GRUPPO TELECOM ITALIA

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SDN and NFV for Network Cloud Computing

a Universal Operating System for Software Defined Infrastructures

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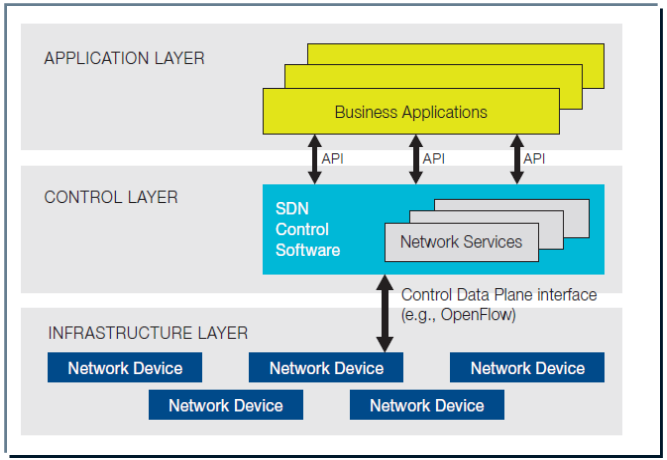
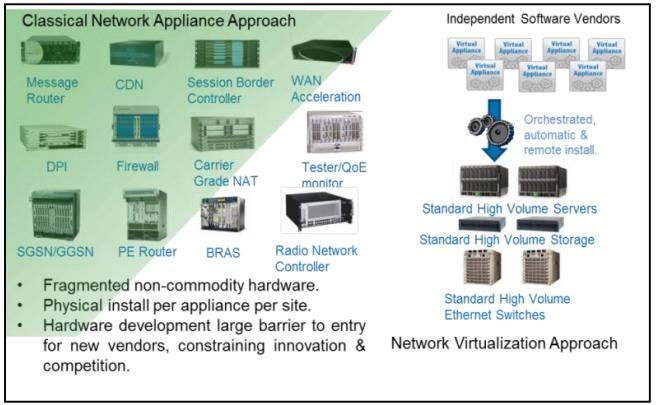
Basic definitions of SDN and NFV

- SDN
  - separation of software (e.g., control plane) from hardware (e.g. data plane, packets forwarding);
  - execution of the software not necessarily in the node but potentially on dedicated IT servers or even in the Cloud;
- NFV
  - virtualization of network functions (e.g. middle-boxes, from L4 to L7) and their dynamic allocation and execution on general purpose hardware.
- SDN and NFV are mutually beneficial.





Source: ONF and ETSI

SDN and NFV are NOT only about Networks !

SDN and NFV are expressions of a systemic trend «integrating» Cloud, Networks and Terminals

Softwarization

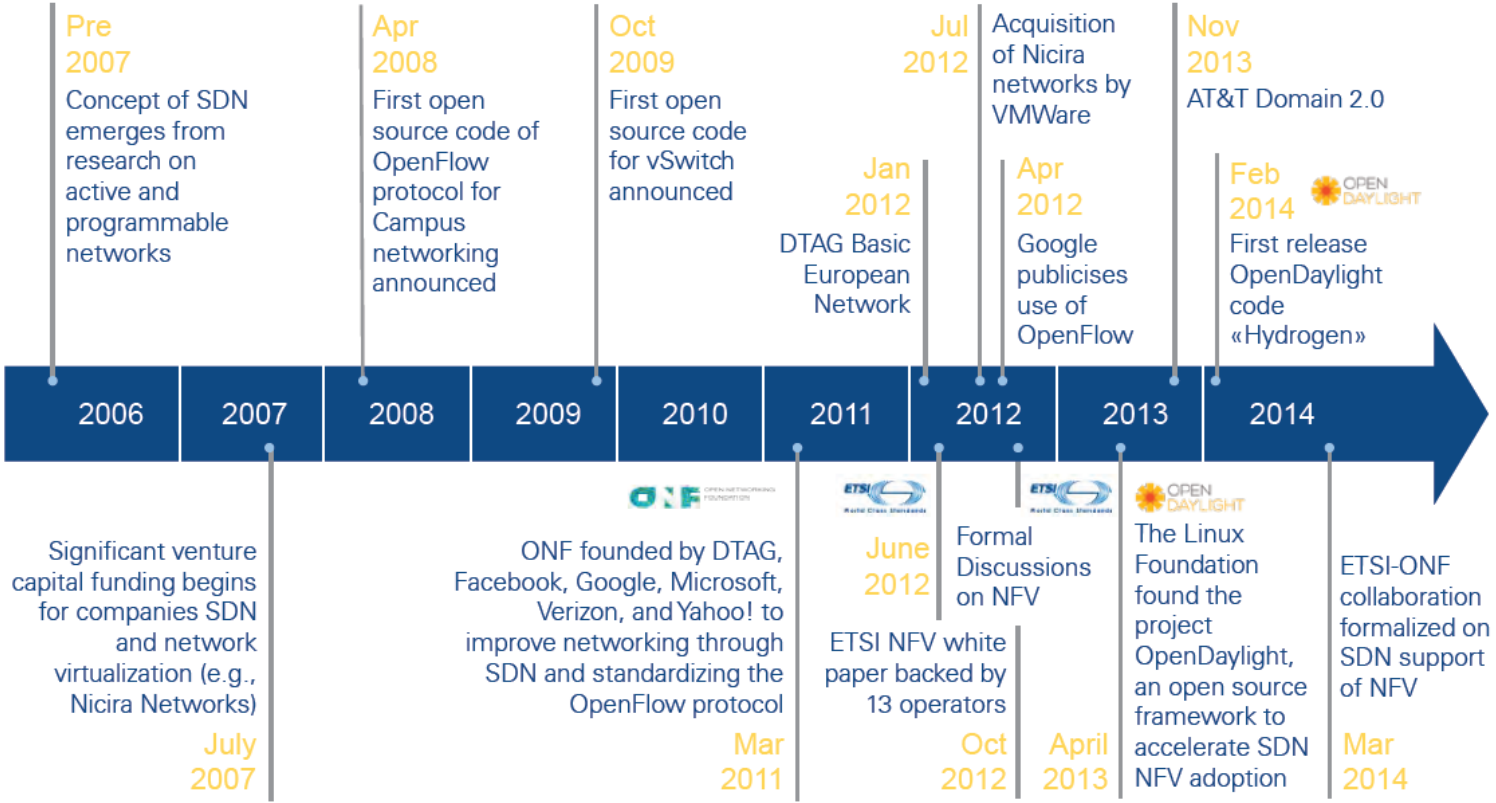
Softwarization in a nutshell…

- A crossing point of key technological trajectories:
  - pervasive diffusion of ultra-broadband;
  - IT HW performance increase (at lower costs);
  - growing availability of Open Source SW;
  - more and more advanced terminals.

Data Centric Era:
mass digitalization

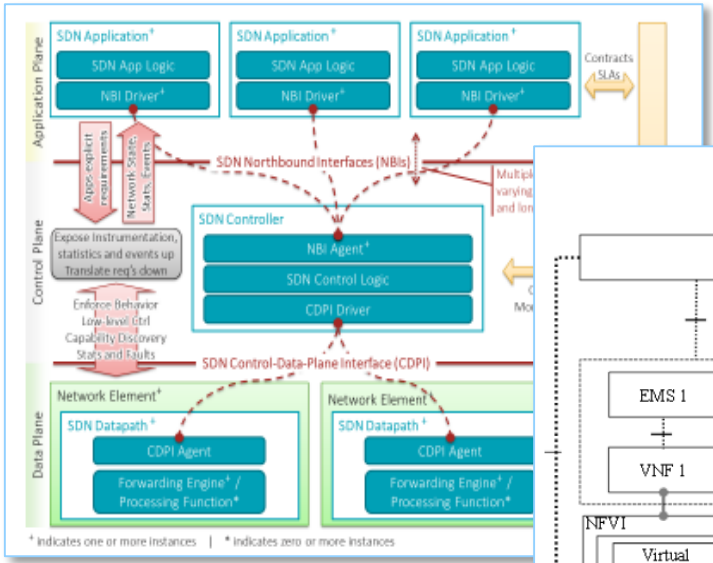
- "Softwarization" in a nutshell:
  - network and service functions (e.g., L2-to-L7) are just like "apps", that can be executed in virtualized resources (e.g., VMs, containers) hosted on a physical ICT infrastructure (up to terminals), fully decoupled.

