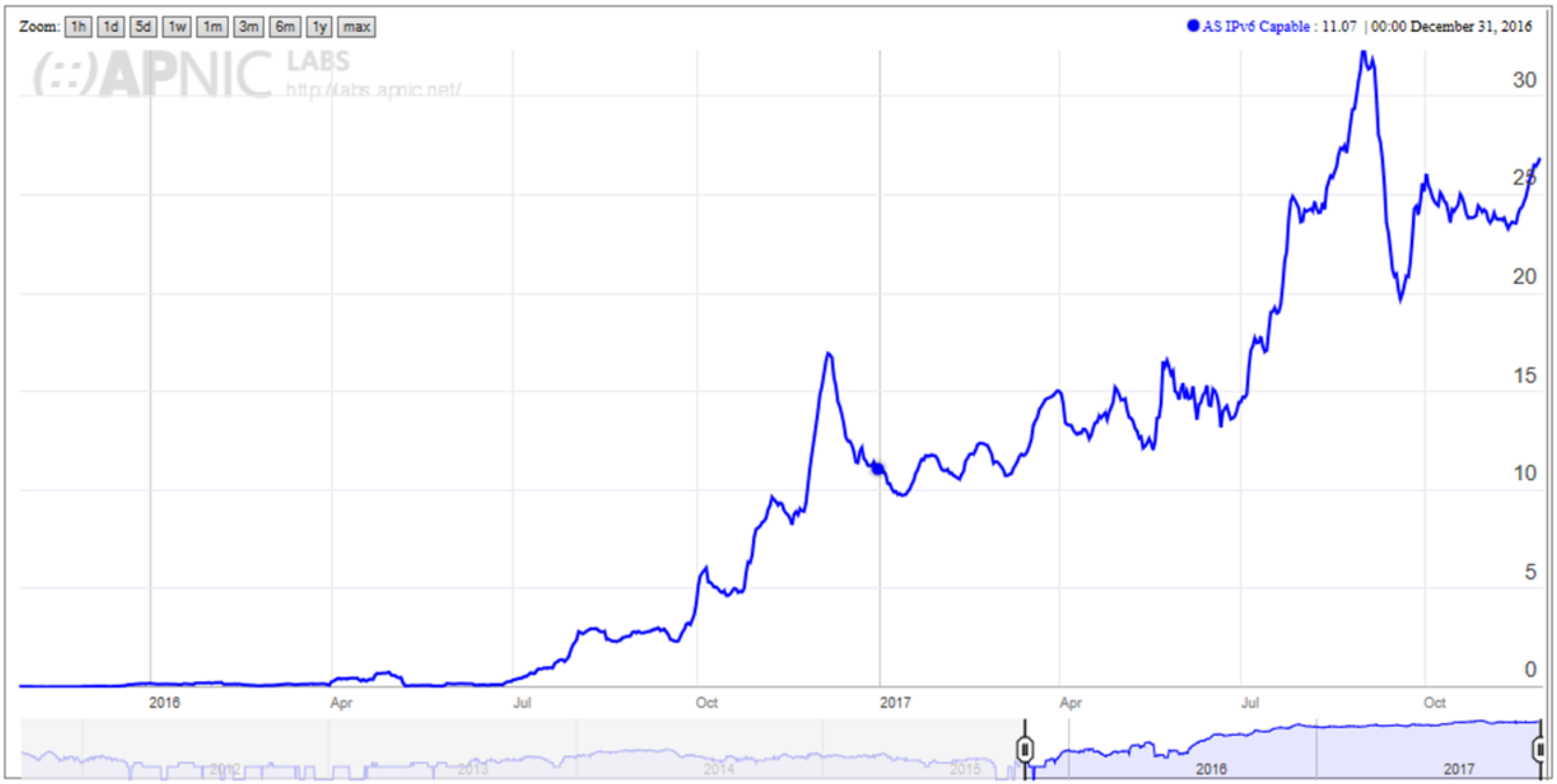
Future Network Outlook

3. New thinking, changing expectations
4. Looking forward to 5G: IPv6 and its role in IoT, Cloud, 5G
5. Further advancements with IPv6
6. EE IPv6-only architecture

Award-Winning IPv6 Capability - Ready to go!

