# Software Defined Networking (SDN) and Network Functions Virtualization (NFV)

Research issues and trends

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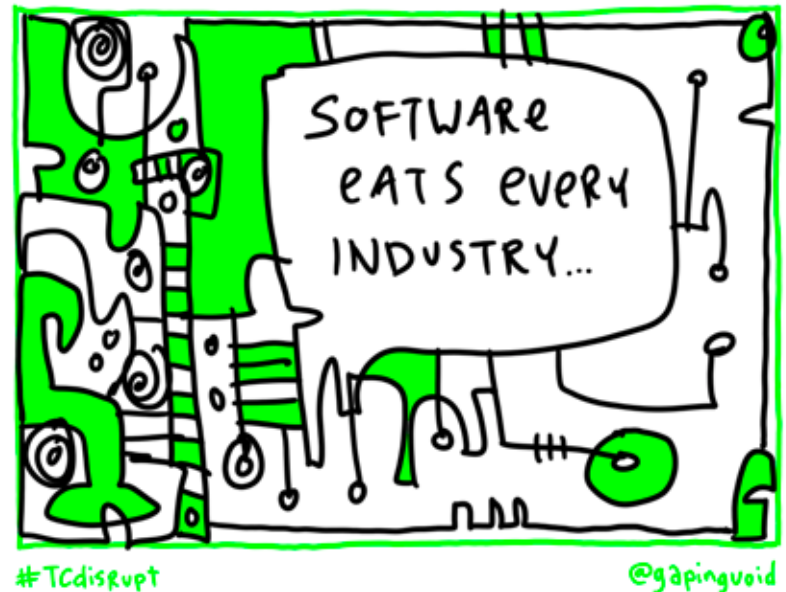
SDN & NFV: Softwarization

- **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.**
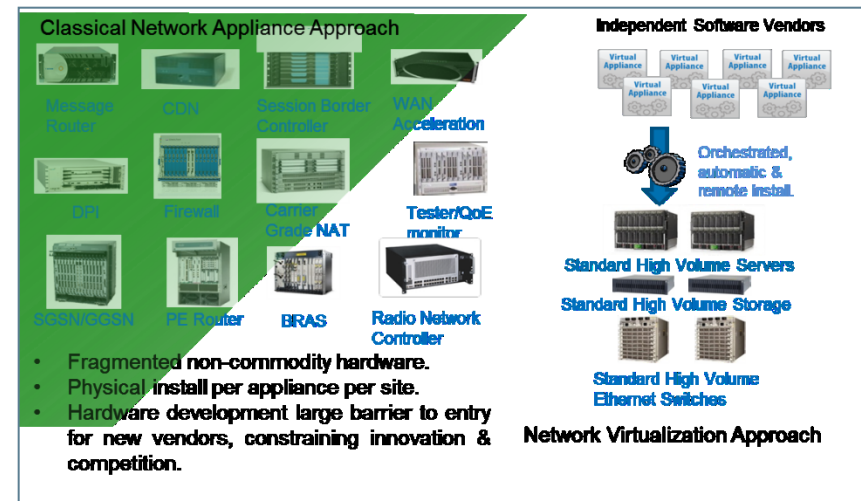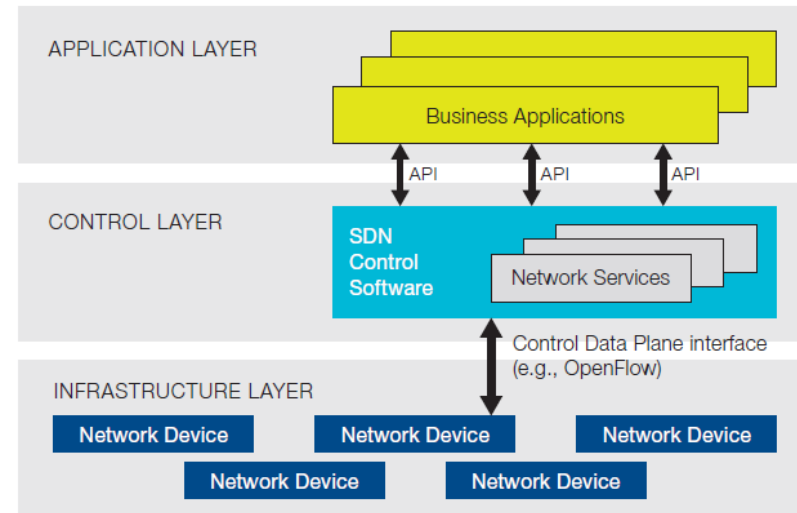
SDN & NFV: Softwarization