Activities on SDN-NFV in Standardization Bodies

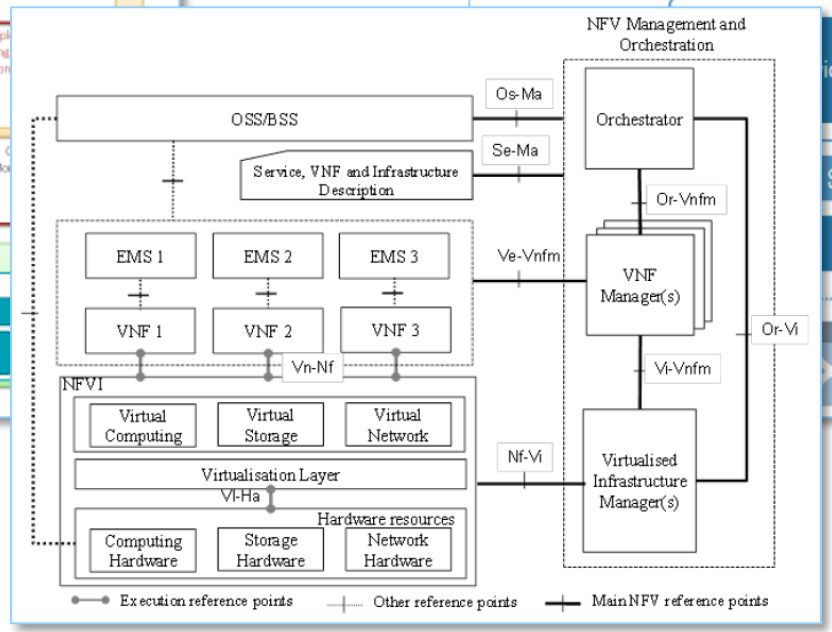


Source: ETSI, ONF, OpenDaylight and press articles

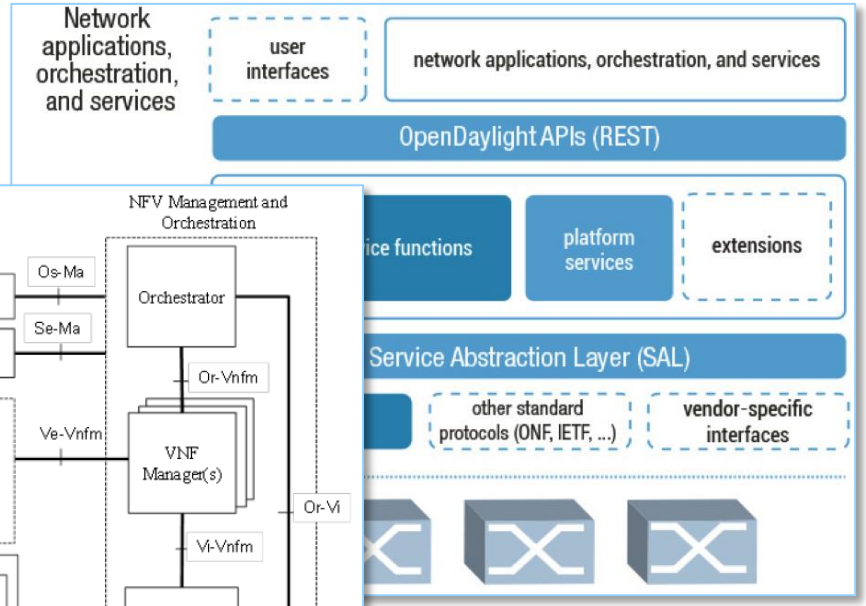
.... some reference architectures



SDN reference architecture
(Open Networking Foundation)

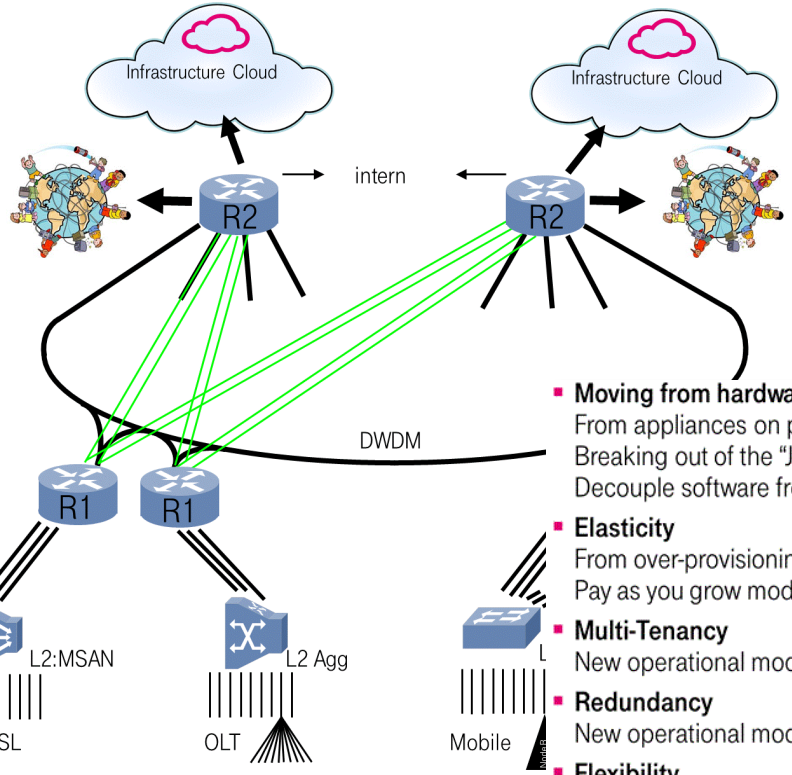


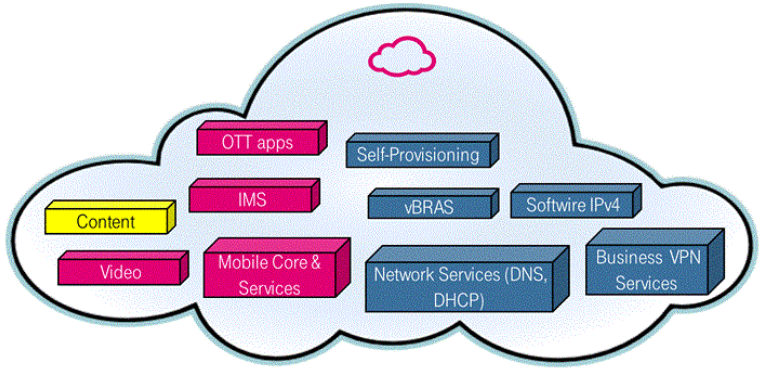
NFV reference architecture
(ETSI)



ODL reference architecture
(OpenDayLight – Linux)

THE TERASTREAM ARCHITECTURE

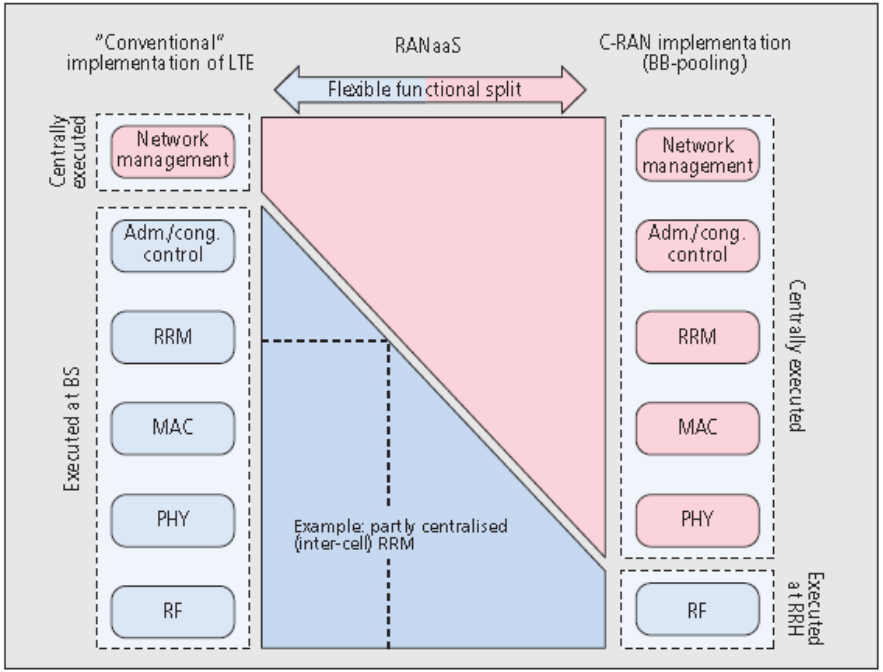




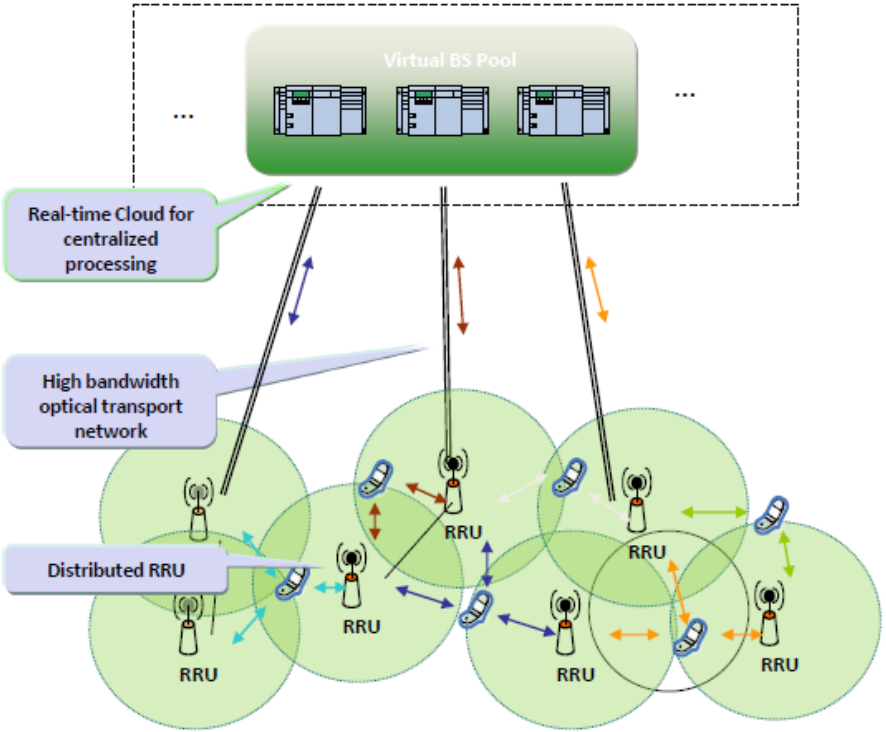
- **Moving from hardware to a software business model**
  From appliances on proprietary hardware to software on commercial off the shelve hardware
  Breaking out of the "Just rolled-out outdated hardware" vicious cycle (e.g. CNTDB)
  Decouple software from hardware through virtualization
- **Elasticity**
  From over-provisioning and over-investment to scaling services based on current need
  Pay as you grow model
- **Multi-Tenancy**
  New operational models: cross-country or central production of services
- **Redundancy**
  New operational models: fast failover to other geographic areas
- **Flexibility**
  New business models – e.g. Infrastructure as a Service for Content Owners
  Enhancement of L2/L3 VPN Services with Security, Loadbalancing, Web/Cloud Services for business customers

LIFE IS FOR SHARING.