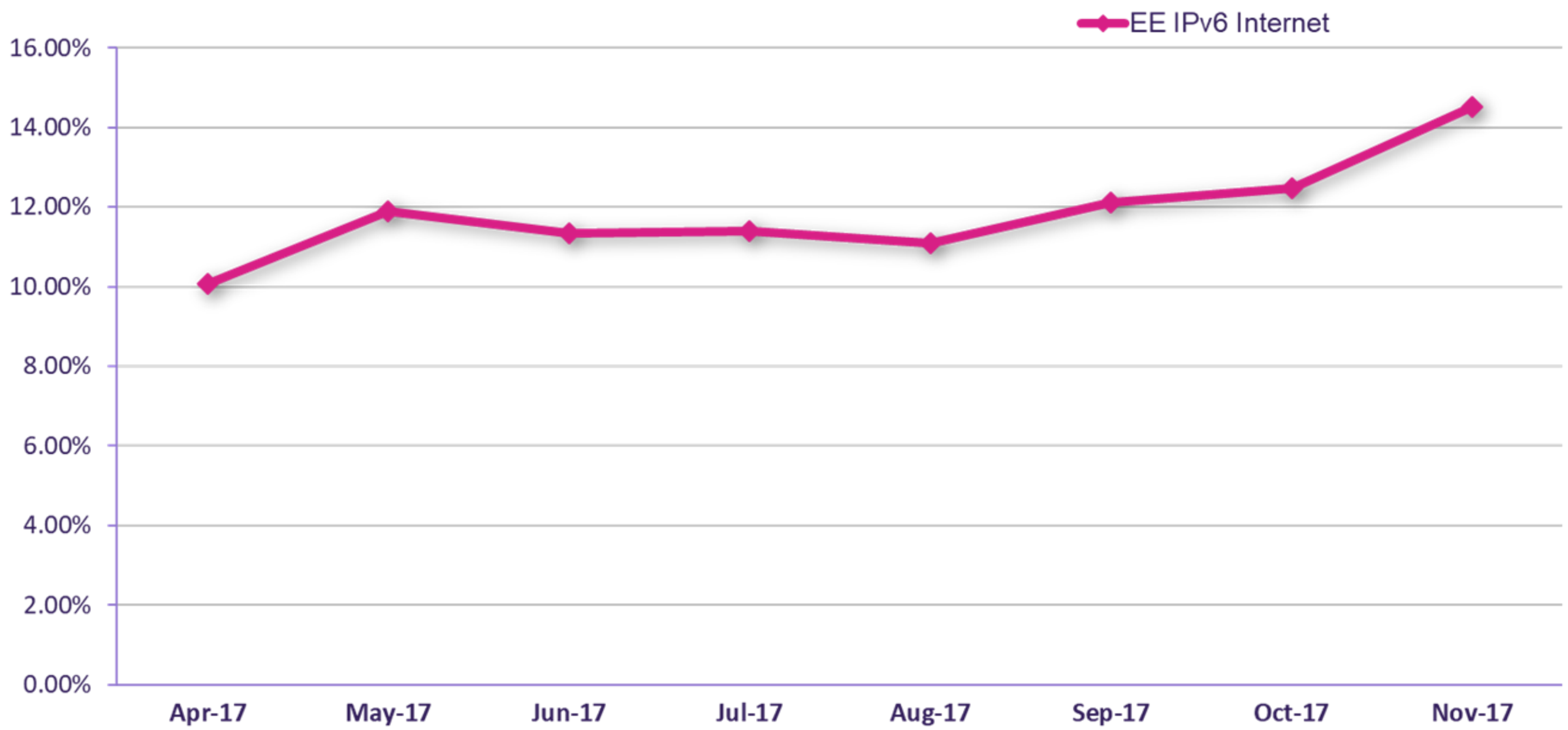
Network Product	Description	Customer Base	IPv6 Headlines
IP Connect	MPLS VPNs	Large corporate	IPv6 capable for >5 years. (Dual stack)
Internet Connect	High speed Internet access.	Large corporate/ISPs.	IPv6 capable for >5 years. (Dual stack) IPv6 address block allocated to all new customers – whether ready to use IPv6 or not.
Business Broadband	Business grade broadband Internet	Smaller businesses/ remote sites.	IPv6 capable with newer CPE. (Dual stack) Static IPv6 address option.
Consumer Broadband	Standard BT Broadband service	Over 6M consumer users	IPv6 enabled with newer CPE. (Dual stack) 25% of users (and growing) use IPv6, accessing IPv6 enabled sites like Google/YouTube/Facebook. IPv6 Forum award.
EE mobile	EE consumer mobile service	20M - 30M handsets	IPv6-only service for compatible handsets on EE PAYM. 12% of base using only an IPv6 address.

