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Unlocking Value from the Networks
Smarter Networks for Smarter Things 15-16 October 2013, Venice, Italy

Manifesto of Edge ICT Fabric

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Technology Trends

HARDWARE

Performance increase of standard HW (e.g., x86)

Costs reductions of IT processing and storage systems

Disaggregation of IT servers in components (e.g., CPU, SSD, HDD)

SOFTWARE

Growing availability of Open Source SW solutions

SW developments of L3-L7 network functions (e.g. middle-boxes)… SDN, NFV

Emergence of ecosystems to develop and customize Open Source

SMART DEVICES

More and more powerful Users' devices (e.g., for video streaming services)

"Things" with Embedded communications (e.g. IoT)

Coming solutions for D2D and M2M communications

open source™

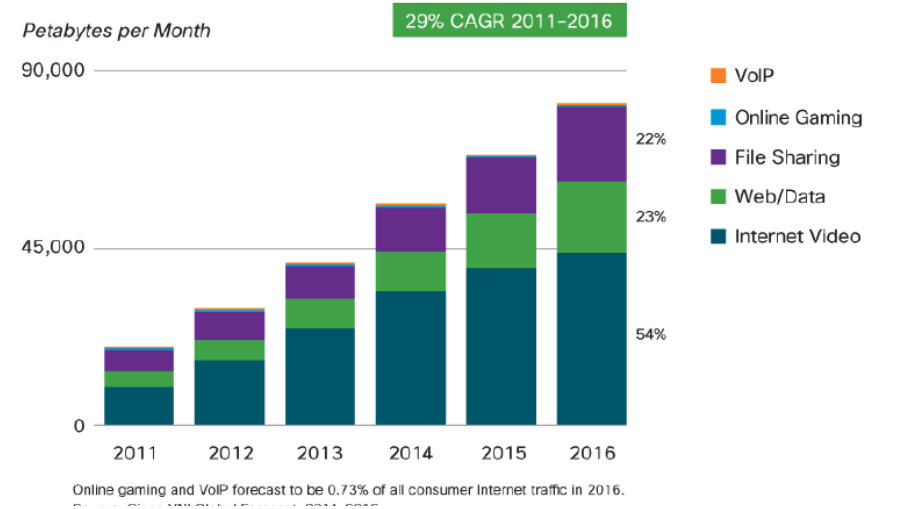
Traffic Drivers

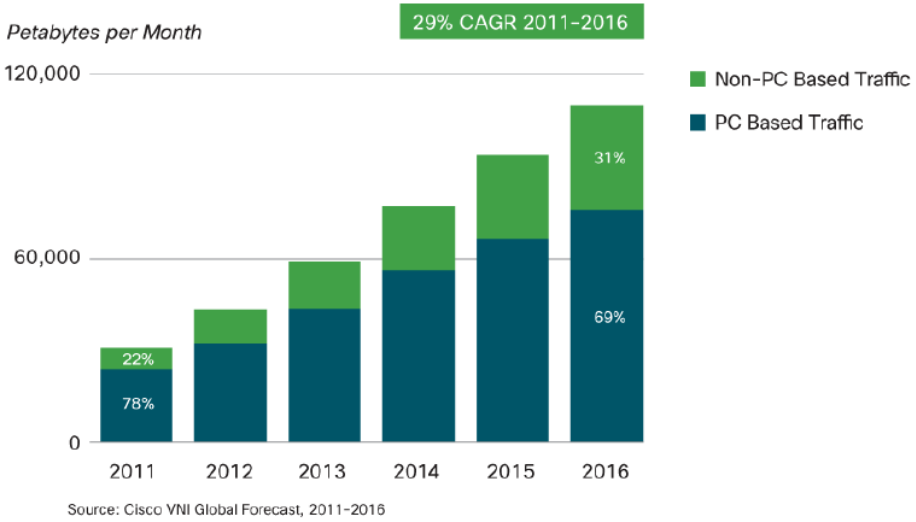
Internet video and Web browsing will drive the market...

Nearly one-third of traffic will come from TVs, Handsets, and other non-PC devices by 2016

Common characteristics:

- it will be generated by a few popular files, accessed in an asynchronous way;
- demand will have predictable distributions (what, when and where will be requested);
- It will delay tolerant, variable quality, suited for best-effort.