C-RAN

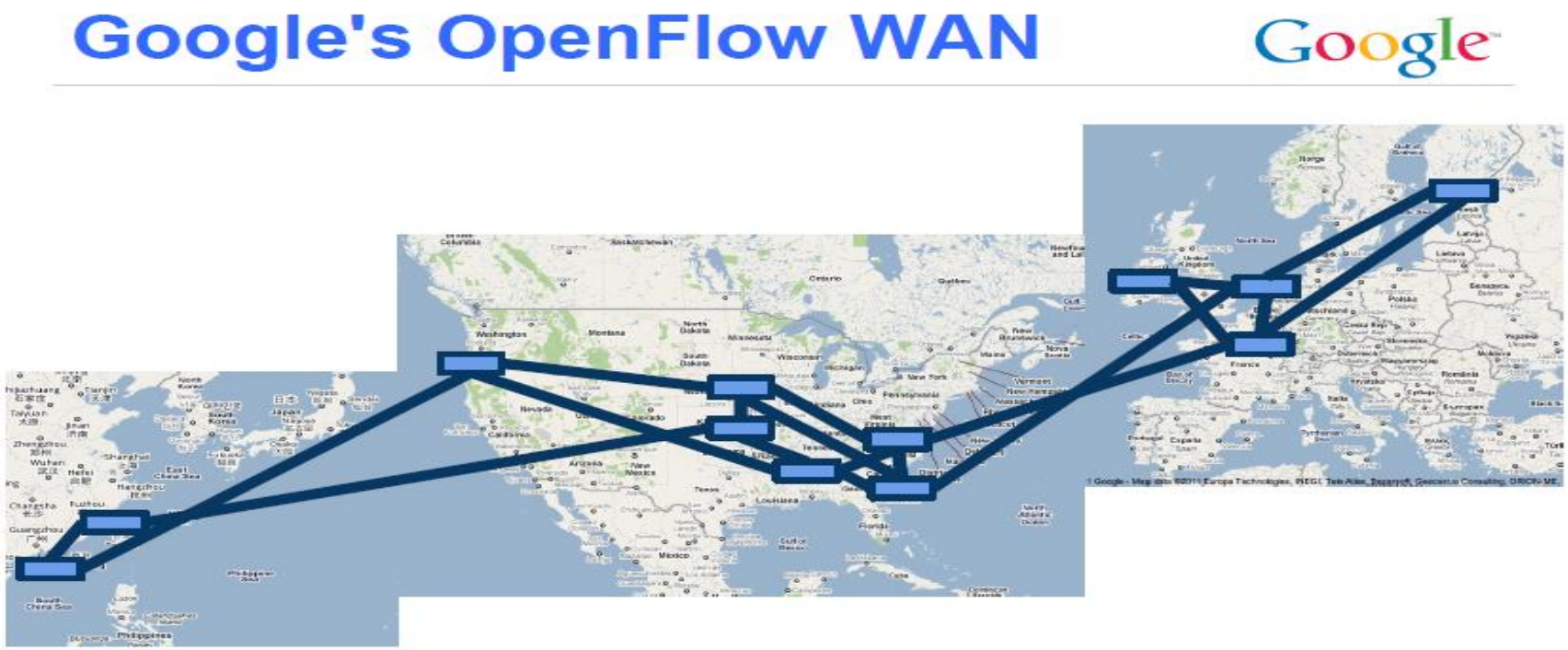


Flexible functional split.



Source: Dr. Chih-Lin I "Softer RAN DEP-Management in a Software-Defined World", Keynote NOMS2014

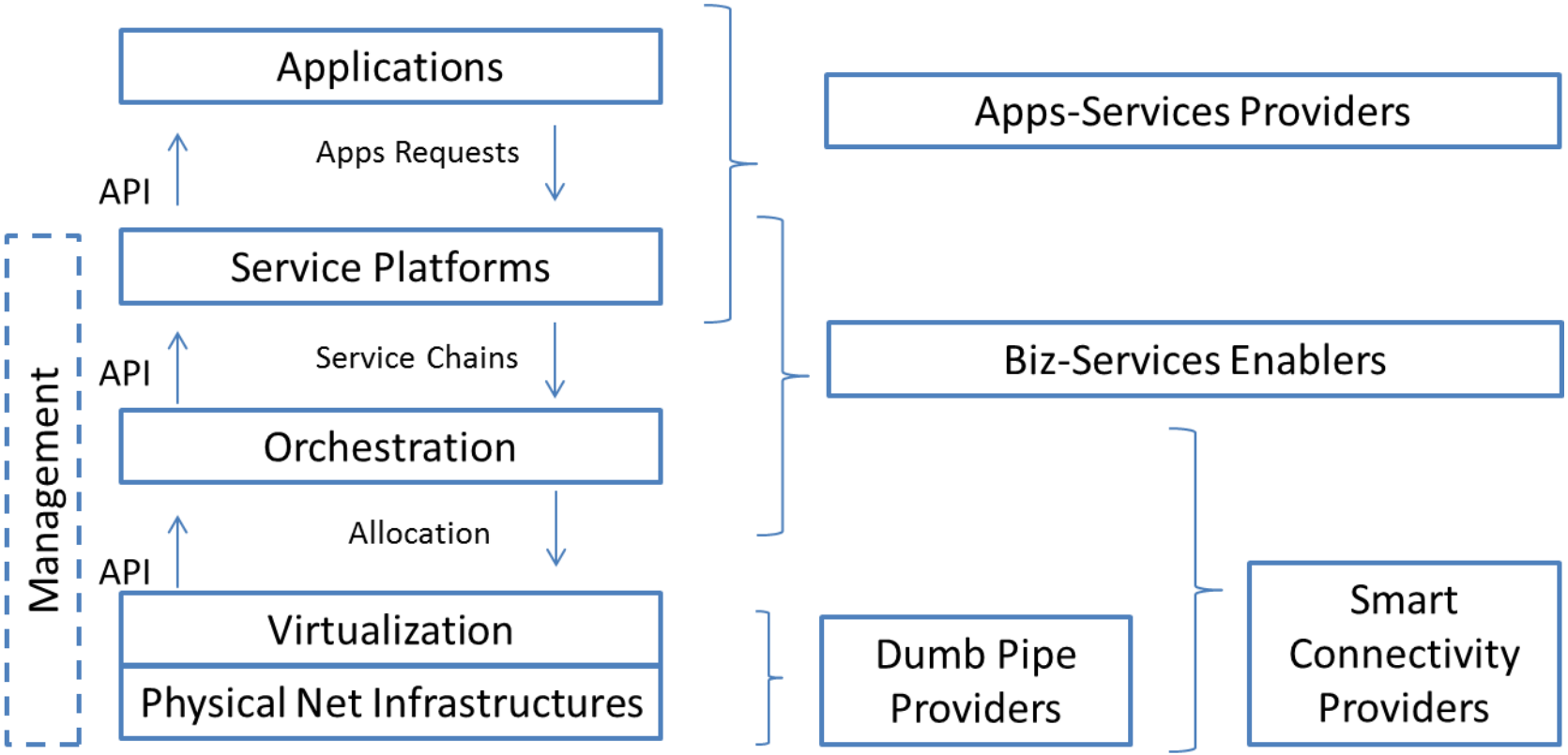
Google G-Scale: a WAN based on SDN paradigm



