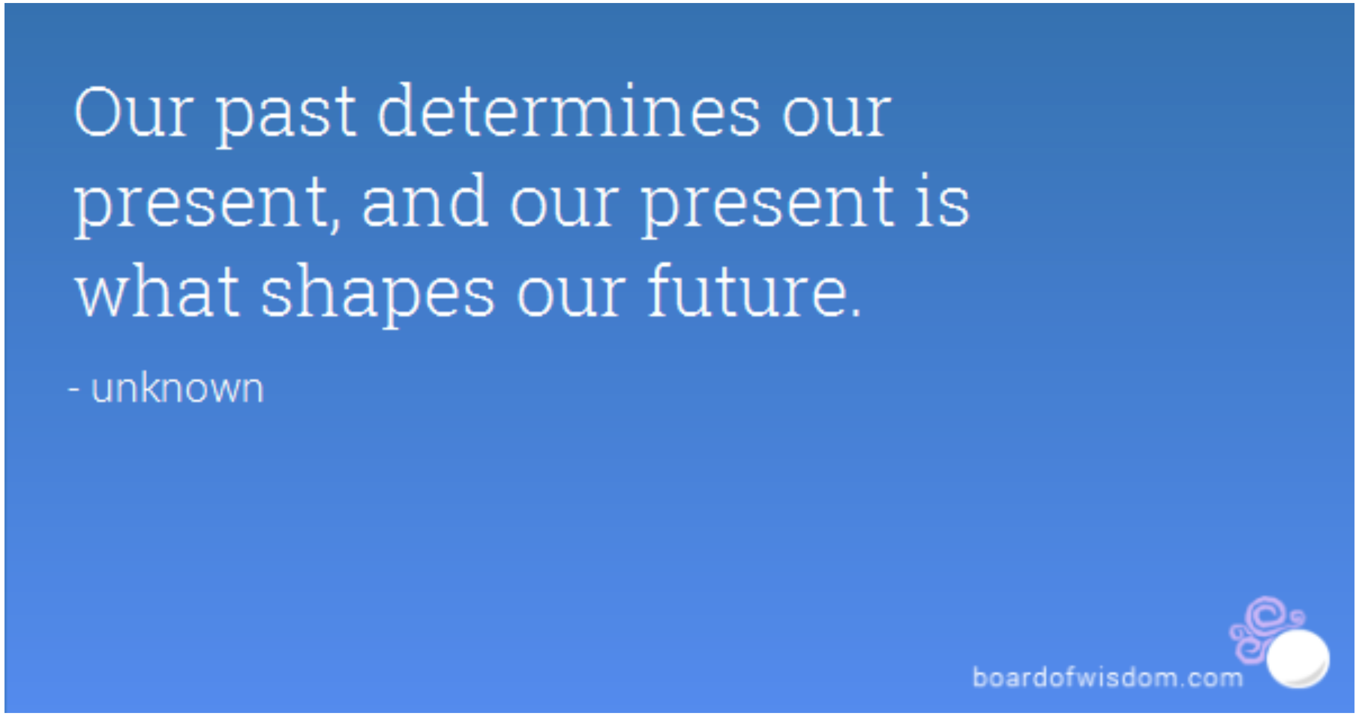
Looking to the Future in Domains of Microservices, Cloud and Edge Computing: *Osmotic Computing*

PROF. MASSIMO VILLARI

HEAD OF FUTURE COMPUTING RES LAB (FCRLAB) UNIVERSITÀ DI MESSINA

http://fcrlab.unime.it/

Our Present is ALREADY Part of Our Future



Our past determines our present, and our present is what shapes our future.

- unknown

boardofwisdom.com

Outline: Part I

Where we are:

- Cloud Computing
- FOG Computing
- Edge Computing
- IoT
- ……..
- ***Big Data: it is the driver***

Outline: Part I

Where we are, in particular:

- MicroServices and Containerization
- Social Platforms
- Serverless
- APIs for any taste:
  - RESTFul
  - CoAP

Outline: Part II

Consolidated Activities:

- Cloud Computing:
- FOG Computing
- IoT
- Big Data

Outline: Part II

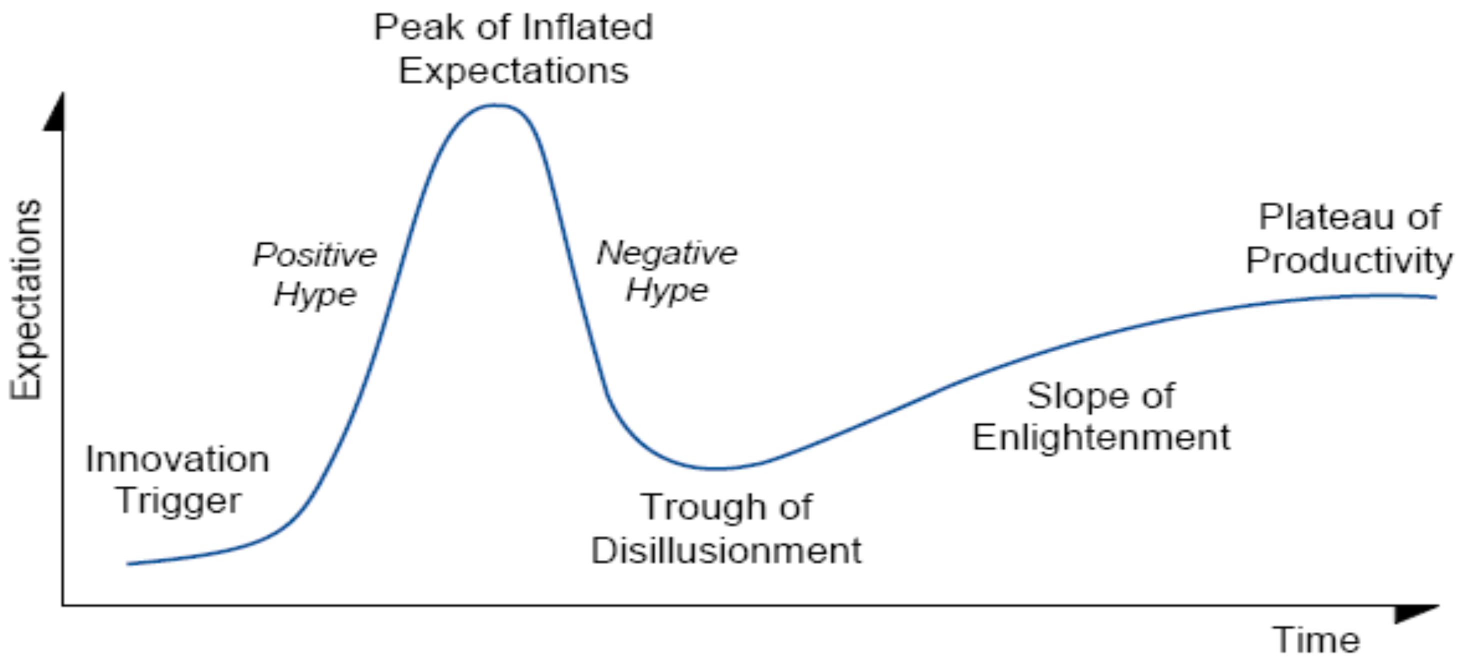
Where are we going??:

- Current Trends
- New Devices
- Needs
- ….

- ***A new concept: Osmotic Computing***

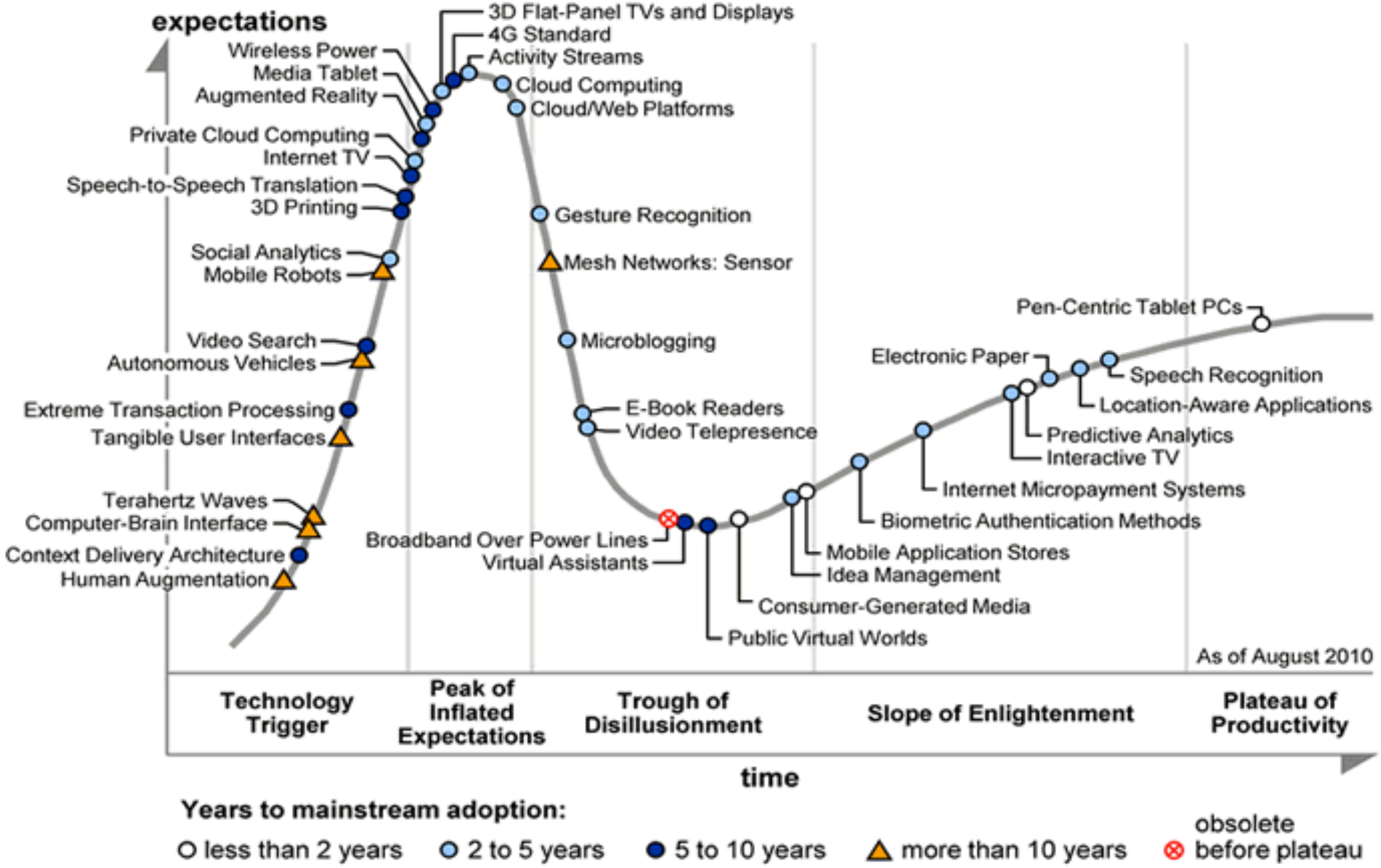
PART I

Simple graphical approach to get a better understanding: *Gartner hype cycle*

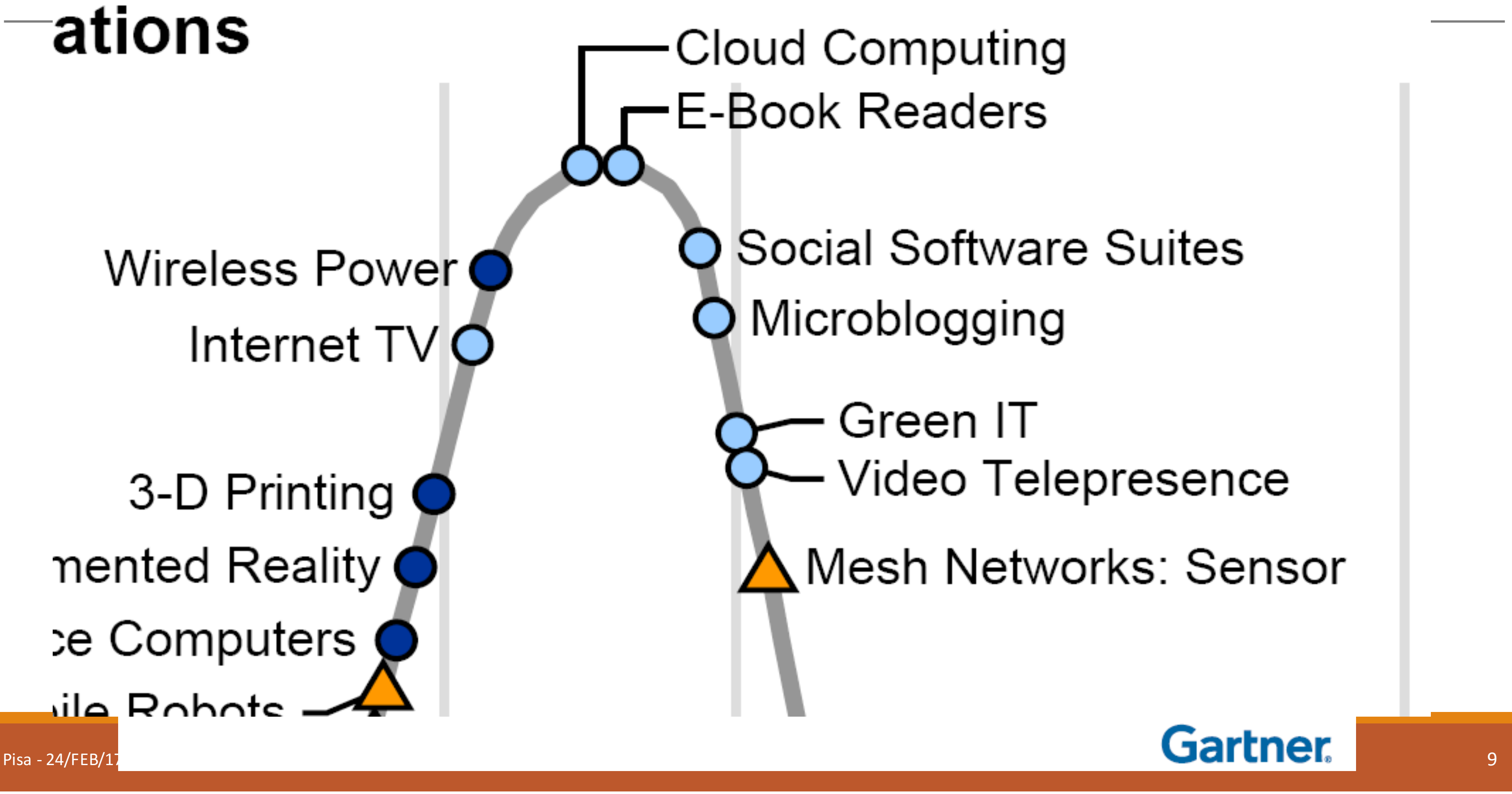


Gartner

Hype Cycle: 2010



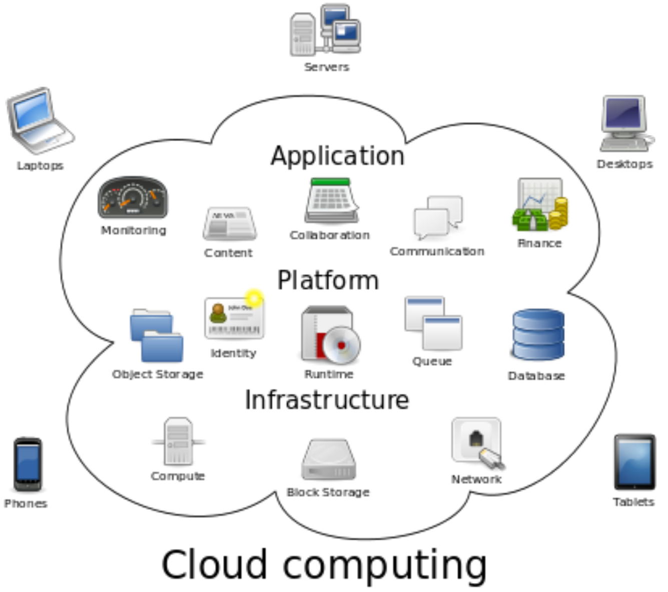
Inside the Hype Cycle: What’s Hot and What’s Not in 2009



Cloud Computing on the wiki

Cloud computing

is a type of Internet-based computing that provides shared computer processing resources and data to computers and other devices on demand. It is a model for enabling ubiquitous, **on-demand access to a shared pool** of configurable computing resources (e.g., computer networks, servers, storage, applications and services),which can be rapidly provisioned and released with minimal management effort. Cloud **computing and storage** solutions provide users and enterprises with various capabilities to store and process their data in either privately owned, or third-party data centers that may be located far from the user–ranging in distance from across a city to across the world. Cloud computing relies on sharing of resources to achieve coherence and economy of scale, similar to a utility (like the electricity grid) over an electricity network.

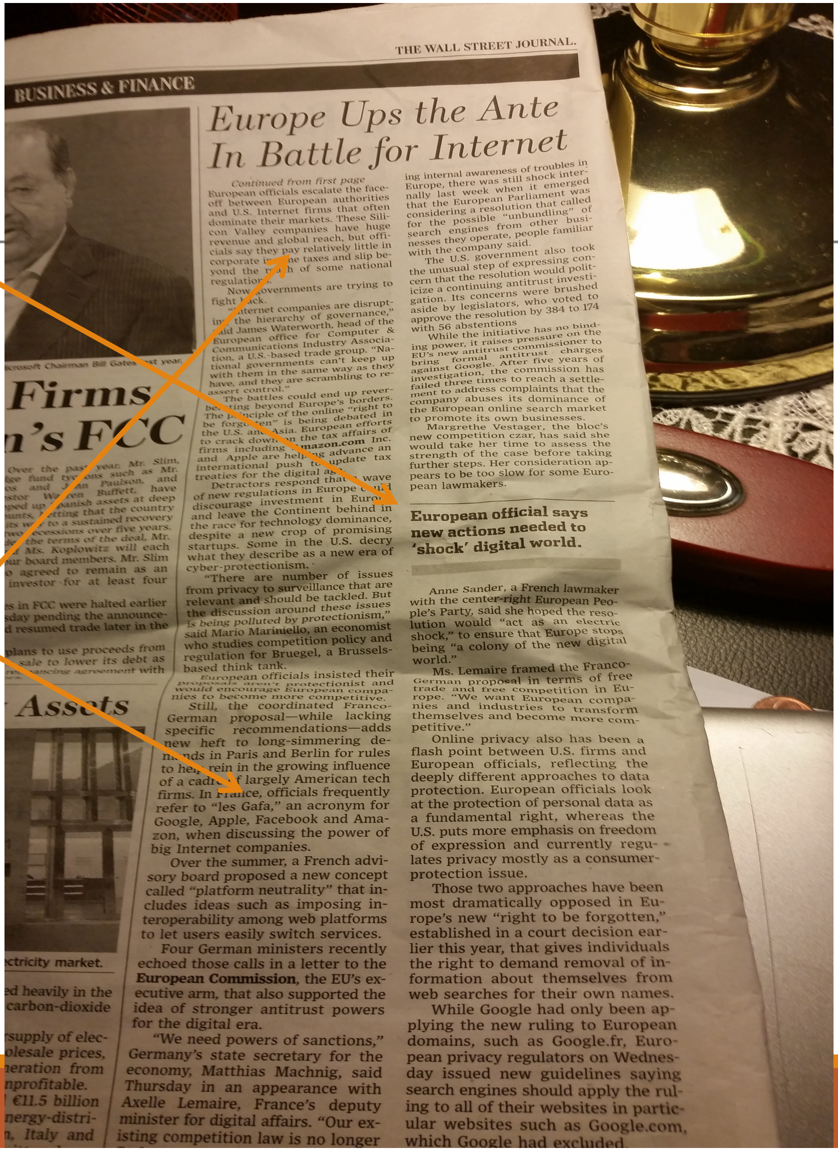


Why Cloud?