Take up of IPv6 - BT



Source: APNIC

IPv6 Internet traffic - EE Mobile



Source: EE Internal

IPv6 Drivers (2012)

- Investment in UK PLC, ISP market pressure
- Public address exhaustion
  - $10 per IP and growing
- Private address exhaustion, beyond 20M endpoints
  - In mobile, connecting 4G Voice-over-LTE / Voice-over-Wifi (IMS) and Data services (multiple IPs per handset)
- Avoidance/Removal of NAT bottlenecks
  - For fixed, trials of CG NAT not satisfactory
  - For Mobile, Facebook, Linkedin cite performance gains of IPv6, believed to be removal of NAT bottlenecks
  - Does not mean removal of security filtering
- Ease of Monitoring
  - Avoid additional Regulatory investment. Operators facing regulatory pressure for logging of data. Global IP address systems cheaper than investing in NAT + associated IP logging/correlation systems.
- IPv6-only motivation (EE Consumer)
  - Removal of the cost and operational burden of two address families in the access and core

Network Outlook

Global reach, mobility

Old thinking

PIC Sepida Ahidi

- Mission critical ≠ public networks

New thinking

PIC: CollegeVine Zen

- Mission critical-private & public networks

Identifying traffic

Old thinking

- Perimeter Security

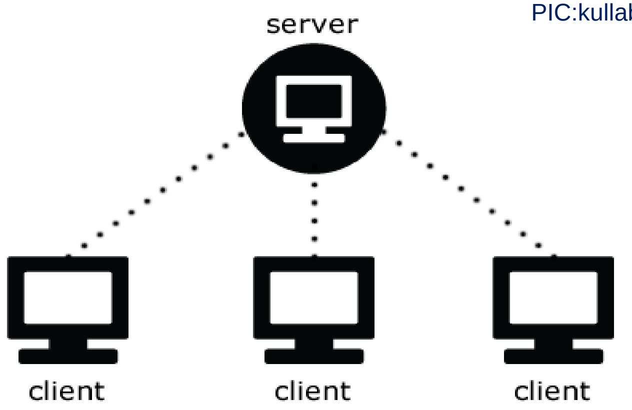
New thinking

- Pervasive security

Optimal access

Old thinking

PIC:kullabs.com