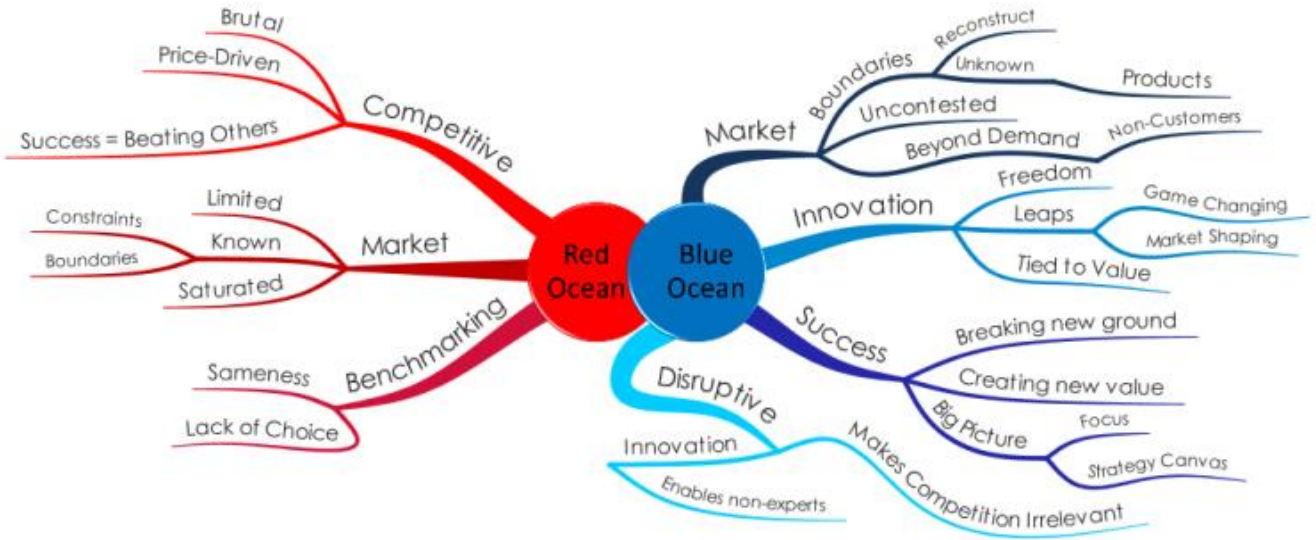
True impact of Softwarization

- Integrating deeper Networks and Clouds, at lower costs:
  - network and service functions are “applications” executed on logical resources (e.g., VMs, Containers), dynamically allocated and moved on an underneath physical infrastructure (up to the terminals), which is fully decoupled;
  - adopting IT-style operational processes (normally used for Data Centers such as dynamic allocation, migration and cloning of logical resources) also for the Network, even up to the Users’ terminals (Edge and Fog Computing);
- Blurring the border between the Network/Cloud and “*what connects to it*”:
  - more and more powerful terminals will become capable of storing large data sets and and executing service components and functions even locally (Fog Computing);
  - smart things, intelligent machines, robots, Self-Driving Cars, etc. will become the future Telecommunication “terminals” for providing new ICT services.

... some reference architectures, interfaces and roles...



Red and Blue Oceans



Two innovation cycles for Softwarization:

Slow and Fast

http://www.blueoceanprinciples.com/why-blue-ocean/

Red Ocean: slow innovation cycle (continuity)

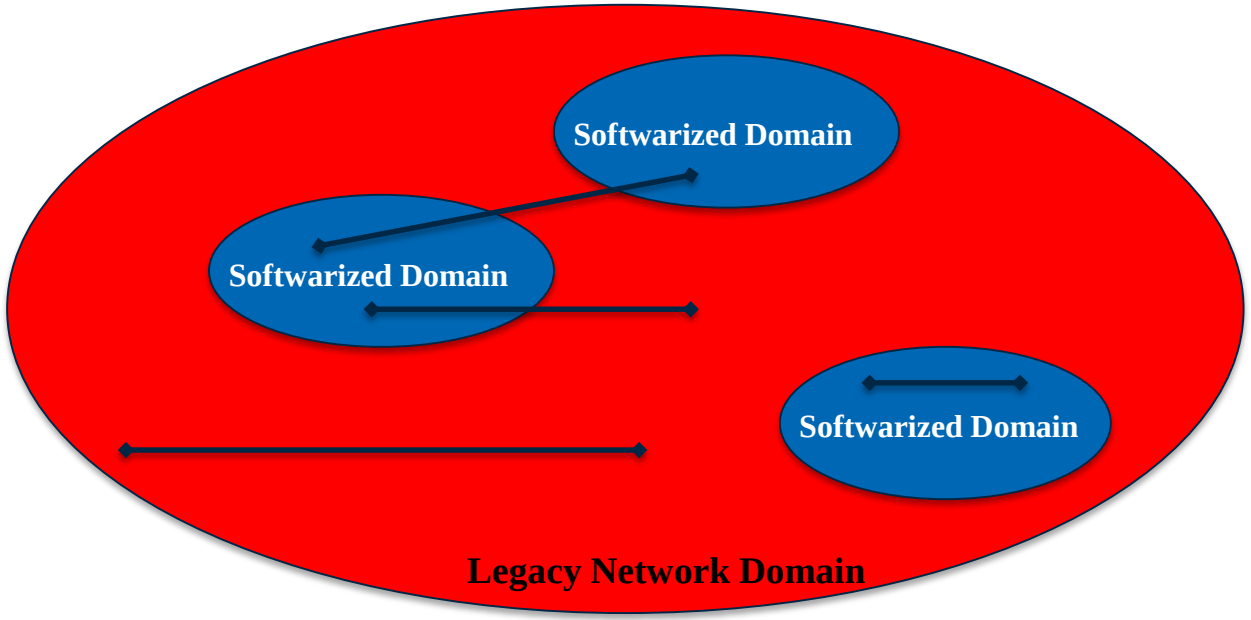
- Smooth evolution of current Telecom infrastructures: e.g., introducing SDN and NFV starting from virtualizing some service functionalities. Main challenges:
  - **interoperability of SDN-NFV with legacy systems** (missing standard interface);
  - **complicated evolution of operational processes**, e.g. OSS/BSS, in order to cope with SDN-NFV complexity (managing millions of S/W processes instead of nodes)
- Main benefits:
  - **potential savings in CAPEX and OPEX** but risk of reducing/compromising said savings by the problem of integrating SDN-NFV with legacy systems;
  - **reducing (partly) the time to market** but, due to the legacy processes, it might be not-enough-short to cope with the market dynamics;
  - **enabling (partly) API-Economy**: introducing programmability but processes are not flexible and fast enough to exploit full potential the APIs model opportunities.

Blue Ocean: fast innovation cycle (disruption)

- Disruptive transformation of the Telecom infrastructures: ”softwarization” of network and service platforms (e.g., true VNO or SD-Operators). Main challenges:
  - **automation of Operation processes for softwarized platforms (a la IT);**
  - **fast adoption of “standard de facto” (market is deciding, rather than waiting for long standardization path);**
- Main benefits:
  - **de-perimetrization** of services: borderless operations in countries where it is possible to rent a physical infrastructure (virtual infrastructure *uploading*);
  - **servitization**: anything can be transformed in a “*gate*” to provide and access new ICT services and data (Internet of/with Things, pervasive robotics/machines);
  - **enabling API-Economy**: processes are flexible and fast enough to exploit full potential the APIs model opportunities.

Red – Blue domains Interoperability

- Interoperability of fully «softwarized» domains» with legacy infrastructure across «standard-de-fact» and/or standardized interfaces.



How the Telecommunications ecosystem will change ?

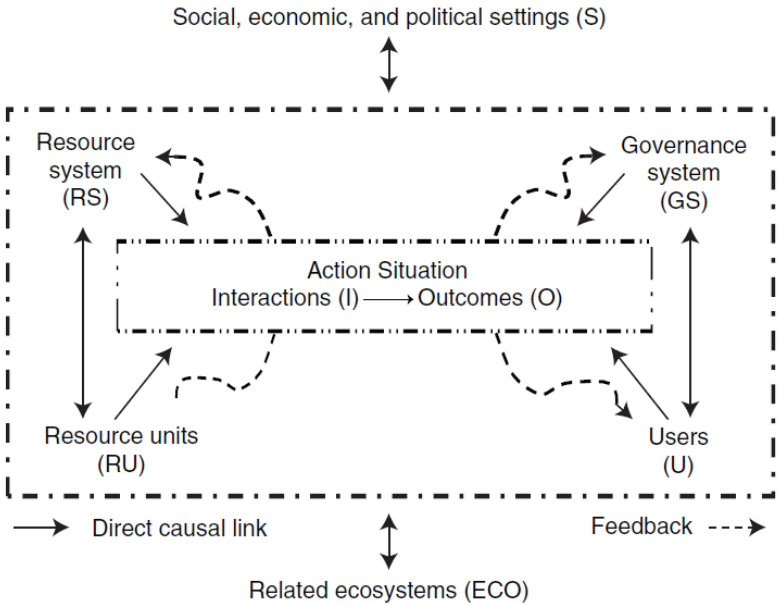
- Competition moving from a CAPEX-oriented models (e.g., based on physical infrastructure) to an OPEX ones (e.g., virtualised functions):
  - the threshold for new Competitors is lowering: new “fully virtual” Operators to enter the market, as less investments will be required (they can rent physical resources from Infrastructure Providers);
- Voice commoditization, “services packaging” and…cognition:
  - voice telephony is likely to become just another OTT service…or
  - telecoms services to become increasingly packaged with other services and made available through a variety of access connectivity services;
  - new service models are to appear (e.g. Cognition as a Service).

How the Telecommunications ecosystem will change ?

- Changes in the Telecommunication ecosystem:
  - Potential emergence of new roles for Operators (e.g., Smart Connectivity Provider, Service Enabler, etc.)
  - OTT are advantaged: they master the SW and they are in the middle of a set of relationships (working with customer equipment manufacturers and their retailers);
  - OTT can become MVNO very quickly;
  - Some telecoms equipment suppliers are repositioning as principally software supply companies: a significant shift in business model:
    - the sale of software licencing has many differences to the sale of equipment !

How the Telecommunications ecosystem will change ?