European official says new actions needed to "shock" digital world

In France: "Les Gafa"
Google, Apple, Facebook and Amazon

These Silicon Valley companies have hide revenue and global reach, but they pay little corporate income taxes



THE WALL STREET JOURNAL.

BUSINESS & FINANCE

Europe Ups the Ante In Battle for Internet

Continued from first page

European officials escalate the face-off between European authorities and U.S. Internet firms that often dominate their markets. These Silicon Valley companies have huge revenue and global reach, but officials say they pay relatively little in corporate income taxes and slip beyond the reach of some national regulation.

Now governments are trying to fight back.

"Internet companies are disrupting the hierarchy of governance," said James Waterworth, head of the European office for Computer & Communications Industry Association, a U.S.-based trade group. "National governments can't keep up with them in the same way as they have, and they are scrambling to reassert control."

The battles could end up reverberating beyond Europe's borders. The principle of the online "right to be forgotten" is being debated in the U.S. and Asia. European efforts to crack down on the tax affairs of firms including **Amazon.com** Inc. and Apple are helping advance an international push to update tax treaties for the digital age.

Detractors respond that a wave of new regulations in Europe could discourage investment in Europe and leave the Continent behind in the race for technology dominance, despite a new crop of promising startups. Some in the U.S. decry what they describe as a new era of cyber-protectionism.

"There are number of issues from privacy to surveillance that are relevant and should be tackled. But the discussion around these issues is being polluted by protectionism," said Mario Mariniello, an economist who studies competition policy and regulation for Bruegel, a Brussels-based think tank.

European officials insisted their proposals aren't protectionist and would encourage European companies to become more competitive.

Still, the coordinated Franco-German proposal—while lacking specific recommendations—adds new heft to long-simmering demands in Paris and Berlin for rules to help rein in the growing influence of a cadre of largely American tech firms. In France, officials frequently refer to "les Gafa," an acronym for Google, Apple, Facebook and Amazon, when discussing the power of big Internet companies.

Over the summer, a French advisory board proposed a new concept called "platform neutrality" that includes ideas such as imposing interoperability among web platforms to let users easily switch services.

Four German ministers recently echoed those calls in a letter to the **European Commission**, the EU's executive arm, that also supported the idea of stronger antitrust powers for the digital era.

"We need powers of sanctions," Germany's state secretary for the economy, Matthias Machnig, said Thursday in an appearance with Axelle Lemaire, France's deputy minister for digital affairs. "Our existing competition law is no longer

ing internal awareness of troubles in Europe, there was still shock internally last week when it emerged that the European Parliament was considering a resolution that called for the possible "unbundling" of search engines from other businesses they operate, people familiar with the company said.

The U.S. government also took the unusual step of expressing concern that the resolution would politicize a continuing antitrust investigation. Its concerns were brushed aside by legislators, who voted to approve the resolution by 384 to 174 with 56 abstentions

While the initiative has no binding power, it raises pressure on the EU's new antitrust commissioner to bring formal antitrust charges against Google. After five years of investigation, the commission has failed three times to reach a settlement to address complaints that the company abuses its dominance of the European online search market to promote its own businesses.

Margrethe Vestager, the bloc's new competition czar, has said she would take her time to assess the strength of the case before taking further steps. Her consideration appears to be too slow for some European lawmakers.

European official says new actions needed to 'shock' digital world.

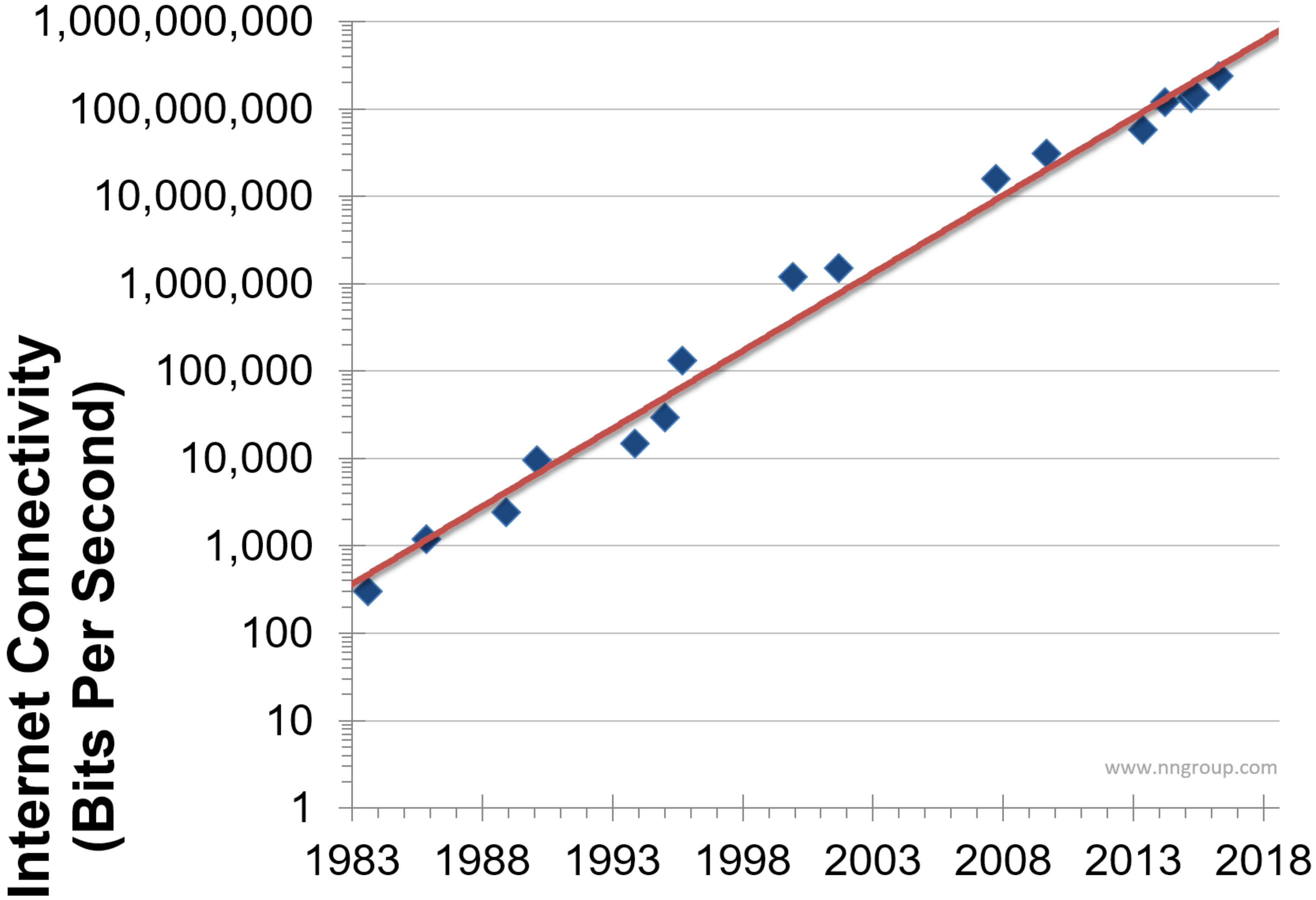
Anne Sander, a French lawmaker with the center-right European People's Party, said she hoped the resolution would "act as an electric shock," to ensure that Europe stops being "a colony of the new digital world."

Ms. Lemaire framed the Franco-German proposal in terms of free trade and free competition in Europe. "We want European companies and industries to transform themselves and become more competitive."

Online privacy also has been a flash point between U.S. firms and European officials, reflecting the deeply different approaches to data protection. European officials look at the protection of personal data as a fundamental right, whereas the U.S. puts more emphasis on freedom of expression and currently regulates privacy mostly as a consumer-protection issue.

Those two approaches have been most dramatically opposed in Europe's new "right to be forgotten," established in a court decision earlier this year, that gives individuals the right to demand removal of information about themselves from web searches for their own names.

While Google had only been applying the new ruling to European domains, such as Google.fr, European privacy regulators on Wednesday issued new guidelines saying search engines should apply the ruling to all of their websites in particular websites such as Google.com, which Google had excluded


Internet Connectivity
(Bits Per Second)
1,000,000,000
100,000,000
10,000,000
1,000,000
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100
10
1
1983
1988
1993
1998
2003
2008
2013
2018
www.nngroup.com

FOG Computing on the Wiki

Fog computing can be perceived both in large cloud systems and big data structures, making reference to the growing difficulties in accessing information objectively.

This results in a lack of quality of the obtained content.

The effects of fog computing on **cloud computing and big data systems may vary; yet, a common aspect that can be extracted is a limitation in accurate content distribution, an issue that has been tackled with the creation of metrics that attempt to improve accuracy**.

Fog networking consists of a **control plane and a data plane**. For example, on the data plane, fog computing enables computing services to reside at the edge of the network as opposed to servers in a data-center.

FOG Computing on the Wiki

Compared to cloud computing, fog computing emphasizes proximity to end-users and client objectives, dense geographical distribution and local resource pooling, latency reduction for quality of service (QoS) and edge analytics/stream mining, resulting in superior user-experience and redundancy in case of failure.

Fog networking supports the Internet of Things (IoT) concept, in which most of the devices used by humans on a daily basis will be connected to each other. Examples include phones, wearable health monitoring devices, connected vehicle and augmented reality using devices such as the Google Glass.

ISO/IEC 20248 provides a method whereby the data of objects identified by edge computing using Automated Identification Data Carriers [AIDC], a barcode and/or RFID tag, can be read, interpreted, verified and made available into the "Fog" and on the "Edge" even when the AIDC tag has moved on.

Open FOG Architecture:

- Security;
- Scalability;
- Open; Autonomy;
- Programmability;
- RAS (Reliability, Availability, and Serviceability);
- Agility; and
- Hierarchy.

Edge Computing on the Wiki

Edge computing pushes applications, data and computing power (services) away from centralized points to the logical extremes of a network. Edge computing replicates fragments of information across distributed networks of web servers, which may be vast. As a topological paradigm, edge computing is also referred to as **mesh computing, peer-to-peer computing, autonomic (self-healing) computing, grid computing, and other names implying non-centralized, nodeless availability**.

To ensure acceptable performance of widely dispersed distributed services, large organizations typically implement edge computing by deploying Web server farms with clustering. Previously available only to very large corporate and government organizations, technology advancement and cost reduction for large-scale implementations have made the technology available to small and medium-sized businesses.

The target end-user is any Internet client making use of commercial Internet application services.

Edge computing imposes certain limitations on the choices of technology platforms, applications or services, all of which need to be specifically developed or configured for edge computing.

Edge Computing on the Wiki

Edge computing has many advantages:

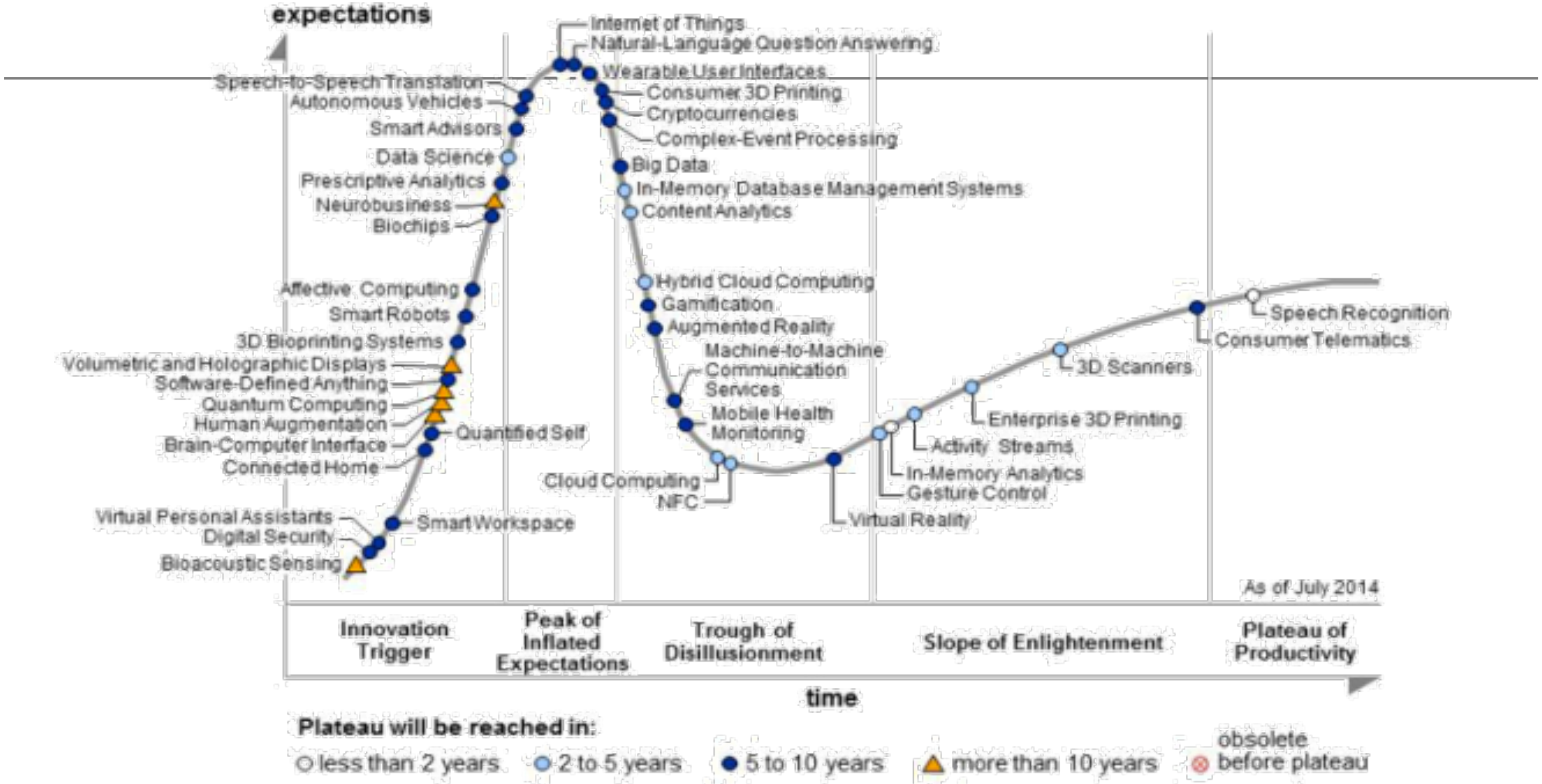
Edge application services significantly decrease the data volume that must be moved, the consequent traffic, and the distance the data must go, thereby reducing transmission costs, shrinking latency, and improving quality of service (QoS).

Edge computing eliminates, or at least de-emphasizes, the core computing environment, limiting or removing a major bottleneck and a potential point of failure.

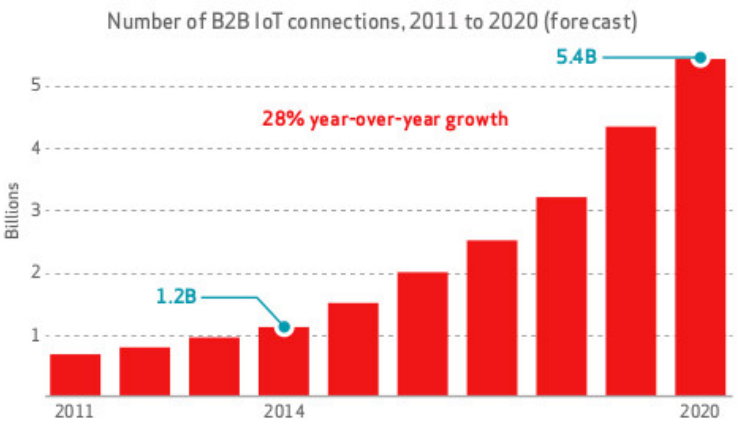
Security is also improved as encrypted data moves further in, toward the network core. As it approaches the enterprise, the data is checked as it passes through protected firewalls and other security points, where viruses, compromised data, and active hackers can be caught early on.

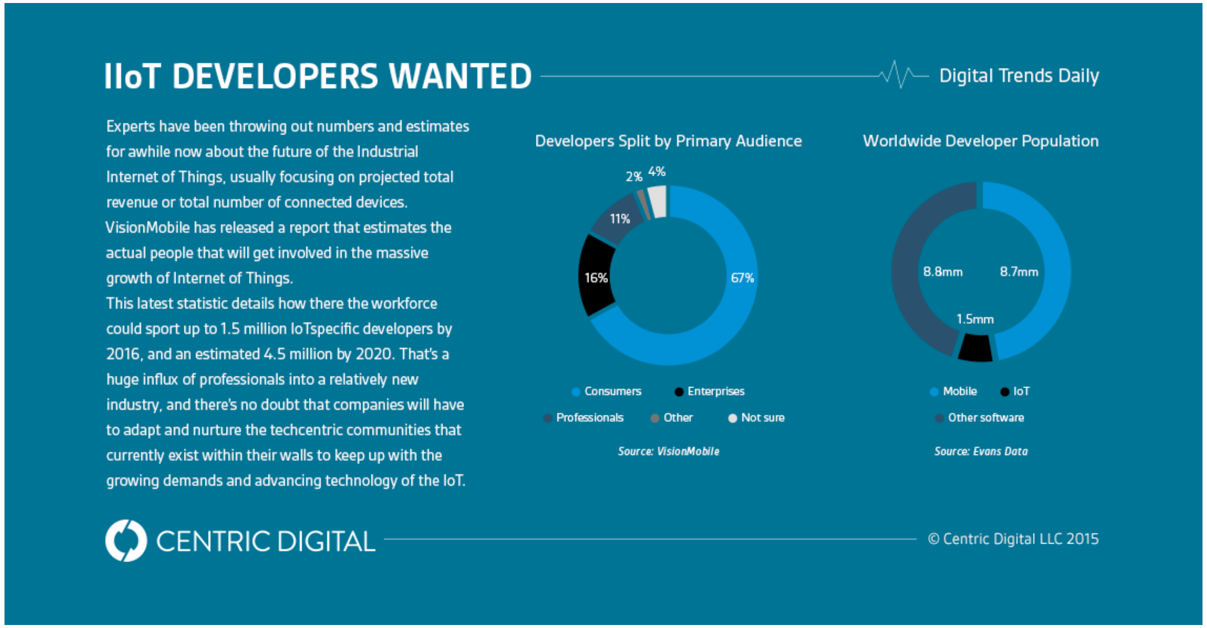
Finally, the ability to "virtualize" (i.e., logically group CPU capabilities on an as-needed, real-time basis) extends scalability. The edge computing market is generally based on a "**charge for network services" model**, and it could be argued that typical customers for edge services are organizations desiring linear scale of business application performance to the growth of, e.g., a subscriber base.

Hype Cycle: 2014



Internet of Things


Number of B2B IoT connections, 2011 to 2020 (forecast)


IIoT DEVELOPERS WANTED

Digital Trends Daily

Experts have been throwing out numbers and estimates for awhile now about the future of the Industrial Internet of Things, usually focusing on projected total revenue or total number of connected devices. VisionMobile has released a report that estimates the actual people that will get involved in the massive growth of Internet of Things.
This latest statistic details how there the workforce could sport up to 1.5 million IoTspecific developers by 2016, and an estimated 4.5 million by 2020. That's a huge influx of professionals into a relatively new industry, and there's no doubt that companies will have to adapt and nurture the techcentric communities that currently exist within their walls to keep up with the growing demands and advancing technology of the IoT.