G. Caire, The Role of Caching in 5G Wireless Networks , IEEE ICC – Budapest 06-10/13-2013

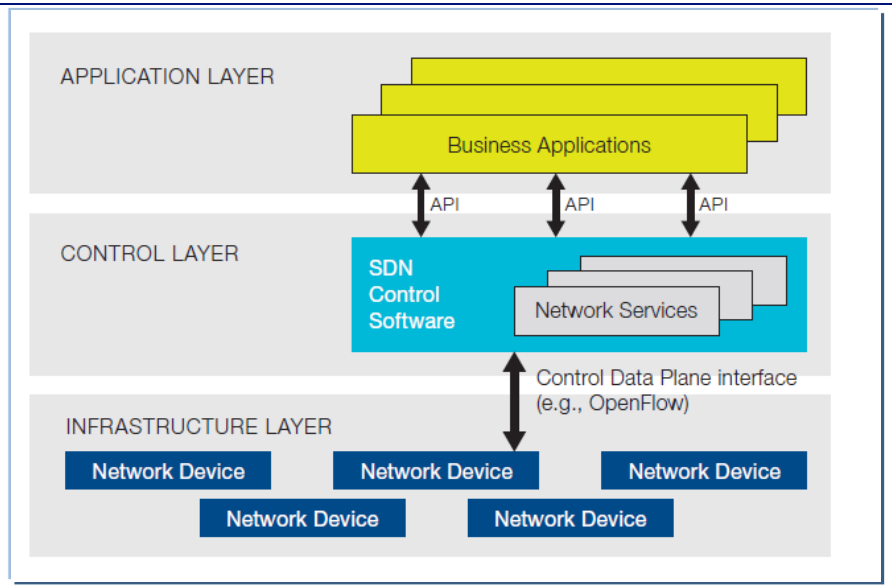
Paradigms and Indicators

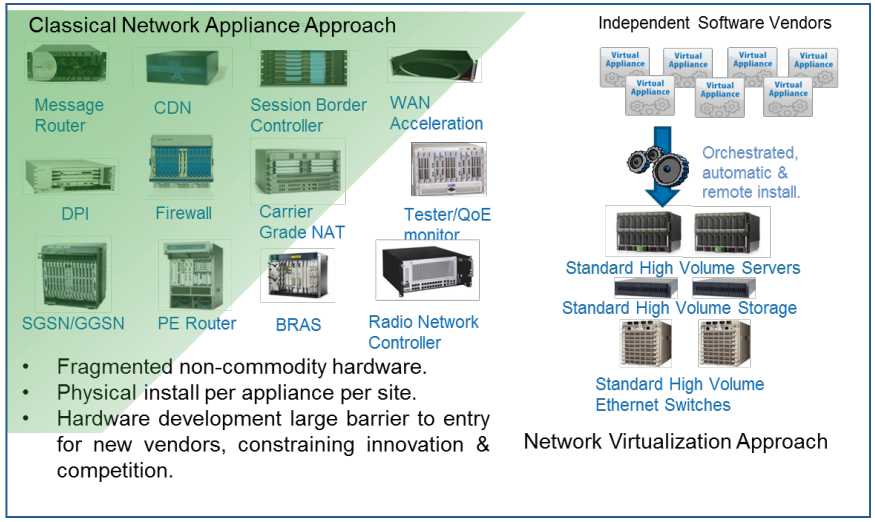
SDN: decoupling SW control plane from HW (data forwarding), and moving logic and states to programmable controllers.

Software Defined Network

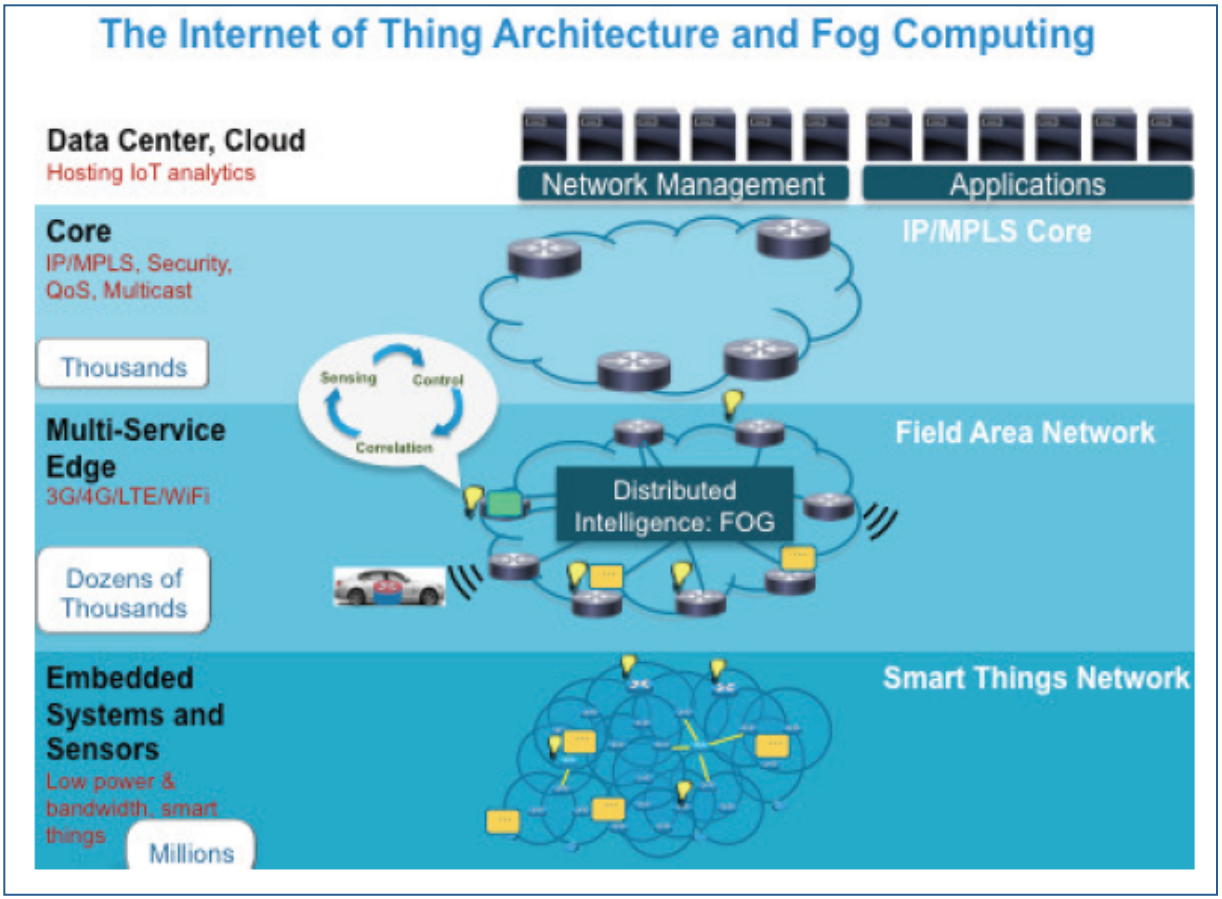
NFV: virtualizing some network functions that can run on standard HW, and that can be moved and instantiated in various locations of the network.

Network Function Virtualization





Paradigms and Indicators



Source: Cisco

FOG COMPUTING:
extending the Cloud Computing up to the edge of the network.

Main characteristics:

- **proximity to Users,**
- **dense distribution;**
- **support for mobility.**

Services (and Data) can be hosted at the edge, up to Users devices.