- Simple Client-Server

New thinking

PIC: EE Times

- Blurring, distributed servers, density of clients

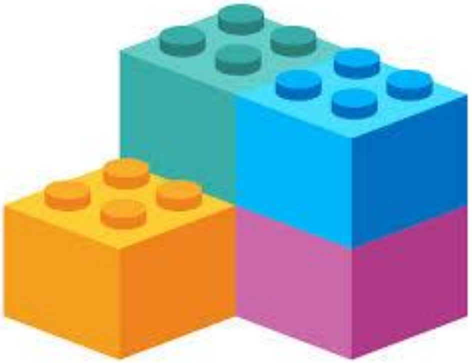
The only way is Automation

Old thinking

PIC:Windowflakes

- Every design is different

New thinking



Clipardbarn.com

- Repeat-o-matic

Role of IPv6

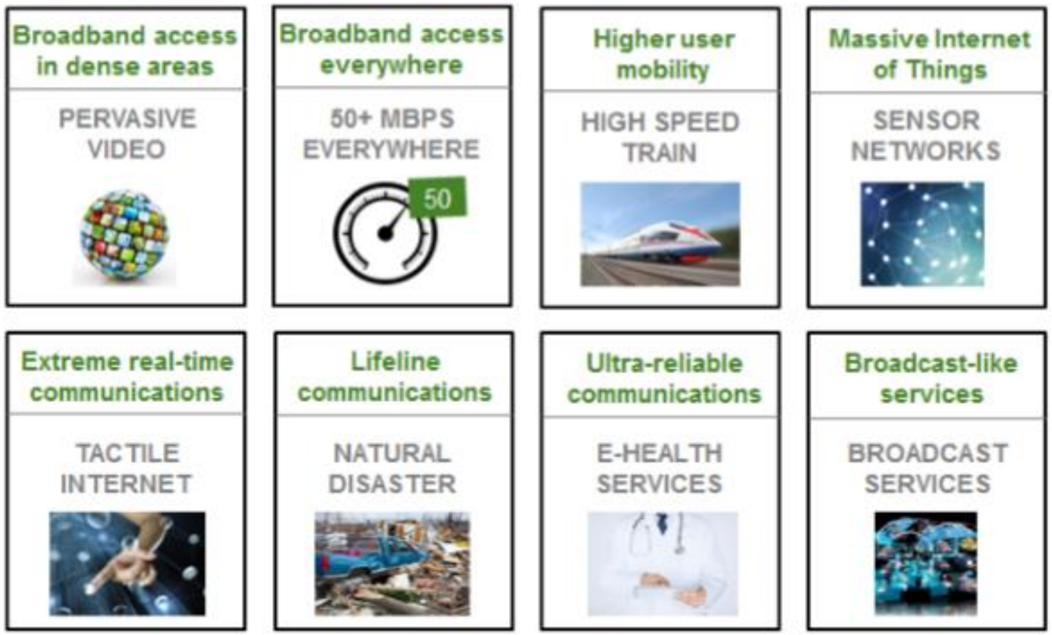
- We need an internet protocol that provides:
  - > Global reachability
  - > Mobility, with less state
  - > Ubiquity, seamless access
  - > Performance
  - > Automation-ready
- In theory no difference between IPv4 (public addressing) and IPv6….
- …until we rinse, repeat, for many cycles….
- IPv4 already beginning to go into degradation, in terms of performance and complexity:
  - > Overlapping private ranges
  - > NAT performance bottlenecks
  - > NAT workarounds (e.g. STUN)
  - > Middle box complexity
  - > Address-constrained thinking, impacting automation and resilience
- IPv6 – nothing more intrinsic than address space. Addressing to scale across future IoT, 5G, Cloud.

Looking forward to 5G

5G: Density, performance

- 5G requires a new network architecture
- Some Radio Access functionality will move towards the Core whilst the Core will move towards the Radio Access
- Small cells are an essential component of 5G
- We expect to see services deeper in the access, closer to the customer (Multi-access Edge Compute MEC)