Developers Split by Primary Audience

Source: VisionMobile

Worldwide Developer Population

Source: Evans Data

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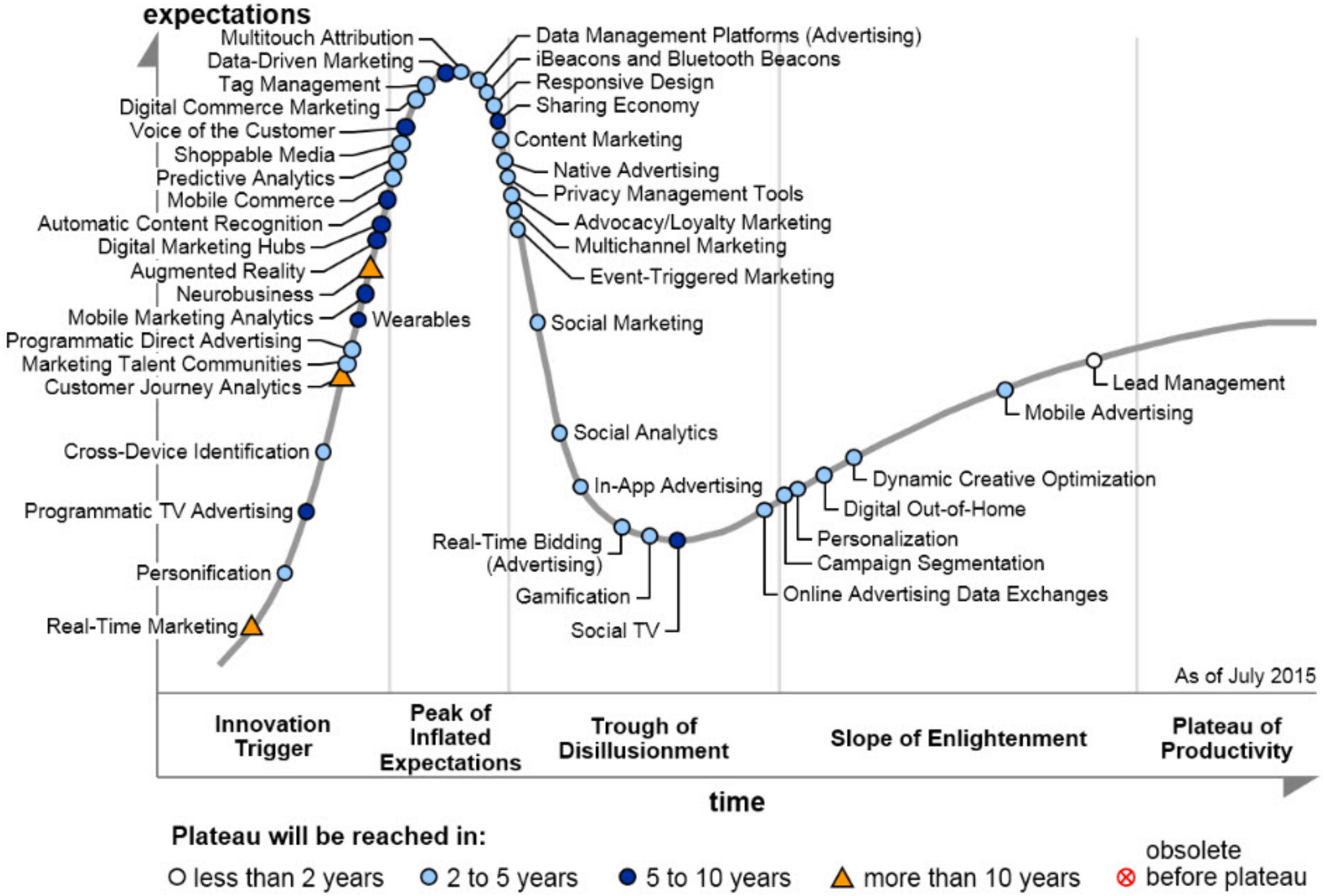
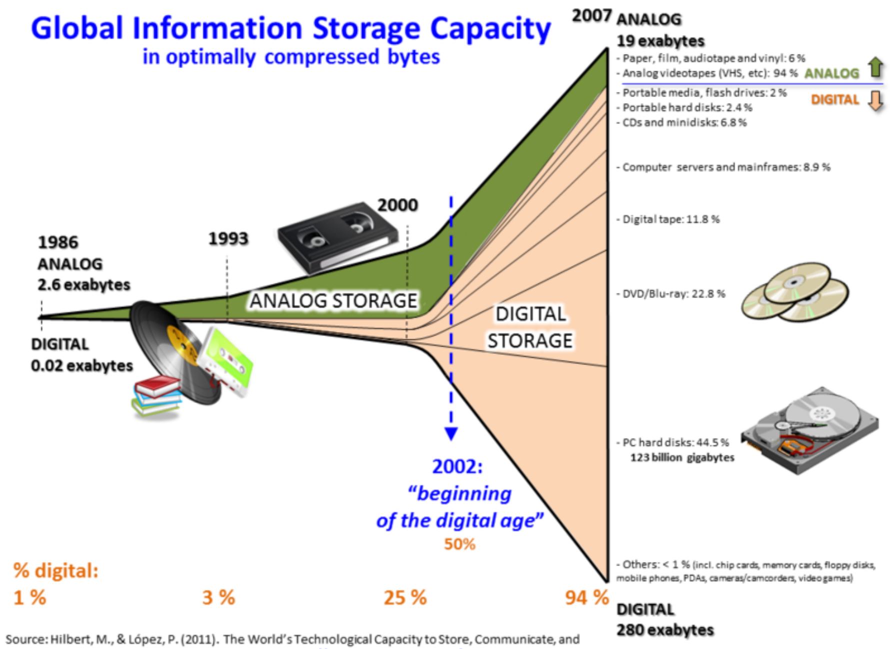
Hype Cycle for Digital Marketing, 2015



Gartner

Data

Big Data Challenges:
include capture, storage, analysis, data curation, search, sharing, transfer, visualization, querying, updating and information privacy. The term "big data" often refers simply to the use of predictive analytics, user behavior analytics, or certain other advanced data analytics methods that extract value from data, and seldom to a particular size of data set.

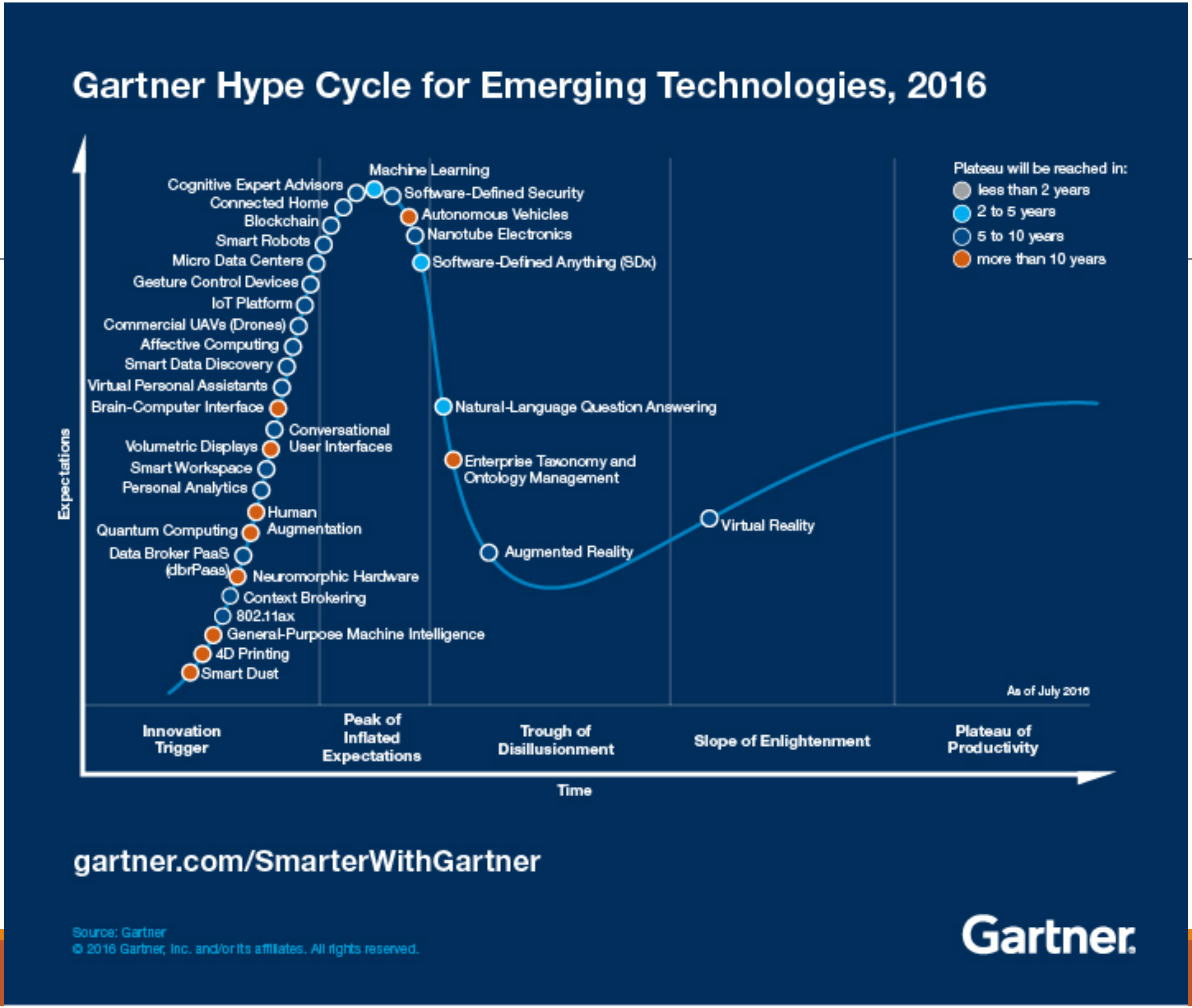


Source: Hilbert, M., & López, P. (2011). The World's Technological Capacity to Store, Communicate, and Compute Information. *Science*, 332(6025), 60 –65. http://www.martinhilbert.net/WorldInfoCapacity.html

Microservice on the Wiki

In a microservices architecture, **services should have a small granularity and the protocols should be lightweight**. A central microservices property that appears in multiple definitions is that services should be independently **deployable.The benefit of distributing different responsibilities of the system into different smaller services is that it enhances the cohesion and decreases the coupling.** This makes it easier to change and add functions and qualities to the system at any time. It also allows the architecture of an individual service to emerge through continuous refactoring, and hence reduces the need for a big up-front design and allows for releasing software early and continuously.

PART II



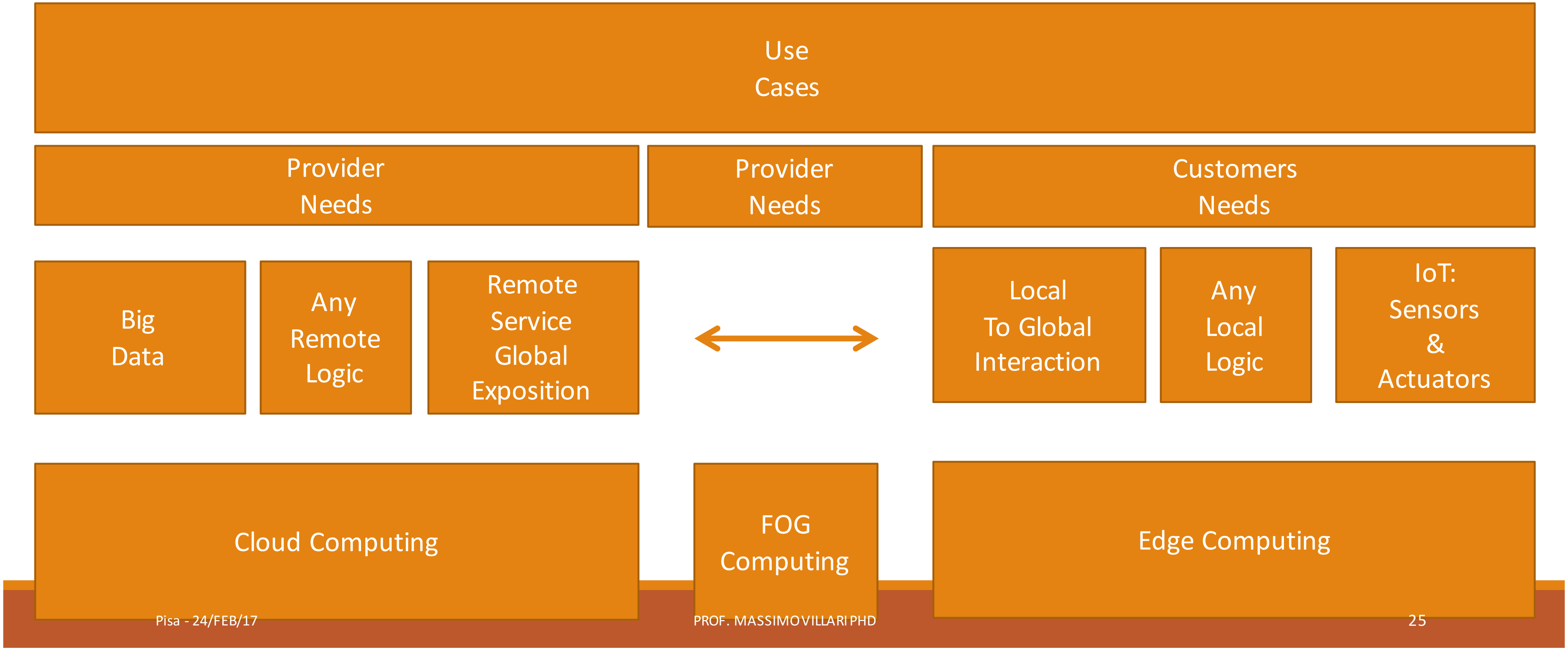
Gartner Hype Cycle for Emerging Technologies, 2016

gartner.com/SmarterWithGartner

Source: Gartner

Gartner

A Common BED



Use Cases

Provider Needs

Provider Needs

Customers Needs

Big Data

Any Remote Logic

Remote Service Global Exposition

Local To Global Interaction

Any Local Logic

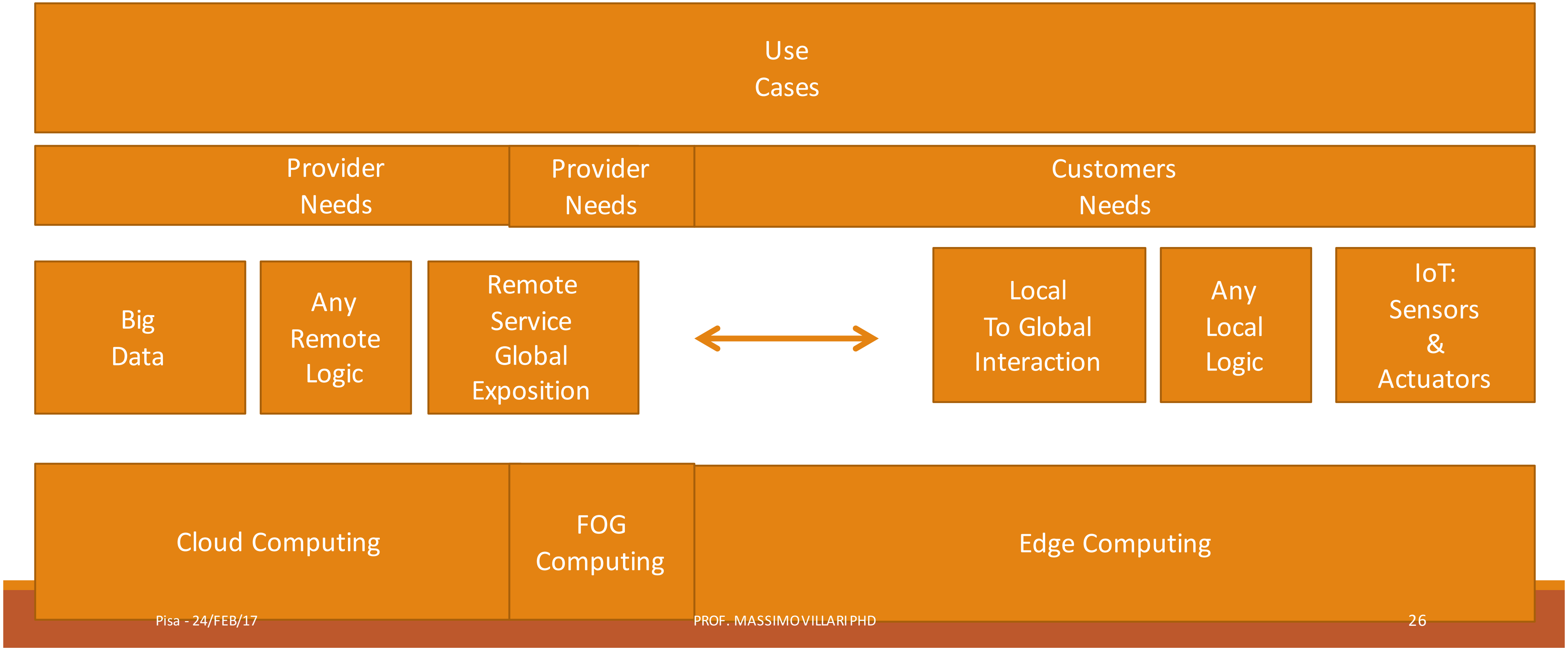
IoT: Sensors & Actuators

Cloud Computing

FOG Computing

Edge Computing

A Common BED



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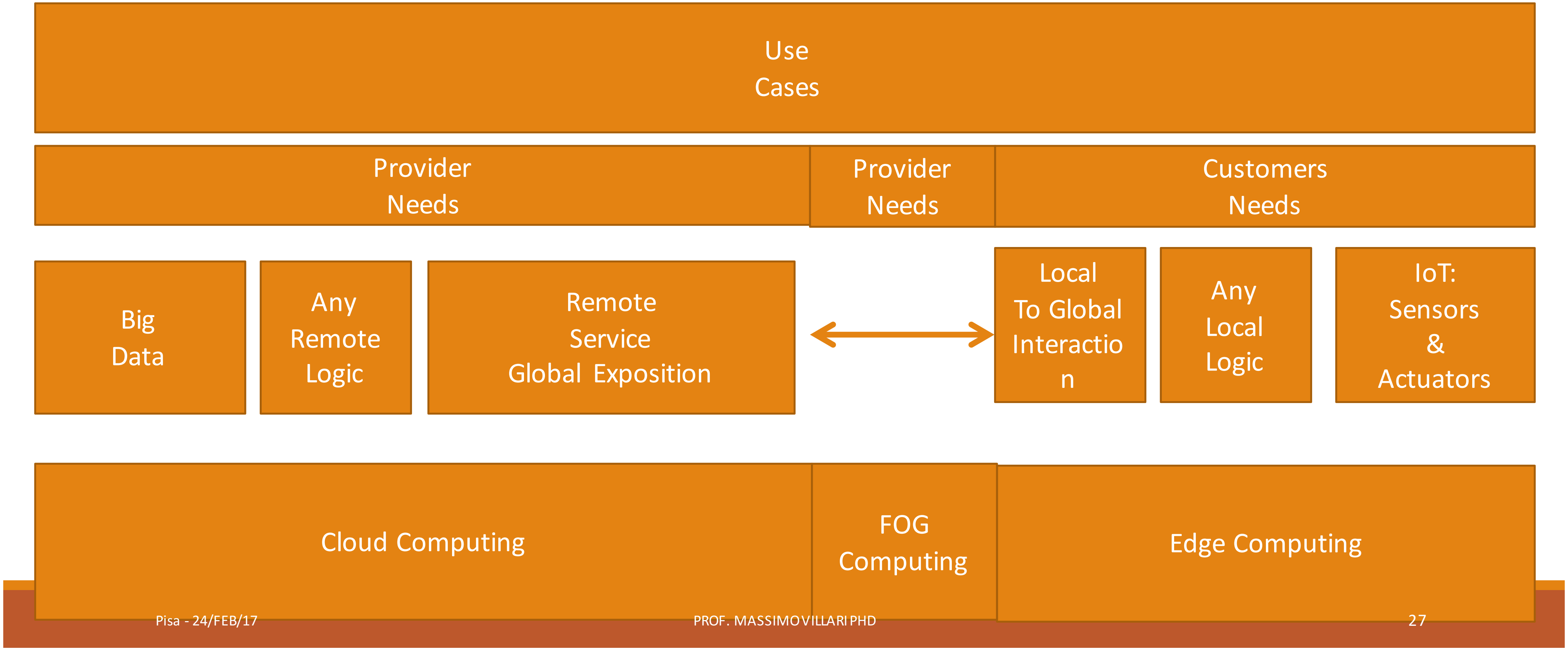

