Cognition-as-a-Service in 5G Networks

5G Networks meeting Cloud Robotics

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Abstract (1 - 3)

- Today the number of devices, terminals, machines connected to the Network is growing at an exponential rate.
- In the future more and more virtual network functionality will be executed part in the 5G network, part in the Cloud and/or part in the end-Users devices, terminals, machines….
- This will enable new services paradigms such as "Anything as a Service", where devices, terminals machines and also smart things and robots will become like innovative "tools" to produce and to use applications, services and data.
- 5G will become the “Nervous System” of the Digital Society and Economy, contributing to a growth more inclusive and sustainable.

Abstract (2 - 3)

- 5G will require a sort of decentralized kernel Operating System (OS) of spanning from the terminals, to the 5G network to the Cloud:
  - The kernel is the central part of an OS, which loads first, staying in memory and providing all the essential services.
  - The kernel is managing input/output requests from software applications, translating them into data processing instructions for the CPU and other components;
  - The 5G kernel OS's primary function is to manage the 5G hardware and other terminal and cloud resources and to allow software applications to run and use these resources.

Abstract (3 - 3)

- A key requirement of the 5G kernel OS will be allowing QoS with very limited values of "latency" (e.g. in the order of 1 ms).
- This will be a key factor of success to develop new ecosystems beased on very low reaction times, e.g., self-driving cars, self-acting machines, robot-as-a-services.
- In this direction, "Cognition as a Service" (CaaS) will be about introducing cognitive capabilities in the 5G OS, so that cognitive apps can be easily developed by means of APIs.
  - These capabilities will be based on methods and control techniques, including (nonlinear) dynamic systems, computational intelligence, intelligent control (adaptive control, learning models, neural networks, fuzzy systems, evolutionary and genetic algorithms), and artificial intelligence.

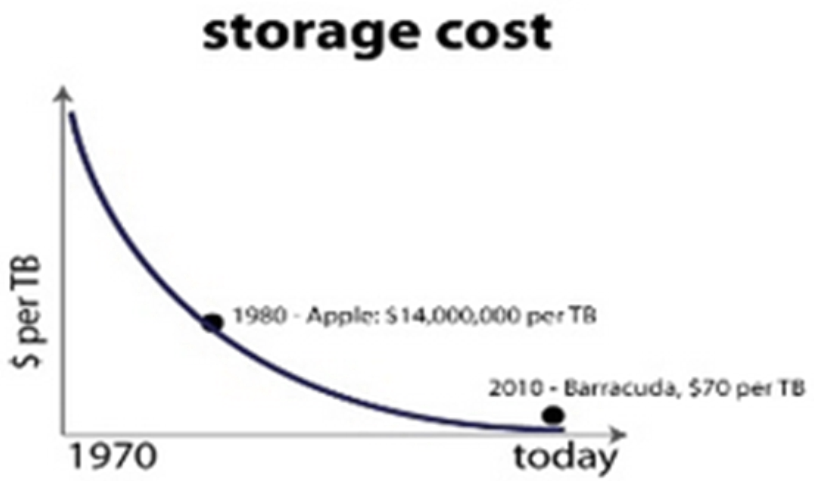
Definitions (1 - 2)