SDN and NFV are different expressions of an overall trend, called "*Softwarization*", a trend driven by:

- increasing performance of general purpose Hardware, at lower and lower costs;

- growing number of communities on Open Source Software;

- moving of intelligence towards the "Edge", around Users;

"*Softwarization*" will optimize Operational "processes", accelerate innovation (as it is doing in IT) and enable ICT ecosystems.
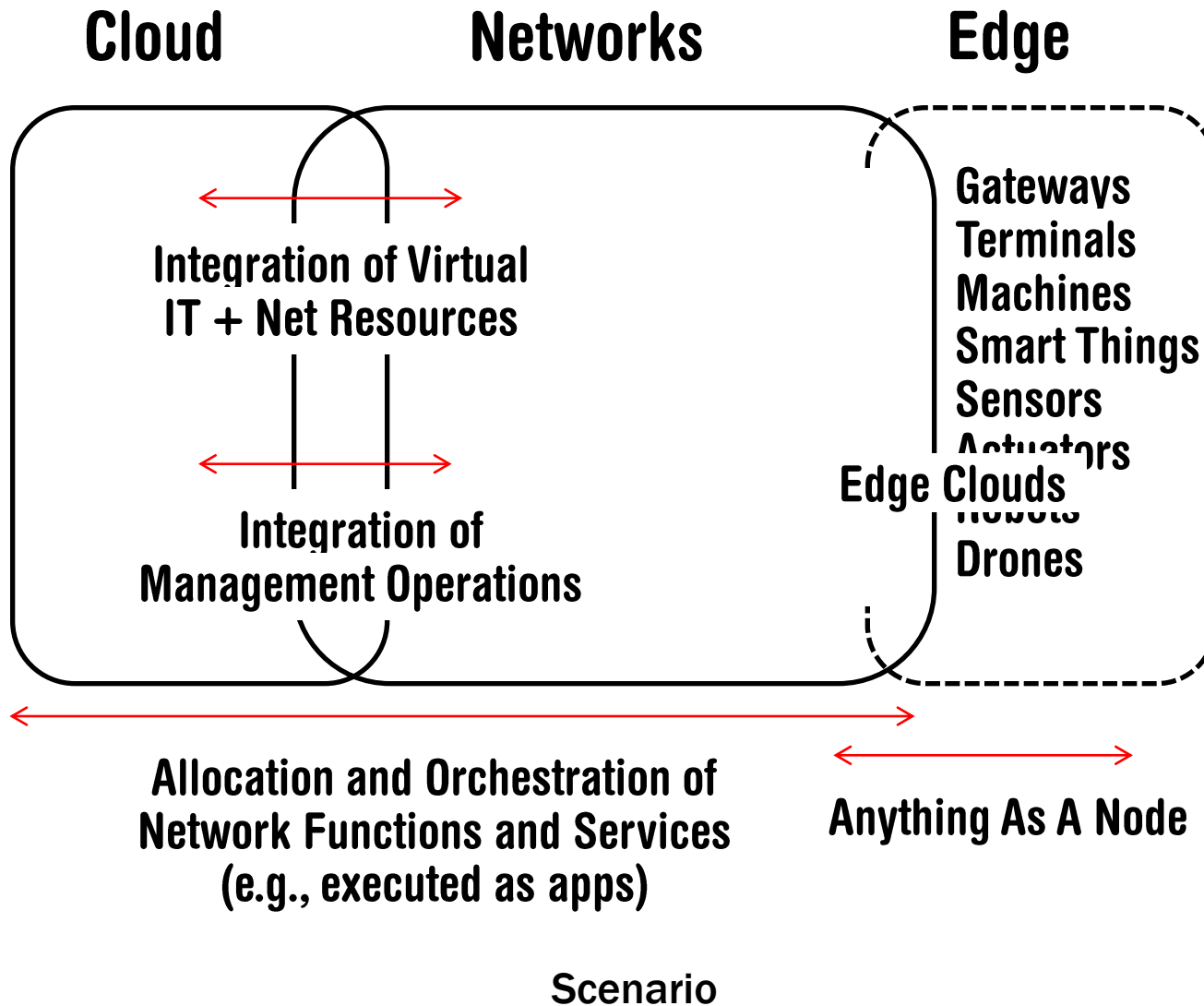
Two Dimensions of Softwarization