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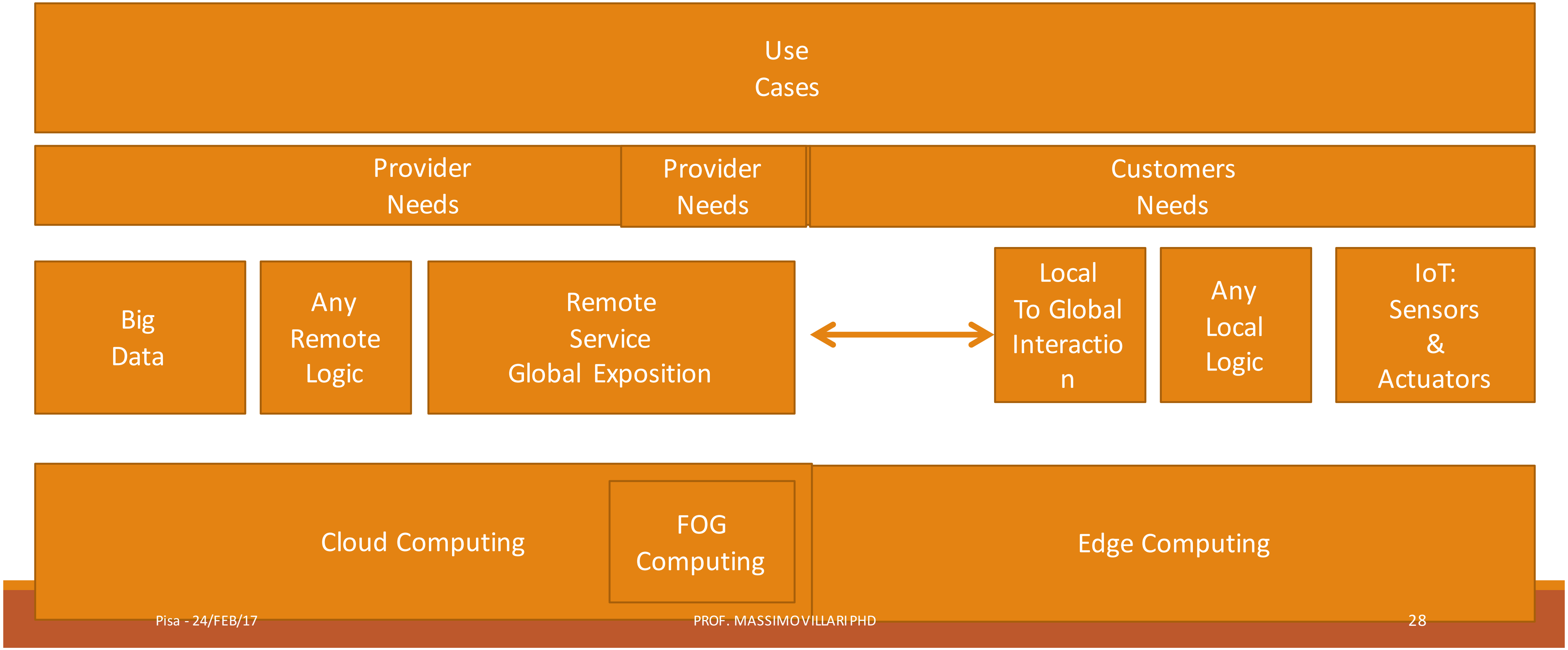

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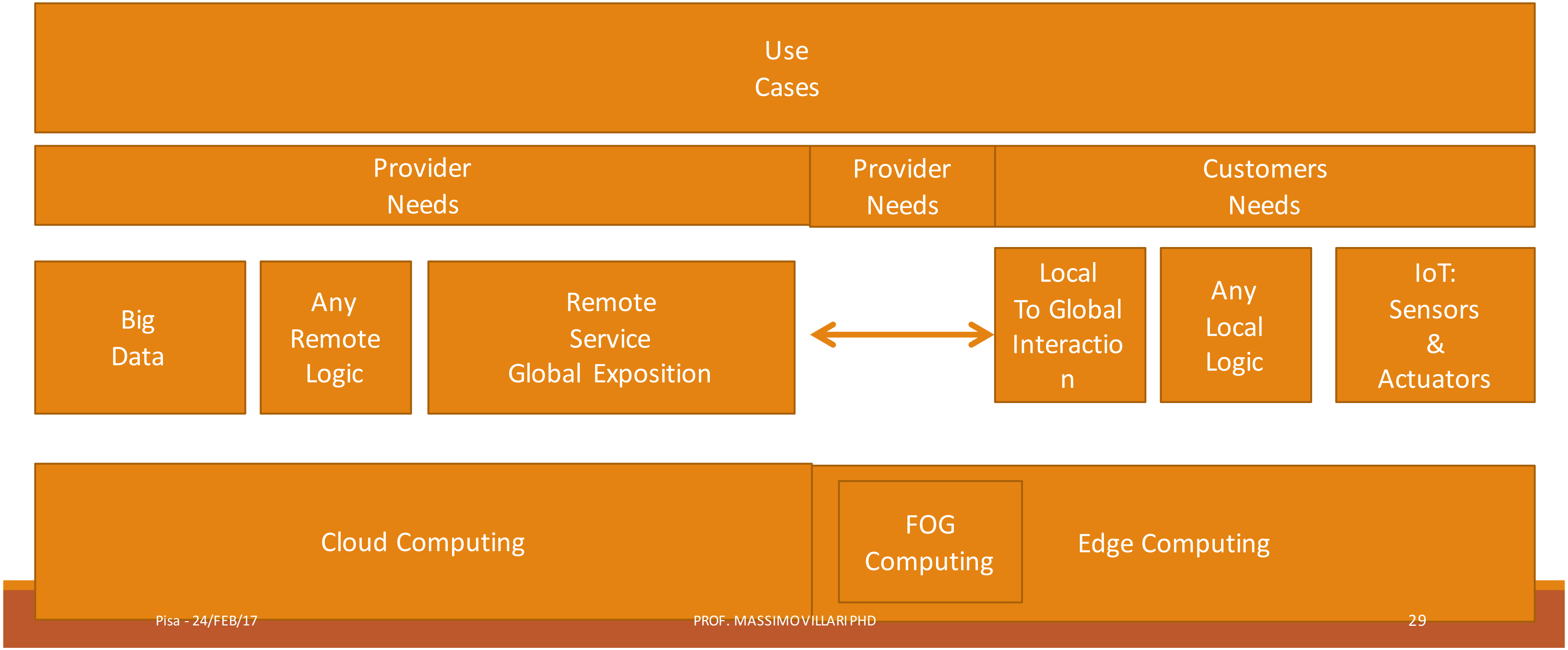

Use Cases

Provider Needs

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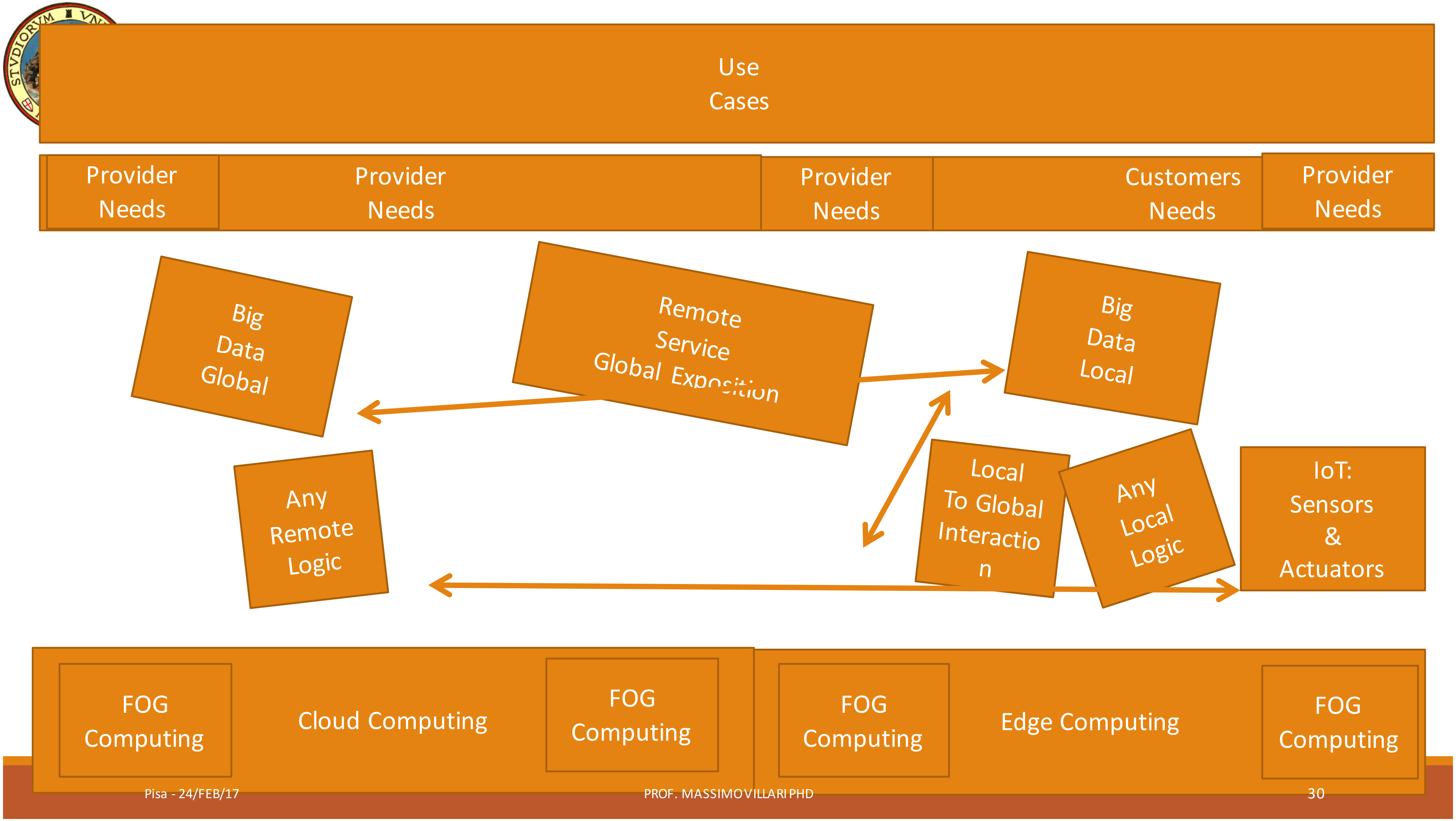


Use Cases

Provider Needs

Provider Needs

Provider Needs

Customers Needs

Provider Needs

Big Data Global

Remote Service Global Exposition

Big Data Local

Any Remote Logic

Local To Global Interaction

Any Local Logic

IoT: Sensors & Actuators

FOG Computing

Cloud Computing

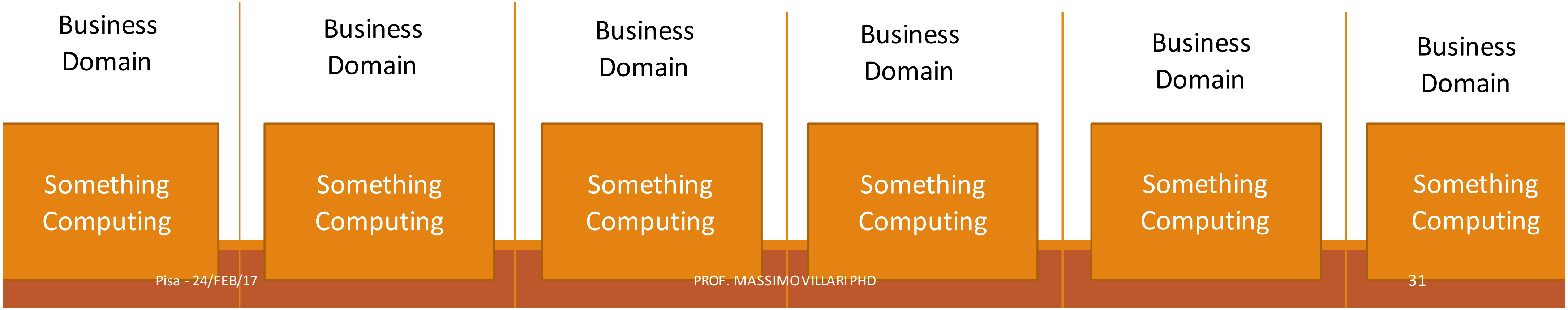
FOG Computing

FOG Computing

Edge Computing

FOG Computing

Something Computing -> Software Defined Anything



Business Domain

Something Computing

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Something Computing

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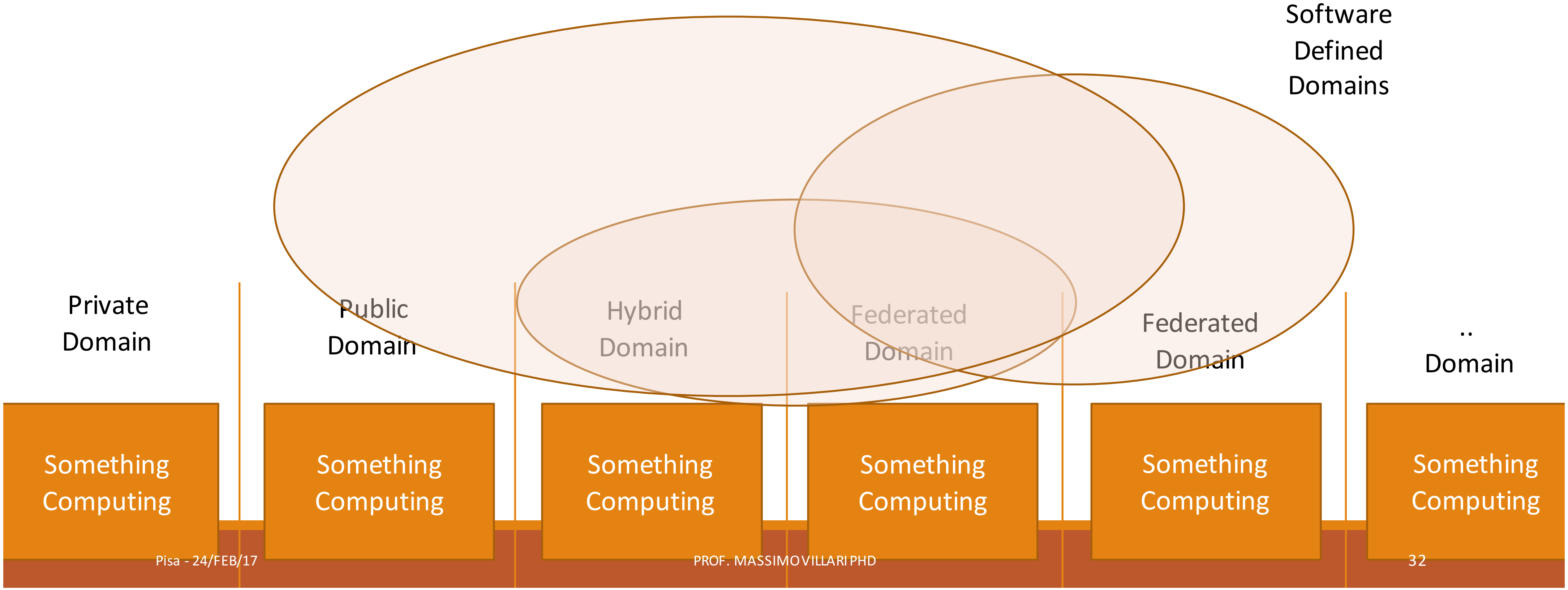
Something Computing

Something Computing -> Software Defined Anything



Something Computing -> Software Defined Anything

In concrete:

- Define a Set of APIs
- Migrability of Services (Micro is better)
- Bounds for Security (No Breaches-> if [yes] delete service
- A priory agreements

Looking at Devices

Smarter?:

- Even more Abstracted
- Even more Capable (Proc. / Storage / Net.)
- Even more Multiple Cores

What devices?: MPU or MCU

MPUs offer more functionality and faster time to market, while MCUs provide a smaller, more cost-efficient solution.

MPU:

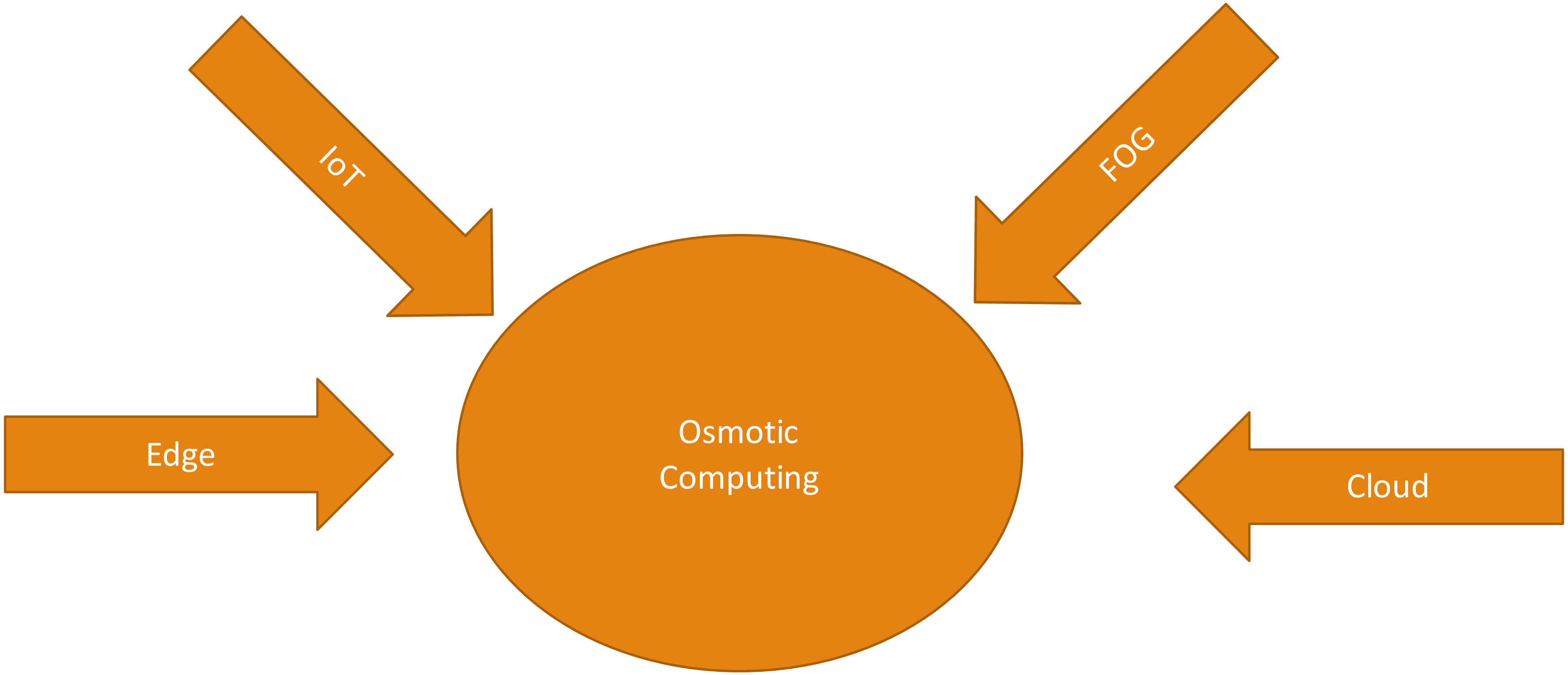
MPUs generally use open-source operating systems such as Linux and Android, although high-reliability applications may require proprietary operating systems like those from Green Hills Software and Wind River. These operating systems include a library of drivers, for example for codecs, Ethernet, USB, etc. Most MPU providers create and maintain both Linux and Android releases for their evaluation boards, often supporting them with large software teams. Full-fledged operating systems make the development of software much more simple and lend themselves to "plug and play" hardware.

MCU:

An MCU delivers the right balance of cost, size, efficiency, and reliability. Vendors leverage modular platforms and value pricing to create multiple part numbers from one die. As a result, designers have a range of options in terms of memory size, pin count, and peripherals to develop the most cost-effective solution. MCUs are sometimes referred to as SoCs because of the large amount of built-in functionality. They typically integrate reset functionality, low-voltage inhibit, clock sources, interrupts, and on-chip regulators, to name a few.