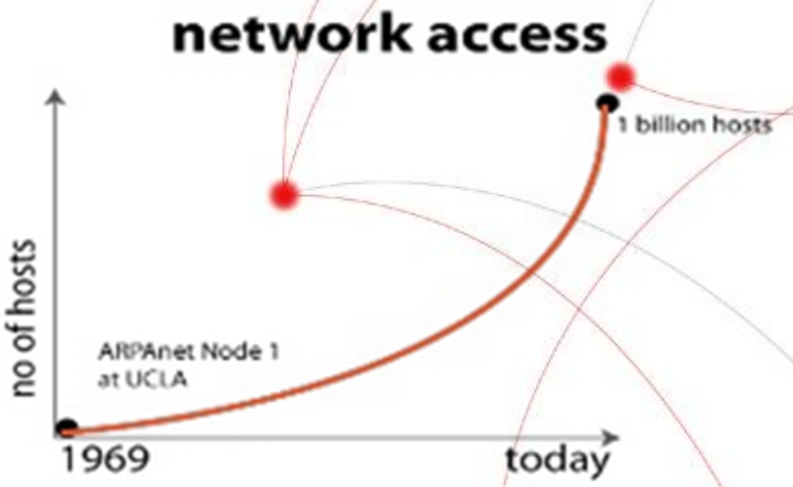
- Virtualization is about the creation of Logical Resources (e.g., VM), a software running on an HW host and emulates HW capabilities (e.g., an x86 CPU);
  - In Data Centers, for example:
    - several racks of servers;
    - each server may have many (host) CPUs;
    - each CPU may run several (guest) VMs.
- Many (but not all) Network Elements and Network Functions can be virtualized, i.e., replaced by software running on VMs:
  - for example, switches, routers, middle boxes (e.g. NATs, firewalls, IDS, etc.) could be virtualized (as long as the data rates are not too high).

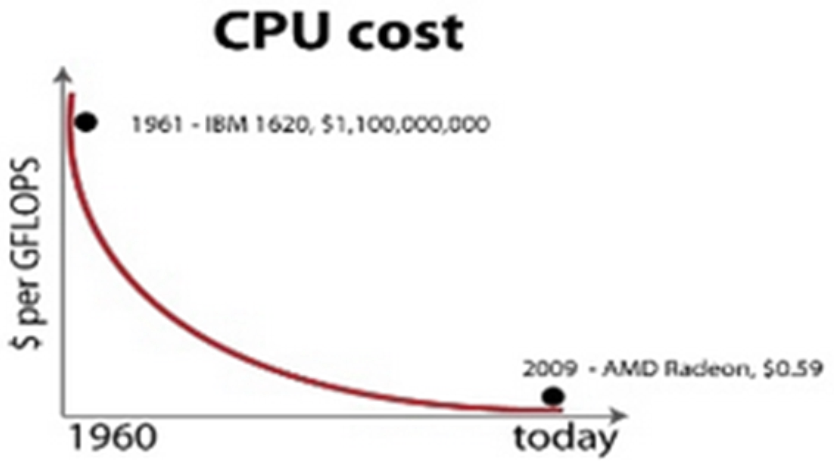
Definitions (2 - 2)

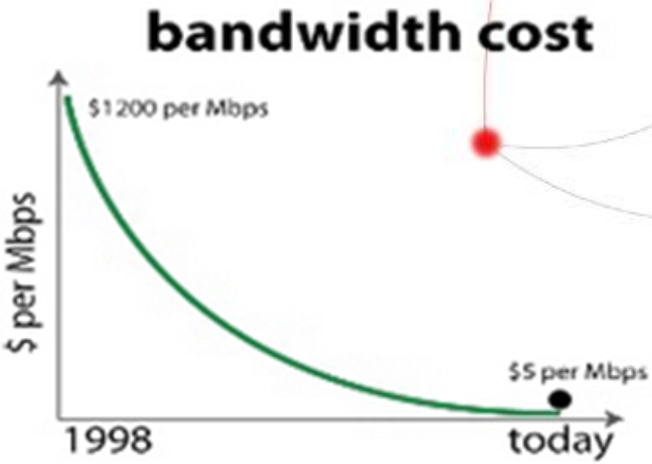
- SDN decouples control from data plane and provides open interfaces to control the connectivity provided by a set of network resources …
- NFV involves the implementation of network functions in software that can run on industry standard hardware, and that can be moved to, or instantiated in, various locations in the network as required, without the need for installation of new equipment;
- SDN and NFV are mutually beneficial but are not dependent on each other. Network Functions can be virtualized and deployed without an SDN being required and vice-versa.