Paradigms and Indicators

OPEN Compute Project

SEARCH

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Hacking Conventional Computing Infrastructure

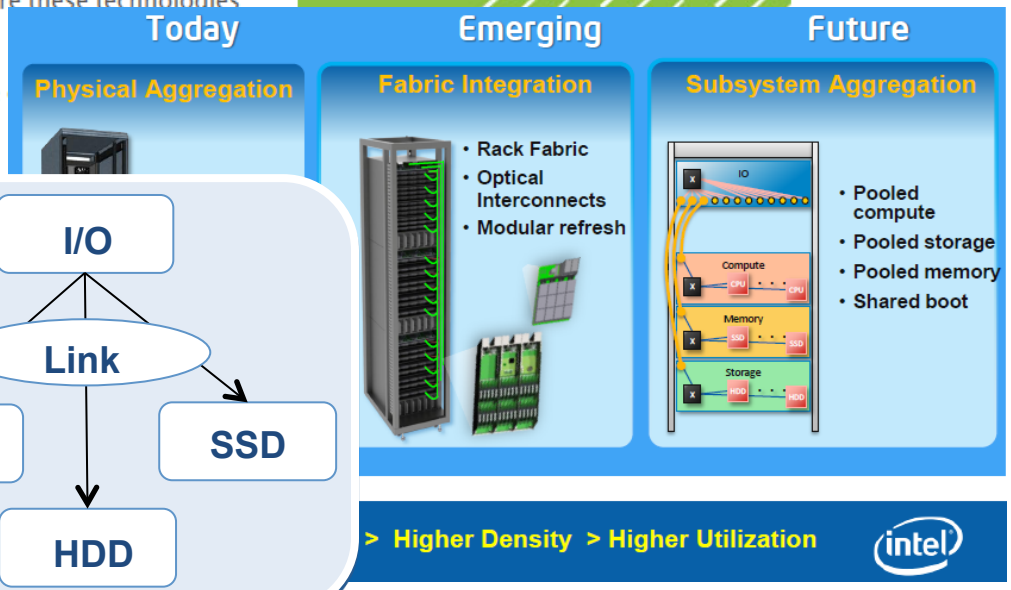
We started a project at Facebook almost two years ago with a pretty big goal: to build one of the most efficient computing infrastructures at the lowest possible cost. We decided to honor our hacker roots and challenge convention by custom designing and building our software, servers and data centers from the ground up – and then share these technologies as they evolve.

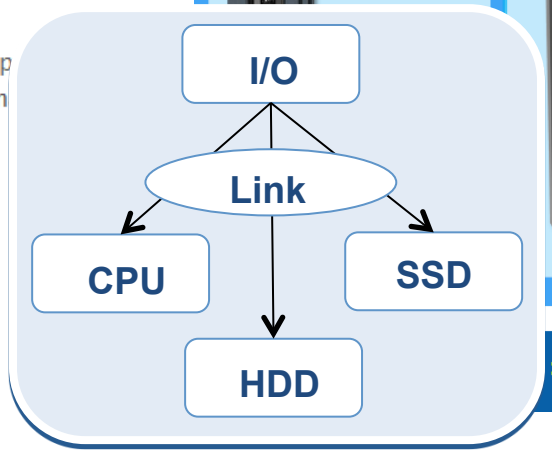
The result is a data center full of vanity free servers which is 38% more expensive to build and run than other state-of-the-art data centers.

Why Open Hardware?

By releasing Open Compute Project technologies as op
servers and data centers following the model tradition
software projects. That's where you come in.

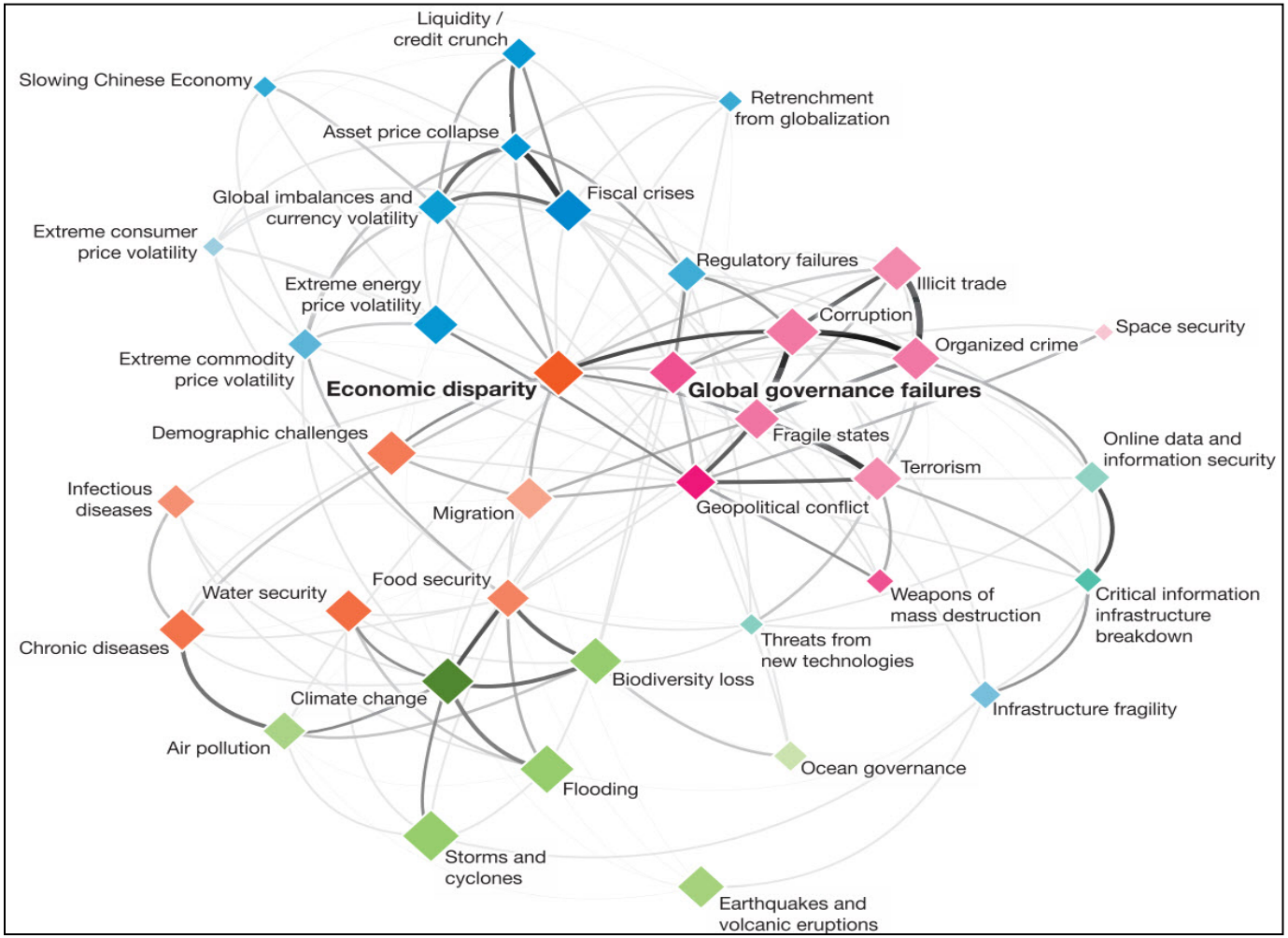
"Open Compute Project is looking to break up servers' systems design into its component parts"