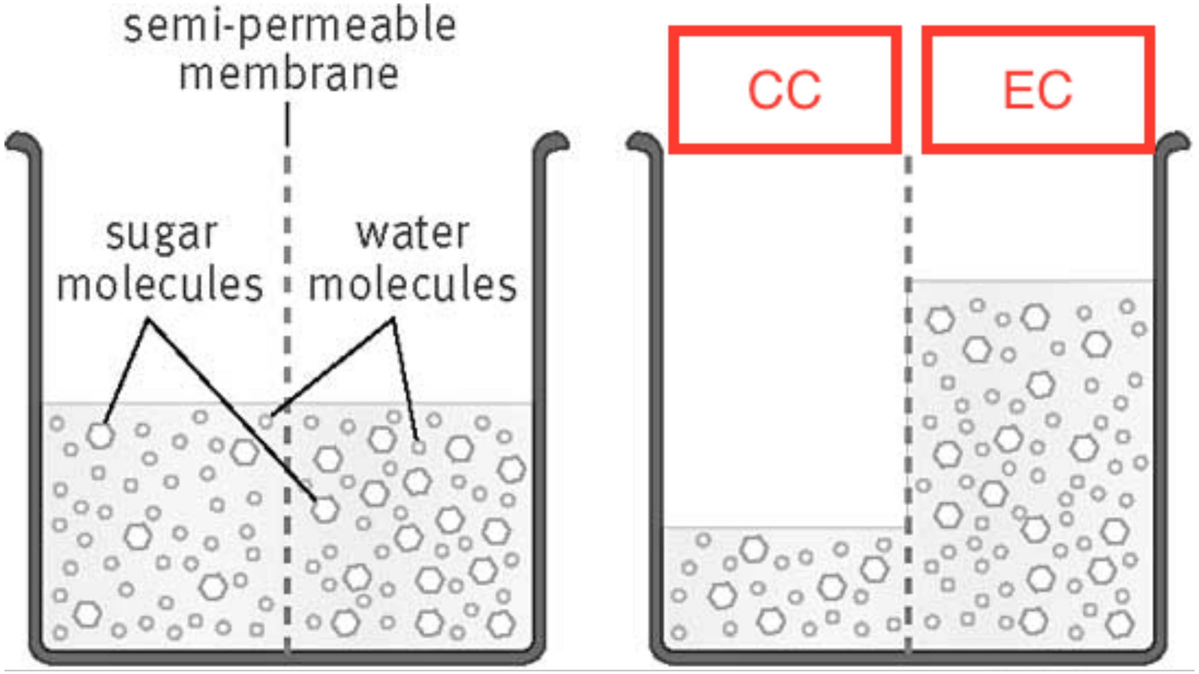
The CPU cores used in MCUs are designed explicitly to deliver the very low interrupt latency and deterministic code execution required for motor control in real-time applications like fans, compressors, washing machines, etc. The Cortex-M4, for example, has a worst-case interrupt latency of 12 cycles and uses a three-stage pipeline.

Looking at the Overall Picture: E2E

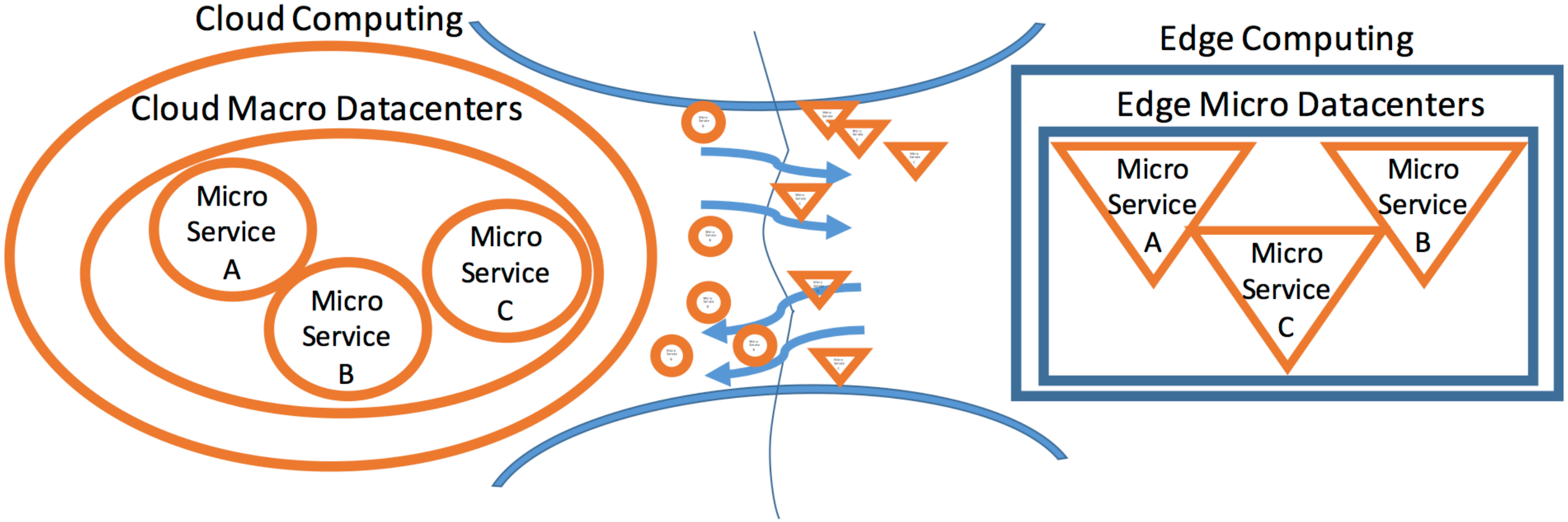


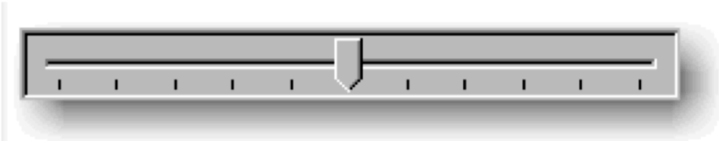
Time for Cooking all Ingredients Together

Osmosis Process

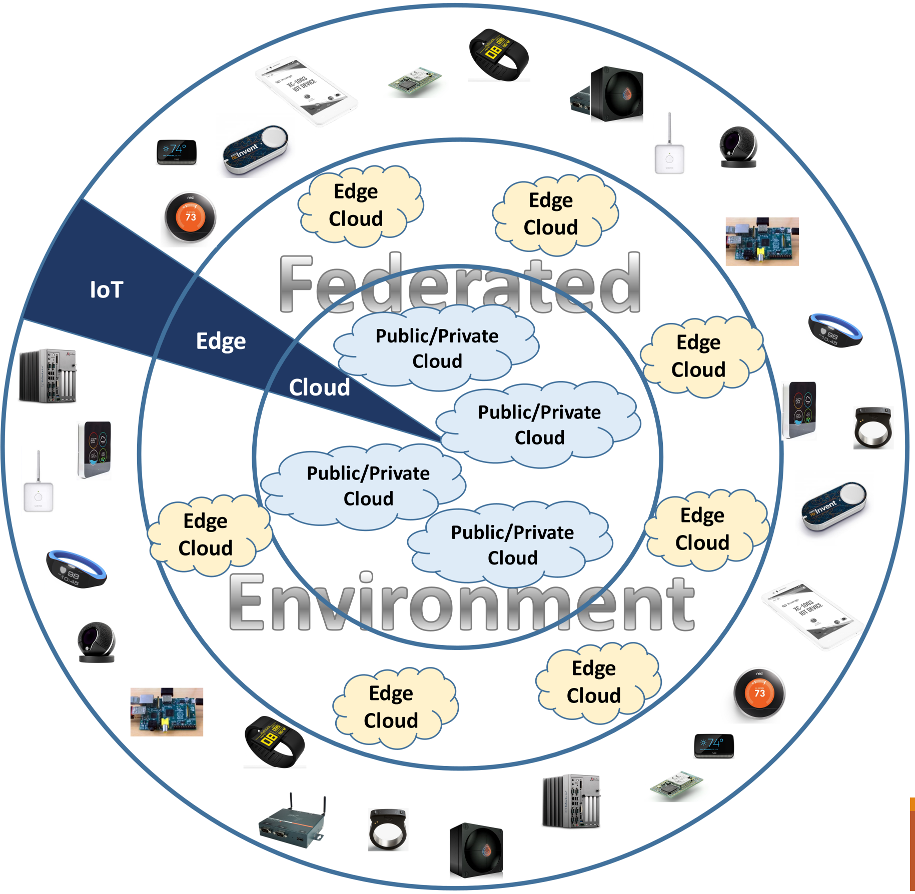


Osmotic Computing Concept

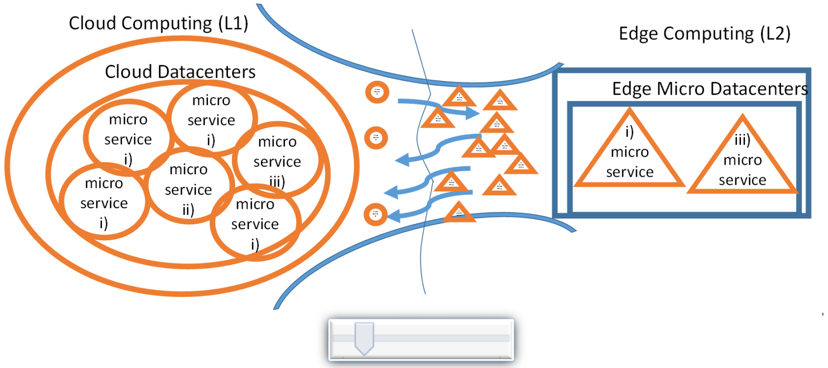


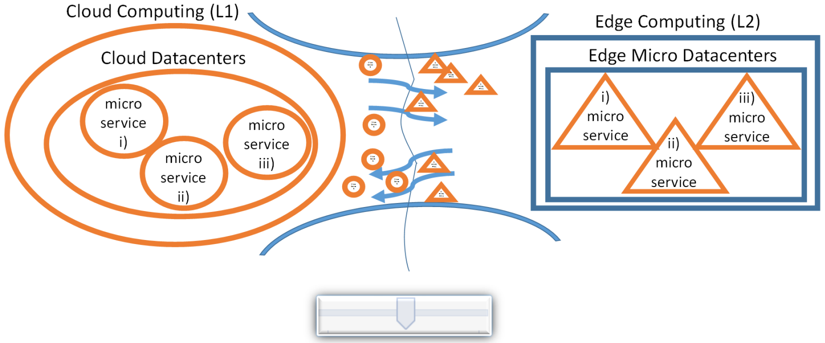


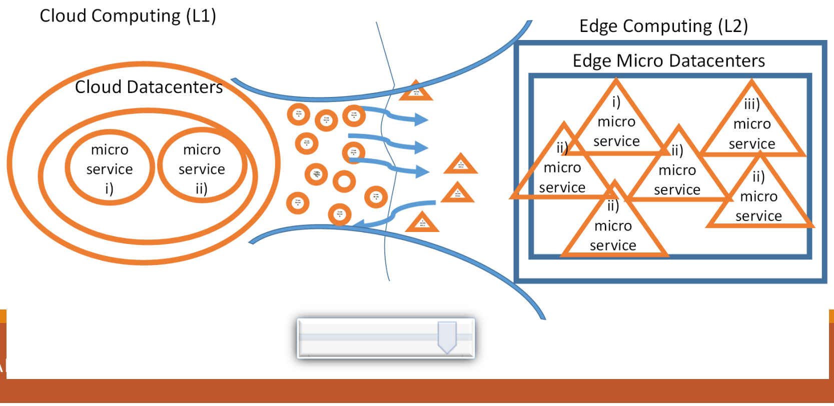
Osmotic Computing Federated Scenario



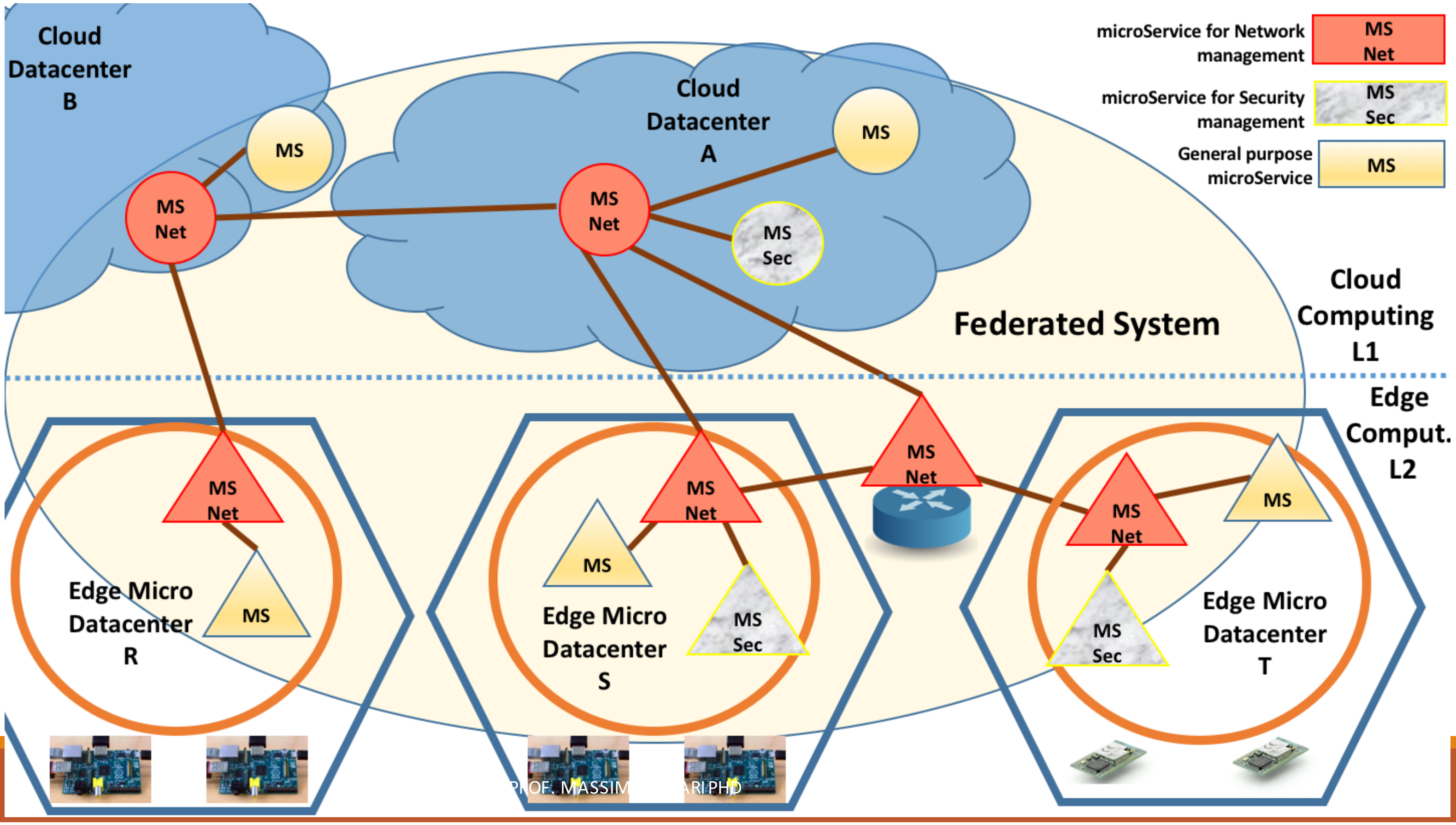
Osmotic Computing

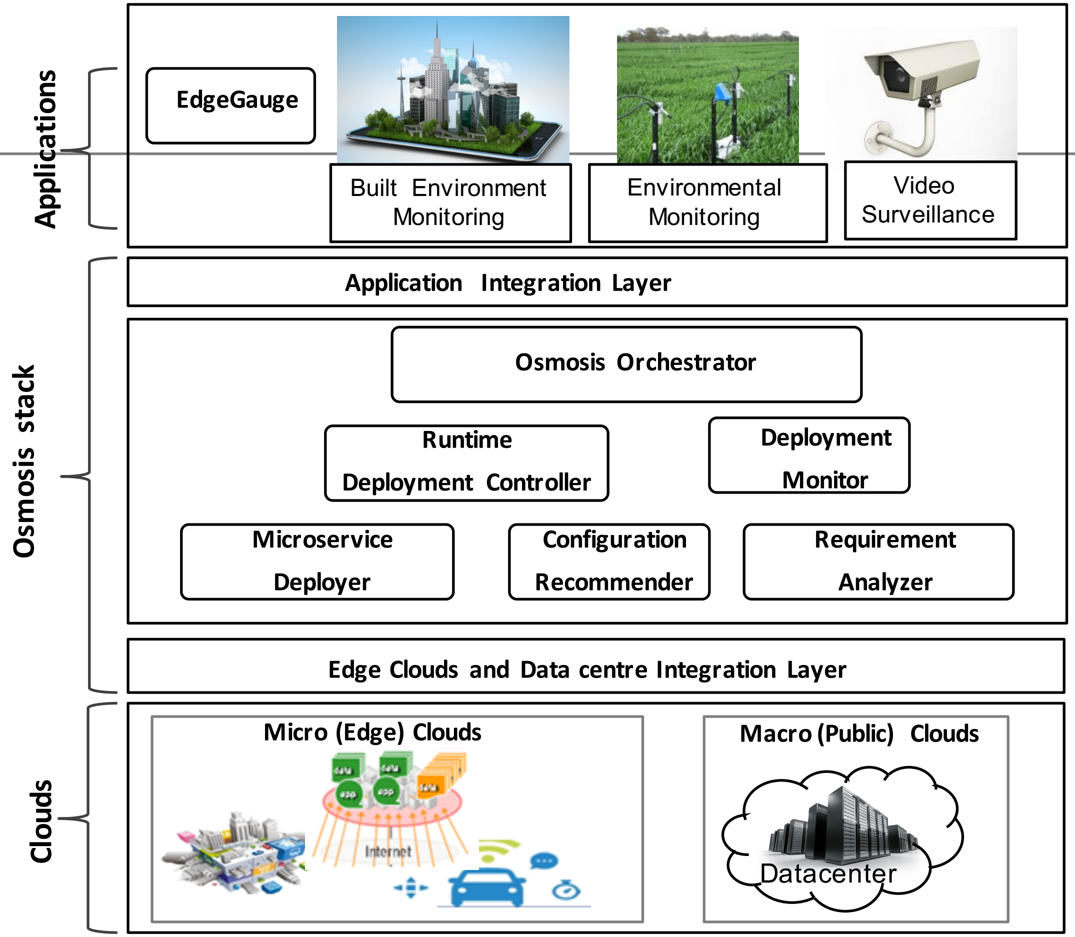


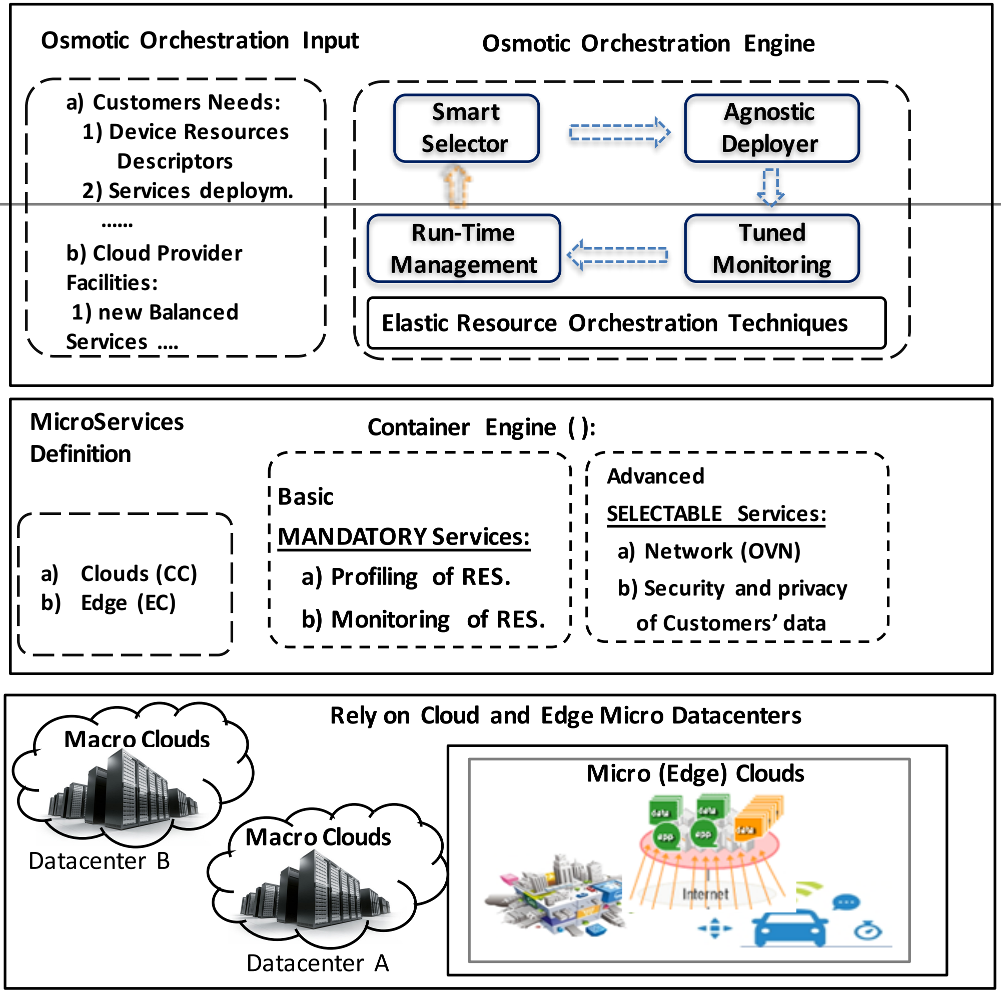




Osmotic Computing




Applications
EdgeGauge
Built Environment Monitoring
Environmental Monitoring
Video Surveillance
Osmosis stack
Application Integration Layer
Osmosis Orchestrator
Runtime Deployment Controller
Deployment Monitor
Microservice Deployer
Configuration Recommender
Requirement Analyzer
Edge Clouds and Data centre Integration Layer
Clouds
Micro (Edge) Clouds
Internet
Macro (Public) Clouds
Datacenter



Osmotic Orchestration Input

a) Customers Needs:
1) Device Resources Descriptors
2) Services deploym.
……
b) Cloud Provider Facilities:
1) new Balanced Services ….