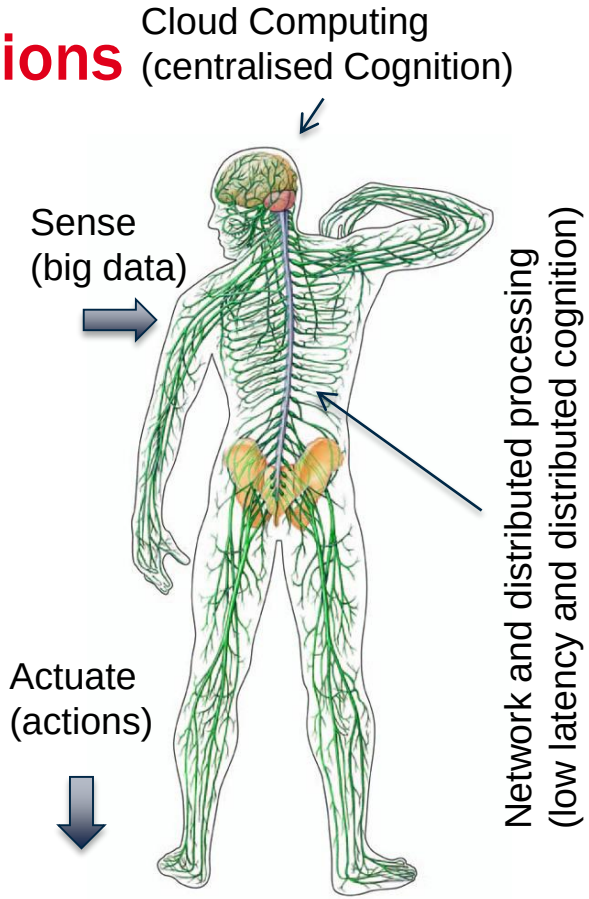
- Digital Society will become a Complex Economic System;
- Polycentric Governance beyond “walled gardens”;
- Prof. Elinor Ostrom, (Indiana University) was awarded in 2009 with the Nobel in Economic Sciences (shared with Oliver E. Williamson) for the results she achieved in analysing how communities of Players can manage ecosystems of resources.



Elinor Ostrom, Beyond Markets and States: Polycentric Governance of Complex Economic Systems

A new role for ICT and Telecommunications

- We'll be able to sense and collect massive data (by sensors, terminals, things);
- To exchange quickly big sets of data (via optical and mobile networks with high bandwidth and low latency);
- To elaborate big data (with Cloud/Edge and Fog Computing) in order to infer decisions for actuating local actions (by any actuators)…
- **ICT and Telecommunications will provide the «nervous systems» to the Digital Society**



The “Cognition” rush: example of a toy

The green CogniToy dinosaur is powered by the IBM supercomputer A.I. engines .

- CogniToy is a green dinosaur with a big blue button on its belly;
- Kids can press the button, then ask a question. And they get an answer;
- the question is processed, and the answer is given, by IBM's Jeopardy-winning Watson artificial intelligence supercomputer system;
- **Cognition (A.I.) is hooking the Smart Toy with the Network and with the Cloud.**

Source: http://www.computerworld.com/article/2887174/tech-toys-train-tots-for-a-troubling-tomorrow.html

The “Cognition” rush: example of an OTT efforts

theguardian
Winner of the Pulitzer prize 2014

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Science

Google a step closer to developing machines with human-like intelligence

Algorithms developed by Google designed to encode thoughts, could lead to computers with ‘common sense’ within a decade, says leading AI scientist

Hannah Devlin Science correspondent

@hannahdev

Thursday 21 May 2015 18.24 BST

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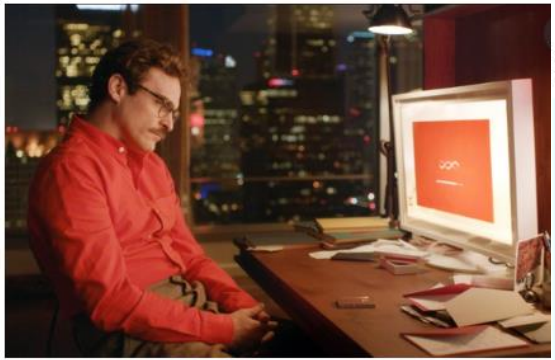


Joaquin Phoenix and his virtual girlfriend in the film Her. Professor Hinton think that there’s no reason w computers couldn’t become our friends, or even flirt with us. Photograph: Allstar/Warner Bros/Sportsphoto

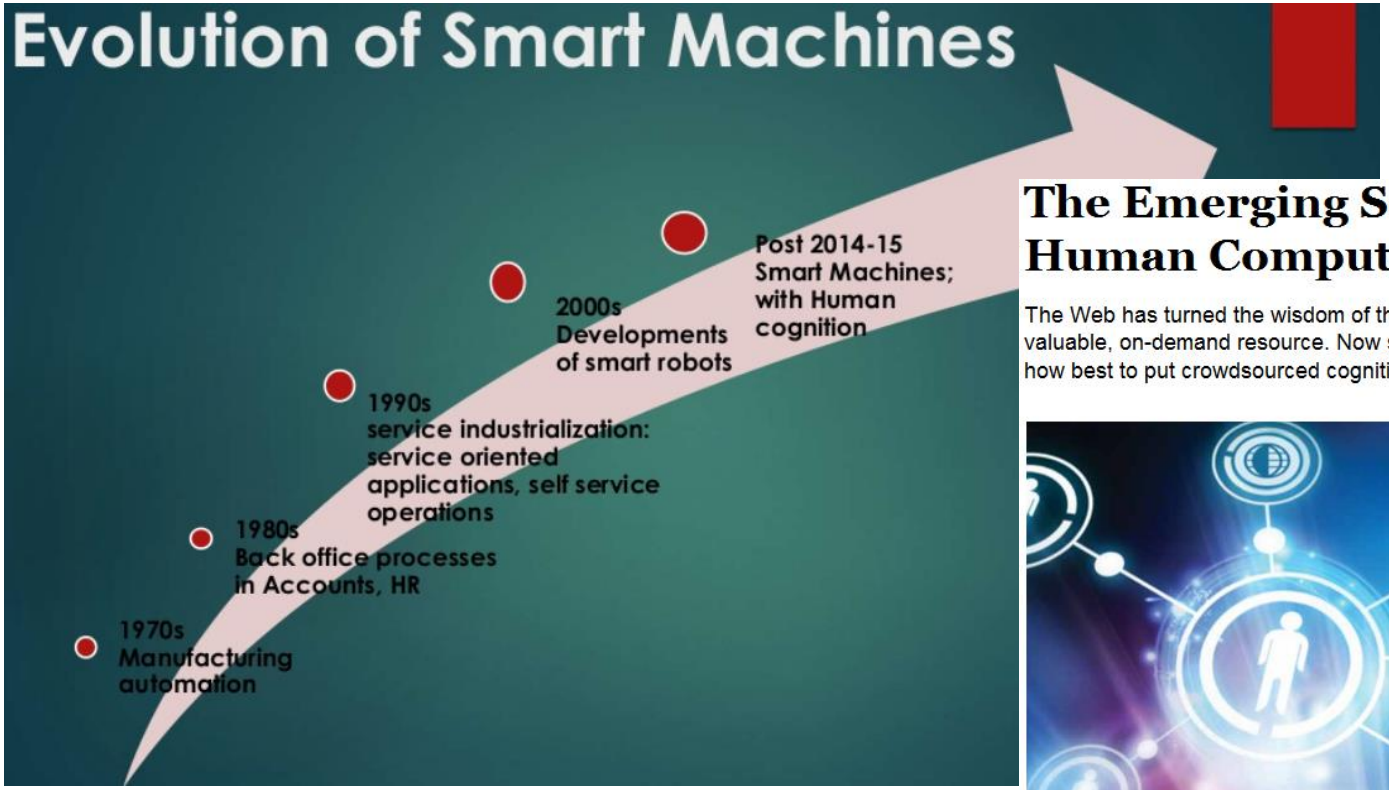
Computers will have developed “common sense” within a decade and we co be counting them among our friends not long afterwards, one of the world’s leading AI scientists has predicted.

Google buys two more UK artificial intelligence startups

Company funds new computer science research partnership with Oxford University, where three of its new artificial intelligence hires will remain lecturers

Google expands efforts to create human-like artificial intelligence with new Oxford University partnerships and British startup acquisitions. Photograph: Science Picture Co./Science Picture Co./Corbis