5G Use Cases



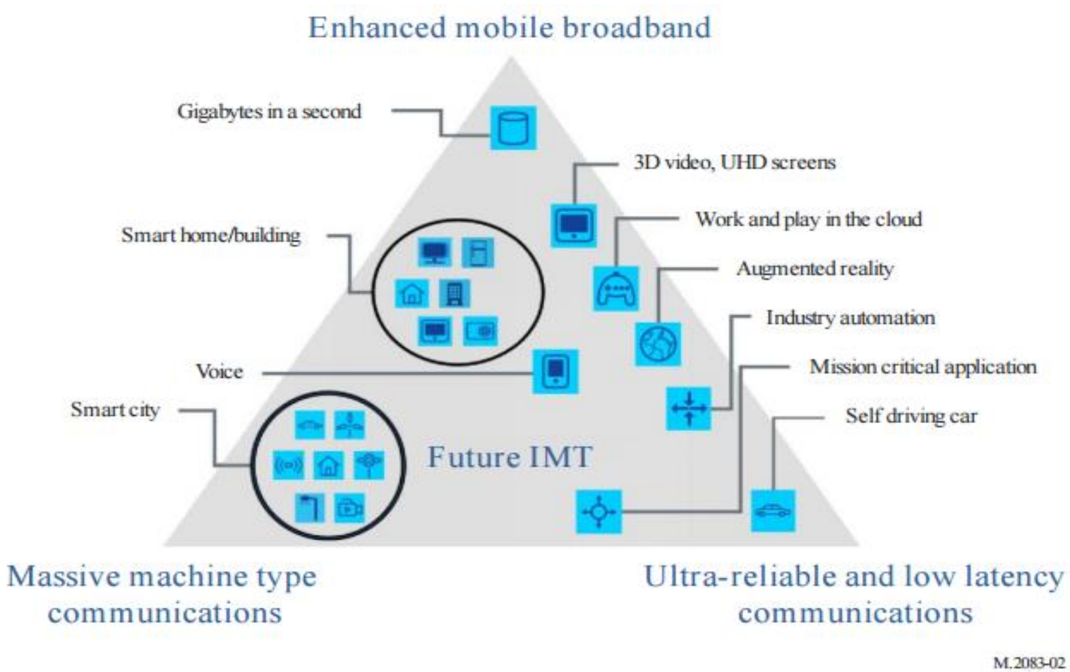
Source: https://www.ngmn.org/fileadmin/ngmn/content/downloads/Technical/2015/NGMN_5G_White_Paper_V1_0.pdf

Highlighted 5G use cases:
- **Enhanced Mobile Broadband (eMBB),**
- **Ultra-Reliable Low Latency Communications (URLLC)**
- **Massive Machine Type Communications (mMTC)**

- URLLC is an overlay and requirements will vary based on use cases: URLLC use cases, UR use cases and LL use cases…
- Initial MTC use cases will be addressed by NB-IoT (4G)

Usage scenarios of IMT for 2020 and beyond

ITU – International Telecommunication Union (org)
IMT2020 – International Mobile Telecommunications specification for “5G”



Source: https://www.itu.int/dms_pubrec/itu-r/rec/m/R-REC-M.2083-0-201509-I!!PDF-E.pdf

ITU-R IMT-2020 Requirements - radio targets

PERFORMANCE

- The minimum requirements for eMBB peak spectral efficiencies are as follows:
  - Downlink peak spectral efficiency is **30 bit/s/Hz**
  - Uplink peak spectral efficiency is **15 bit/s/Hz**
- The target values for the user experienced data rate are as follows in the Dense Urban – eMBB test environment:
  - Downlink user experienced data rate is **100Mbps**
  - Uplink user experienced data rate is **50Mbps**

SUPER LOW LATENCY

- The minimum requirements for 1-way user plane latency over the radio interface are:
  - 4 ms for eMBB
  - 1 ms for URLLC (3GPP target = 0.5ms)

(→Leaving little margin for CG-NAT or additional state in middleboxes)

DENSITY

- The minimum requirement for **mMTC** connection density is 1,000,000 devices per km^2

(→What does this mean for address density?)

IPv4-constrained-thinking (IP Layer3) is not compatible with the 5G strategic targets.
Further study on replacements to TCP (Layer4) for low latency - ETSI NGP study

Further advancements possible with IPv6

Devices & Things

- Better battery life: More efficient networking with IPv6, removal of NAT, device-to-device

V6-centric Networking

- i.e. Unconstrained by address shortage
- Hybrid access (but we need a good solution to multi-homing)
- IPv6 Prefix Delegation: Good for mesh networks / sensor networks
- New routing paradigms (IPv6 Segment Routing, traffic engineering in IPv6 address field)

In the Cloud

- Facebook's pure IPv6-only data centre
- An IPv6 address as a virtual network function process id