Osmotic Orchestration Engine

Smart Selector

Agnostic Deployer

Tuned Monitoring

Run-Time Management

Elastic Resource Orchestration Techniques

MicroServices Definition

a) Clouds (CC)
b) Edge (EC)

Container Engine ( ):

Basic

MANDATORY Services:

a) Profiling of RES.

b) Monitoring of RES.

Advanced

SELECTABLE Services:

a) Network (OVN)

b) Security and privacy of Customers' data

Rely on Cloud and Edge Micro Datacenters

Osmotic Computing *Challenges*

IEEE Cloud Computing > Volume: 3 Issue: 6 (Dec 2016): Osmotic Computing: Massimo Villari ; Maria Fazio ; Schahram Dustdar ; Omer Rana ; Rajiv Ranjan A New Paradigm for Edge/Cloud Integration

A. Runtime Microservice Deployment

B. Microservice configuration

C. Microservice Networking

D. Microservice Security

E. Edge Computing

F. Microservice workload contention and interference evaluation

G. Monitoring

H. Microservice orchestration and elasticity control

Osmotic Computing *Challenges*

Runtime Microservice Deployment:

An Osmotic Computing framework should provide a **microservice Engine**, allowing users and developers to deploy containers running microservices on IoT and Edge devices, enabling microservice execution and deployment. The innovation delivered by Osmotic Computing will **facilitate the creation of a market of virtual IoT based applications**. Software adaptation and versioning mechanisms will allow Edge Cloud providers to deploy microservices consisting of a **heterogeneous pool of physical devices**. Benefits of Osmotic Computing include deployment of **distributed IoT oriented microservices, software consolidation, and service optimization.**

Osmotic Computing *Challenges*

Microservice configuration:

In Osmotic Computing developing holistic decision-making frameworks that automate configuration selection across microservices and resources in Cloud and Edge datacenters to meet QoS constraints is necessary. To this end, novel decision-making techniques based on multi-criteria optimization (e.g., Genetic Algorithms) and multi-criteria decision making (e.g., Analytic Network Process) techniques should be investigated.

Osmotic Computing *Challenges*

Microservice Networking:

Osmotic Computing is based on an abstraction of networks that spawn from Cloud to Edge and vice versa for improving the performance of the communication among microservices. The network here represents an enabler that allows us to **dynamically adjust the overall microservices behavior according to user requirements.** The network management advances in Osmotic Computing should include the development of an **interoperability layer** for remote orchestration of heterogeneous Edge devices, for example, exploiting **Software Defined Networking (SDN) and Network Function Virtualization (NFV) capabilities**, accessible through an API.

Osmotic Computing *Challenges*

Edge Computing

The approach suggests the need to combine **"mobile offloading" with "data centre offloading"** i.e., we off-load computation initially carried out within a datacenter to a mobile device. **This "reverse" off-loading** enables computation to be undertaken closer to the phenomenon being measured (overcoming latency and data transfer costs). The Osmotic Computing approach is therefore focused on **understanding the types of microservices which would be more relevant to execute at the Edge**, rather than within a datacenter environment, and vice versa.

Osmotic Computing *Challenges*

Microservice workload contention and interference evaluation

The co-deployed microservices on Cloud or Edge datacenters can lead to **contention problems which will affect QoS**. During deployment of microservices, orchestration techniques must consider which microservices should be combined on a datacenter resource, to minimize resource contention due to workload interference. **Workload resource consumption and QoS are not additive**, so understanding the nature of their composition is critical to deciding which microservices can be deployed together.

Research in Osmotic Computing should be focus on novel **microservice consolidation techniques** that can **dynamically detect and resolve resource contention** via microservice performance characterization, workload prioritization and coordinated deployment.

Osmotic Computing *Challenges*

Monitoring

(i) monitor and instrument data (workload input and QoS metrics, disruptive event) across microservices, Cloud datacenter, intransit network, and Edge datacenter

(ii) detect root causes of QoS violations and failures across the infrastructure based on workload and QoS metrics logs.

Researchers should investigate scalable methods (based on self-balanced trees) to

monitor QoS and security metrics across multiple-levels of Osmotic Computing including microservices, Cloud datacenters and Edge micro-datacenters.

Osmotic Computing *Challenges*

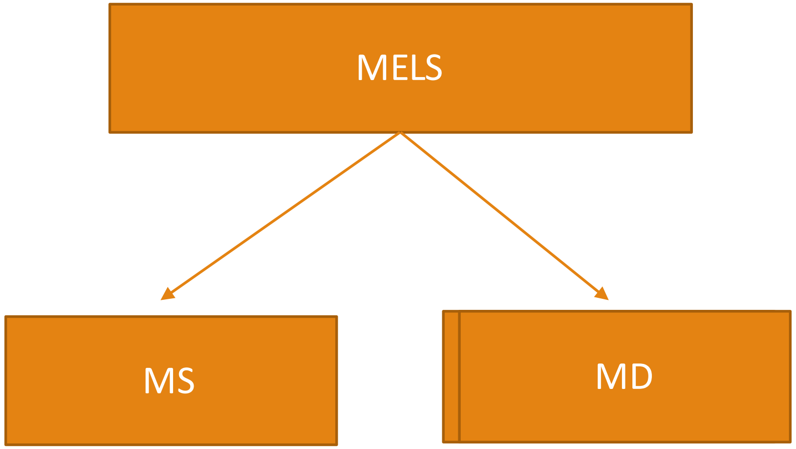
Microservice orchestration and elasticity control

In Osmotic Computing , the traditional **notion of run-time control and reconfiguration** which only considers resources hosted in Cloud datacentes, to resources that are deployed and available at the Edge, should be **extended**. **Machine learning techniques for developing predictive models to forecast workload** input and performance metrics across multiple, colocated microservices on Cloud and Edge datacenter resources should be investigated. Additionally, **intelligent, QoS-aware, and contention-aware resource orchestration algorithms** should be developed based on the above models, **monitoring systems, and configuration selection** techniques.

Osmotic Computing *into details*

MicroELementS (MELS) split into two main abstracted components:

- MS(MicroServices) and
- MD(MicroData).



Osmotic Computing *into details*

It will appear Soon in CN4IoT/Springer - Osmotic Computing:
Basic Elements and Their Details

Main root of the hierarchy is represented from MicroELementS, whereas underneath there are MSs and MDs.

The leaf of hierarchy is represented by:

- MUS
- MOS

- MUD
- MOD

U for User and O for Operational.

Osmotic Computing *into details*

It will appear Soon in CN4IoT/Springer - Osmotic Computing:
Basic Elements and Their Details

Main root of the hierarchy is represented from MicroELementS, whereas underneath there are MSs and MDs.

The leaf of hierarchy is represented by:

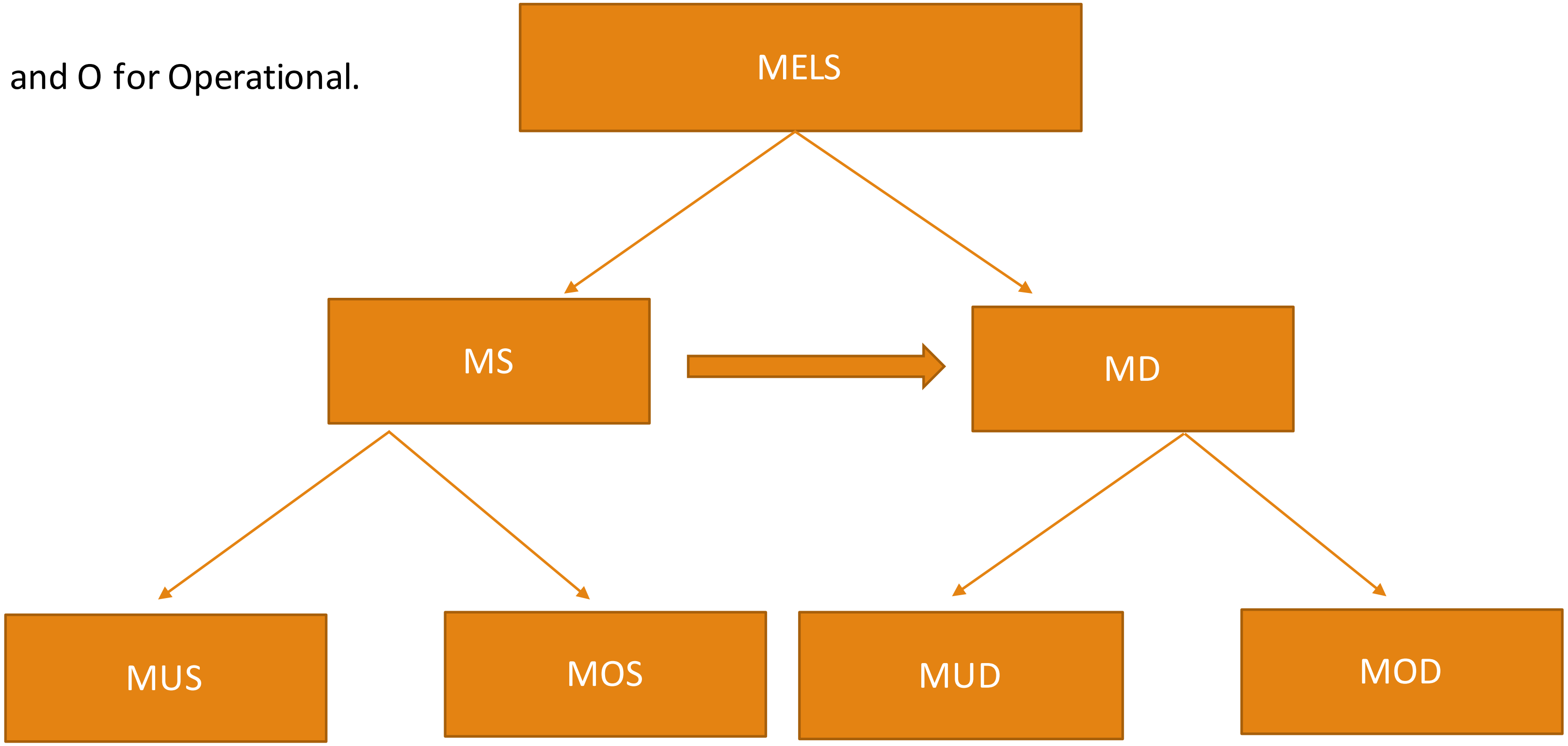
- MicroOperationalService (like an Operating System) and
- MicroUserService(like a user application on OS).

- MicroOperationalData(-> MS configuration; <- MS monitoring) and
- MicroUserData(-> User Data; <- User Data from IoT).

MD and MS are mobile, can be portable and cross-platform.

Osmotic Computing *into details*

U for User and O for Operational.



Name space for MELS

MS:nameUrl:tag_UUID.

- MUS:nameUrl:tag_UUID
- MOS:nameUrl:tag_UUID

MD:nameUrl:tag_UUID

- MOD:nameUrl:tag_UUID
- MOD:nameUrl:tag_UUID

MS

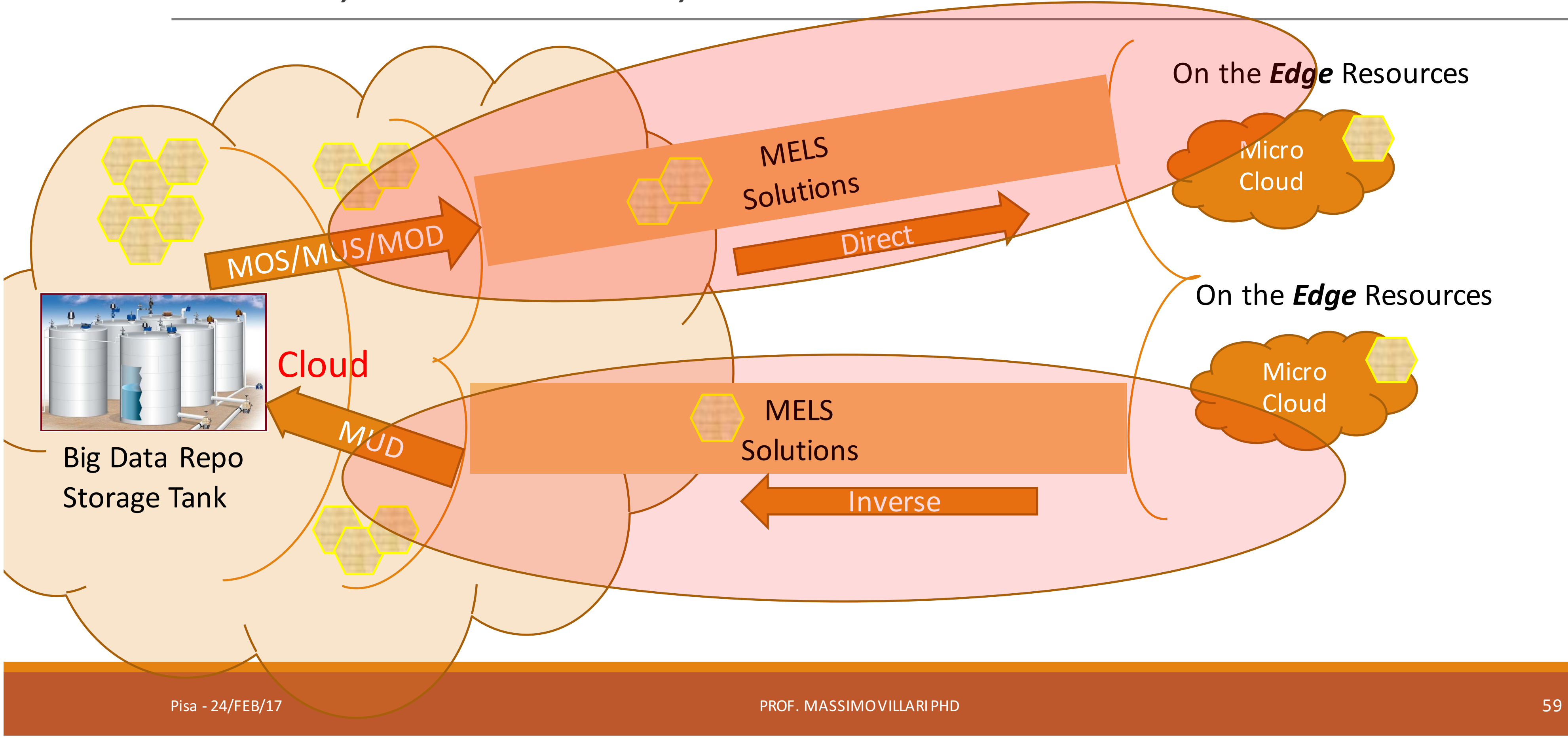
MD

MS:nameUrl:tag_UUID.MD:nameUrl:tag_UUID

Osmosis equivalences:

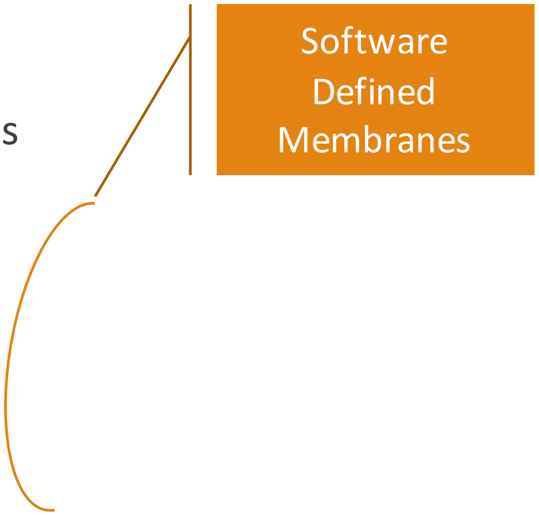
- Solutions,
- Membranes (semipermeable and impermeable),
- Storage Tanks,
- Chambers, and
- Tubes

Osmosis: Solutions, Membranes (semipermeable and impermeable), Storage Tanks, Chambers, and Tubes



OC: Software Defined Membrane (permeability)

- Membranes As A Filter
- Membranes assembled from MS
- Membranes Assimilated at Gateways and/or Proxys
- Able to be permeable or impermeable

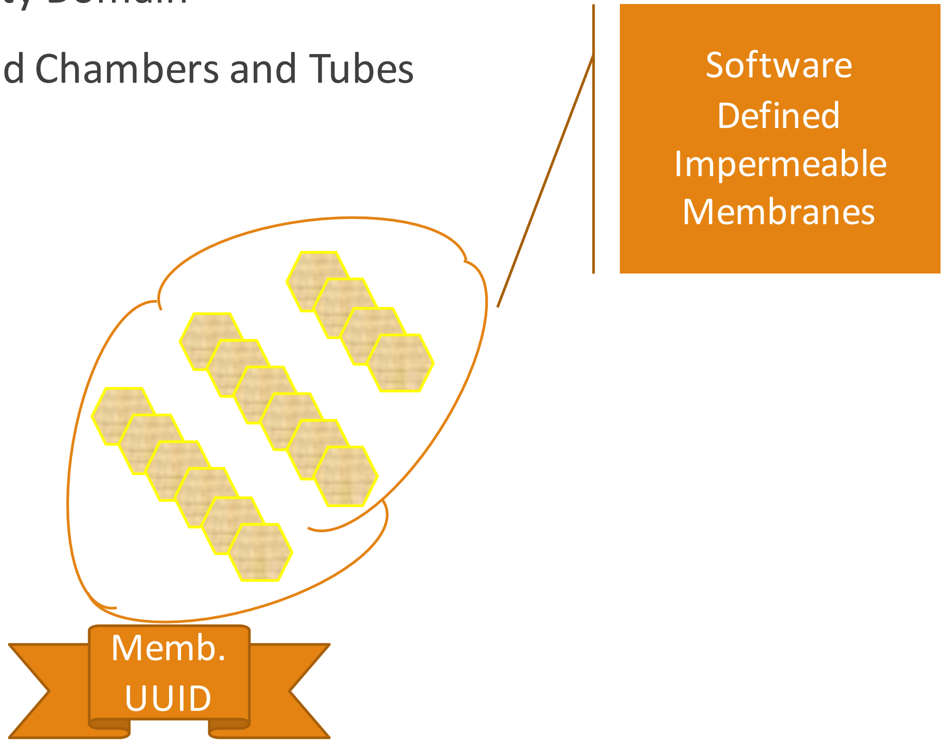


Software Defined Membranes

OC: Software Defined Pressure in Chambers and Tubes

Security Domain

Around Chambers and Tubes



Software Defined Impermeable Membranes

Big Security Issues in the EDGE ☹

In November 2013, the owner of a smart TV made by LG Electronics discovered that the device was collecting information about his viewing habits, even when the "collection of watching info" feature was turned off. Worse, the TV also sent back to LG's servers the names of files stored on external media devices and even network shares.

