Softwarization
And the Disappearing
Internet of Things

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Abstract

▶ The borders between "the Network and the Cloud" and "the Network and what is connected to it" are going to disappear;

▶ in fact, terminals, devices, machines, smart things are becoming like terminals, end-nodes, storing data locally and even executing network functionality and service components;

▶ "Softwarization" will transform Telco-ICT infrastructures into a "continuum" of logical resources - from terminals, through the Network, up to the Cloud Computing.

▶ This "continuum" will be so *embodied* into reality that it will *disappear*…or it will appear only if it's not working properly !
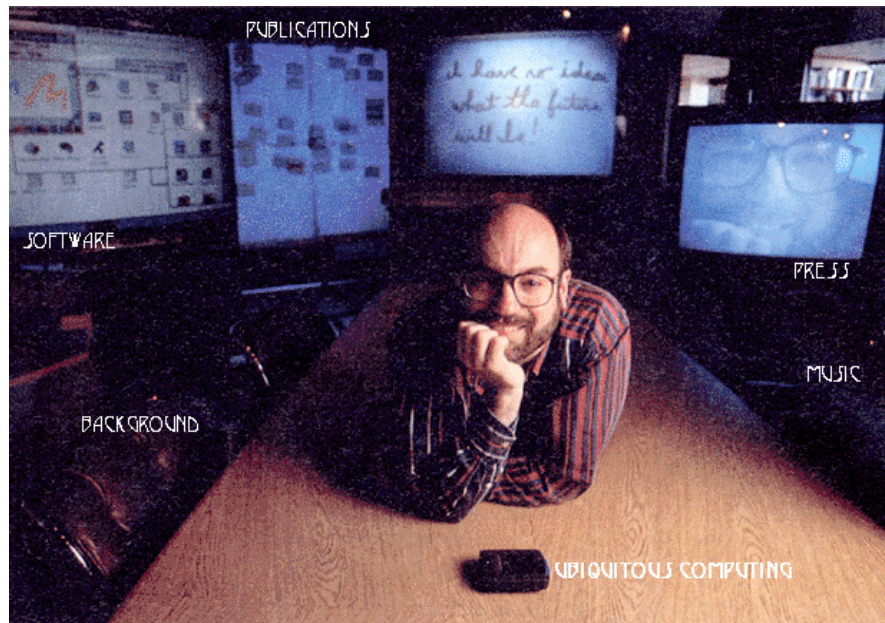
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"...the Internet will disappear"
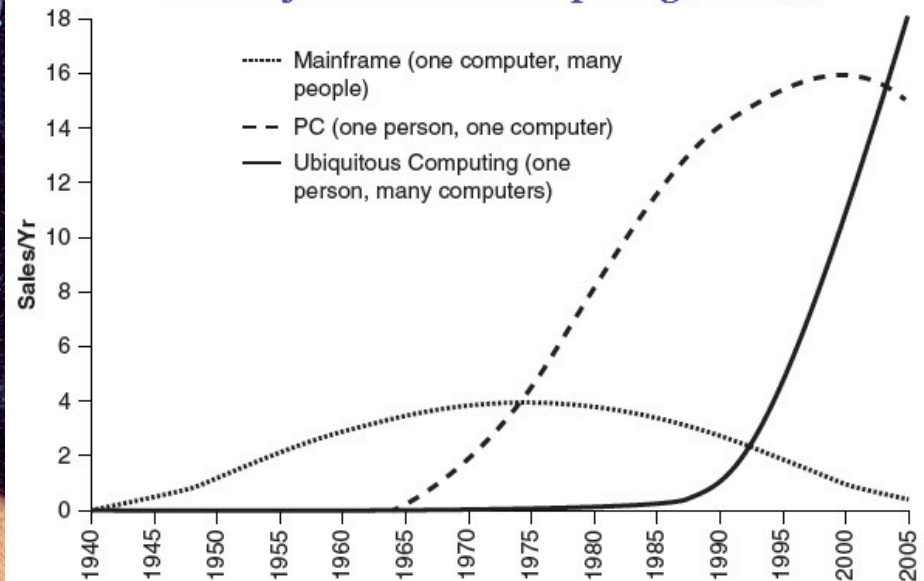
Eric Schmidt

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A Vision of the 90's !

"The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it."
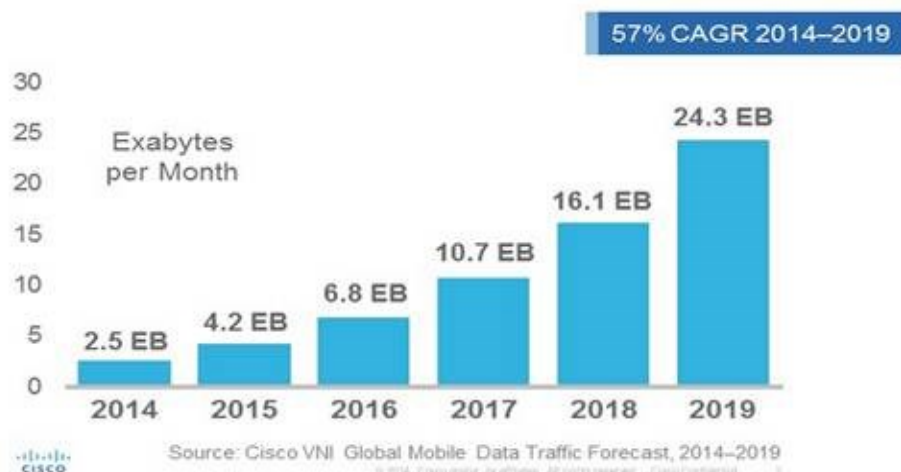
Marc D. Weiser (Xerox Parc)

https://www.ics.uci.edu/~corps/phaseii/Weiser-Computer21stCentury-SciAm.pdf

Technology is Accelerating, Costs are Decreasing...