Drivers (1 - 2)









Source: http://www.slideshare.net/medriscoll/driscoll-strata-buildingdatastartups25may2011clean

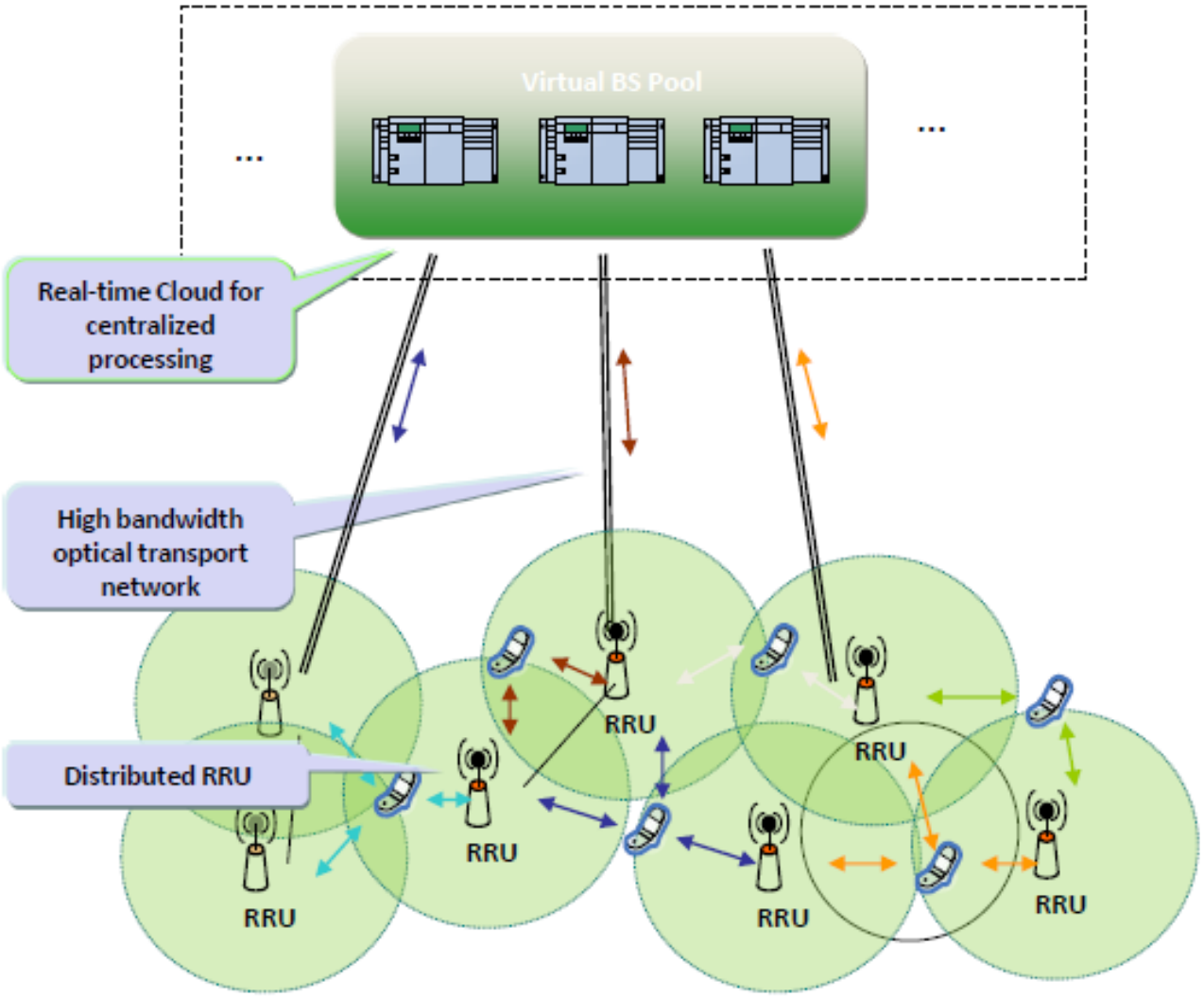
Drivers (2 - 2)