1. **Integrating profoundly Cloud/IT resources and Carriers' Networks:**

   - **distributed virtual platforms executing any network function (e.g., L4-L7) and services as "applications" (on VMs, dynamically allocated and moved on general purpose HW);**

2. **Blurring the distinction between the "Carriers' Network" and what connects to it, i.e., the End-Users "Terminals":**

   - **any devices, machines, smart things, robots, drones…will look like nodes (at the edge) providing the End-Users with "any services".**
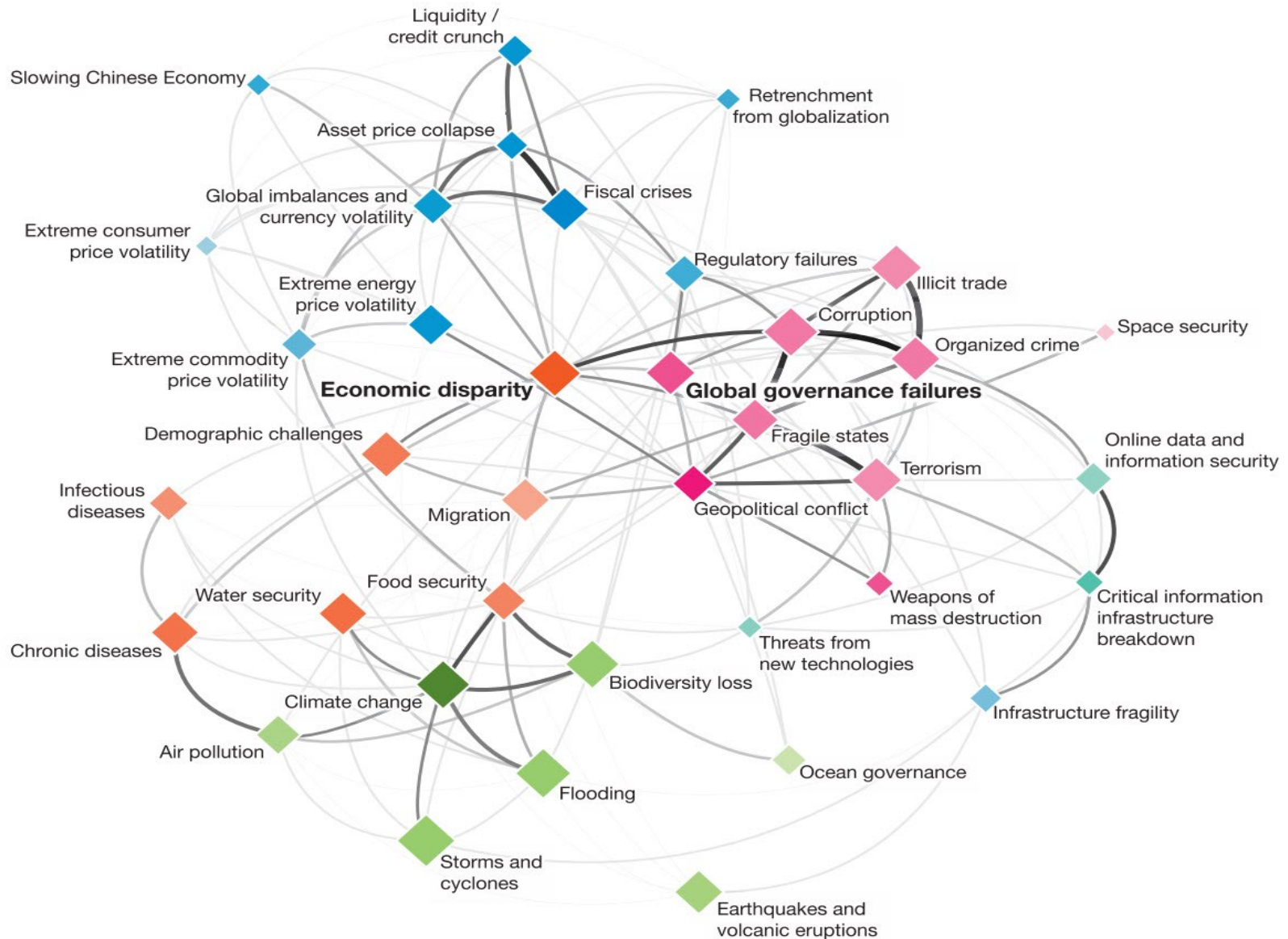
VM: Virtual Machine
HW: Hardware