▸ Three Laws are converging to a "tipping point":

  ▸ Moore's Law: processing power of chipsets is doubling every 24 months (costs halves for the same level the processing power);

  ▸ Gilder's Law: bandwidht of communication systems triples every 12 months (costs decrease);

  ▸ Metcalfe's Law: the value of a network is proportional to the square of the number of nodes (costs of getting connected decrease, but the value increases as the network it grows).

Global Mobile Data Traffic Growth / Top-Line
Global Mobile Data Traffic will Increase 10-Fold from 2014–2019

57% CAGR 2014–2019

Exabytes per Month

Year	Value
2014	2.5 EB
2015	4.2 EB
2016	6.8 EB
2017	10.7 EB
2018	16.1 EB
2019	24.3 EB

Source: Cisco VNI Global Mobile Data Traffic Forecast, 2014–2019

cisco

▸ One-third of traffic will come from TVs, Handsets, and other non-PC devices (Internet video and Web);

▸ generated by a few popular files, accessed in an asynchronous way;

▸ predictable distributions (what, when and where will be requested);

▸ delay tolerant, variable quality, suited for best-effort.

Intelligence is Moving Toward the Edge

▶ The number of terminals, devices, smart things, machines connected to the Network is growing at an exponential rate;

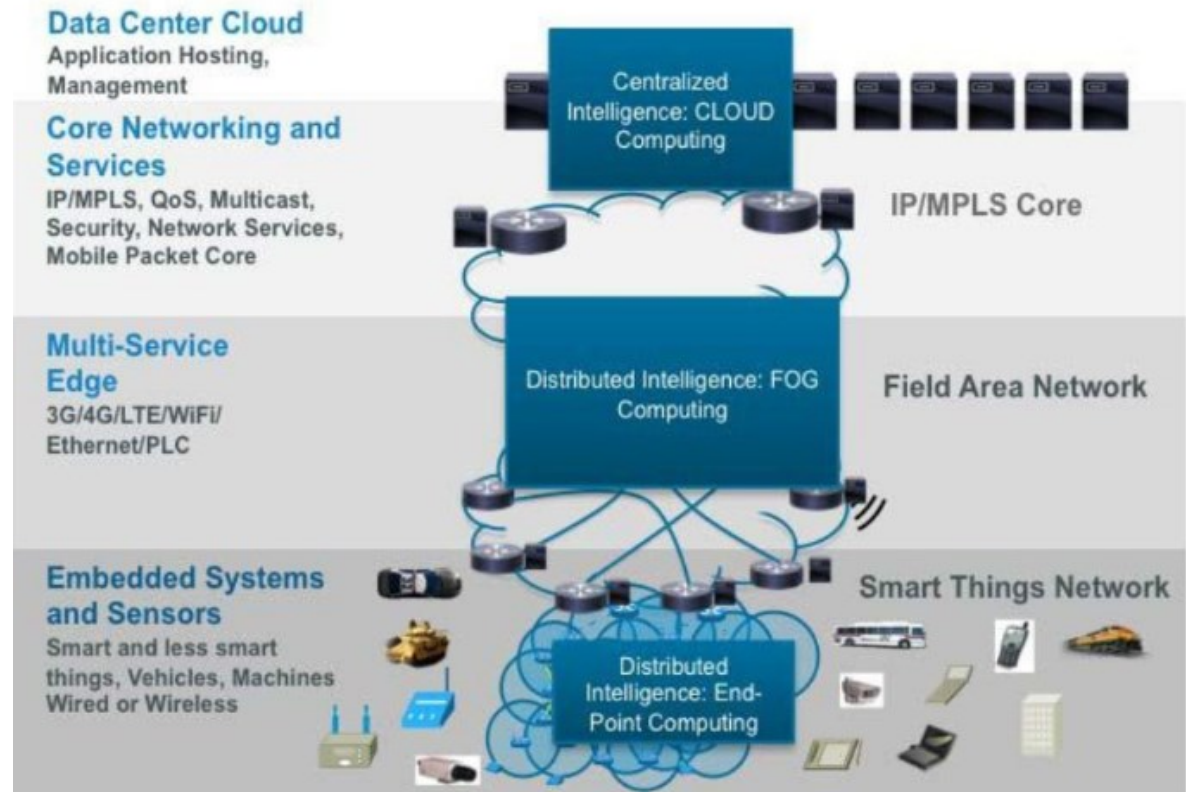▶ they are more and more powerful and so capable of executing applications and storing big quantities of data;

http://www.businessweek.com/articles/2013-02-14/smartthings-aims-to-deliver-the-internet-connected-home

▶ Cloud Computing is being complemented by the enormous processing and storage power of local edge nodes, terminals, machine, smart things... (Edge Computing, Fog Computing)

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Intelligence is Moving Toward the Edge

▸ Fog Computing is extending the Cloud Computing up to the edge of the network. Services can be executed (and data stored) at the edge, up to the Users devices<

▸ main characteristics:

    ▸ proximity to Users,

    ▸ dense distribution;

    ▸ support for mobility.