- **Softwarization a driver towards 5G Networks**
  - **Reducing Capex and Opex**
    - **e.g., limiting equipment costs, delaying HW investments and reducing power consumption (e.g., economies of scale of IT)**
  - **Optimizing Operations and increasing speed of Time to Market**
    - **e.g., learning lessons from OTTs**
    - **e.g., minimizing the typical network operator cycle of innovation**
  - **Enabling a variety of eco-systems**
    - **e.g., New Players (even small) can enter (just OPEX): more innovation to bring new services and new revenues quickly at lower risk.**
  - **Moving competition towards SW, towards Opex-based businesses**

Scenarios and Use Cases (1 - 3)

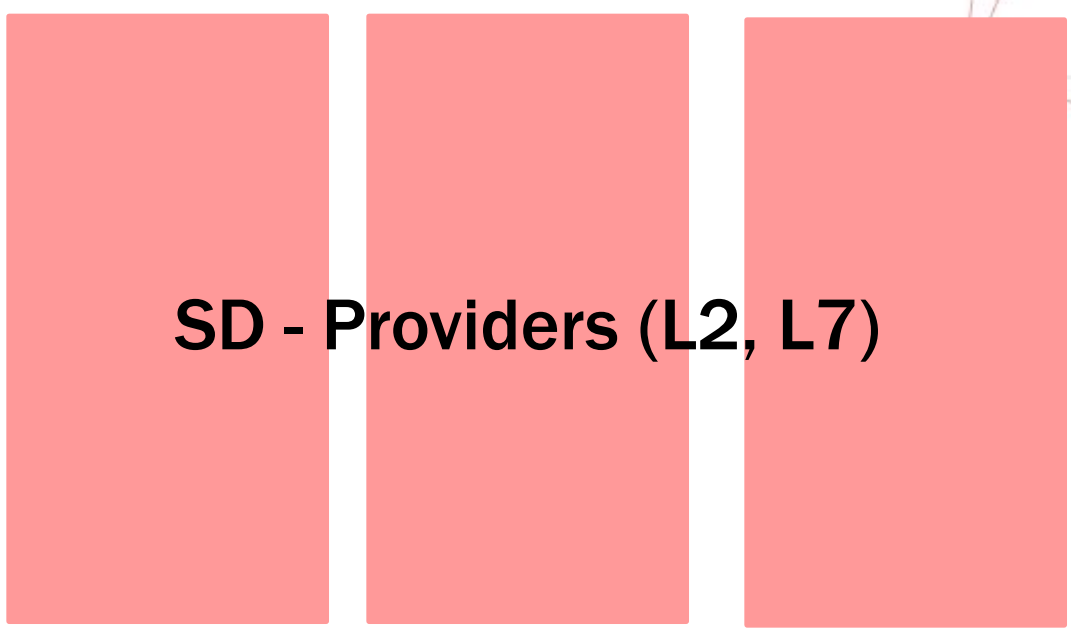
- A number of scenarios are possible depending on:
  - Split of Roles:
    - Infrastructure Providers (L1, processing, storage)
    - Software Defined – NS Providers (L2-L7) vs OTTs
      - with split degree (in execution, integration, management of L2-L7 VNFs)
  - Geographical dimensions:
    - National vs EU wide (e.g., EU Digital Single Market) deployments;
- Business (models) sustainability and regulation are among the key "control variables" of such scenarios.