http://www.opencompute.org/

…towards an hyper-connected World



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

Visions and Biz Models…

- Hyper-connected World = a *"small and complex"* World;

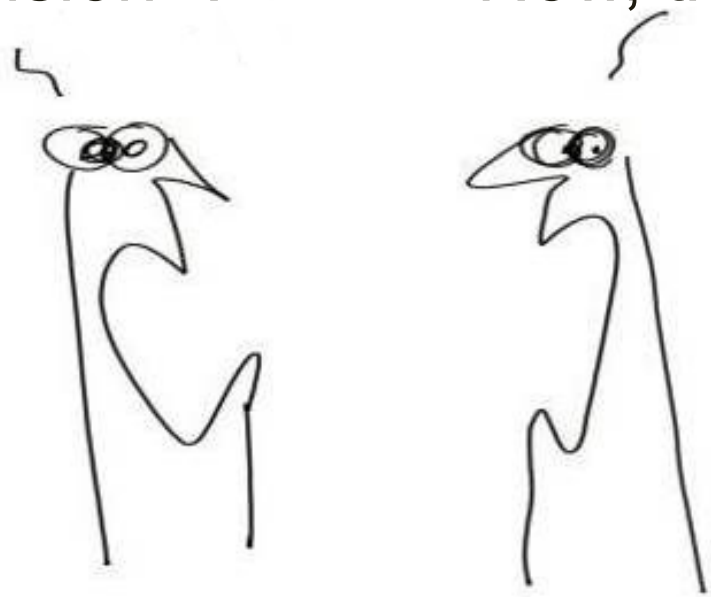
- *"Complexity comes at a cost, it's hard to turn back" (*):*
  - *approaches for pursuing sustainability based on conservation, pricing and optimization are valid in the short term, then they are bringing to the collapse;*
  - *Roman Empire was an clear example;*
  - *long-term sustainability depends on solving key problems of society, but this requires increasing further the complexity;*
  - *but this will bring to a shift of paradigm*

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

Visions and Biz Models…

Bla, bla, bla …
This is the “Vision” !

Looks really great !
Now, throw it away…



Vision: Edge ICT Fabric

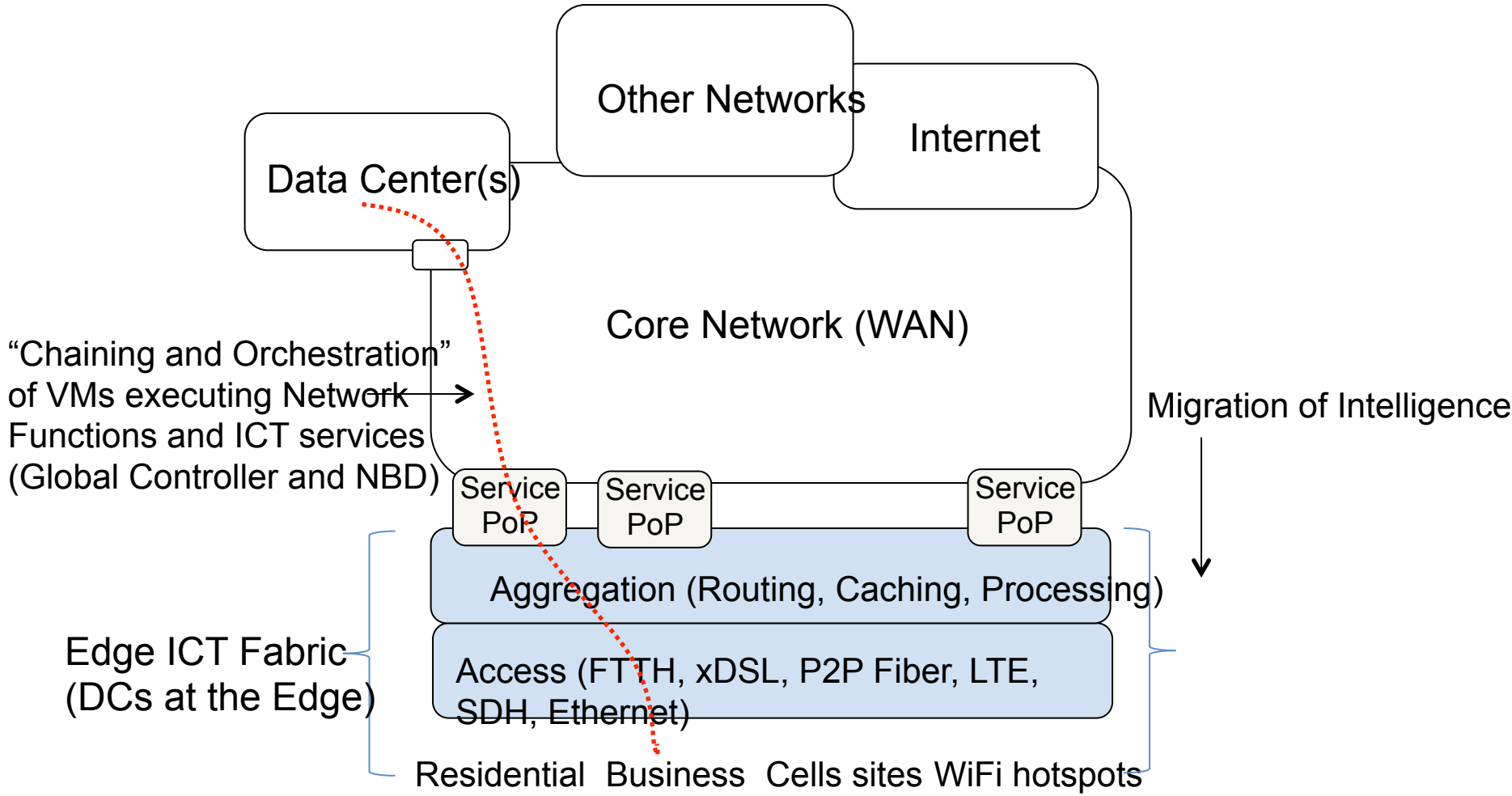
"Edge ICT Fabric"