Data Center Cloud
Application Hosting, Management

Core Networking and Services
IP/MPLS, QoS, Multicast, Security, Network Services, Mobile Packet Core

Multi-Service Edge
3G/4G/LTE/WiFi/ Ethernet/PLC

Embedded Systems and Sensors
Smart and less smart things, Vehicles, Machines Wired or Wireless

Centralized Intelligence: CLOUD Computing

IP/MPLS Core

Distributed Intelligence: FOG Computing

Field Area Network

Distributed Intelligence: End-Point Computing

Smart Things Network

Source: CISCO

Intelligence is moving toward the Edge

▶ Cloud vs Fog Computing

	Key Use Cases	Areas of application	Software frameworks	Key requirements	Actors (end users and providers)
Cloud Computing at the Core	Large Batch Jobs	Deep data mining, search, financial algorithms	MR/Hadoop	Scalability, security, availability	Enterprises, individuals
	DC Bursting				
	Web Hosting	E-commerce	Web applications		
	Storage				
Fog Computing	Mobile Content Delivery	Video streaming, gaming	rendering, transcoding	Low latency	end subscribers, service providers
	Geo-distributed Sensor/Actuator Networks	Smart cities, environmental monitoring	Fusion/aggregation, MR	Geo-distribution, security, privacy	Utilities, federal/state agencies, car manufacturers
	Large Scale Distributed Controlled Systems	SCV, Smart Grid, Int. Transportation	Control loops	Partitioning/ quasi-autonomy, security	

Source: CISCO

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Technology Adoption is Accelerating

▸ …cell phone took less than 10 years to reach 25% of the US population while the telephone took over 30 years.
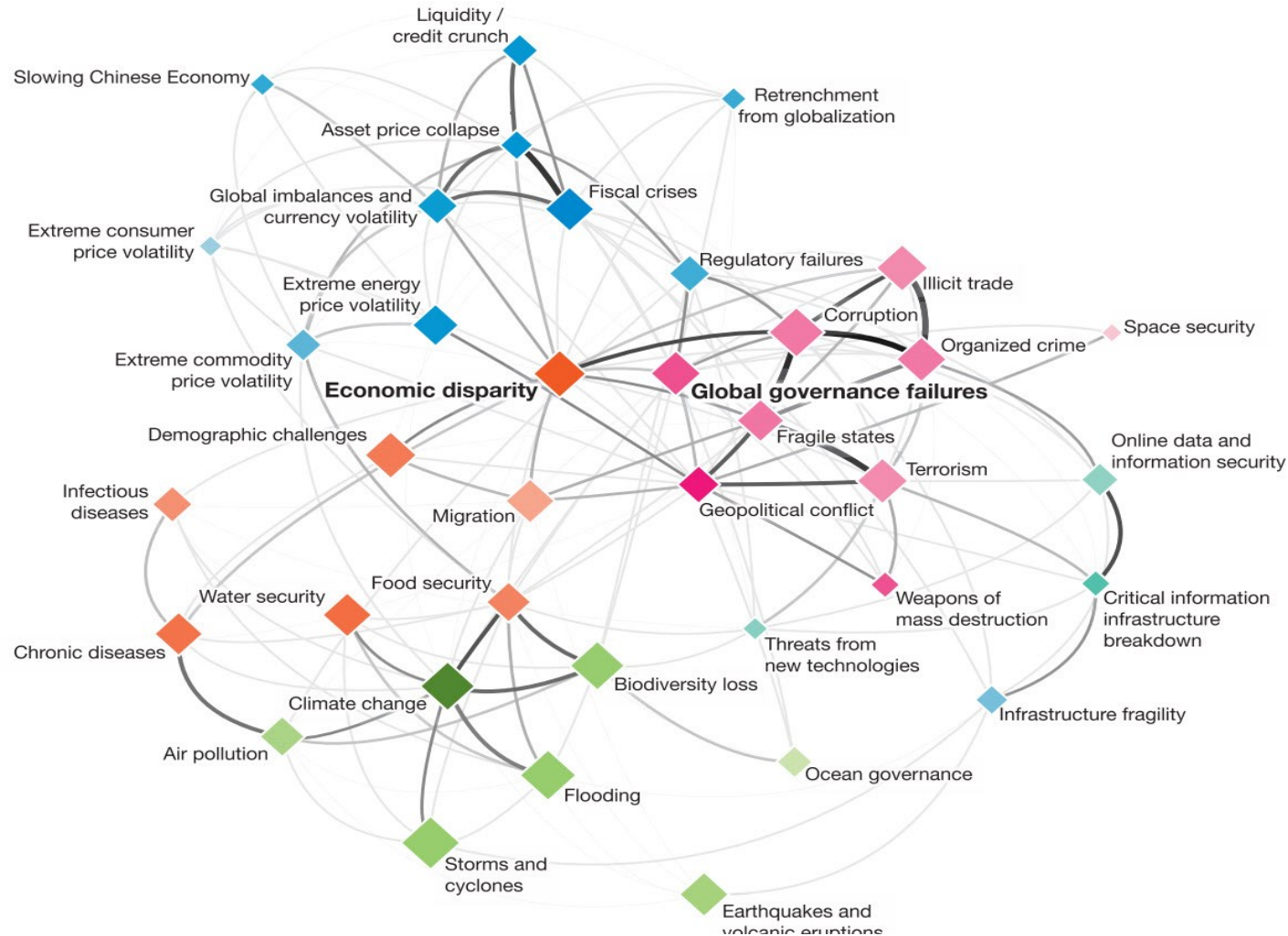