2 more wireless baby monitors hacked: Hackers remotely spied on babies and parents

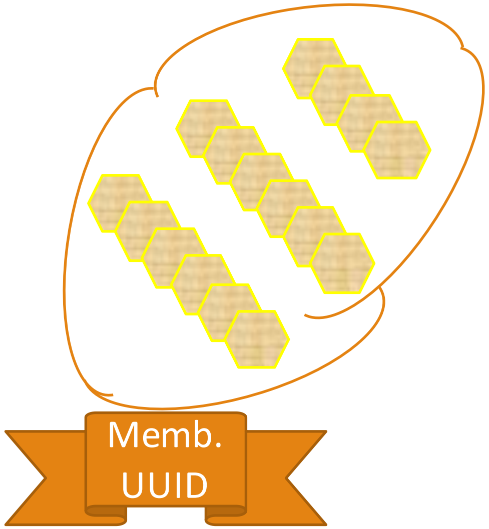
Two more wireless baby monitors were hacked. One family heard voices as the camera followed them about the room; the second mom was freaked out and scared as a hacker remotely controlled the camera to follow her movements.

OC: Software Defined Pressure in Chambers and Tubes

Security Domain

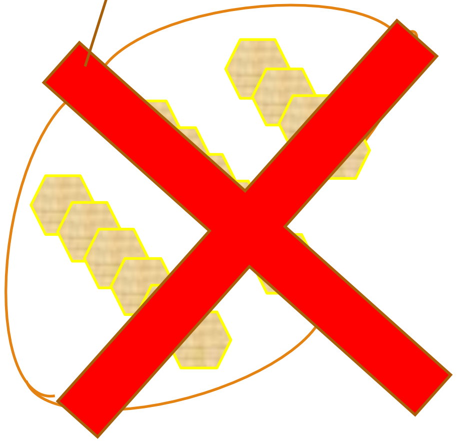
Around Chambers and Tubes

Software Defined Impermeable Membranes

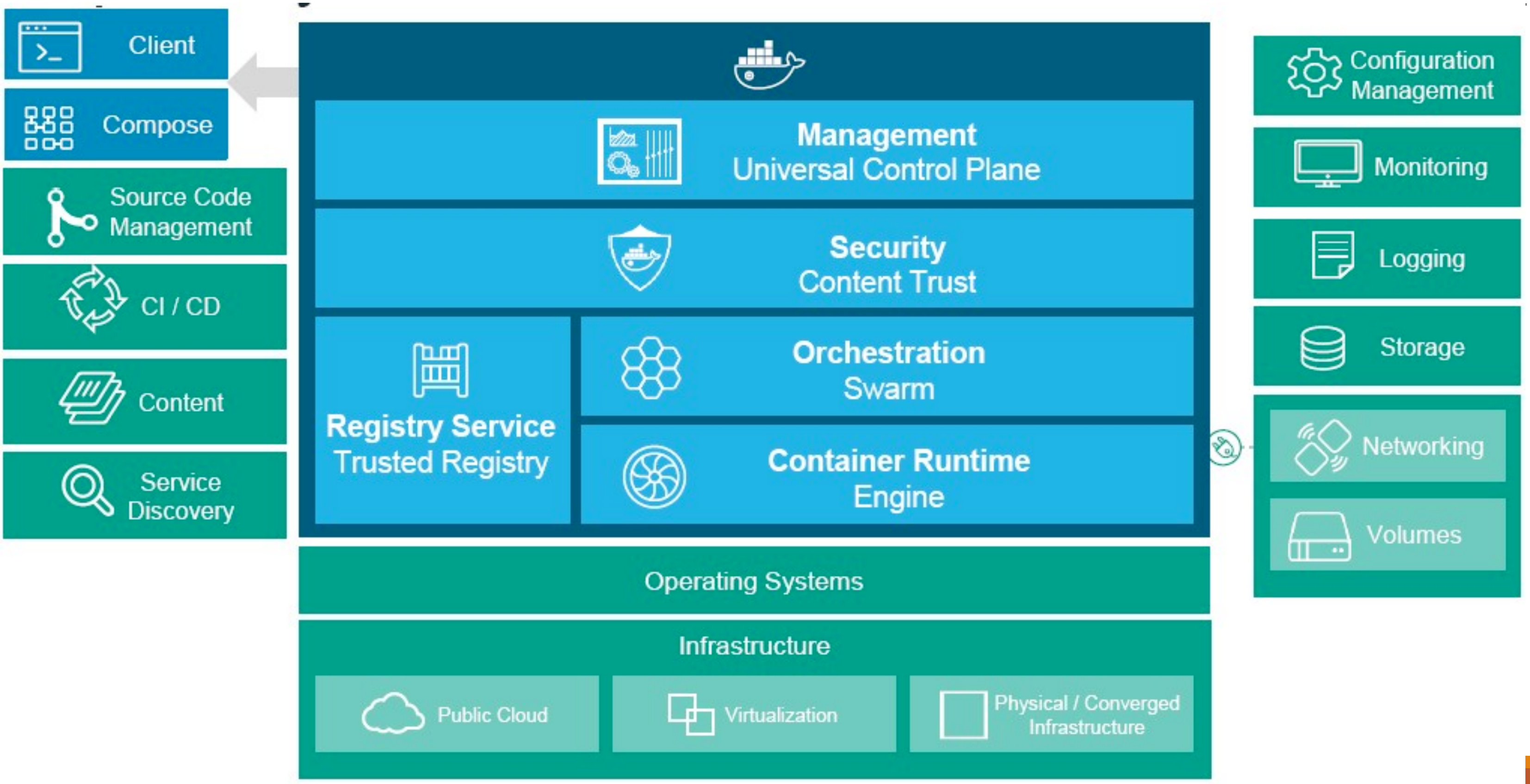


Memb. UUID

Software Defined Security And Disruption of it

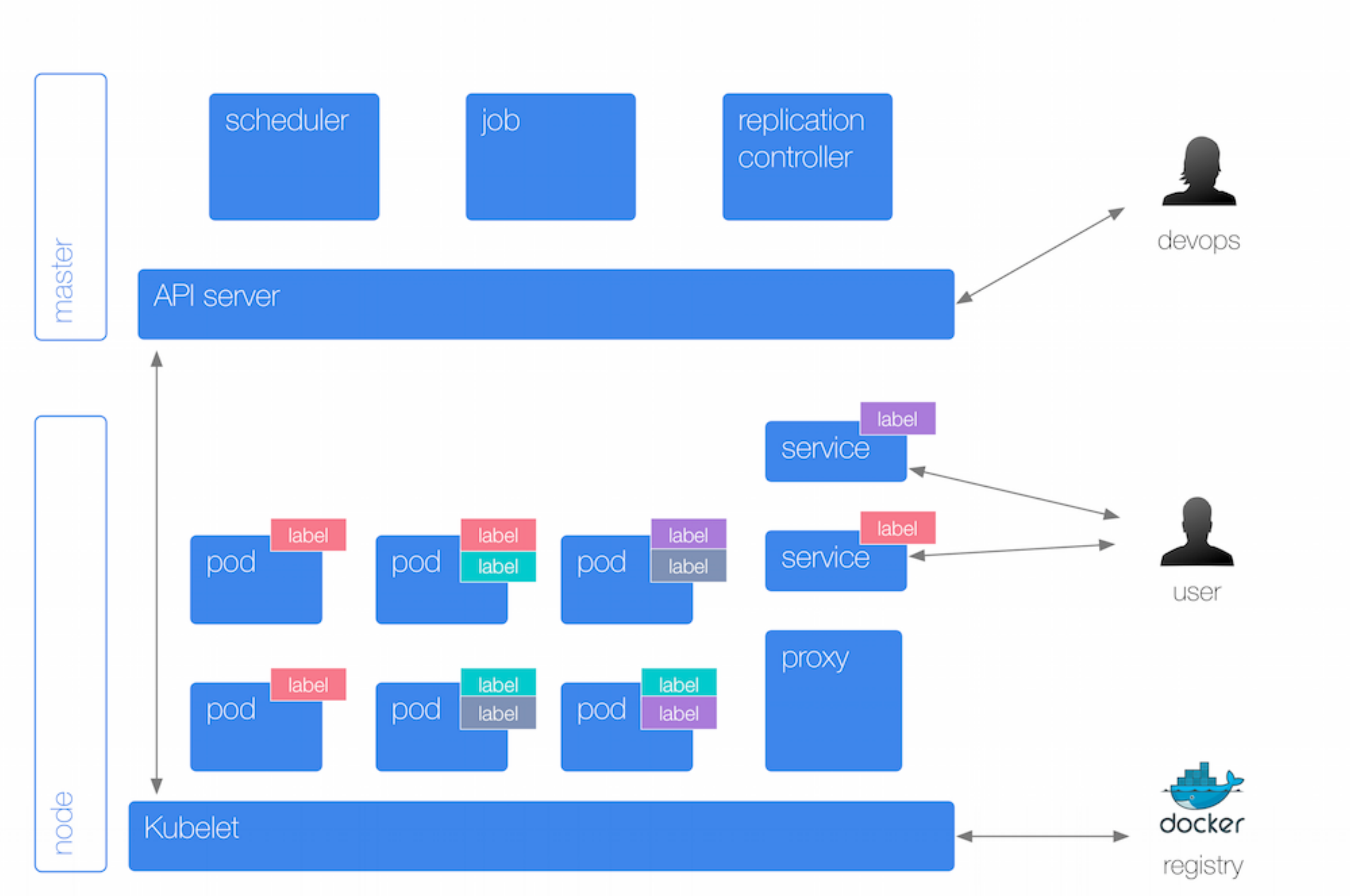


Osmotic NOT from Scratch: eg. containerization

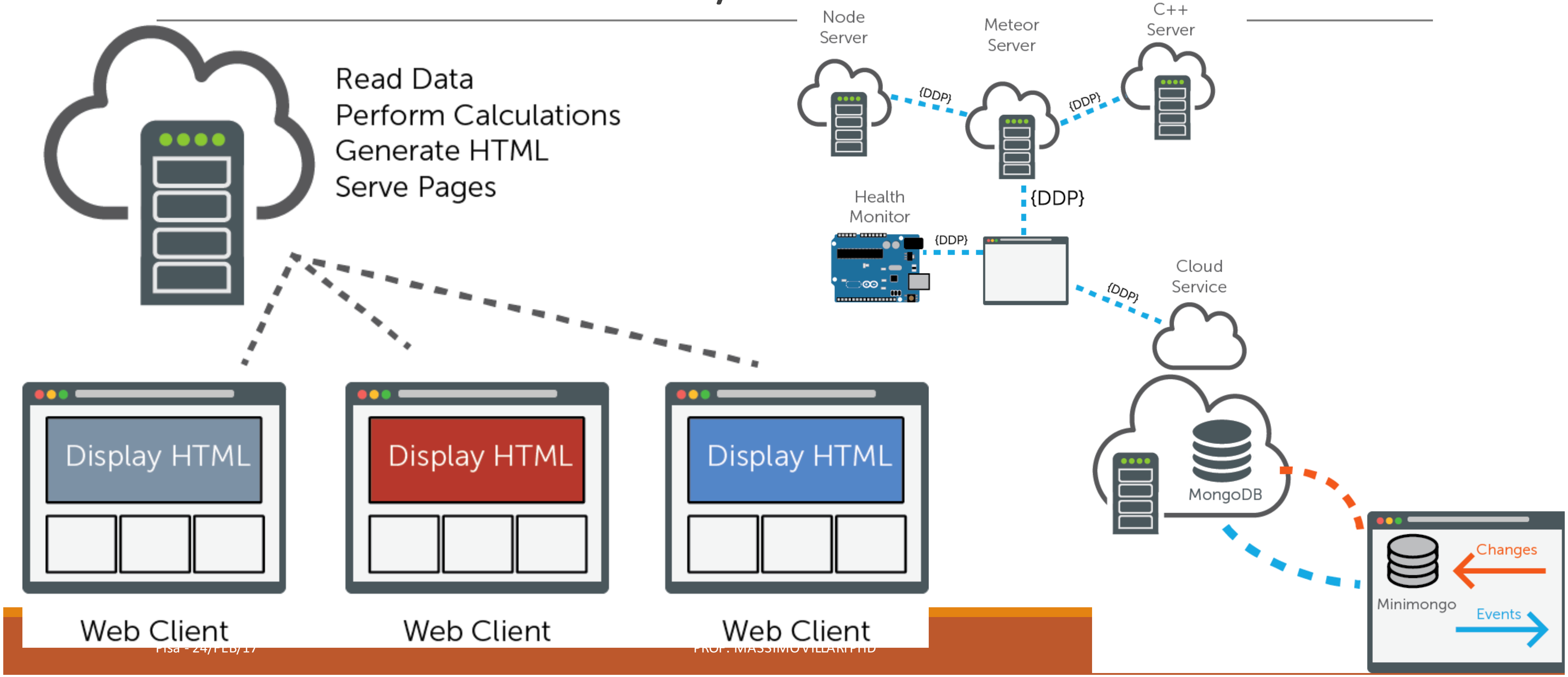


Osmotic NOT from Scratch: eg. containerization

Here
PODS are equals to MELS



Osmotic NOT from Scratch: eg. Javascript MeteorJS on MPU/MCU



Osmotic Computing: in Docker and JS Meteor or..

In 1- MSs (MOS and MUS) are equals to Container

In 1 – MD can be:

- MOD in YAML for deploying Services
- MUD in Json for charactering Filesysyem layers in AUFS and LayaoutFS

i.e., Kubernates leverages the approach of more MOS for deploying the Agents

In 2- MS (MOS and MUS) are equals to Javascript code:

In 2 – MD can be:

- Json

*** The TOSCA Simple Profile in YAML V1.1 is now out for a public review.**
For details and links to the specification, see the announcement at https://www.oasis-open.org/news/announcements/15-day-public-review-for-tosca-simple-profile-in-yaml-version-1-1-ends-march-2nd

Osmotic Computing *which devices: mpu/mcu*

Ubuntu - VMware Player File Virtual Machine Help
Ubuntu Desktop
7:23 AM
Simon Holmes
WinLinShare
To direct input to this virtual machine, press Ctrl+G.
MacBook Air
Espruino
pico
SparkFun ESP32 Thing (DEV-13907)
ESP32
HDMI

With Raspberry

A new Prototype with:

- Archlinux Read Only Mode
- Docker
- Kubernates and Hypecube
- Fl..

For the Future (looking at life cycles of Microservices) :

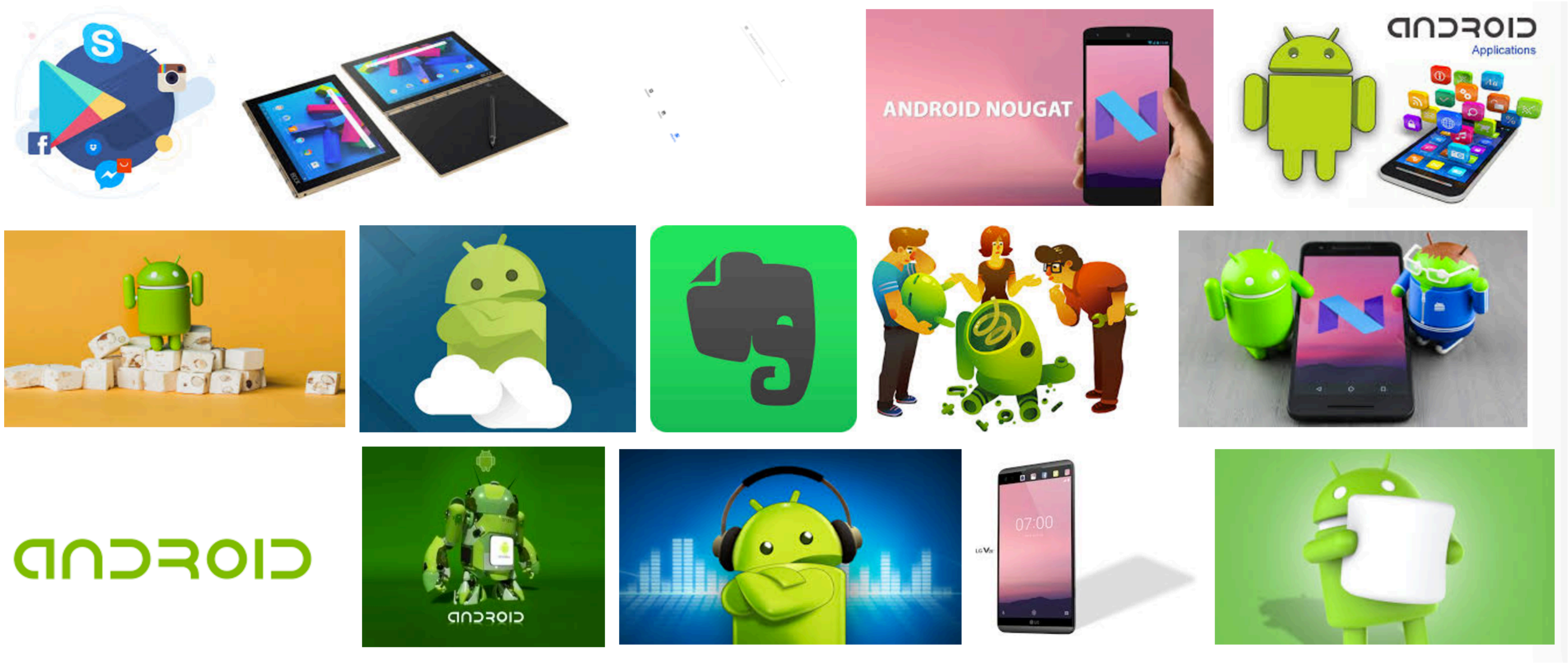
- PXE in Raspberry
- Filesystem and with Snapshot, TAGs and Versioning
-

With ESP 8266: looking at platforms and protocols

A new Prototype with:

- LUA and Python Architectures
- Simple Code Injection
- CoAP Client and Server in Python

