5G: The Software Network and Virtualization Opportunities

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Challenging scenarios

- **Broadband/Dense**
  - High traffic
  - Cost

- **Mission critical**
  - Latency
  - Reliability
  - X-operator

- **Coverage**
  - Shaded areas
  - Cost

- **Crowd**
  - High density
  - Sporadic events
  - Uplink traffic
  - Correlation of traffic

- **Professional / Disaster relief**
  - Multicast
  - Availability
  - Security

- **Machine type**
  - Many devices
  - Battery consumption

Applications can use different types of communication
WHAT ARE WE TRYING TO BUILD?

THE HIGHEST PERFORMANCE NETWORK?
(BW, Latency, Availability, Programmability)

THE LOWEST COST PER BIT NETWORK?
(Capex, Opex, inc. Energy)

THE MOST PERSONALIZED NETWORK?
(User-optimized, Predictive, Sentient...?)

ALL OF THE ABOVE ... BUT WHY?
Hierarchical Needs Model (Based on Maslow Model)

- **Biological and Physiological Needs**
  - Basic Life Needs: Air, Food, Drink, Shelter, Warmth, Sex, Sleep etc.

- **Safety Needs**
  - Protection, Security, Order, Law, Limits, Stability etc.

- **Belonging & Love Needs**
  - Family, Affection, Relationships, Colleagues, Communities etc.

- **Esteem Needs**
  - Achievement, Status, Responsibility, Reputation etc.

- **Cognitive Needs**
  - Knowledge, Meaning, Self-Awareness etc.

- **Aesthetic Needs**
  - Beauty, Balance, Form etc.

- **Self-Actualization Needs**
  - Personal Growth, Self-fulfillment etc.

- **Transcendence Needs**
  - Helping others self-actualize

And help others achieve too

And feel that we have achieved something

To allow time to appreciate life

And knowledge & wisdom

To acquire status and respect

And connect, communicate & collaborate

Securely

To live...
WE NEED TO BUILD THE NETWORK OF YOU ... THAT

Allows you to connect, communicate and collaborate with...

PEOPLE

PLACES

POSSESSIONS
WE NEED TO BUILD THE NETWORK OF YOU ... THAT

Creates time ... ... by creating a virtual you

... but how and when?
THE WORLD IS **CHANGING FASTER THAN EVER**

1.5B TABLETS (2017)
2B WEARABLES (2018)
6.5B M2M CONNECTIONS (2017)
6.5M CLOUD SERVERS (2015)
0.5B SDN INVESTMENT (2013)
THE CHALLENGE
THE **UBB** FUTURE: SOLVING THE RADIO CAPACITY PROBLEM

THE FUTURE OF WIRELESS IS SMALL....AND WIRED (CONVERGED)
Broadband efficiency

Integrate all available spectrum

New air IF

Mm-wave

Licensed, Shared & Unlicensed spectrum

Unified framework for multi-antenna Efficient support

(massive) MIMO

MORE SPECTRUM (Hz)

MORE SPECTRAL EFFICIENCY (Bits/Sec/Hz)

MORE SPATIAL EFFICIENCY (Bits/Sec/Hz/User)

INCREASE CAPACITY

Small cells

Flat architecture Interference handling

“One Smart” approaches:
- target user experience
- cross-layer optimization
-- Less bits per service

One step: Integration of design
THE UBB FUTURE: THE WIRELINE ANSWER

10-20x

MORE SPECTRUM
(Hz)

MORE
SPATIAL
EFFICIENCY
(Bits/Sec/Hz/User)

MORE
SPECTRAL
EFFICIENCY
(Bits/Sec/Hz)

5x

2x

25 50

1

10 20 50

100

1000

150 300

5x

2x

MORE SPECTRAL EFFICIENCY
(Bits/Sec/Hz)

MORE SPATIAL EFFICIENCY
(Bits/Sec/Hz/User)

THE FUTURE OF WIRELINE IS DEEP FIBER... AND SHORT COPPER LOOPS
NETWORK OPERATORS

Assets: Ultrabroadband Access
New Services: Limited and Closed
E/R: Increasing Network spend, flat revenue
Innovation Speed: Years

WEBSCALE OPERATORS

Assets: Massive global compute and storage
New Services: Limited but Open APIs to Web
E/R: Increasing DC spend, growing revenue
Innovation Speed: Days

THE NEW OPPORTUNITY
THE REVOLUTION: SOFTWARE-DEFINED NETWORKS

CREATE & EXPOSE VIRTUAL PRIVATE NETWORKS (OF VNFs AND PNFs)

SCALE THE NETWORK

AND NETWORK FUNCTION VIRTUALIZATION

CREATE & MANAGE VIRTUAL NETWORK FUNCTIONS (VNFs)

SCALE THE BUSINESS
WHY NFV?