Technology Adoption
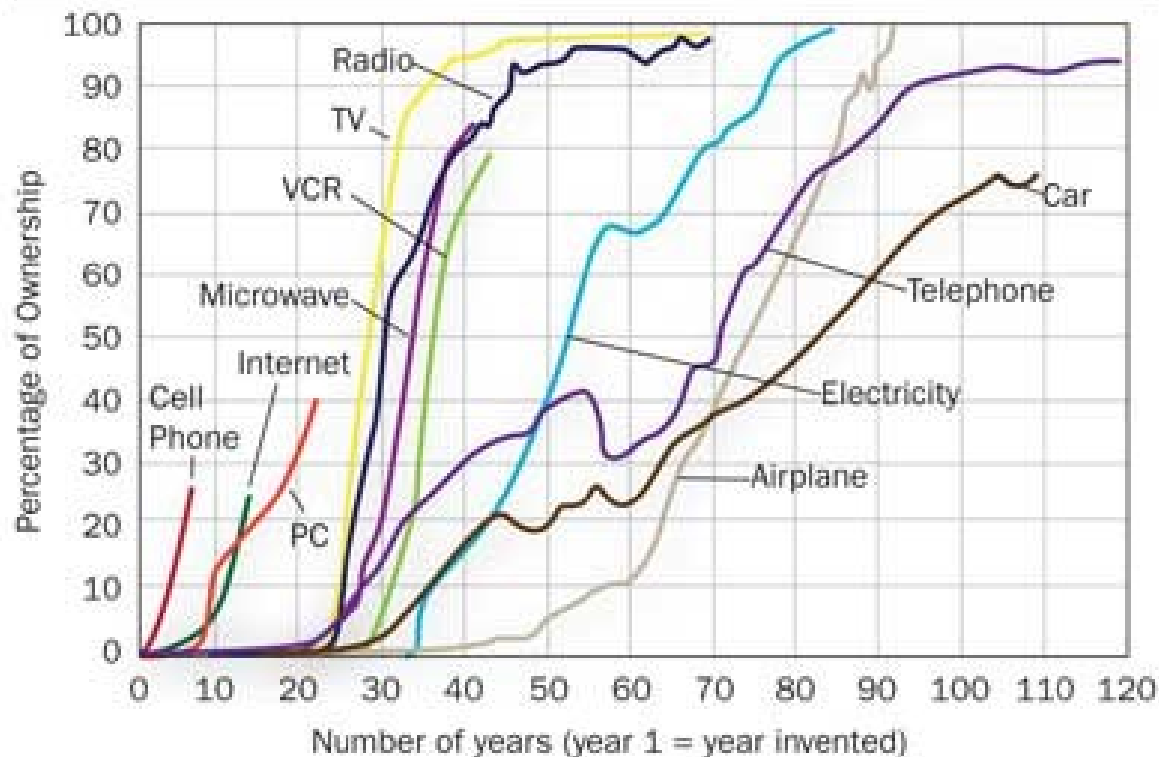
Source: Forbes Magazine

Open Source

▶ …wider and wider availability of Open Source S/W and H/W

ICT Fades Into a Hyper-Connected Reality Impacting Several Variables

Systemic interdependencies of the socio-economic variables of the hyper-connected world (credit: World Economic Forum)

Two Enabling Technologies: SDN and NFV

▸ SDN: **separation of Software** (e.g., control plane) **from Hardware** (e.g. data plane, packets forwarding).

▸ NFV: **virtualization of network functions** (e.g. middle-boxes) for a dynamic allocation and execution on general purpose Hardware.

▸ SDN and NFV are mutually beneficial, but are not dependent.

Source: ONF and ETSI

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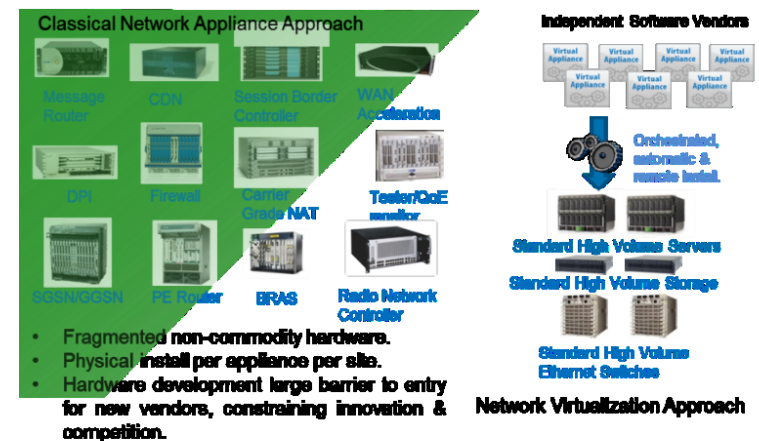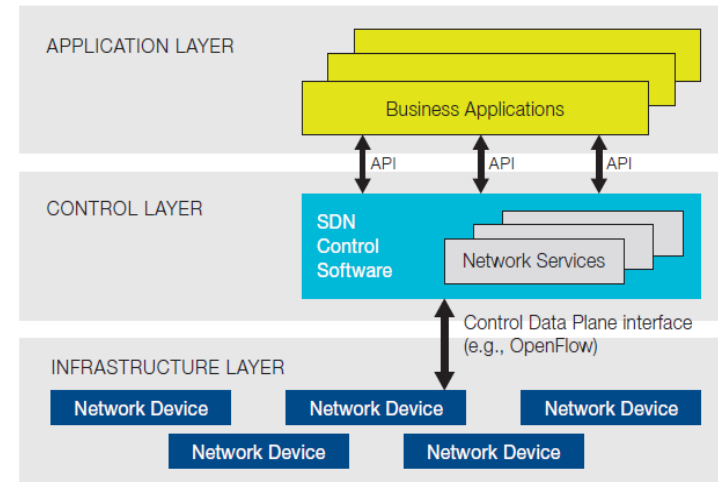
Softwarization of Telco-ICT Infrastructures