- **Looks like distributed Data Centers, at the edge;**
- **It includes the sheer number of processing, storage and communication resources which are amassing around Users;**
  - **Pools of VMs are executing dynamically network functions (L3-L7) and ICT services, as apps, on standard hardware;**
  - **Data are cached locally.**

Why this name ?

- **"Edge":** part of the network from the aggregation nodes up to the CPE, machines, Users' devices and smart things…;
- **"Fabric":** a distributed system of loosely coupled storage, networking and processing functions interconnected by high bandwidth links; … also DC network, optimized for "server-to-server connectivity".

Network Scenario



"Clouds of Virtual Machines at the Edge", IEEE Com. Mag. Future Carriers Networks, July, 2013

Business Scenario

- **It is about shifting the focus of SDN/NFV "from the core network to the edge": because it will cost less and it will lead to short term revenues;**

- **Deploying SDN/NFV for core networks would mean:**
  - **a dramatic impact on Operations (OSS, BSS);**
  - **investing upfront and hoping to generate revenues (with current business models…);**
  - **a change of "culture" and organization in Telcos.**

- **…but unleashing the "power of the edge" would mean "open innovation" and new business opportunities !**

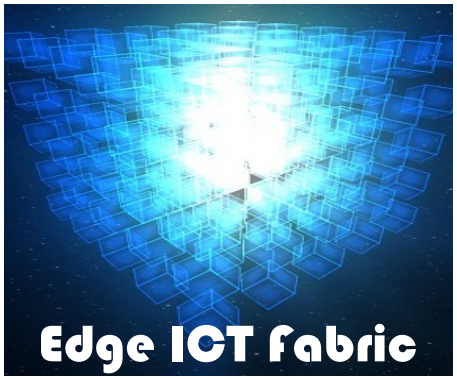
The “power of the edge”

- **A Smartphone has 200 Mflops, a PC some tenth of Gflops, a PlayStation hundreds of Gflops… → hundreds of petaflops of distributed processing capacity “at the edge”;**
- **Near future Users’ devices having 100 GB of memory: a density of 5000 people/km^2 → 500 TB/km^2 of distributed storage capacity.**

Titan: 18 Petaflops

Google Compute Engine

…a few Petaflops



…hundreds of Petaflops

Flops: floating point operations per second

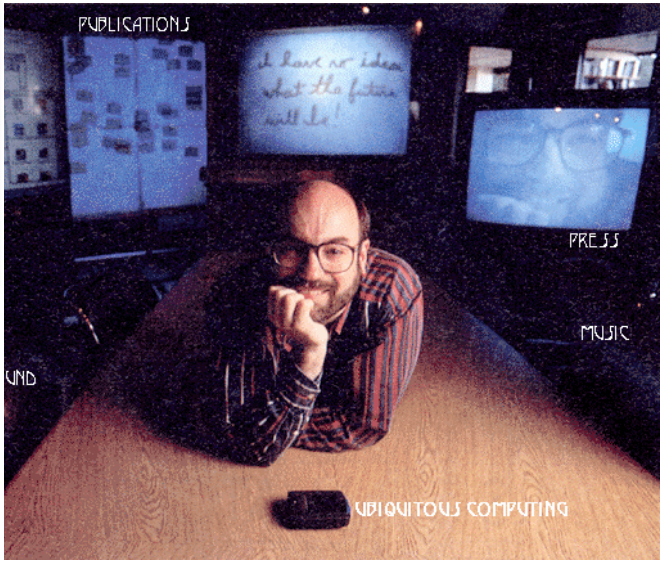
A shift of paradigm

"The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it."

Marc Weiser

"Any sufficiently advanced technology is indistinguishable from magic."

