Charting a Future Internet Path for Bhutan

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Technologies

- IPv6 deployment to end users
  - Required to carry on scaling the Internet
- NAT does not scale
  - Lack of IPv4 addresses for NAT translations
  - Latency introduced into network
  - Exceptional cost of devices vs deploying IPv6
- A network with IPv6 fully deployed to consumers will see >60% traffic on IPv6
  - <40% traffic accessing legacy IPv4 via NAT

Content is the future

- Internet usage in Bhutan

Network Operator	ASN	Traffic %
Google	15169	55
Facebook	32934	23
Akamai	20940	4
Limelight	22822	4
Highwinds	20446	4
ESDS	45815	4
Apple	6185	3
TATA (India)	4755	3
Amazon	16509	2

Content is the future

- Internet is now a big content network
  - Google and Facebook dominate (traffic!)

- Challenges:
  - How to get content to the users efficiently and at least cost
  - Content Caching in Bhutan
    - (in addition to Google Global Cache)
  - How to scale the access network

Consumer Access

- Future of Internet access is Mobile
  - Desktop PC sales declining sharply
  - Laptop sales not increasing
  - Tablet and Smartphone sales increasing
  - Fibre to the Home is expensive/impractical outside built up areas
- Copper access
  - Dialup obsolete long ago
  - ADSL depends on copper quality and distance from exchange
  - 25Mbps theoretical, 10Mbps “realistic”, often only a few Mbps is possible
  - Globally LTE is replacing ADSL/Cable access

Consumer Access

- 4G/LTE is the global norm now
  - 100Mbps to the handset (theoretical)
  - 5G (1Gbps to handset) promised for early 2020s
- 3G & 2G are outdated technologies
  - Too slow (<2Mbps to handset)
  - Too expensive to operate and maintain
- Operator priority is deploying LTE network
  - With full IPv6 support (IPv6 is part of LTE standard)
  - (With access to legacy IPv4)

Consumer Access

- Challenges:
  - How to provide LTE density to meet user demands?
  - Spectrum choices *versus* handset availability *versus* roaming capability for foreign visitors?
  - How to provide support for IPv6 as well as for legacy IPv4?
  - Profusion of mobile towers, or shared infrastructure?

Enterprise Access

- Access for:
  - Small enterprise
  - Large enterprise
  - Town/City apartment living
- Copper access
  - Now obsolete – 1980s and 1990s technology
  - TDM networks are expensive to operate and maintain
  - Low bandwidths: 64kbps to 2Mbps only

Enterprise Access

- Fibre is the future
  - Fibre to the kerb/front door
  - Access speeds at 1Gbps (or parts there of) or even 10Gbps (or parts there of)

- Challenges:
  - Who deploys fibre to the building?
  - How to deploy fibre to the building?
  - How to allow Internet Service Providers access to it
    - Fibre pairs?
    - Wavelengths?
    - Who runs the fibre backbone?

Enterprise Networks

- Core network:
  - Single-mode fibre
    - Multi-mode is expensive and very limited
  - 10Gbps is de facto standard
    - Managed 10Gbps switches are commodity
- Access network:
  - 1Gbps to the desktop (copper)
  - 10Gbps fibre uplinks to the Core
    - Switches with 10/100/1000 and 10Gbps uplink are commodity
- Dual stack (IPv4 & IPv6) essential
  - Reduces the dependency on NAT

International Connectivity

- Content providers route by round trip time
  - BGP used to inform about content caching only
  - Totally changes the BGP redundancy model we are accustomed to
- Bhutan content fed from Singapore & Mumbai datacentres
- Challenges
  - Redundancy?
  - Landlocked country / diverse paths / transit costs
  - Phuentsholing/Gelephu to Chennai/Mumbai/Dhaka ?

Recommendations

- Service Providers:
  - Mobile: 4G is a priority (MUST be with IPv6)
    - 3G is heading to obsolescence
  - Consumer access: fibre (affordable?) or 4G
  - Business access: fibre

- Businesses:
  - Campus backbone – 10G fibre is cheap, pointless doing less