▸ Diffusion of ultra-broadband, chipsets and IT hardware advances and tumbling costs, growing availability of Open Source software are creating the conditions for a change of paradigm in Telco-ICT domains;

▸ The combined effect of all these drivers are bringing 1) more and more powerful terminals, and 2) the "Softwarization" of Telco-ICT infrastructures.

▸ "Softwarization" is appearing under the form of divers technologies and models (Cloud Computing, Edge-Fog Computing, SDN, NFV), sharing the same common denominator:

  ▸ all network and service functions can be virtualised and dynamically allocated onto logical resources hosted onto an underneath physical infrastructure, fully decoupled.

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Impact of Softwarization
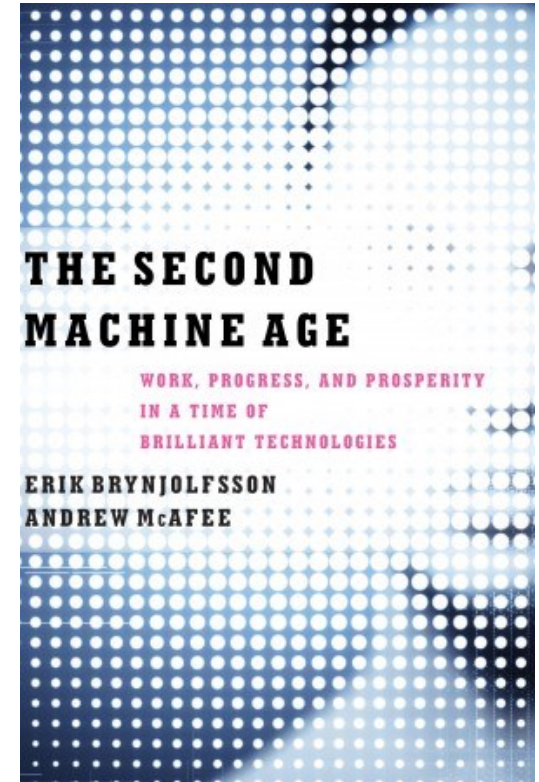
▶ …integrating of Cloud/IT and Networks resources:

▶ It will be possible executing any network and service function as "applications" on logical resources, dynamically allocated and moved on a physical infrastructure, which is fully decoupled;

▶ processes normally adopted for DCs, such as dynamic allocation, migration and cloning of logical resources as VMs (e.g. for server consolidation, load balancing, etc.) will be performed also for the Network, even up to Users' terminals;

▶ …blurring the border between the Networks and what connects to the Networks:

▶ any terminal, devices, machines, smart things, robots, drones…will become like "network nodes" (powerful and full of capabilities);
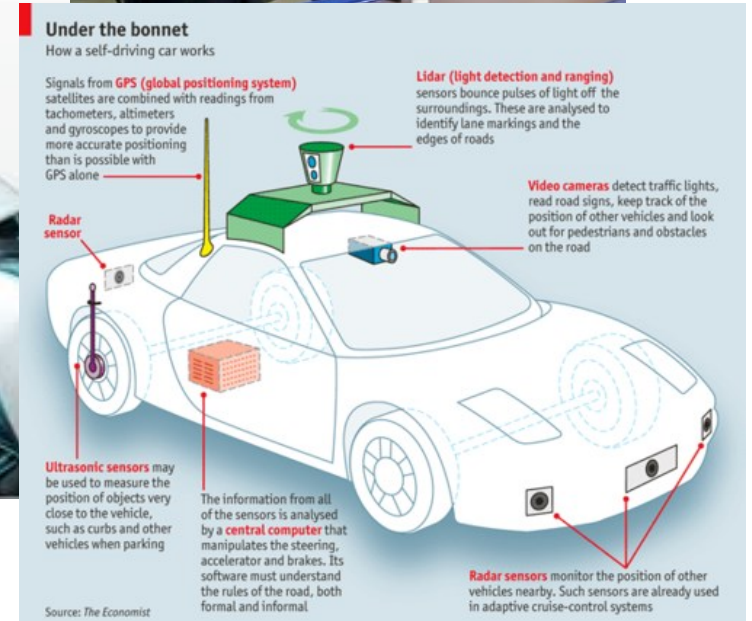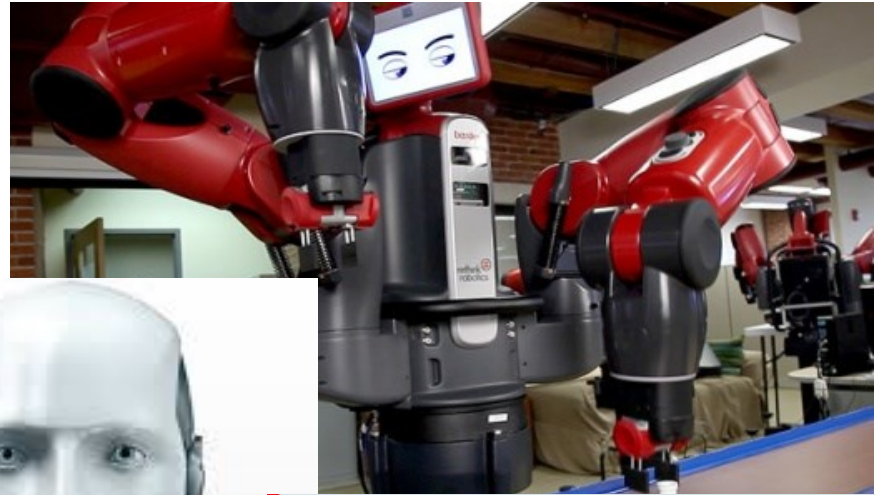
Impact of Softwarization