The “Cognition” rush: an overall trend

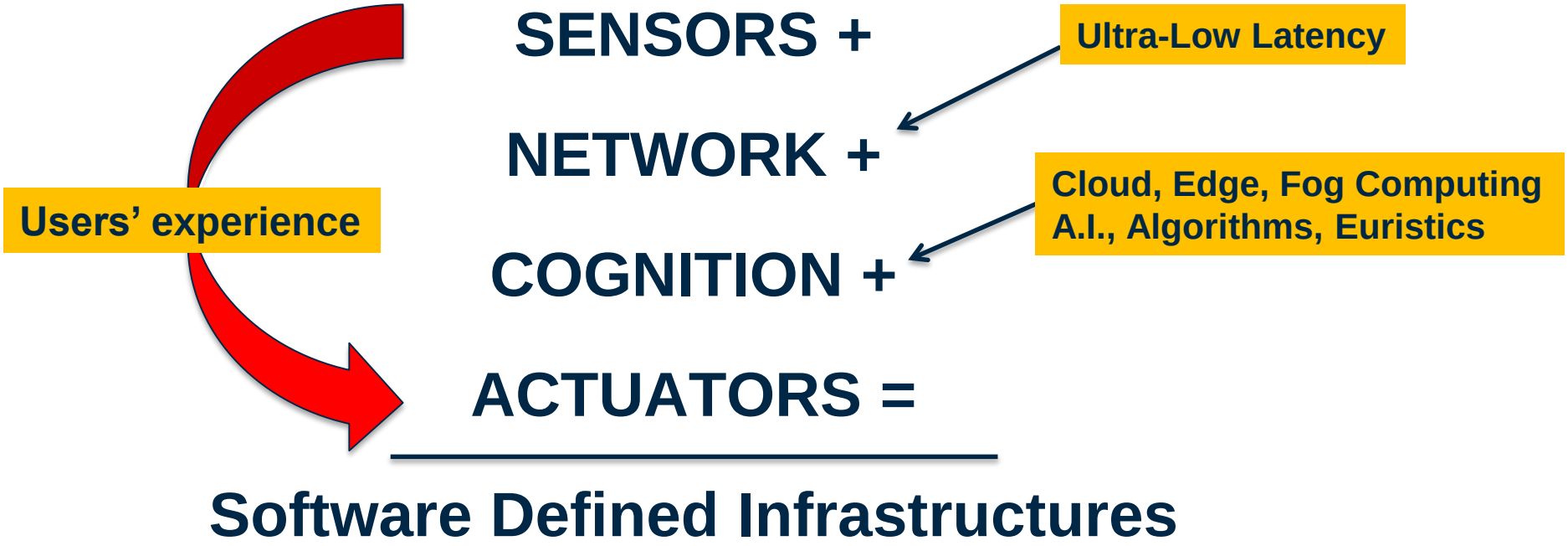


The Emerging Science of Human Computation

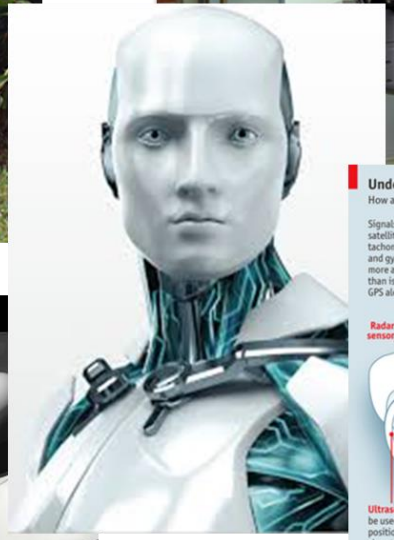
The Web has turned the wisdom of the crowd into a valuable, on-demand resource. Now scientists are asking how best to put crowdsourced cognition to work.

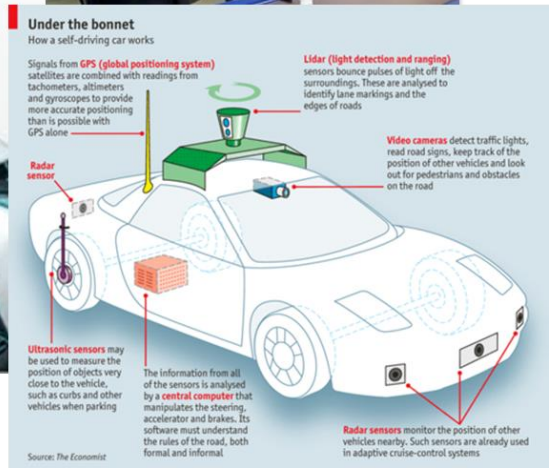
http://www.slideshare.net/GarimaNanda/seminar-smart-machine

Not just SDN-NFV for Networks
Software Defined – Infrastructures up to the Terminals



Telecommunication terminals of the future...





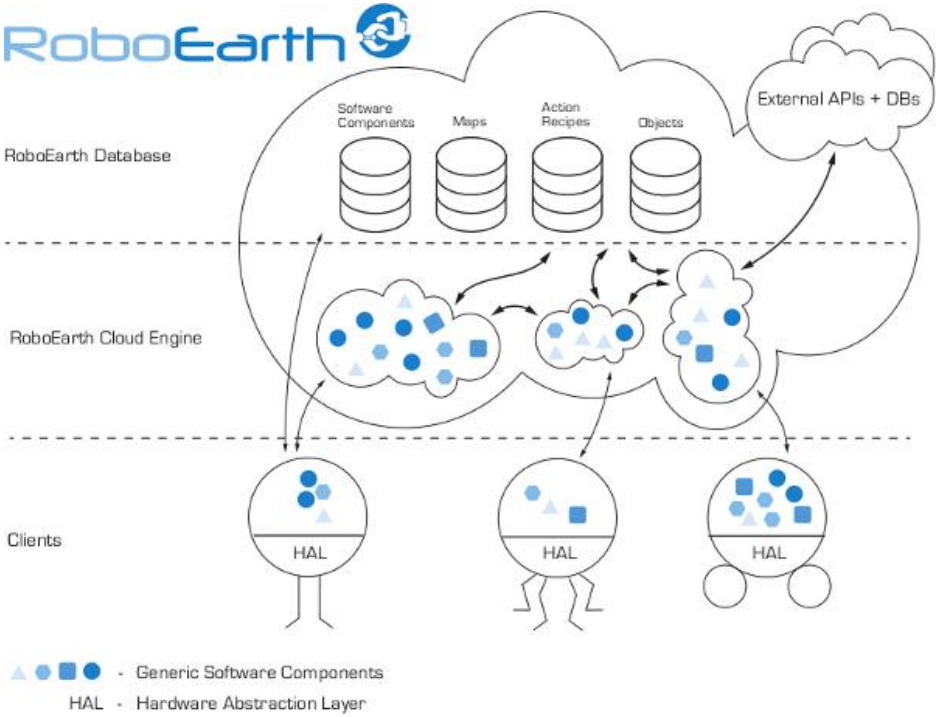
Telecommunication terminals of the future…

http://www.icub.org/

- *YARP (Yet Another Robot Platform): a set of libraries decoupling devices from software architecture*
- *YARP abstracts the transport mechanism from the software components, allowing any software component to run on any machine. It supports shared memory for local communication, and TCP/IP, UDP, and multicast for communication over a network…*

- What if “connecting” icub to the Cloud via an ultra low latency Network ?
- What if “controlling” icub with the Universal OS ?

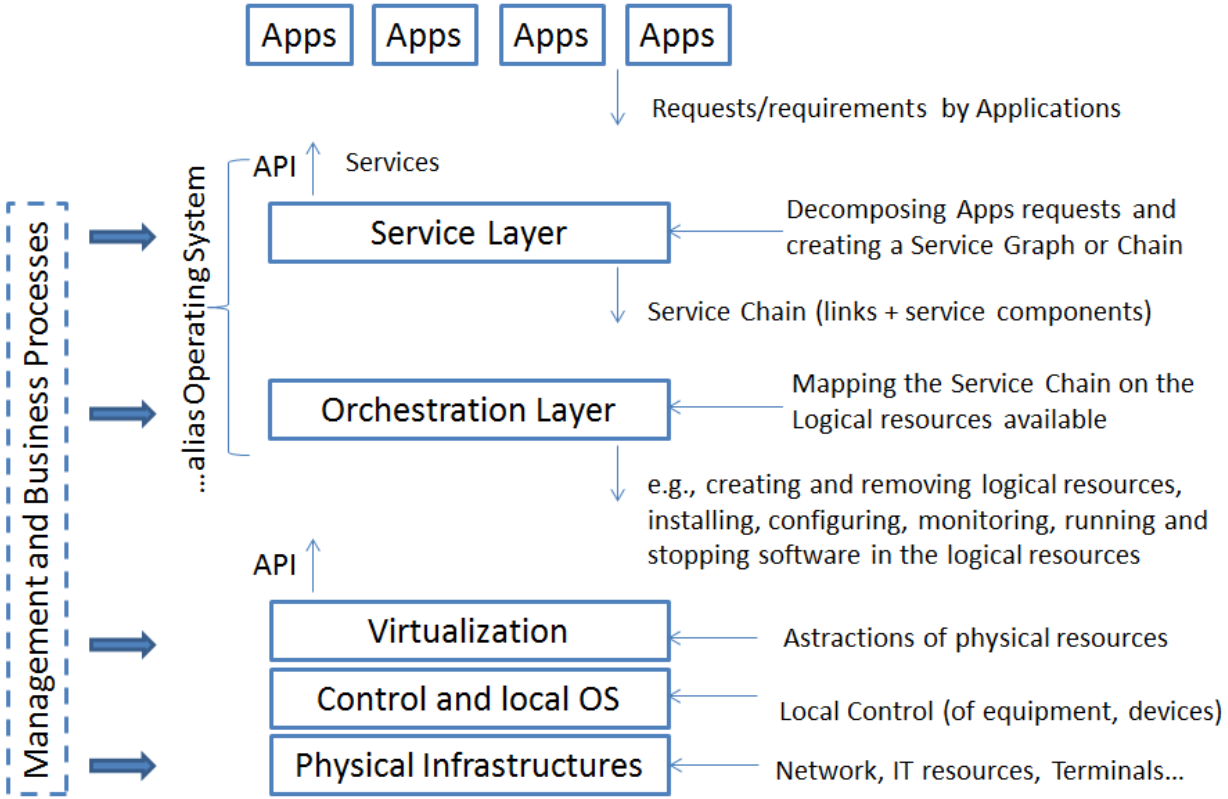
Telecommunication terminals of the future...



http://roboearth.org/

- *The RoboEarth Cloud Engine is an open source framework designed specifically for robotics applications.*
- *It helps robots to offload heavy computation by providing secure customizable computing environments in the cloud.*
- There are striking similarities with SDN-NFV Orchestrator (e.g. OpenStack)
- Robots can be attached and controlled/orchestrated as nodes or terminals of a Telecom Network !