Arthur C. Clark



Red Ocean vs. Blue Ocean

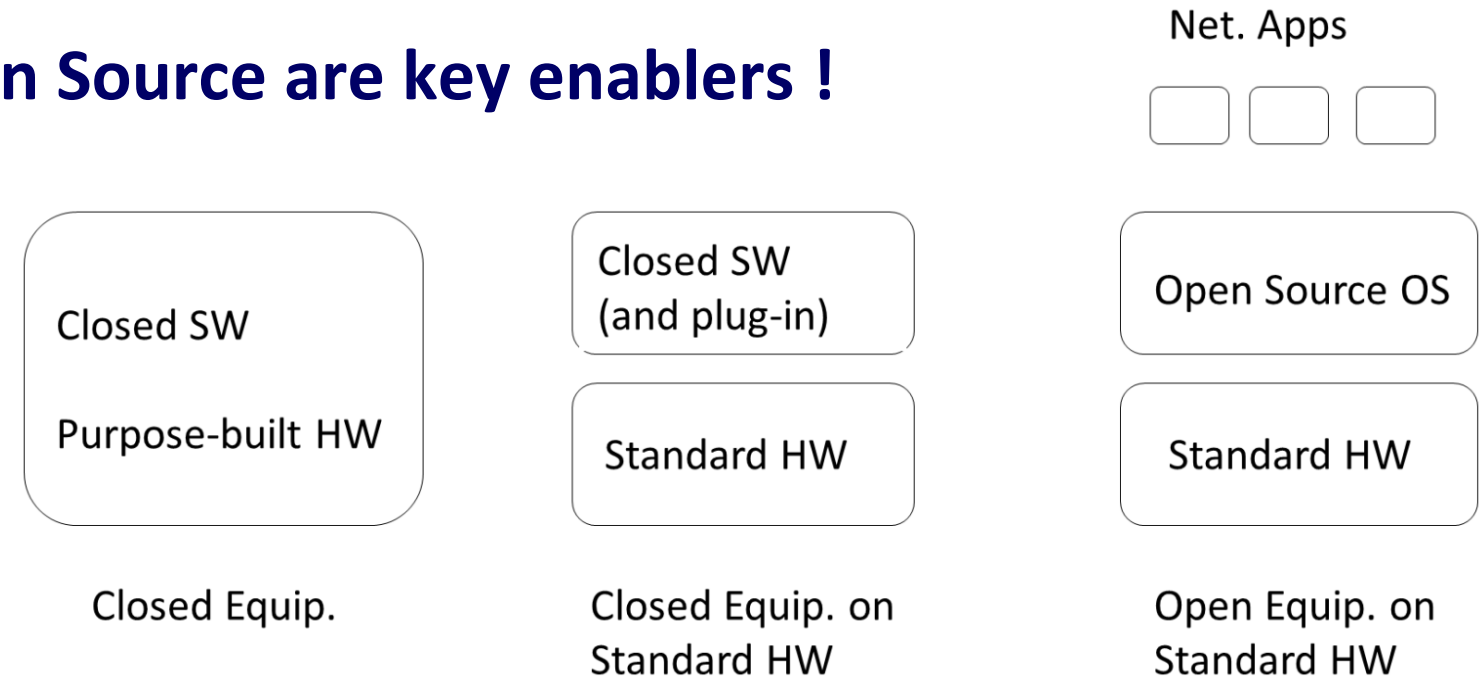
This shift of paradigm brings towards a Blue Ocean…

Red Ocean Strategy	VS	Blue Ocean Strategy
Compete in **existing** market space.		Create **uncontested** market space.
Beat the competition.		Make the competition **irrelevant**.
Exploit **existing** demand.		Create and capture **new** demand.
Make the value-cost trade-off.		**Break** the value-cost trade-off.
Align the whole system of a firm's activities with its **strategic choice of differentiation or low cost**.		Align the whole system of a firm's activities in **pursuit of differentiation and low cost**.

Blue Ocean: Open Source

Standard Hardware and

Open Source are key enablers !

