What Software Networks Are
How We Use Them Now
How We Foresee They Will Be Used
The Ossified Network

- Many complex functions baked into the infrastructure
- Pervasive standardization
  - Much beyond a lingo for interoperability
  - Limit differentiation
- An industry with a “mainframe-mentality”, reluctant to change
  - As a whole
  - A path of lowest resistance for all actors
The Network Dystopia...

Segmented management: High OPEX, often with low utilization of resources, high complexity, and slow time-to-market for deploying any kind of network service...
...Makes IT Nonsense
Mapping to computers how networks have evolved...
The Key Role of Virtualization
A layered model virtualizing devices and resources
The Business Drivers

- Build the infrastructure as a pool of general resources
- Functionality is provided on-demand wherever it is needed
- The infrastructure can be updated in a much easier way
- New functions can be added or improved by just updating a software image
- Management and operation can be performed by means of software image configuration and orchestration

- Flatten network CAPEX by simpler procurement and reuse
- Lower network OPEX by reducing complexity and unifying operation mechanisms
- Shorten time to market and address long-tail services
The Concepts

- **NFV**: Separate functionality from capacity
  - Increase network elasticity
  - Address heterogeneity

- **SDN**: Decouple the control and forwarding functions
  - Gain programmability
  - Abstract infrastructure
Software Defined Networking
The First Steps towards Software Networks

Network equipment as Black boxes

Open interfaces (OpenFlow) for instructing the boxes what to do

Boxes with autonomous behaviour

Decisions are taken out of the box And made by specific apps

Management systems adapted to manage black boxes

Simpler management by means of dedicated applications
The NFV Framework

Logical Abstractions

SW Instances

Virtual Resources

Virtualization SW

HW Resources

End Point

E2E Network Service

Network Service

VNF

VNF

VNF

VNF

Logical Links

VNF : Virtualized Network Function

NFV Infrastructure

Virtual Compute

Virtual Storage

Virtual Network

Virtualization Layer

Compute

Storage

Network
The Software Networks Realm

• SDN and NFV are deeply related
  o Though historically separated
• And they require each other in most cases
  o NFV would be extremely difficult to achieve without SDN
  o Most of the SDN use cases are related to NFV
  o What has been recognized by the community
• One single realm
  o Started to be termed as “Software Networks” in the 5G PPP
A Proper Balance between NFV & SDN

Service-layer SDN
Simplify management, closing the gap between business logic and operation

NFV
- Separation of HW and SW
- No vertical integration
  - HW vendor ≠ SW vendor ≠ Mgmt vendor
- Once network elements are SW-based, HW can be managed as a pool of resources

Infrastructural SDN
- Virtual backplane
  - Separation of control and data plane
  - Easy orchestration with SW domain
The Momentum of Software Principles

- Software Networks allow for applying IT and software engineering principles to networks
  - Operating system structure
  - Integrated development environments
  - Machine learning
  - APIs
  - DevOps and continuous integration
  - ...

- And bring an enormous momentum to networking technologies
  - As long as we avoid re-ossifying them
Building by Example: The OSM Case
Applying Model-Driven Principles

- Addressing practical aspects identified in real deployments
- Avoiding to become stuck to a rigid architecture
- Retaining essential interoperability requirements
- Integrating existing solutions
- Considering NFV and SDN in a holistic approach
The Human in the Loop: The NetIDE Concept

• NetIDE aims at supporting the whole development lifecycle of network apps in a platform-independent fashion
  o A controller- and gear-independent approach to SDN development
  o Integrated development and tool support for the network design cycle
  o Support for emulator-in-the-loop and simulator-in-the-loop configurations
• Open collaboration made possible
  o During the whole development process
  o At deployment time
• Embedding intent-based networking
  o Separate the what from the how
  o And connect both through the IDE

Diagram:

- App1
- App2
- Client Controller Platform
- Controller Platform (FL, Ryu, etc.) backend
- NetIDE Core
- shim client
- Server controller platform
- Network Element
- Network Element
- Network Element
Intent as the New Frontier

- Separate ‘what I want to do’ from ‘how I need to do it’
  - Go a step forward in abstraction
  - Transparent recursion
- A common interface for applications
  - To SDN controllers and NFV MANO stacks
- Integrated development environments
  - Put the human in the loop, as in general software development
  - With a single, integrated entry point
  - Seek for application-network co-design
- Several on-going activities in ETSI, IETF, ONF...
  - Hope they follow a path aligned with model-driven development
Vertical Function Virtualization
Creating v-Boxes

- A physical box is mapped to a set of containers (a VNF)
- Inefficient and inflexible
  - Still uses many processes and requires encoding/decoding across interfaces
  - High-availability requires duplication
- But much simpler to digest by the current procedures
  - Operators, vendors, regulators
Horizontal Function Virtualization
Thinking cloud-like

- Consolidation of multiple physical network infrastructures into one
  - Node disaggregation, lowers complexity
  - Blur boundaries between architectural boxes
  - Achieves better service scalability, flexibility
  - Supports new business models and differentiation

- Challenges current practices
  - Operation common practices, purchase processes...
  - Development and maintenance plans and practices
  - Standards roadmaps and regulation enforcement points
Welcome to the Continuum

• Think software
  o Multi-language, multi-tenant, multi-thread...
  o Human in the loop
• There will be a continuum of solutions
  o As usual in software space
• Rely on the technologies themselves
  o NFV brings additional degrees of freedom
  o SDN supports smoother migration paths
• And consider intent-based interfaces as the next line for convergence
  o Expanding the realm(s)
  o And the buzzwords
Applying It Today: The Home vCPE

FROM...

Home environment

CPE

IPv4
NAT
TR-069
UPnP
FW
DHCP
Access Point
Switch
Modem

FROM...

Home environment

CPE

Access Point
Switch
Módem

Operation and service deployment are greatly simplified

New functions (e.g. IPv6) only needed in network environment

Simplification removes all incompatibilities

... TO

Network environment

Network environment
Defining the vCPE Elements

- **IPFE, per-user contexts**
  - AAA
  - Q-in-Q traffic
  - Gateway
  - Bridge to VSP
  - Tunnels to NAT
  - IPv6 auto-config

- **vCPE NAT**
  - PCP support
  - 1:1 and M:N modes

- **DHCP**
  - IPv4/IPv6

- **Customer Portal**
  - User parameter management

- **Diagnostic Tool**
  - L2-based remote diagnostics
  - Sample of future services on the platform
Potential Scenarios

1. **Evolutionary**
   vCPE leverages on currently deployed infrastructure (BRAS) while integrating virtualization technologies for some specific vCPE functions.

2. **Virtualized platform**
   Every vCPE function is virtualized and runs on an NFVI. The IPFE is implemented as a VNF.

3. **Vertical virtualization**. The vCPE IPFE function is integrated in a full SW vBRAS.
Applying it Today: Elastic Security

Deeper

Metadata interface

REAL-TIME ANALYSIS

CENTRALIZED INTELLIGENCE

 NFV domain

SDN domain

OF Controller

Access

Security

OPENFLOW

xDRs

Other data

Network Big Data

RELEVANT INFO

Mitigation

OF Switch

Copy

Metadata interface

Raw user traffic
From Heterogeneous to Uniform Security

Security Applications independent from user terminals

Security Enforcement independent from user location
The SECURED Framework Architecture

1. Trust
2. Authenticate
3. Get Policies
4. Get Apps
5. Protect!
The SECURED Components at Work
So Do We Need 5G?

- Better way of providing current services
  - Lower cost, improved performance, improved experience continuity...

- Support of new services that cannot be provided with 4G technologies
  - Ultra low latency, massive IoT/MTC services...