▸ Softwarization will allow:

  ▸ sensing and collecting massive data (by sensors, terminals, things);

  ▸ exchanging quickly big sets of data (transported by fixed and mobile networks with high bandwidth and low latency);

  ▸ elaborating big data (with Cloud and Fog Computing) in order to make decisions for actuating local actions (by any actuators)…

▸ …but this how "cognition" (nervous system) works!

  ▸ collecting, elaborating and exchanging data and information to adapt (autonomically) to the environment and also learning;

▸ Softwarization will create a sort of «nervous systems» fully embedded into the Digital Society!

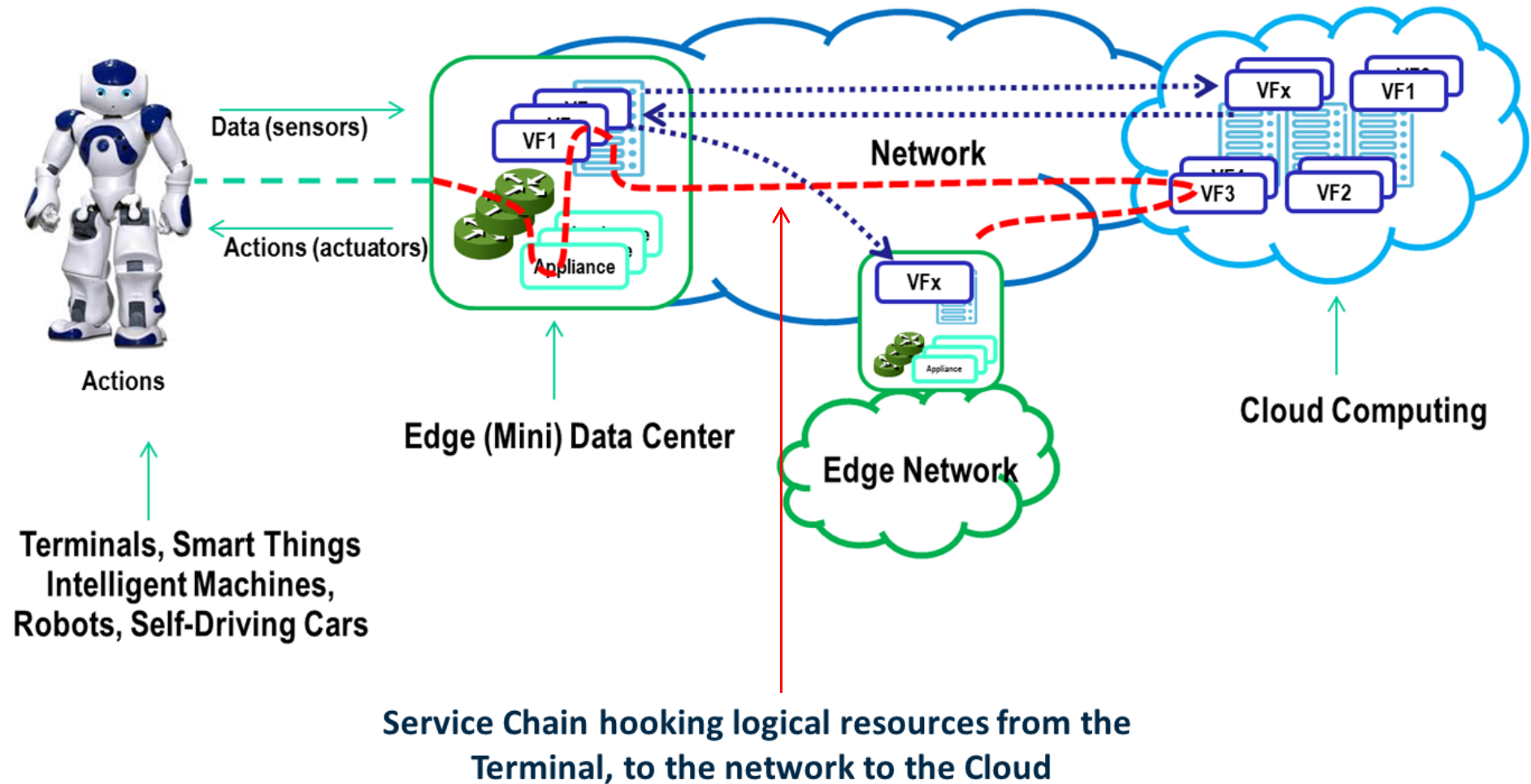# Softwarization Enabling Pervasive Machine Intelligence