Looking for a Universal Operating System…



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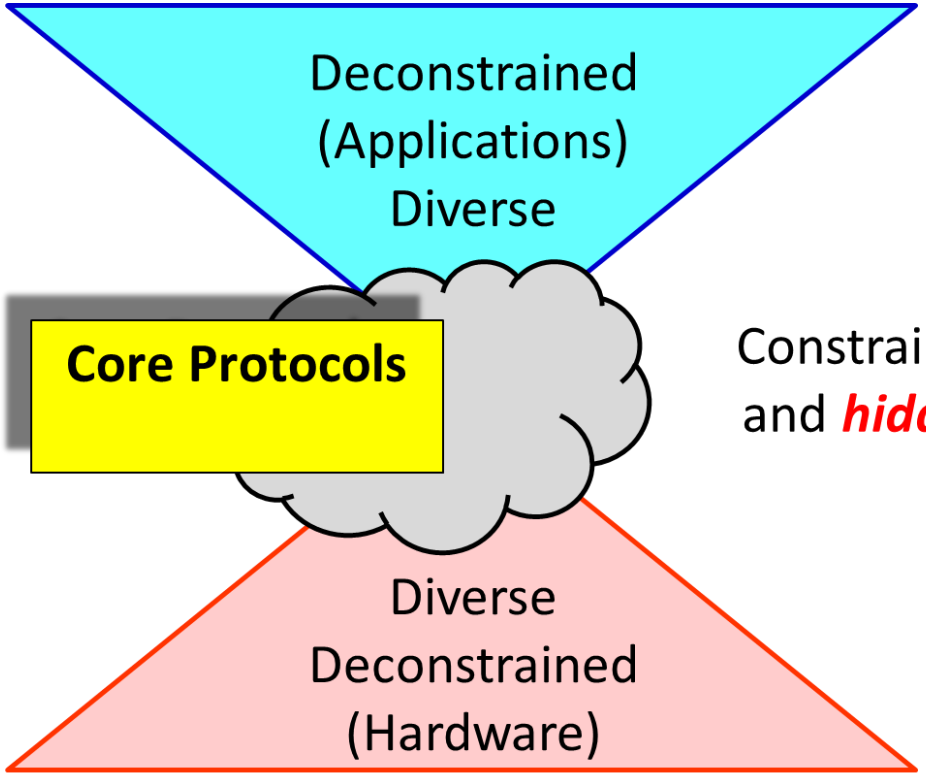
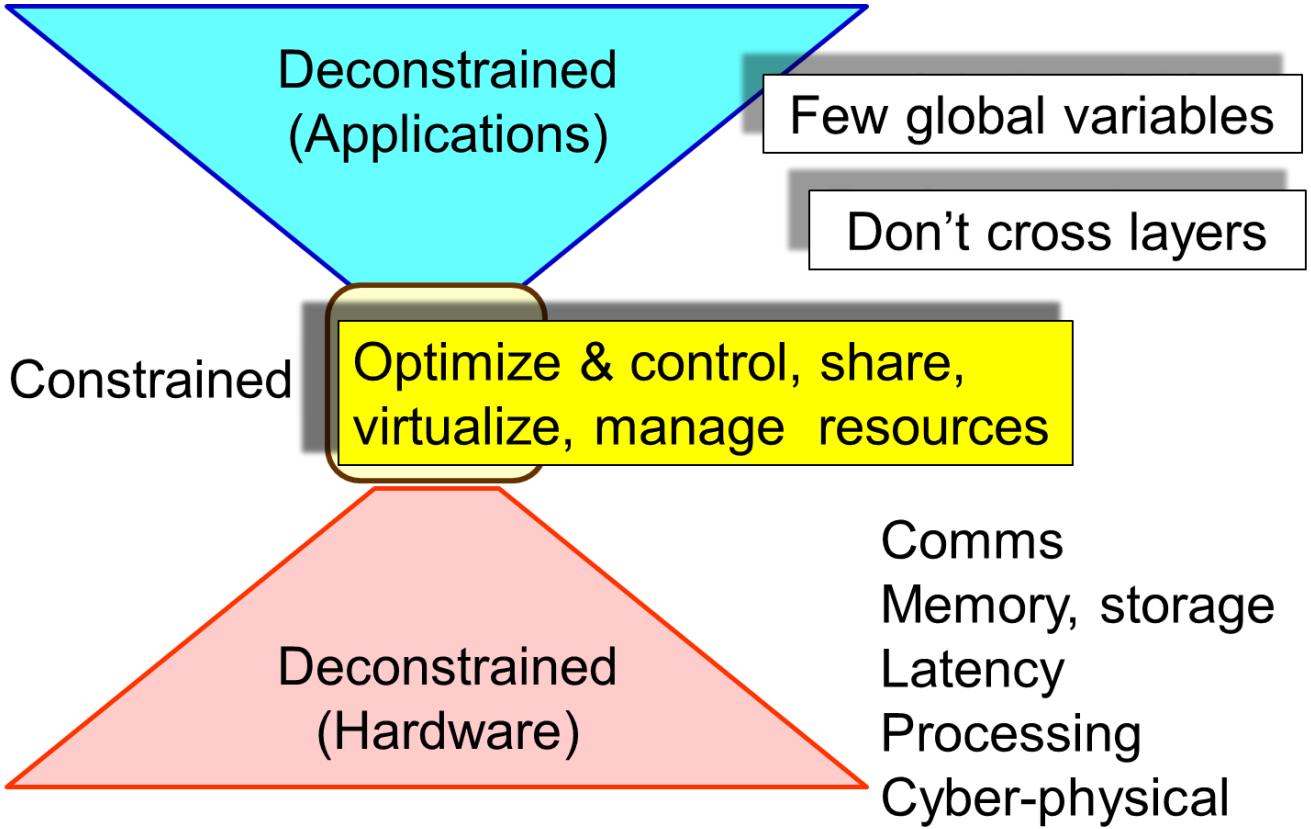