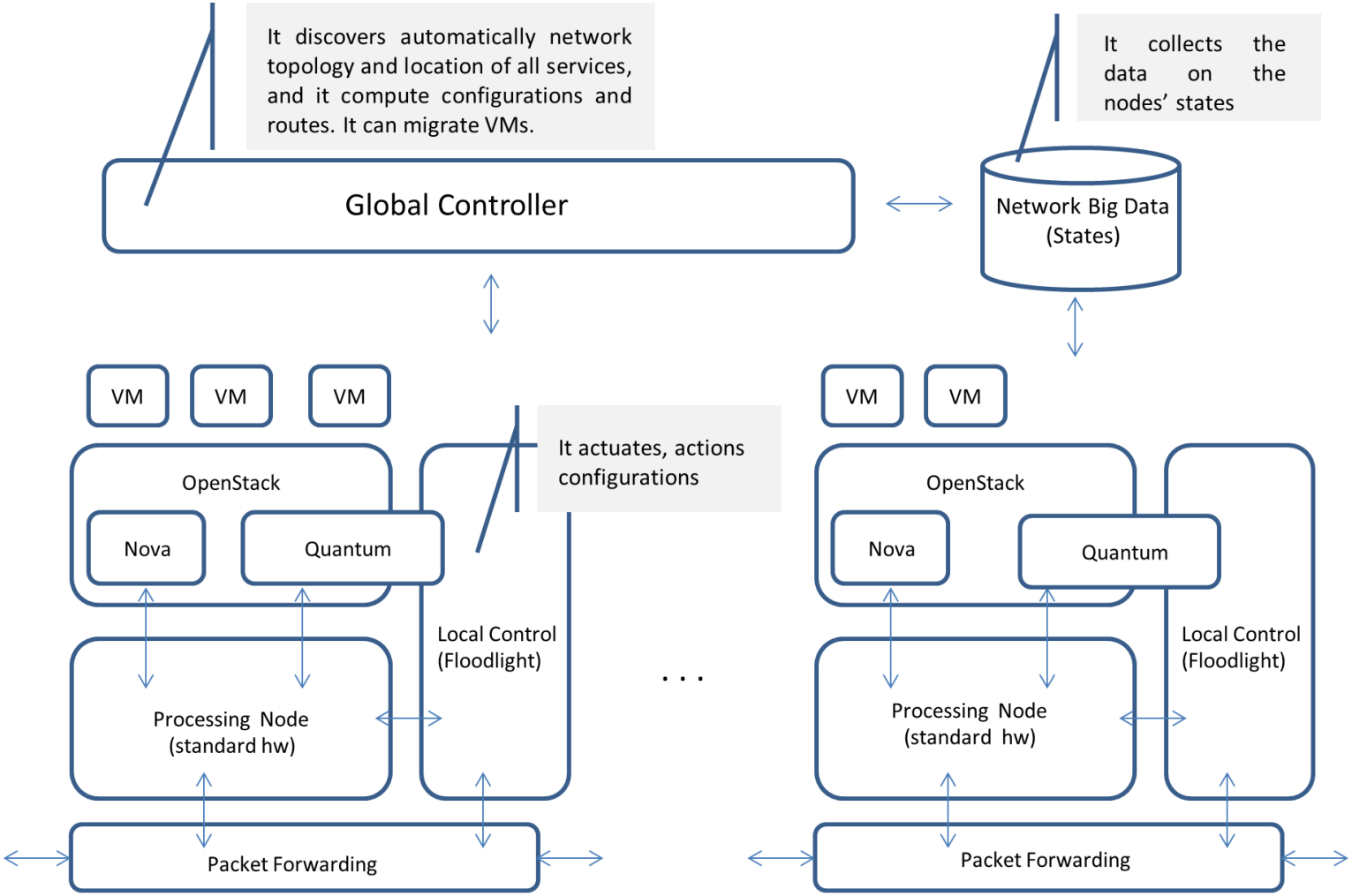


Legacy

Lowering CAPEX. But OPEX ?
(Risk of Vendors' SW lock-in)

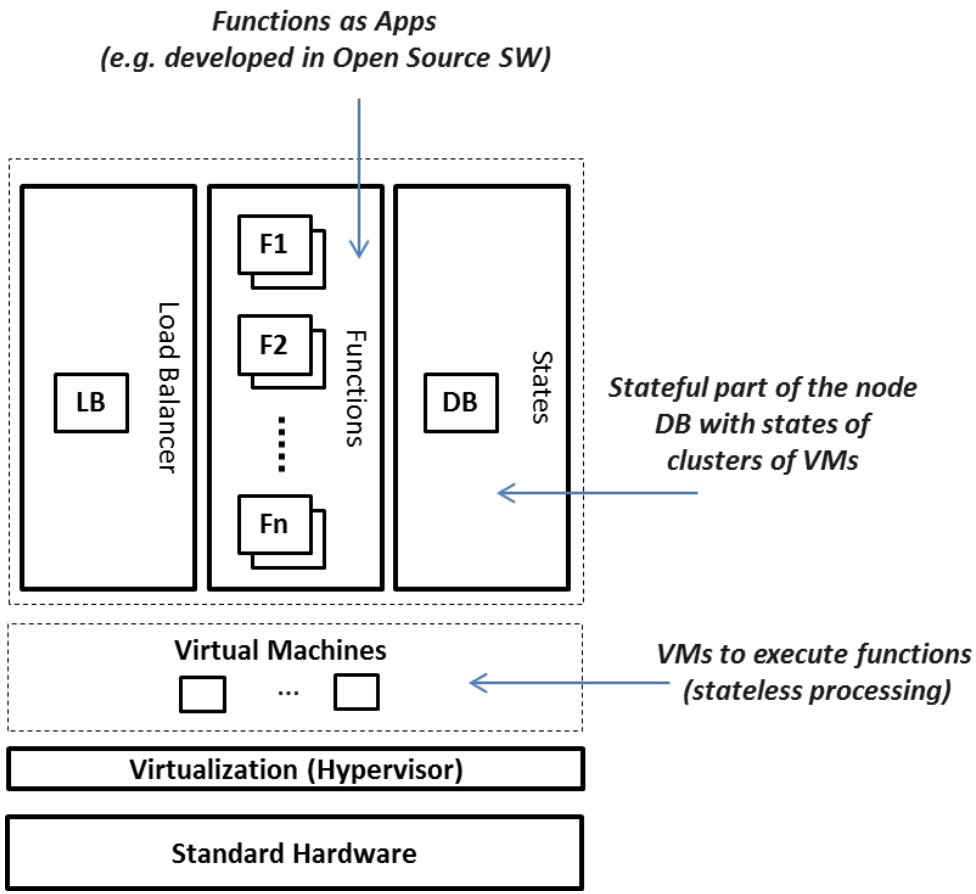
Lowering CAPEX and OPEX
Competition on Net Apps.

Example of Node Prototype - 1



Example of Node Prototype - 2

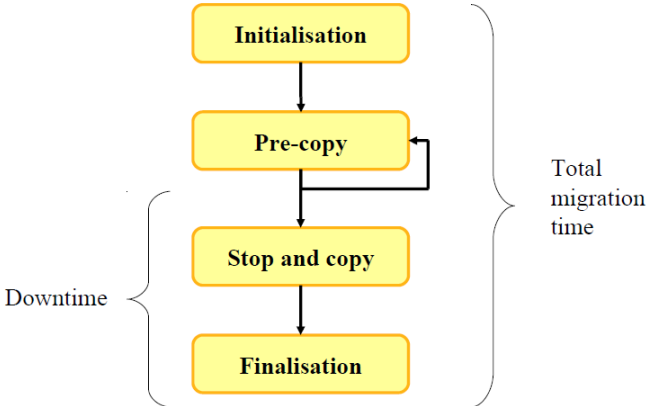
- Edge Node concept
  - Standard HW;
  - Open source SW;
  - Architecture should be scalable from Users' devices, to CPEs up to aggregation nodes;
  - Stateless processing of network functions (as apps) by pools VMs;
  - Separation stateless part from stateful part of the node.