- Capacity to personalize services for specific applications
  - Vertical industrial applications, safety...

Source: GSMA

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5G New Service Capabilities

- 5G to support efficiently three different types of traffic profiles
  - High throughput, e.g. video services
  - Low energy, e.g. long-living sensors
  - Low latency, e.g. mission critical services

- 5G to cover network needs and contributes to digitalization of vertical markets
  - Automotive, transportation, manufacturing, banking, finance, insurance, food and agriculture
  - Education, media
  - City management, energy, utilities, real estate, retail
  - Government
  - Healthcare

- 5G to scale to growing demand and different network layouts
  - Anticipated dramatic growth in number of terminal devices
  - Continuous growth of traffic (at a 50-60% CAGR)
  - Heterogeneous network layouts
  - With power consumption reduced or equal to current networks and reduced management complexity within networks
5G Key Requirements

- 1,000 X in mobile data volume per geographical area reaching a target ≥ 10 Tb/s/km²
- 1,000 X in number of connected devices reaching a density ≥ 1M terminals/km²
- 100 X in user data rate reaching a peak terminal data rate ≥ 10Gb/s
- Guaranteed user data rate >50Mb/s
- 1/10 X in energy consumption compared to 2010
- 1/5 X in end-to-end latency reaching 5 ms for e.g. tactile Internet and radio link latency reaching a target ≤ 1 ms for e.g. Vehicle to Vehicle communication
- 1/5 X in network management OPEX
- 1/1,000 X in service deployment time reaching a complete deployment in ≤ 90 minutes
- Mobility support at speed up to 500km/h for ground transportation
- Accuracy of outdoor terminal location ≤ 1m

(these key requirements are not expected to be met all at the same time)
Vertical Common Technical Topics

- Network coverage extension: indoor, rural areas, roads...
- Network robustness improvements. Availability even in case of natural disaster
- Latency improvements (very low latency <5ms / guaranteed latency ~ 50ms)
- Long battery life
- Coordination schemes for multi RAT
- QoS management for specialized services
- Low cost services for low ARPU markets
- Security and confidentiality
- Network slicing / traffic engineering addressing SDN enabled networks
- Proximity services: discovery, communication, network relay...
- Context awareness for radio protocols
- Unlicensed spectrum
- Business models
Slicing the Network
The slice concept as the basic building block

- An homogeneous infrastructure
  - Separating capacity (HW) and functionality (SW) => NFV
  - Programmable, recursive and composable control => SDN
- Software Networks are key to achieve it
Reaching Up the User Planes
The Whole (5G) Picture
Putting It All Together

Data Plane must be Distributed

Control Plane can be Centralised

FUNCTION
(Software defined)

CAPACITY
(Homogeneous infrastructure)

LOCAL PoPs
- CDN (*)
- Video (*)
- PCSCF (*)
- Security (*)
- S/PGW (*)
- BNG (*)
- DPI (*)
- CGNAT (*)
- IPv6 Router (*)

REGIONAL DATA CENTRES
- SDP (*)
- NGIN (*)
- IMS (*)
- SRVCC (*)
- DHCP (*)
- MME (*)
- PCRF (*)
- DNS (*)
- MME (*)
- DRA (*)
- SPR (*)

Interconnection

HW and SW decoupling

OS + Hypervisor

COTS HW

SDN Switching

COTS HW

SDN Switching

CDN (*)
Video (*)
SDP (*)
NGIN (*)
IMS (*)
SRVCC (*)
SRVCC (*)

COTS HW

SDN Switching

Service Domain

Network Domain

Infrastructure Domain

service

access

aggregation

local points of presence

core

regional data centres

Telefonica
Enough Is Enough

- A great opportunity to redefine how to conceive and build networks
  - Build a formal discipline of networking
  - Make relevant gains in reducing cost and complexity
- The archetypal paradigm shift
  - Much like what Java brought for application development
- And many exciting possibilities ahead