IPV6-ONLY @ EE

1. Voice/IMS

OPERATOR VOICE OVER IP / LTE / WIFI

2a. Data

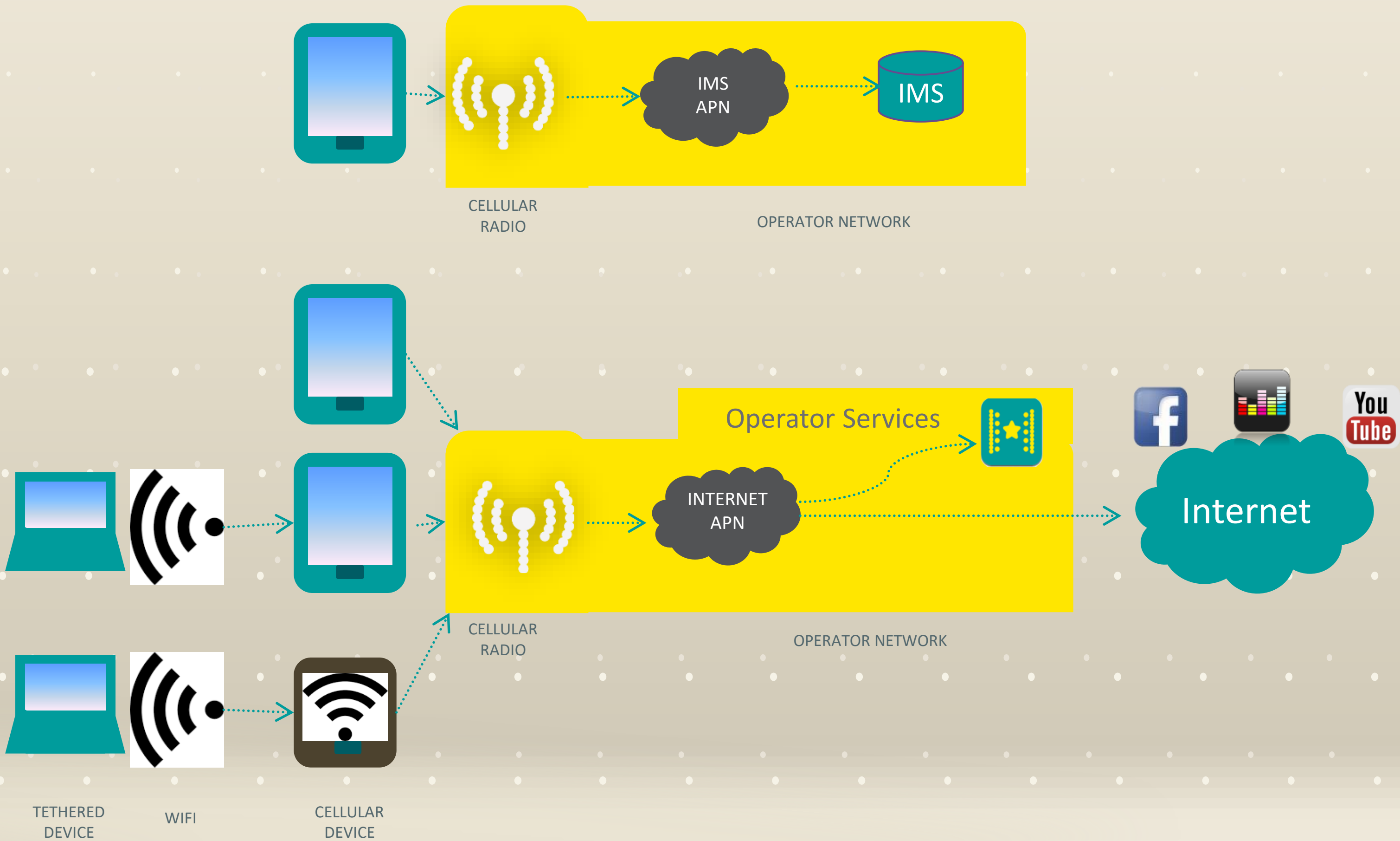
DATA FROM INTERNET OR OPERATOR SERVICE

2b. Tethered Data

WIFI TETHERING FROM HANDSET

3. Mobile Broadband

MYFI OR DONGLE



Summary

IPv6 will not degrade when considering:

- **Densification for 5G and IoT**
  - **prefixes to endpoints**
  - **Many multiple addresses per interface**
- **Lower latency – absence of NAT**
- **Less state - Better battery life**
- **Address scale,**
  - **Automation-ready**
  - **Aids Pervasive monitoring and security**

Thank you! Any questions?

Nick.Heatley @bt.com