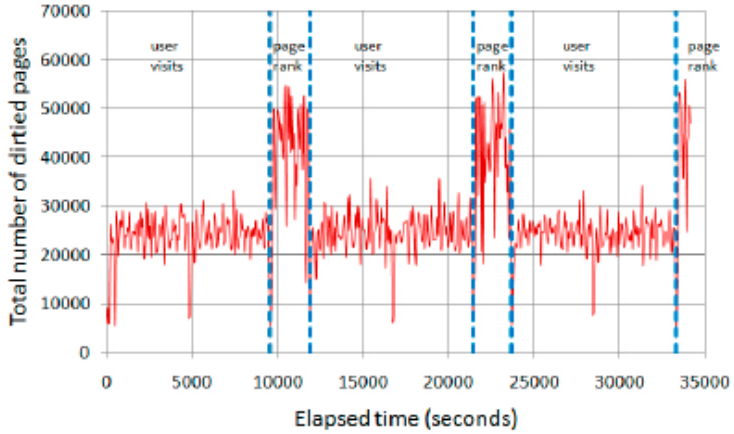


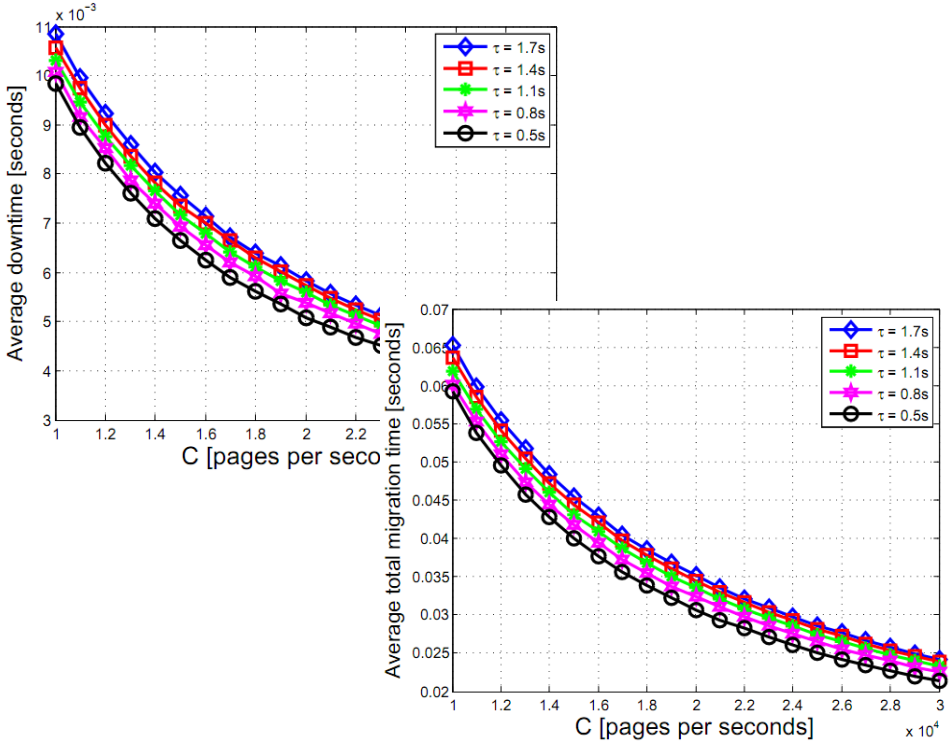
Experimental results

Live move of VMs (executing functions) across the Edge

Algorithms for live moving of a VM



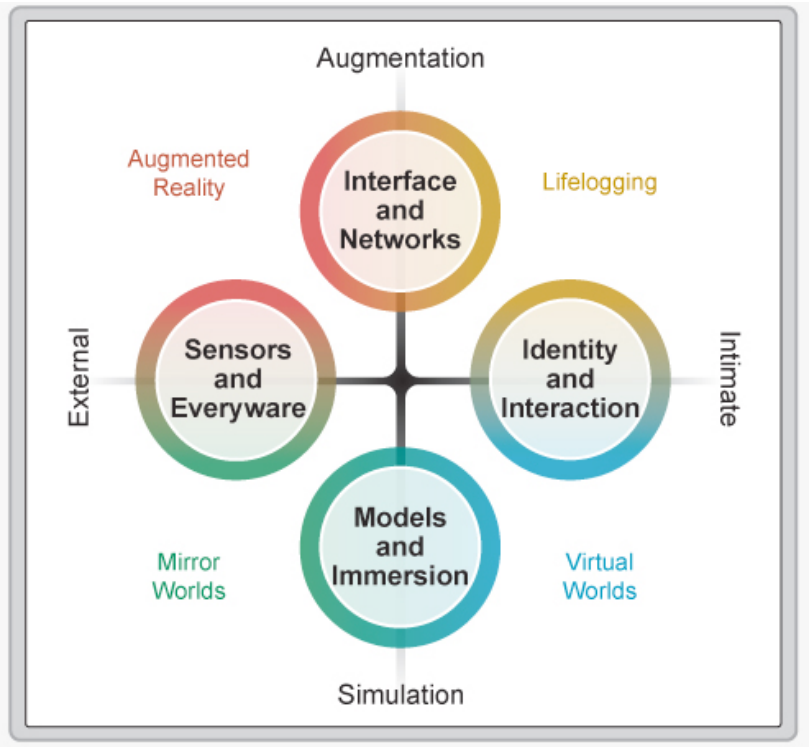




Link capacity and page dirty rate of the apps are the major factors impacting VMs migration (non-linear effect on performance).

Use Case: the Metaverse

- *Long-term sustainability depends on solving key problems of society, but this requires increasing further the complexity;*
- ICT should disappear into the fabric daily activities and businesses should go virtual;
- Socio-economic impacts on:
  - Education
  - Health care
  - Agriculture processes
  - Industry and Production processes
  - Infotainment
  - E-commerce



Metaverse is the integration of the physical and virtual worlds achievable by creating a fabric of ICT resources around Users.

Conclusions

- **Edge ICT Fabric**
  - Looks like distributed Data Centers at the edge;
  - It includes a sheer number of processing, storage and communication resources which are amassing around Users;
    - Pools of VMs executing dynamically network functions (L3-L7) and ICT services, as apps, on standard hardware;
    - Local caching of data.
- **Edge ICT Fabric is shifting the focus of SDN/NFV "from the core network to the edge"**
  - it will cost less and it will lead to short term revenues;
- **Processing and Caching "at the edge" has a great potential in the short term**
  - it relaxes the constraints on the backhaul (savings);
  - it execute services closer to the Users (better performance);
  - it creates new biz ecosystems (new revenues).

Thanks and Arrivederci !

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