Scenarios and Use Cases (2 - 3)



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

Scenarios and Use Cases (3 - 3)



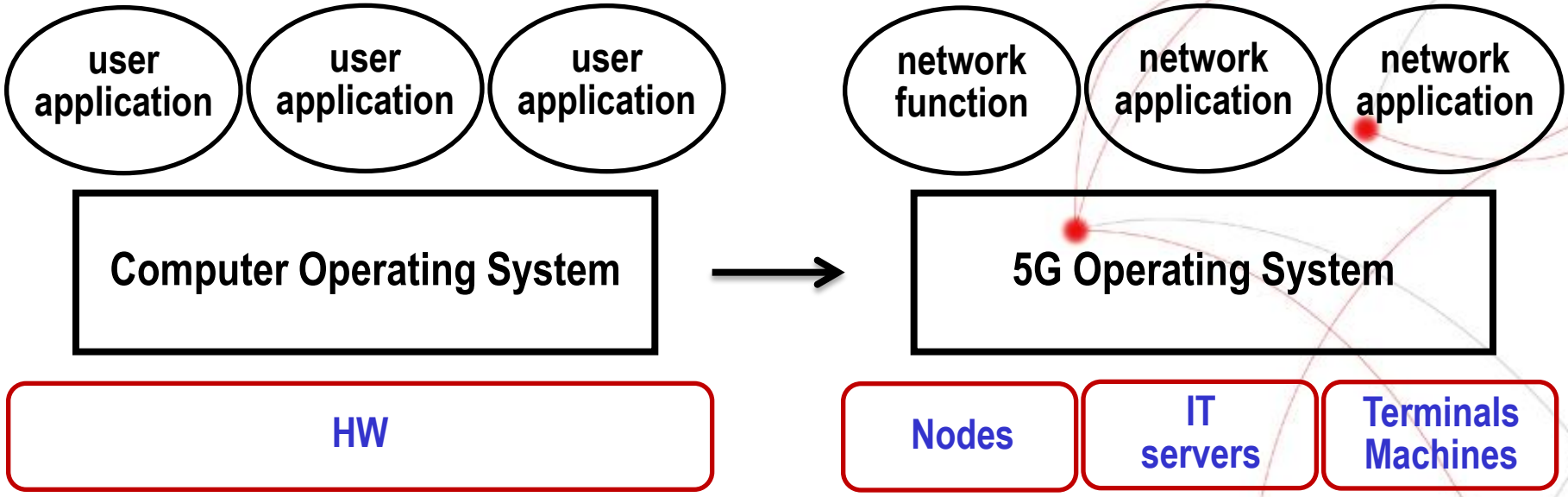
OPEX

CAPEX

Potential Industrial Impacts (1 - 5)

- Moving competition from CAPEX (HW) to OPEX (SW) is lowering the threshold for new Players to enter:
  - New forms of cooperation and competition;
- A degree of merging between traditional telecoms equipment suppliers and IT equipment suppliers.
- Some telecoms equipment suppliers may decide to reposition as principally software supply companies: this will require a significant shift in business model.
- OTT in the middle of a complex value chains (selling advertising and marketing information, but also working with customer equipment manufacturers and their retailers)
- Potential split of roles also for Network Operators:
  - Voice telephony will increasingly become just another OTT service;
  - New service (and business) models have to be developed.

Potential Industrial Impacts (2 - 5)



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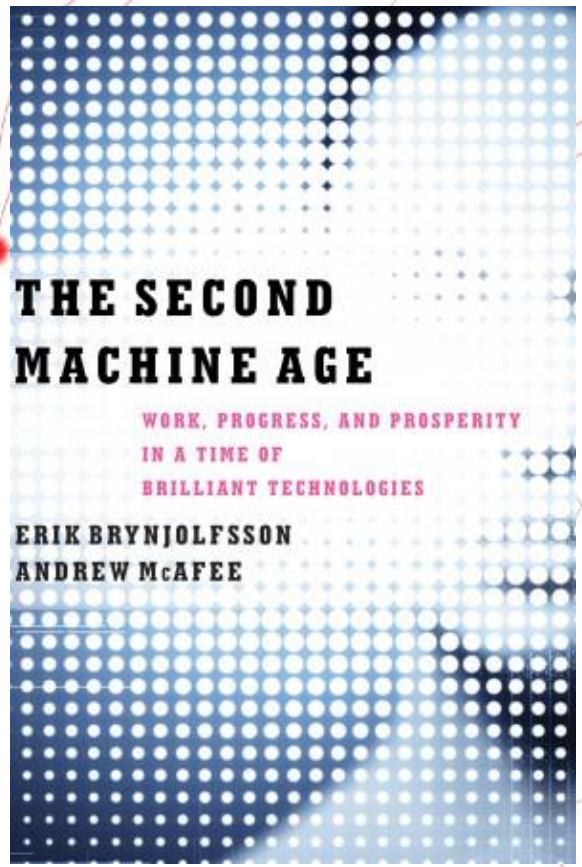
Potential Industrial Impacts (3 - 5)