▸ An intelligent machine (i.e., a robot) could be considered as a sort of future "terminal" combining sensors, actuators and processing power:

  ▸ It collects data from the environment through its sensors, it executes its "cognition" (i.e., its service logics), it actuates the decisions through its actuators;

  ▸ The service logics of the robots can be executed in logical resources (VMs or Containers) in a local host or remotely (e.g., where more powerful resources are available)

THE SECOND MACHINE AGE

WORK, PROGRESS, AND PROSPERITY IN A TIME OF BRILLIANT TECHNOLOGIES

ERIK BRYNJOLFSSON
ANDREW McAFEE

Machines, Smart Things, Robots Will be the Future Terminals

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Machines, Smart Things, Robots Will be the Future Terminals

Service Chain hooking logical resources from the Terminal, to the network to the Cloud

CogniToys: Internet of Smart Toys that Learn and Grow

The green CogniToy dinosaur is powered by one of the most powerful supercomputer artificial intelligence engines ever built.

▸ *The first 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.*

▸ *Here's the mind-blowing part: the question is processed, and the answer is given, by IBM's Jeopardy-winning Watson artificial intelligence supercomputer system.*

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

Where the «Value» is Moving

Service Logics, Mathematics, A.I.

↓

**Open Software
(Applications)**

↓

**Logical Resources
(e.g., VMs, Containers, etc)**

↓

**Hardware
(e.g., CPU)**

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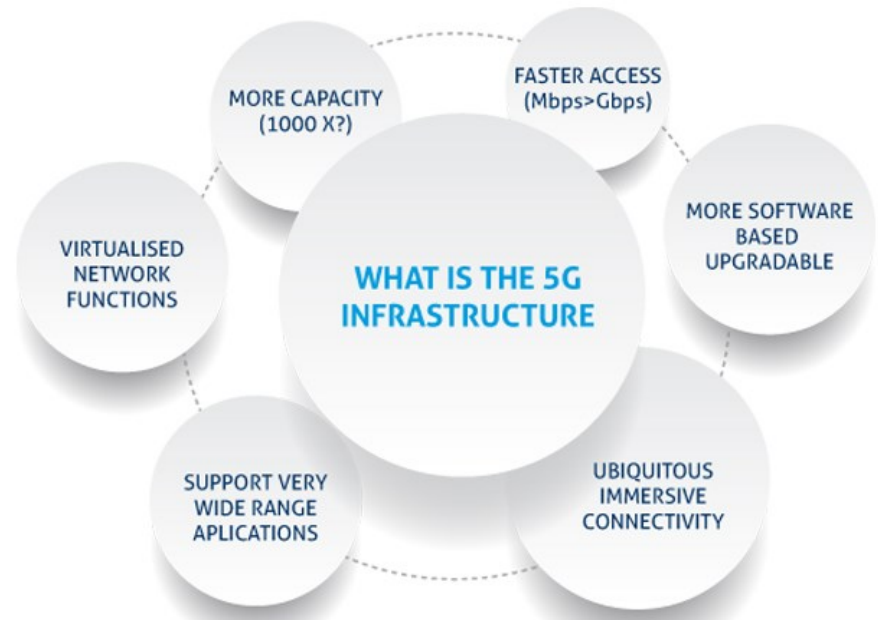# Red Ocean or Blue Ocean?

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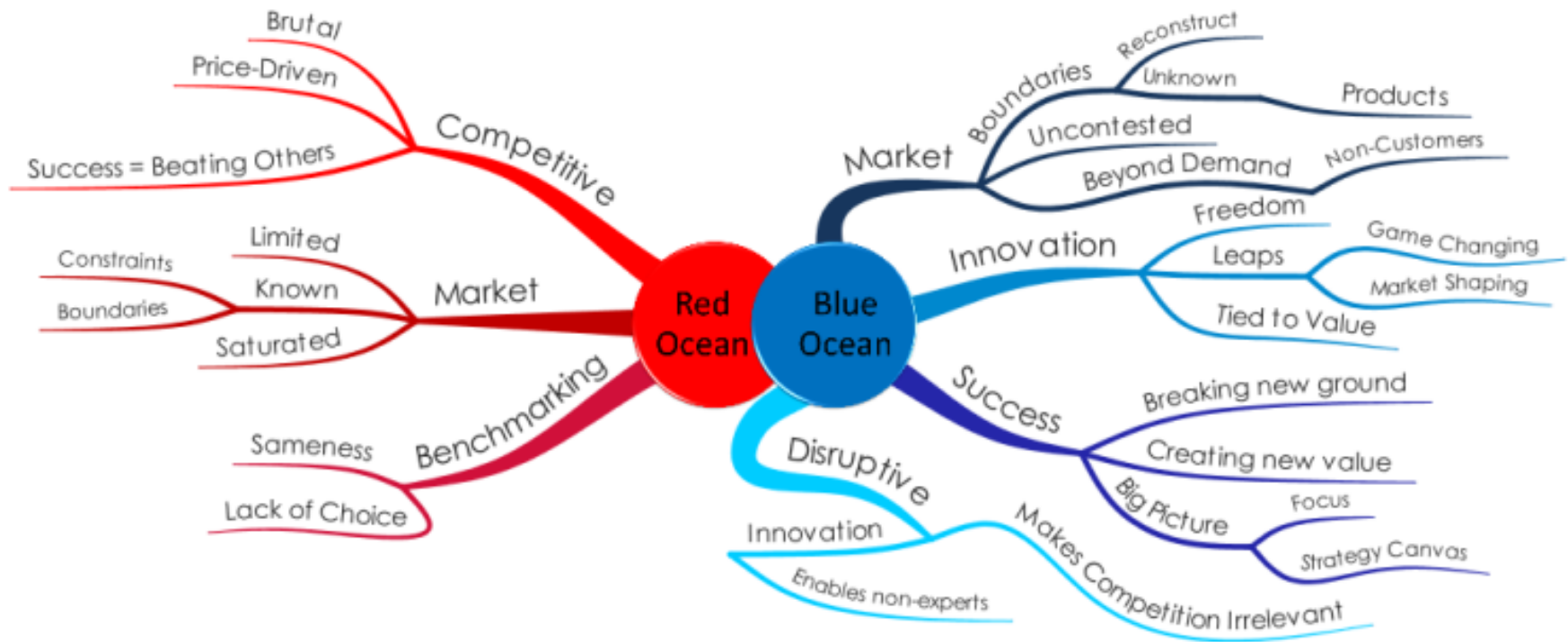
Towards 5G