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Two Dimensions of Softwarization

Cloud　　　**Networks**　　　**Edge**

Integration of Virtual
IT + Net Resources

Integration of
Management Operations

**Gateways
Terminals
Machines
Smart Things
Sensors
Actuators
Robots
Drones**

Edge Clouds

**Allocation and Orchestration of
Network Functions and Services
(e.g., executed as apps)**

Anything As A Node

**Anything
As A Service**

Scenario

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A Vision of the Future: an Hyper Connected World

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

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A Vision of the Future: an Hyper Connected World

"*Softwarization*" will be a game changer, as it has a huge potential of bringing ICT to disappear into the "fabric of Society";

We need a change of paradigm for exploiting this huge potential;

- "*Complexity came at a cost, it's hard to turn back*" (*):

  - sustainability approaches based on cost reductions are valid only in the short term, then they are bringing to collapse;

    – Lessons Learnt: the collapse of the Roman Empire;

  - long-term sustainability depends on solving key problems of Society (food, water, energy), jumping into "Open Innovation";

    – Softwarization is the "tool" of the future.

(*) Joseph A. Tainter Human Resource Use: Timing and Implications for Sustainability

A Vision of the Future: an Hyper Connected World

Study o the expected impacts of future "*Softwarization*" on US labor market (Oxford Martin School);