- **Softwarization will make easier to create new ICT ecosystems:**
  - Data collection (by any sensors, terminals, things, machines…),
  - data transfer/exchange (by fixed and mobile low latency networks),
  - data elaboration (by Cloud) to make centralized and optimized decisions (cognition as a service) for actuating actions (by any actuators)…



This is indeed a "Nervous System":

- collect, elaborate and exchange information to understand the environment and to adapt to changes with proper reaction times;
- the reaction time is a key factor of success to avoid collapses !

Potential Industrial Impacts (4 - 5)

Cloud Computing

Big Data

Cognition

5G

Sensors

New Apps and Services

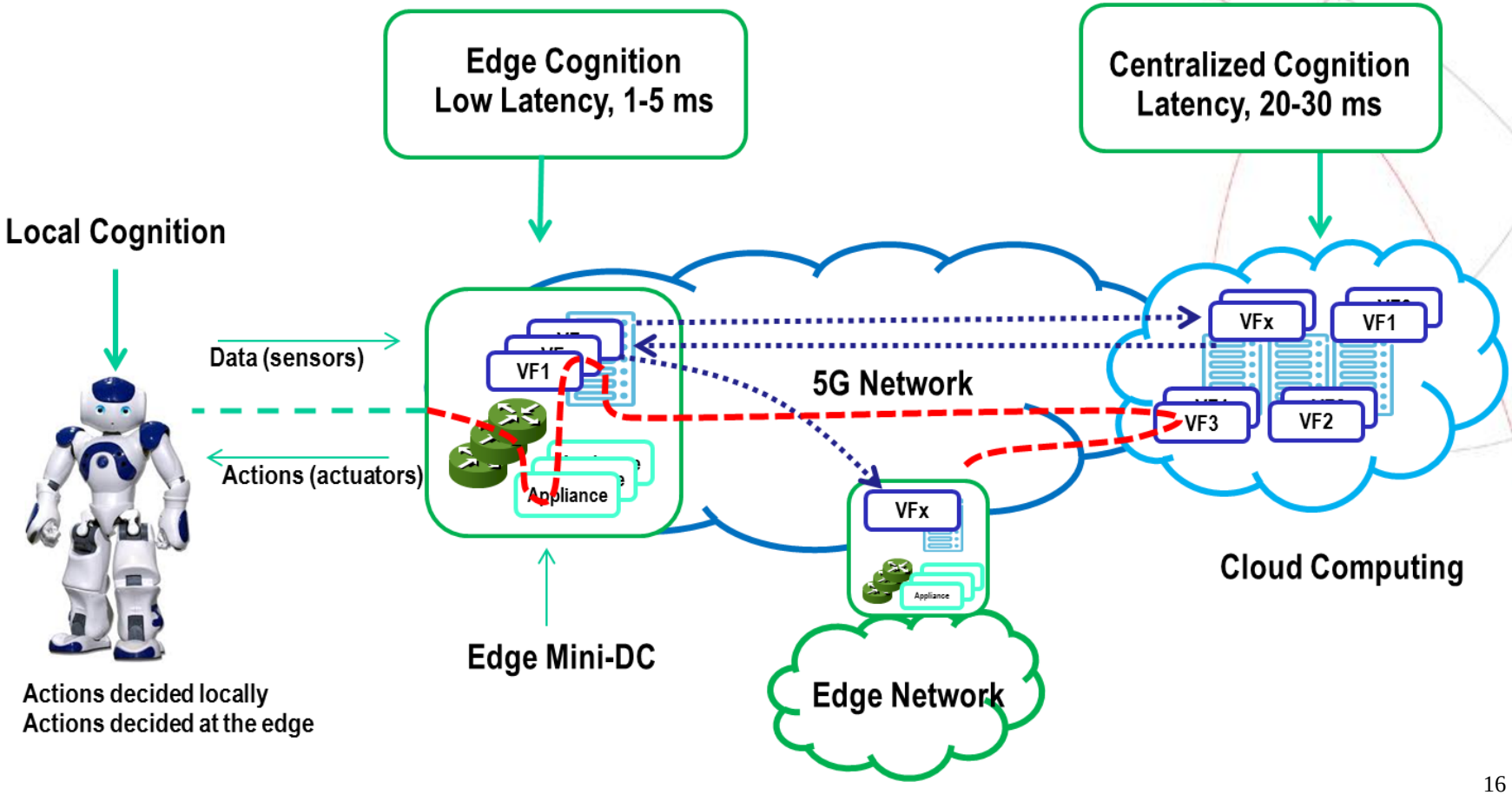
Actuators

terminals, things, machines, drones, robots

5G latency: units of ms

Potential Industrial Impacts (5 - 5)

- "Cognition as a Service" (CaaS) will be about introducing cognitive capabilities in the 5G OS, so that cognitive apps can be easily developed by means of APIs.



5G is changing… the "equation" of the Internet

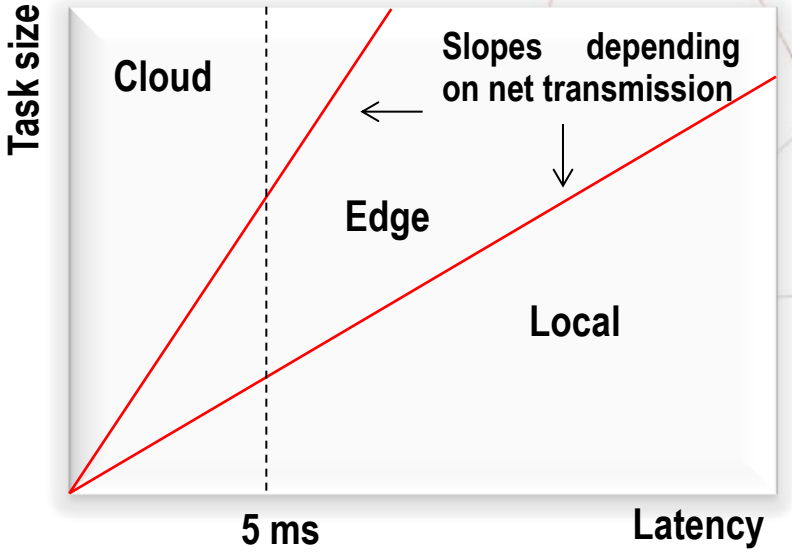
"Latency" is a wider concept than traditional "end-to-end latency":

it is rather based on three major component [1]:

- **transmission delay + routing and switching + IT response time**

optics **"processing-storage (e.g., SDN, NFV)"**

Advances on Chipset (optics and hardware)