▸ 5G will be a very high capacity and ubiquitous infrastructure, bringing to convergence fixed and mobile accesses, and integrating processing and storage capabilities.

Source: http://5g-ppp.eu/about-us/

Softwarization Scenarios for Telecom Operators - I

▶ **Scenario Red: gradual evolution (continuity)**

  ▶ pursuing a gradual evolution in exploiting SDN-NFV onto legacy Telco infrastructures: e.g., starting from virtualizing some functionality.

  ▶ Main challenges:

  – **interoperability of SDN-NFV with legacy systems**, **need of Standards** (delays, lock-ins) and above all need of **enhancing of the legacy operational processes**, e.g. OSS/BSS, in order to cope with SDN-NFV (complicated, maybe impossible).

  ▶ Main benefits:

  – **potential savings in CAPEX and OPEX but** risk of jeopardizing said savings by the growing "complexity" and heterogeneity of the Telecom infrastructure;

  – **(partly) reducing the time to market but** it might be not short enough to cope with the dynamics of the market and the competitors pursuing the scenario blue (next slide);

  – **Partial API-tization**: processes are not flexible and fast enough to exploit fully APIs model opportunities.

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Softwarization Scenarios for Telecom Operators - II

▸ **Scenario Blue: disruption (point of discontinuity)**

　　▸ Some Telcos (or even new Players) will exploit full potential of "softwarization" much faster than in a Red scenario); they will jumps ahead in the markets, as fully Virtual Operators. Markets will decide the "standard de facto". Virtual Operators to adopt faster operational processes (IT-style) shortening the time-to-market.

　　▸ Main challenges:

　　　　– **Orchestration, Security, Privacy**

　　▸ Main benefits:

　　　　– **borderless operations** in any country where it is possible to rent a physical infrastructure;

　　　　– **anything as a Service**: anything can be transformed in a "gate" to provide and access new services and data (Internet of/with Things, pervasive robotics/machines);

　　　　– **full API**: processes to all allow Third Parties, Enterprises, residential Users (or even machines) to access and use APIs at various levels.

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Orchestration and Control: Towards a Distributed OS

▶ Orchestration should take care of the different steps involved in the provisioning of virtual functions and service;

▶ Orchestration capabilities includes, for example:

  ▶ Creating, monitoring, removing a Virtual Link;

  ▶ Placing, Monitoring and Removing VM;

  ▶ Installing, configuring, monitoring, running and stopping code in VMs;

  ▶ Creating and enforcing policies;

  ▶ Optimize placement of VMs into the physical networks and the traffic routing between VMs (e.g., double constrained optimization problem in "almost" real time).

"What about Cyber Security?"

A.I. and Industrial Mathematics

Research & Development Agenda

1. A.I. and Industrial Mathematics (methods and tools)

2. Mastering the Software (Open Source)

3. Orchestration and Control (a distributed OS)

4. QoS for Fully Virtualised Infrastructures

5. Security by Design

6. Privacy

7. New Service Paradigms (sustainability)

8. New Value Chains and Business Models

▸ IEEE SDN Initiative a cross-Society IEEE worldwide program based on an international technical community of experts engaged in the research, design and development of revolutionary advances in *Software Defined Networks* (SDN) and *Virtualization*.

▸ IEEE SDN Initiative is composed by seven committees: Conference, Education, Publications, Publicity, Standards, Pre-industrial and Outreach. Along these committees, Initiative will address specific stakes and challenges raised by *Softwarization* that goes beyond technical issues to also encompass skill development and economics.

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http://sdn.ieee.org/

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http://iot.ieee.org/

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Conclusions

▸ ICT acceleration and cost reductions;

▸ Softwarization is a «systemic» trend (Cloud, SDN, NFV…) blurring the borders between Terminals-Networks-Cloud;

▸ New «roles» for the Networks are possible (Blue Ocean):

  ▸ Intelligent Machines, Smart Things, Robots, Drones, Self-Driving Cars… will become the «future terminals», just like «virtual end nodes» providing new services (e.g., ultra-low-latency remote control, cognition-as-a-service, security-as-a-service…);

  ▸ The "Internet of – X" will be so *embodied* into reality to *disappear*… and ICT will become the new tool of the Digital Society and Economy.

Thank You and Arrivederci

http://ieee-sdn.blogspot.it/
https://twitter.com/a_manzalini
http://sdn.ieee.org/