NETWORK PROVIDER
“DATA CENTER”

VIRTUALIZED APPLICATION

SERVER CARD

APPLICATIONS

HYPERVISOR

APPLICATIONS

SERVER

TOR

VSWITCH

MEMORY

COMPUTE

STORAGE

SWITCH

PHYSICAL INTERFACES

APPLICATION A

APPLICATION B

APPLICATION C

IT

DATA CENTER
WHY & WHEN NFV?

**DYNAMIC CONTROL GAIN**

- HIGH
  - CORE ROUTERS & 100G+ SWITCHES
  - FTTx, RF, COHERENT OPTICAL, CMTS
  - EDGE ROUTERS
  - PACKET GATEWAYS
  - RADIO ACCESS NETWORK
  - MEDIA GATEWAYS
  - MEDIA SERVERS & CDN
  - CONTROL PLANE FUNCTIONS
  - NETWORK APPLIANCES
  - NETWORK APPS (IMS)
  - CHARGING APPLICATIONS
  - EMS/NMS
  - NFV/SDN CONTROL
  - OSS/BSS
  - ANALYTICS PLATFORMS
  - CPE

- LOW
  - LESS
  - MORE

**COST GAIN**

- LESS
  - MORE

**YES**

**MAYBE**

**NEVER**

**NOW**
WHAT AND WHY SDN?

I'm here and I'm App X

Automatic, Optimized IP Networking & Transport
Massive (Ms of VMs) Scalability
No VM limitations
Any User IP @
Multi-tenant Security
THE ESSENTIAL **BUSINESS VALUE** OF NFV + SDN

**CAPEX**
- Infrastructure optimization through Virtualization
- Multi tenancy
- Resource pooling
- Usage based pricing

**OPEX INFRASTRUCTURE**
- Simplified network operations
  - Easier Monitoring
  - Less spares and inventory management
  - Easier management (Standard HW)
  - Self-healing
  - Simplified capacity planning
  - Power & real estate

**OPEX APPLICATION**
- Higher grade of automation
  - Faster installation
  - Faster introduction of new services
  - Faster provisioning
  - Faster migration to new HW
  - Process simplification

**REVENUE**
- Agility and flexibility
  - Elastic scaling
  - Network slicing
  - New revenue streams
  - Speed to market
  - New customer segments

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**WEBSCALING THE NETWORK**

Higher asset utilization
Lower CapEx

More efficient operations
Lower OpEx

New services & markets
Higher Revenue
STARTING POINT: SEPARATE NETWORKS
THE START OF ...

VINE SDN CONTROLLER

VINE Node

TOR
vCPE
vCDN
vVLAN
vFAN

TOR
vCPE
vCDN
vVLAN
vFAN

TOR
vCPE
vCDN
vVLAN
vFAN

TOR
vCPE
vCDN
vVLAN
vFAN

SDN-Enabled OLT

SDN Enabled Router

SDN Enabled Packet-Optical Node

SDN-Enabled L2 CPE

Base Station w/L1

SDN Enabled (Small/L1) Access Node

Virtualized Integrated Network Edge

Access

Metro

Core

Internet

THE NEXT WAVE

Federation

Enterprise DC

Fixed, Mobile & Enterprise Service Core (IMS/VoLTE, AAA, OSS/BSS)

Federation

L2 CPE

vPE Router

DC SDN CONTROLLER

WAN SDN CONTROLLER

vBNG

vSGW

vPGW

vSDN CONTROLLER

Fixed, Mobile & Enterprise Service Core (IMS/VoLTE, AAA, OSS/BSS)

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Bringing It all Together
Building the Infinite Capacity, Adaptable Network

- Monitor, control, and manage failures to achieve the expected customer experience.
- Monitor customer experience. Balance customer needs, application characteristics, and network conditions.
- Provide network wide, application-aware command and control capabilities.
- Use analytics-driven placement of functions within heterogeneous pools of network, storage, and compute resources.
- Anticipate, prevent, and resolve shared resource conflicts.

Optimized Experience
Graceful Failure
Cross-Layer Control
Zero Contention

UBB ACCESS
DYNAMIC CLOUD
CLOUD OPTIMIZED PLATFORM
CLOUD OPTIMIZED ROUTING

CONSUMERS
BUSINESSES
HOMES

PROGRAMMABLE NETWORK

vNF
TECHNOLOGY & ARCHITECTURE SHIFTS
**conclusion**

**CONVERGE:** WIRELINE+WIRELESS; IP+OPTICAL; BUSINESS+CONSUMER; OPCOs+OSSs

**TRANSFORM:** LEGACY TO IP; COMPLEXITY TO SIMPLICITY; BYTES TO SERVICES

**VIRTUALIZE:** ALL SW AND LOWER CAPACITY SYSTEMS

**DISTRIBUTE:** CLOUD AND NETWORK FUNCTIONS; NODES AND CELLS

**OPTIMIZE & AUTOMATE:** EVERYTHING, EVERYWHERE, ALWAYS
"THE SECRET OF CHANGE IS TO FOCUS ALL OF YOUR ENERGY, NOT ON FIGHTING THE OLD, BUT ON BUILDING THE NEW."
— Socrates

THE TIME IS NOW