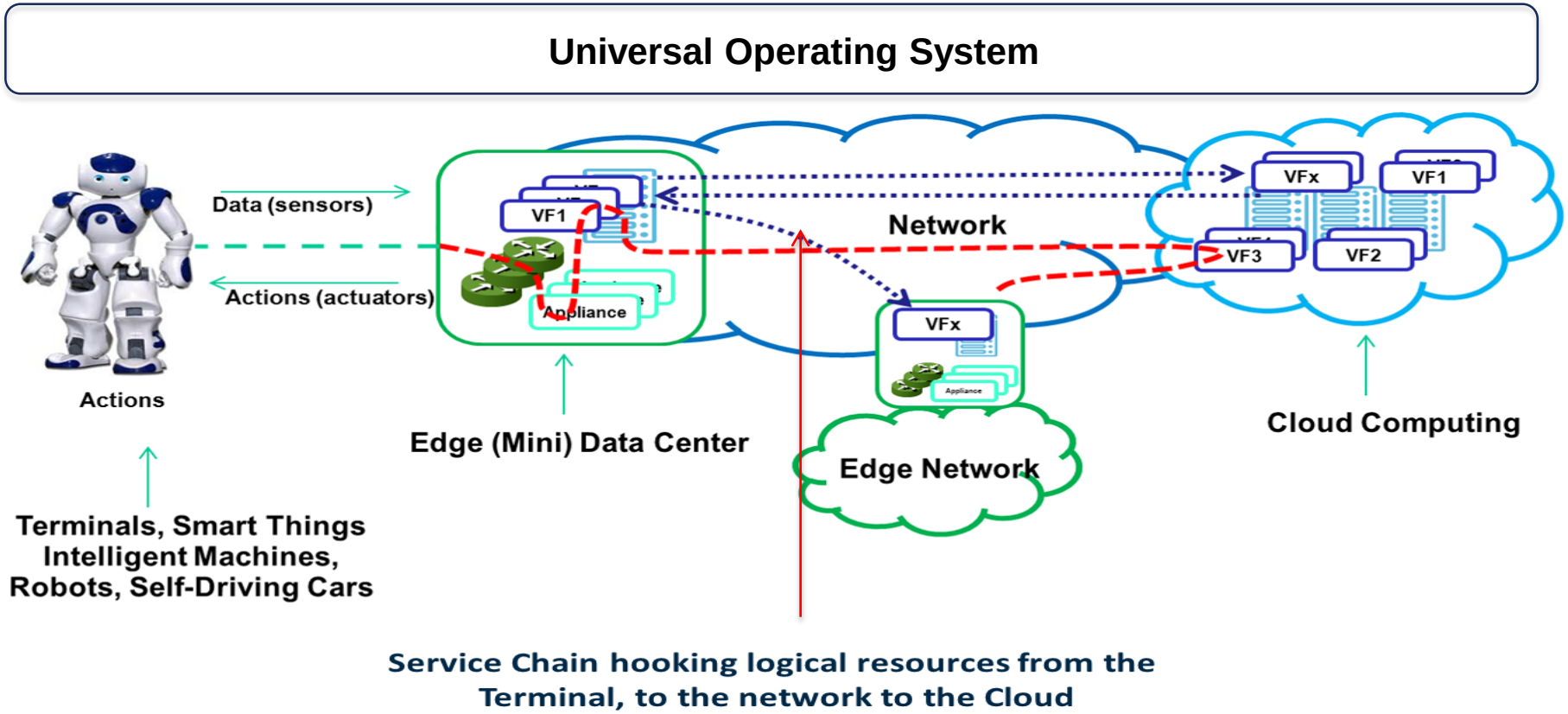
Slide courtesy John Doyle

Looking for a Universal Operating System…

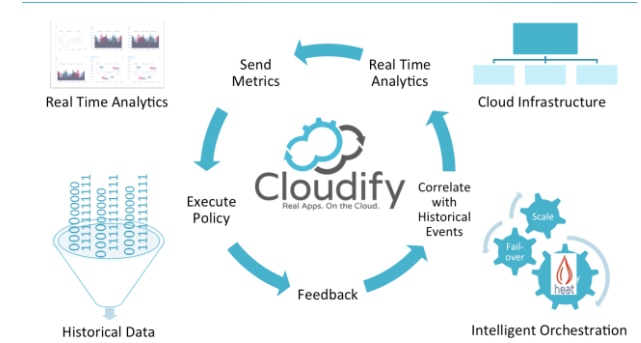


Source: J. Doyle

Looking for a Universal Operating System…



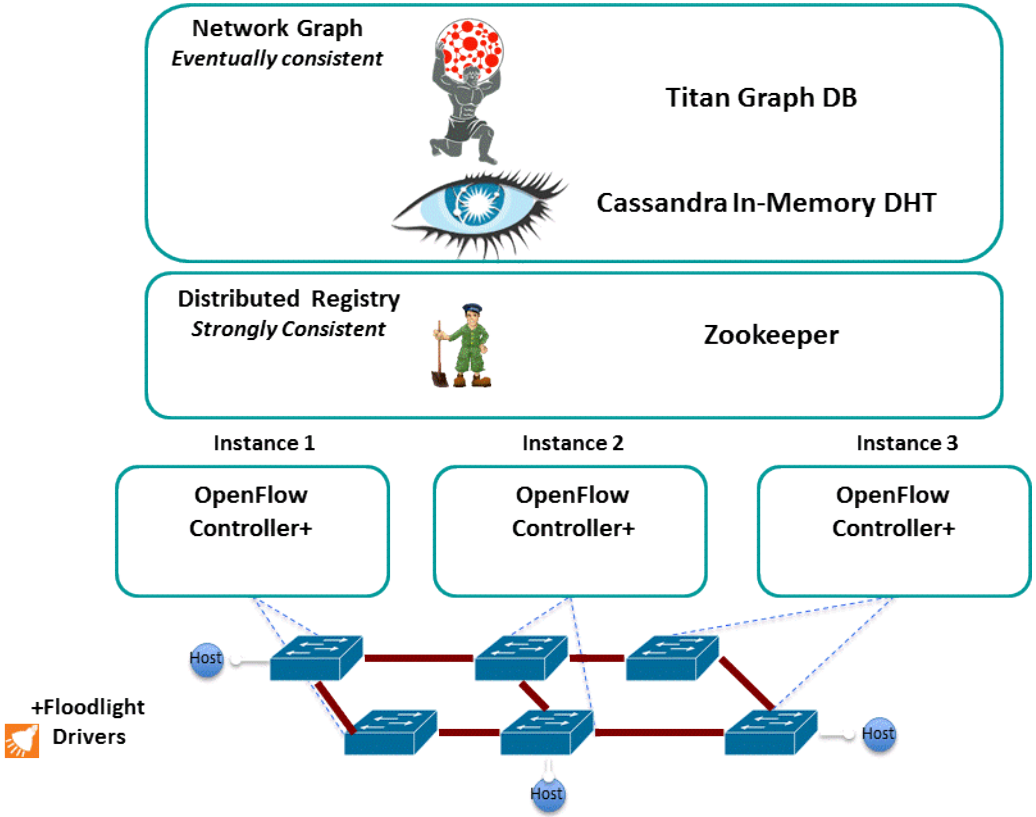
Developing with Open Source Software



- Cloudify adds monitoring, logging, alerts, analytics, workflow automation, software stack configuration, and dependency management;
- OpenStack is a free and open-source cloud computing software platform, which can be used as a based for an Orchestrator;
- OpenDaylight is an open source project developing a modular, pluggable, and flexible controller platform for SDN-NFV.

http://getcloudify.org/openstack-architecture-cloudify.html

Developing with Open Source Software



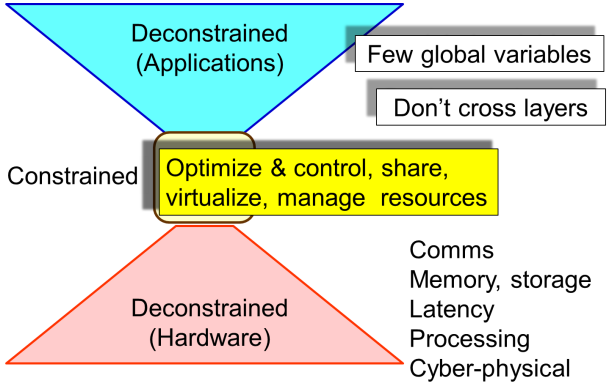
Source: ON.OS

Innovation Agenda

- What are the abstractions to be provided and used at the different levels ?
- What virtualization techniques ?
- How orchestrating applications life-cycles, how managing software and hardware infrastructure's resources ?
- What kind of controllers for different kind resources (up to terminals)?
- Which levels of "programmability" will be offered to Third Parties and Users through dynamic APIs ?
- How automating Operations processes ?
- How ensuring multi-domain, multi-vendor interoperability for virtual platforms (clash Standardization traditional processes vs Standards-de-facto) ?
- How facing Security and Privacy issues with solutions "by design" ?

Conclusions

- SDN and NFV are NOT only about Networks !
- SDN and NFV are expressions of a systemic trend «integrating» Cloud, Networks and Terminals;



- Two innovation cycles: slow and fast;
- Softwarization will create a «new value» for the infrastructures which will become the «Nervous System» of the Digital Society and Economy;
- Robot, Drones, Intelligent Machines ill become «Terminals» of the future.

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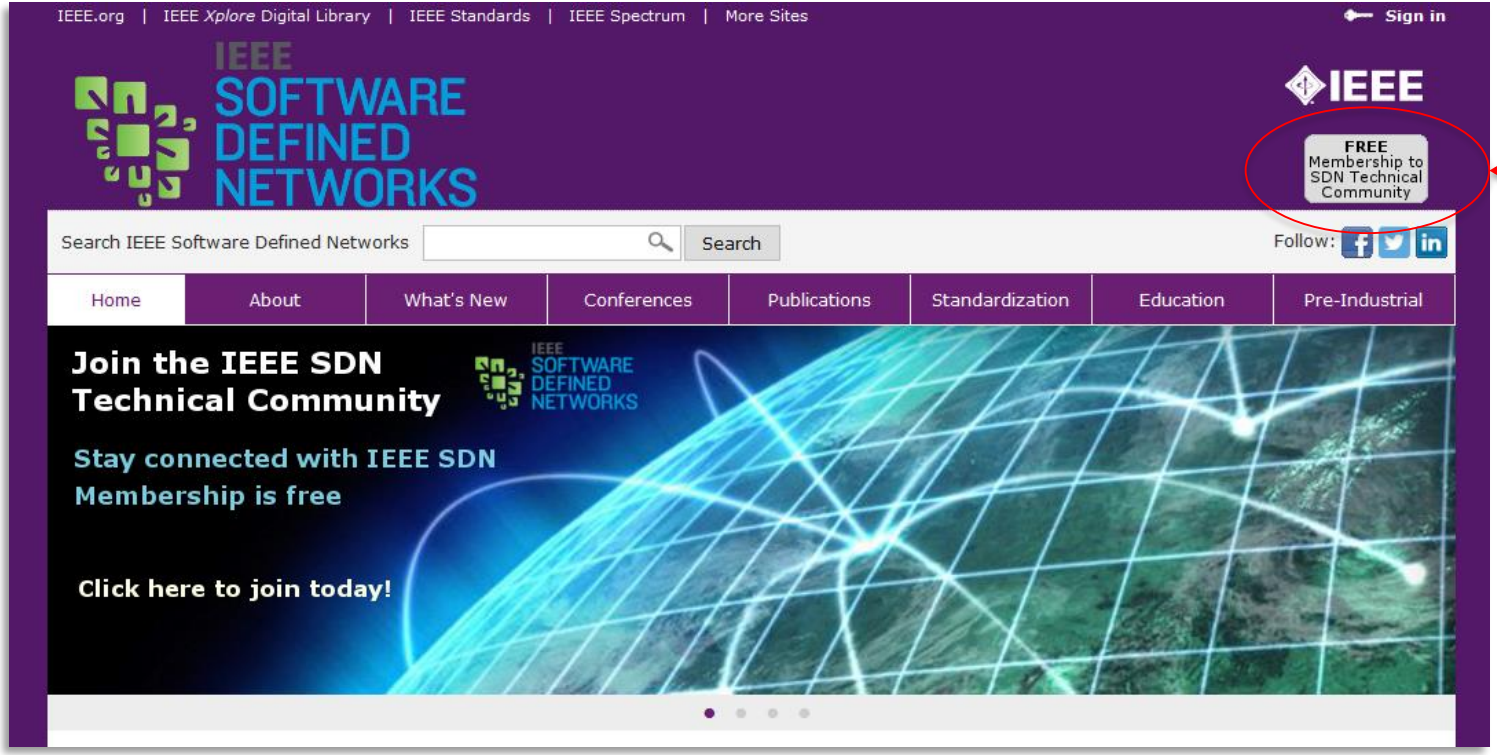

Thanks
Arrivederci !

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http://sdn.ieee.org/