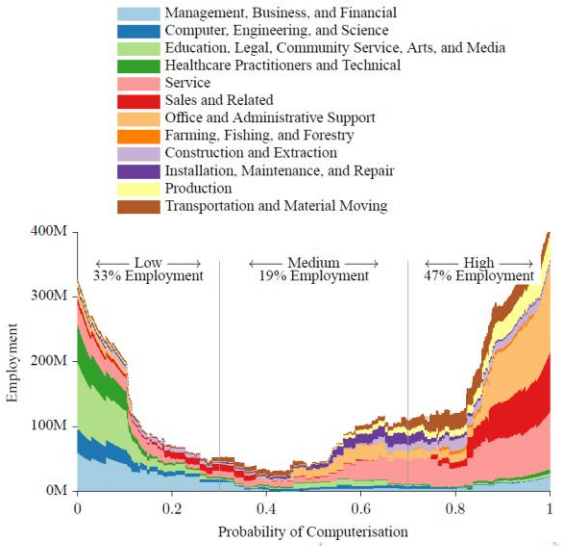
Where "executing" what function (L2-L7) ?

[1] others are: serialization, data protocols, and queuing and buffer management…

Socio-Economic Impacts

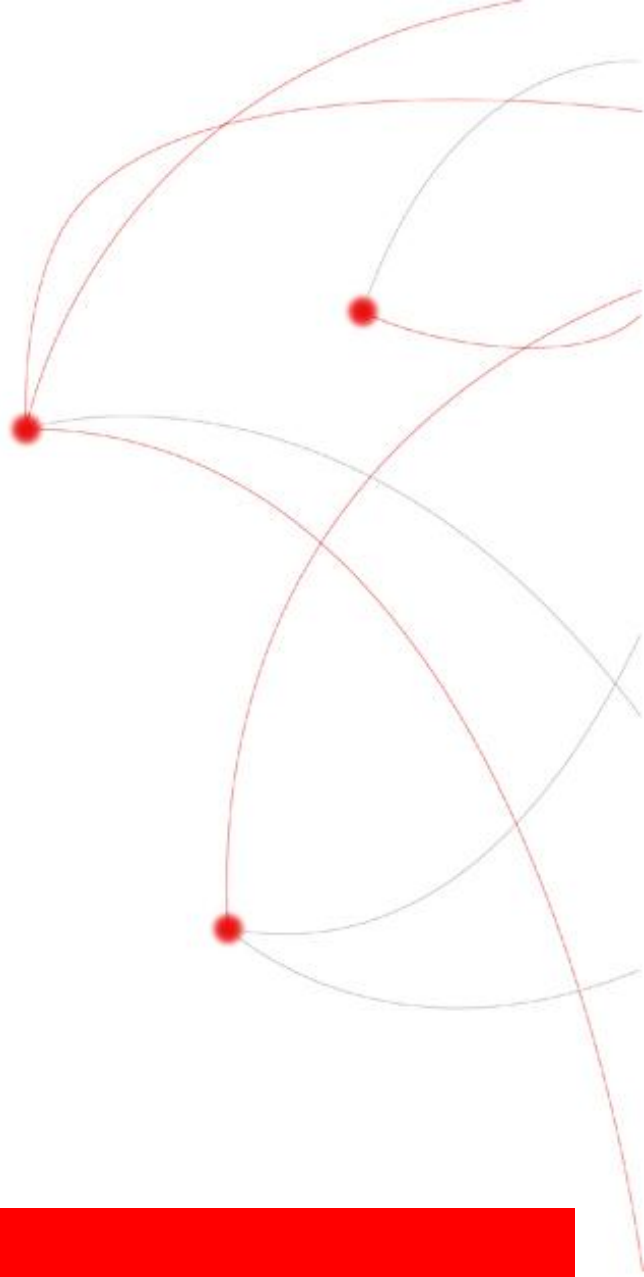
"…as technology races ahead, low-skill workers will have to reallocate to tasks not-susceptible to Computerization, i.e., requiring creative and social intelligence".

"…the number of employees per business revenue is falling". There is a need of "making increasing individual and collective intelligence a national objective of each country".



http://millennium-project.org/

http://www.futuretech.ox.ac.uk/sites/futuretech.ox.ac.uk/files/The_Future_of_Employment_OMS_Working_Paper_1.pdf



Thank You

Arrivederci !

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