SDN, NFV, and Mobile Edge Enabling Future Carrier Networks

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Evolving Verizon’s Solutions

INTERNET OF THINGS

INTERNET SERVICES

INTERACTIVE ENTERTAINMENT

DIGITAL MEDIA

GLOBAL BROADBAND NETWORK

• Largest 4G LTE Network available
• 112.1 M retail connections

• Serving 99% of the Fortune 500 customers
• Global Broadband network serves 2,700 cities in 150+ countries

• Nation’s largest all-fiber Network and the first commercial 100G deployment
• 5.8 M Fios video customers

VERIZON

Fortune 500 Rank: #15

2014 Capital Investment: $17B

2015 Revenues: $131.6B
Verizon Growth

**WIRELESS**
Total LTE Traffic

**YOY % GROWTH**
110%

**GLOBAL**
Total Global Public IP Traffic

**YOY % GROWTH**
44%

**Fios**
Total FIOS Internet Traffic

**YOY % GROWTH**
57%

Usage Growth Outpacing Today’s Networking Efficiency Innovation

*Figures represent 1Q15 YOY growth*
## Connectivity Era

<table>
<thead>
<tr>
<th>Pre-Internet Era</th>
<th>Browsers Era</th>
<th>Search Era</th>
<th>Early Content Era</th>
<th>eCommerce Era</th>
<th>Personal Era</th>
<th>Everything Era</th>
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</thead>
<tbody>
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![Graph showing the evolution of technology eras from 1970 to 2020](image-url)
Latency

Latency Requirements in Milliseconds

- High Frequency Trading (HFT): <1 ms
- VR Gaming
- Cloud assisted car driving
- AR-Non gaming
- Hi-res Cloud Gaming (FPS)
- Fios On Demand & Go90
- Webpage 1st fold load
- IM Chat

Max tolerable network delay
Max expected application delay for processing buffering display, etc.

Only Feasible in Edge Cloud
Centralized Cloud Implementation Viable
5G Vision

5G will enable very diverse use cases with extreme range of requirements

- >10 Gbps peak data rates
- 100 Mbps whenever needed
- 10-100 x more devices
- M2M ultra low cost
- 10 years on battery
- 10 000 x more traffic
- Ultra reliability
- <1 ms radio latency

(LOW POWER) WIDE AREA

CROWD

ULTRA-DENSE

OUTDOOR

A trillion of devices with different needs

GB transferred in an instant

Mission-critical wireless control and automation
Future Technologies
Purposeful Migration & Distributing Network

**EXISTING (WITH AUTOMATION)**

- APP
- OS
- Vendor Specific Hardware

**VIRTUALIZATION**

- Router
- OS
- Virtual Machine
- Hypervisor
- x86 COTS Hardware

**SOFTWARE DEFINED NETWORKING**

- Router
- SDN Controller
- Control Plane Software
- Data Plane
- Forwarding Box

**EDGE COMPUTING**

**KEY DRIVERS**

<table>
<thead>
<tr>
<th>SCALE RELIABILITY</th>
<th>HIGHEST PERFORMANCE</th>
<th>LOWEST COST PER BIT</th>
<th>MOST PERSONALIZED</th>
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</thead>
<tbody>
<tr>
<td>Dynamic Service Offerings</td>
<td>Capital Intensity</td>
<td>Lifecycle Management</td>
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High-Level Architecture

OSS/BSS

Service Orchestration

End-to-End Orchestration

NFVO

Catalogs/Repositories

VNFs

VNFM

VIM

VNFs

NFVI

SDN Controllers

EMS

PNFs

End-to-End Orchestration

NFV Service Assurance

Portals

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Cultural Shift

Change Management
Agile Processes

DevOps
Linux OS
Hypervisor, Container...

NFV/SDN
Generic
Compute/Storage

Orchestration
Enhanced Customer Control

Re-envision, Retool, Retrain
Verizon’s Approach

**Partnerships & POCs**

- Open Network Lab
- Open Compute Project
- Architecture Council
- AT&T
- Verizon
- SK Telecom
- Facebook
- Verizon
- Intel
- Cisco
- Ericsson
- Juniper
- Nokia
- Samsung
- Red Hat

**Open Standards & Open Source**

- ETSI
- ONF
- ONOS
- OpenStack
- 3GPP
- TM Forum
- MEF
- OpenDaylight

Create a future network that operates at the pace of software.
http://innovation.verizon.com/
India Innovation Lab

OSS/BSS

Service Orchestration

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Portals
Thank you.