"…as technology races ahead, low-skill workers will have to reallocate to tasks not-susceptible to "Computerization" – i.e., tasks requiring "creative and social intelligence".
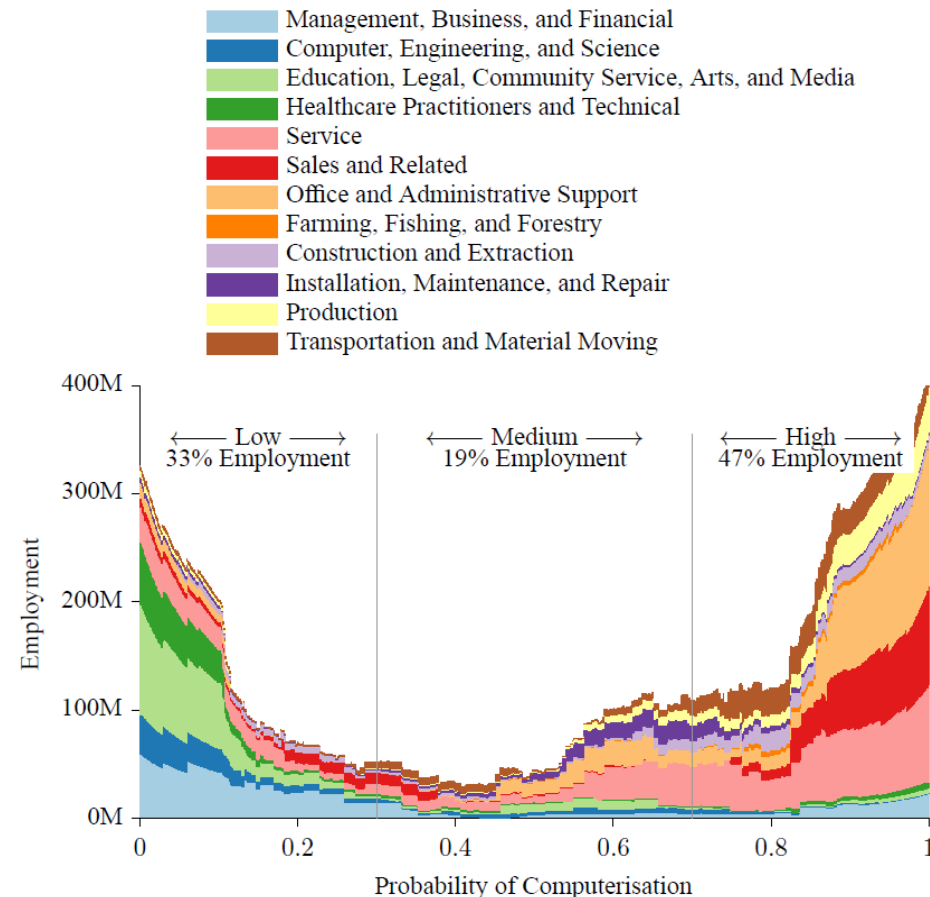
THE FUTURE OF EMPLOYMENT: HOW SUSCEPTIBLE ARE JOBS TO COMPUTERISATION?
http://www.futuretech.ox.ac.uk/sites/futuretech.ox.ac.uk/files/The_Future_of_Employment_OMS_Working_Paper_1.pdf

Implications of Softwarization on Future Networks

Core Networks

– **potential reductions of CAPEX and OPEX**

  • **…need to test the performance**

– **convergence of IT and Networks nodes and systems**

  • **…big impact on operations processes**

– **standardization of interfaces**

  • **… a plethora of Standards de Facto**

– **interoperability with legacy equipment**

– **development of high-skill jobs for mastering the software**

Implications of Softwarization on Future Networks

Edge Networks

— **resonance with the ongoing migration of "intelligence" towards the Edge, i.e., smart resources around the End-Users;**

— **potential of enabling ICT ecosystems, by addressing socio-economic "problems" (i.e., the fabric of Society);**

— **the move of competition from HW to SW will lead to:**

  • **lowering the threshold for new Players to enter the edge arena;**

  • **new forms of competition and collaboration among Players;**

  • **new value chains and new business models.**

RT&D Issues

- **Key areas will include:**

  - **New Management and Orchestration approaches integrating abstractions of processing, storage and networking;**

  - **Developing and controlling "intelligence" into End-Users devices, machines, smart things…drones, robots;**

  - **Standardization of interfaces for interoperability;**

  - **Addressing Security and Privacy;**

  - **Developing New Business Models and Ecosystems;**

  - **How pursuing Open Source Hardware and Software;**

  - **Education and Development of new skills.**

Thank you
Arrivederci !

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