Osmotic Computing *which oth. devices??*

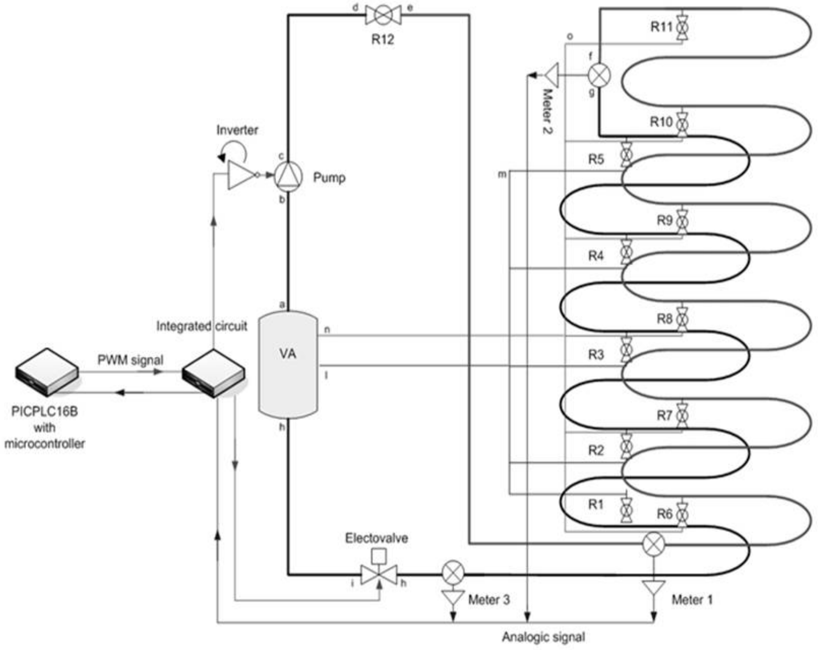


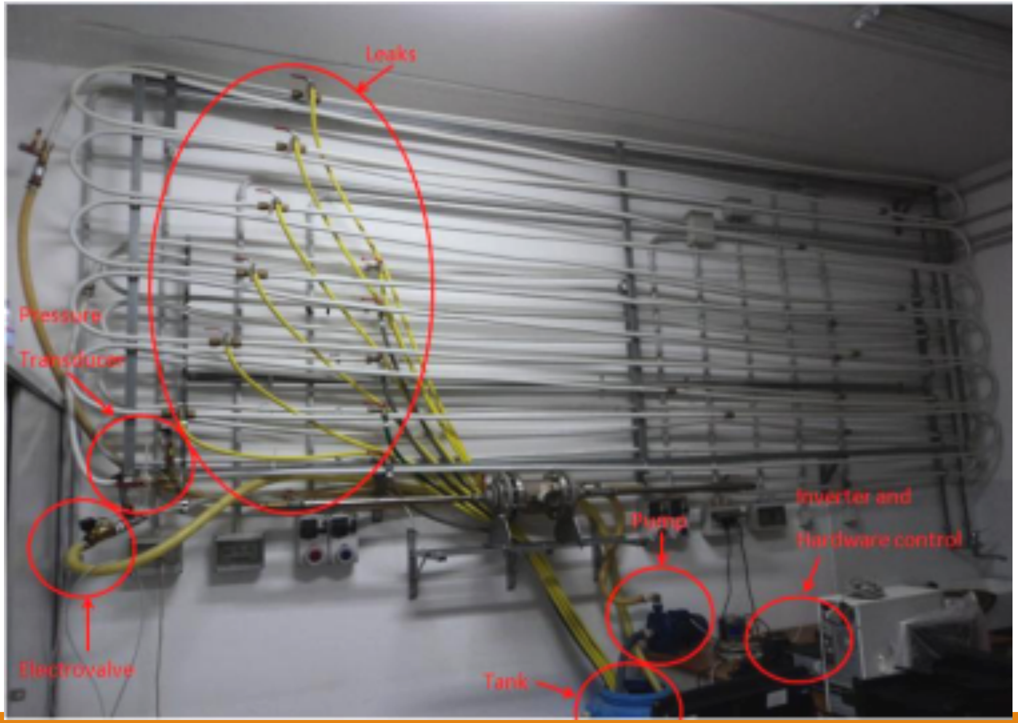
Osmotic Computing On the Cloud

Reusing the existing cloud infrastructure:

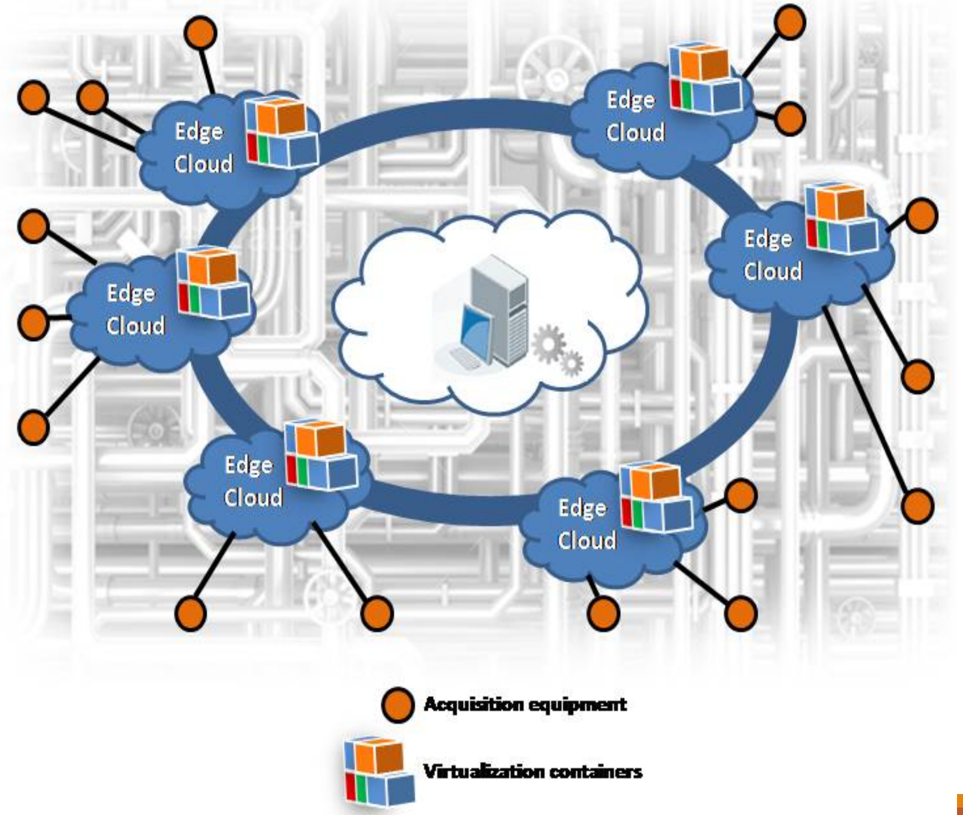
- Cloud Storage
- Cloud Processing
- NFV-SFC
- IAM
- NoSQL DB: eg., MongoDB
- APIs RESTFul
- …
- VMs and Containers

Osmotic Computing Use-Cases: Acquedotto

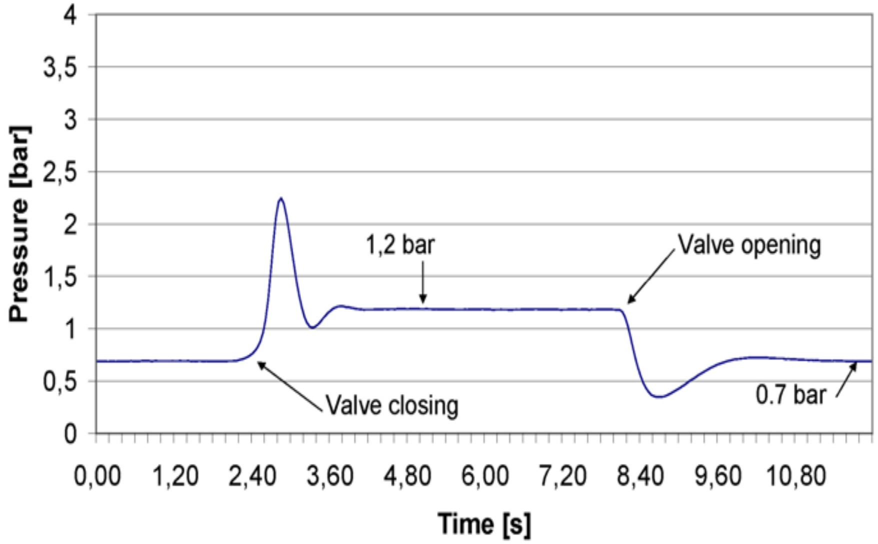


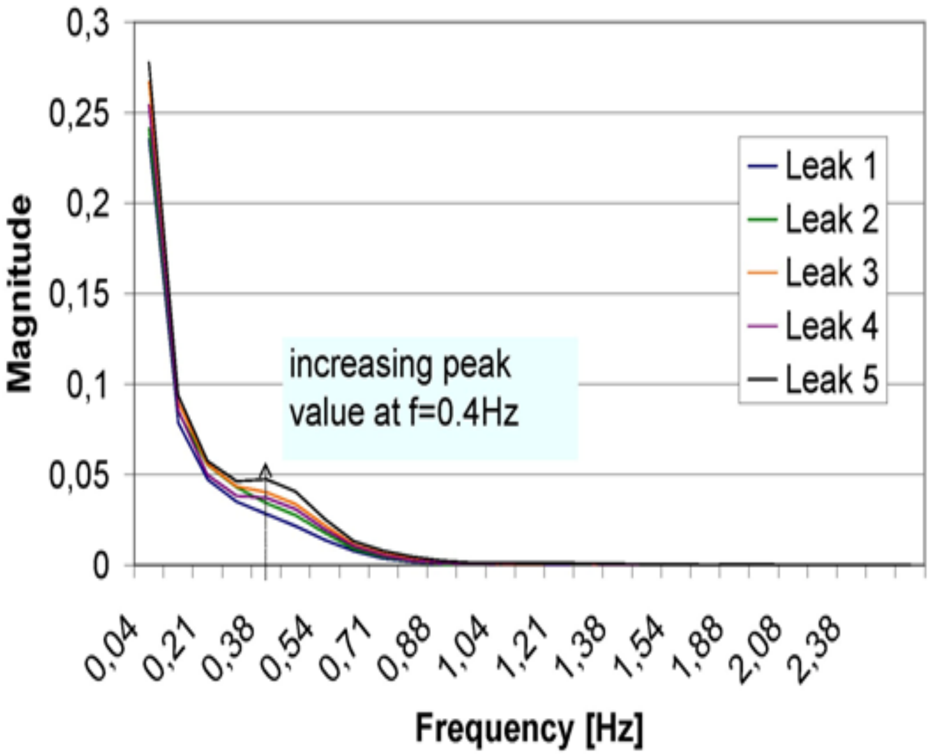


Osmotic Computing Use-Cases



Osmotic Computing Use-Cases: FFT





Hazard the applicability

User Interfaces (UI):

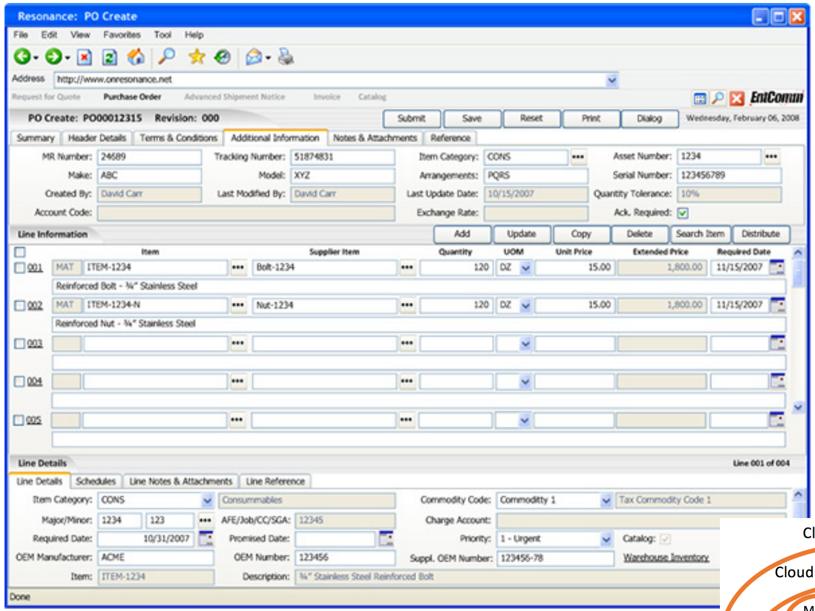
- Social ??
- Serverless ??

Software Defined Osmosis for People

From Smart to Osmotic Cities

Osmotic for UI

Software Defined Membranes



Resonance: PO Create

File Edit View Favorites Tool Help

Address http://www.onresonance.net

Request for Quote | Purchase Order | Advanced Shipment Notice | Invoice | Catalog

EntComm

PO Create: PO00012315 Revision: 000

Submit | Save | Reset | Print | Dialog

Wednesday, February 06, 2008

Summary | Header Details | Terms & Conditions | Additional Information | Notes & Attachments | Reference

MR Number: 24689 | Tracking Number: 51874831 | Item Category: CONS | Asset Number: 1234

Make: ABC | Model: XYZ | Arrangements: PQRS | Serial Number: 123456789

Created By: David Carr | Last Modified By: David Carr | Last Update Date: 10/15/2007 | Quantity Tolerance: 10%

Account Code: | Exchange Rate: | Ack. Required: ☑

Line Information

Add | Update | Copy | Delete | Search Item | Distribute

□		Item	Supplier Item	Quantity	UOM	Unit Price	Extended Price	Required Date
□ 001	MAT	ITEM-1234	Bolt-1234	120	DZ	15.00	1,800.00	11/15/2007
	Reinforced Bolt - ¾" Stainless Steel							
□ 002	MAT	ITEM-1234-N	Nut-1234	120	DZ	15.00	1,800.00	11/15/2007
	Reinforced Nut - ¾" Stainless Steel							
□ 003								
□ 004								
□ 005								

Line Details | Line 001 of 004

Line Details | Schedules | Line Notes & Attachments | Line Reference

Item Category: CONS | Consummables | Commodity Code: Commodity 1 | Tax Commodity Code 1

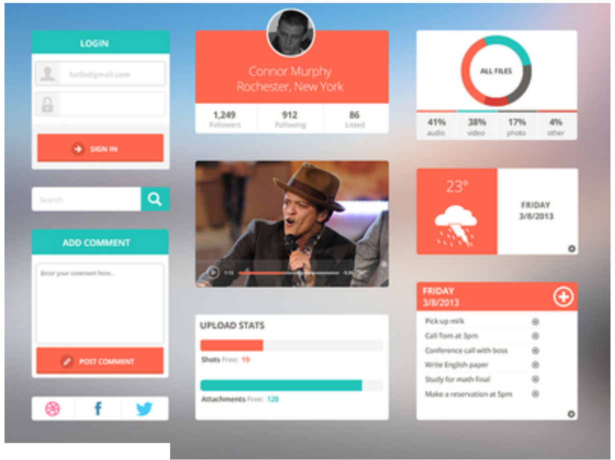
Major/Minor: 1234 123 | AFE/Job/CC/SGA: 12345 | Charge Account:

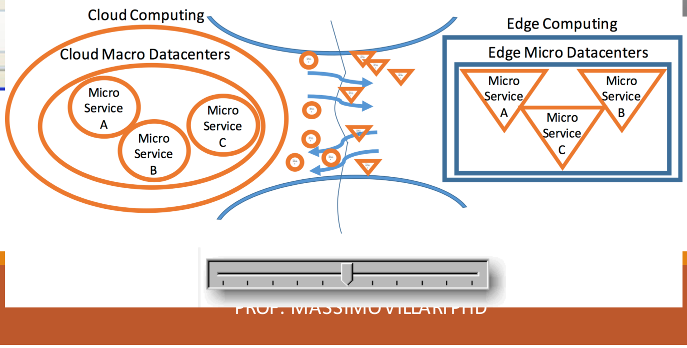
Required Date: 10/31/2007 | Promised Date: | Priority: 1 - Urgent | Catalog: ☑

OEM Manufacturer: ACME | OEM Number: 123456 | Suppl. OEM Number: 123456-78 | Warehouse Inventory

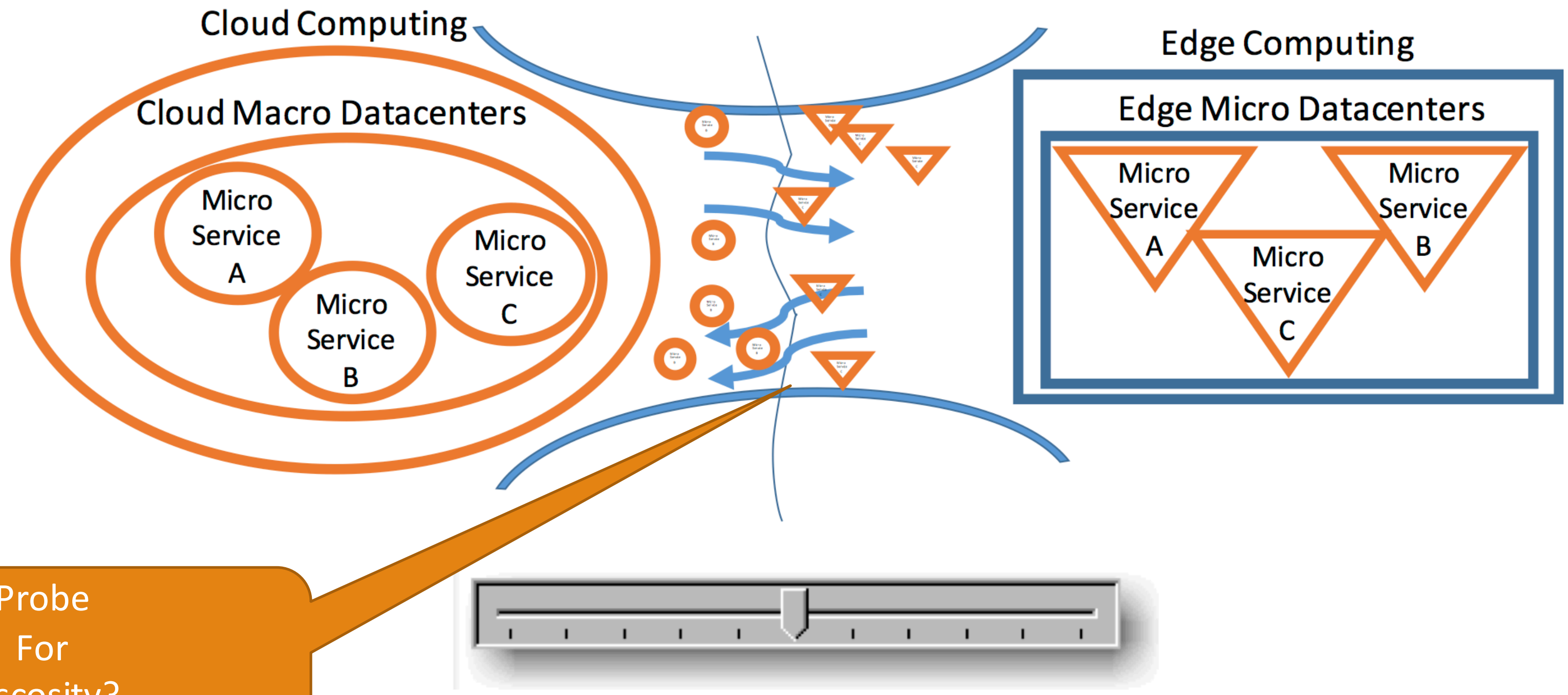
Item: ITEM-1234 | Description: ¾" Stainless Steel Reinforced Bolt

Done





Osmotic Computing Concept



Probe
For
Viscosity?
Is the e2e delay under 20ms?

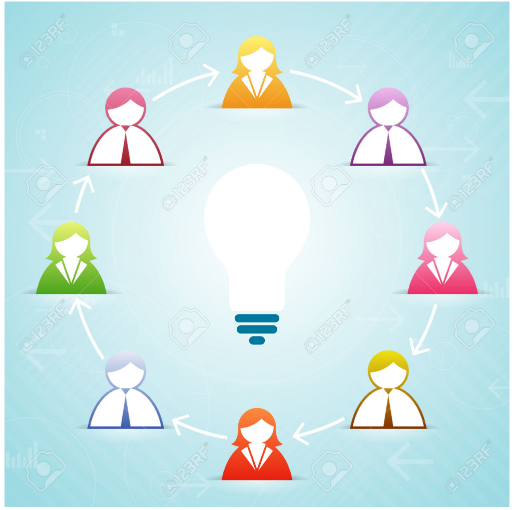
Software Defined Osmosis for People

Multidisciplinary Boards of People

(different knowledge and IT Skills)

- Osmotic Collaboration Virtual IT Tools

Software Defined Membranes

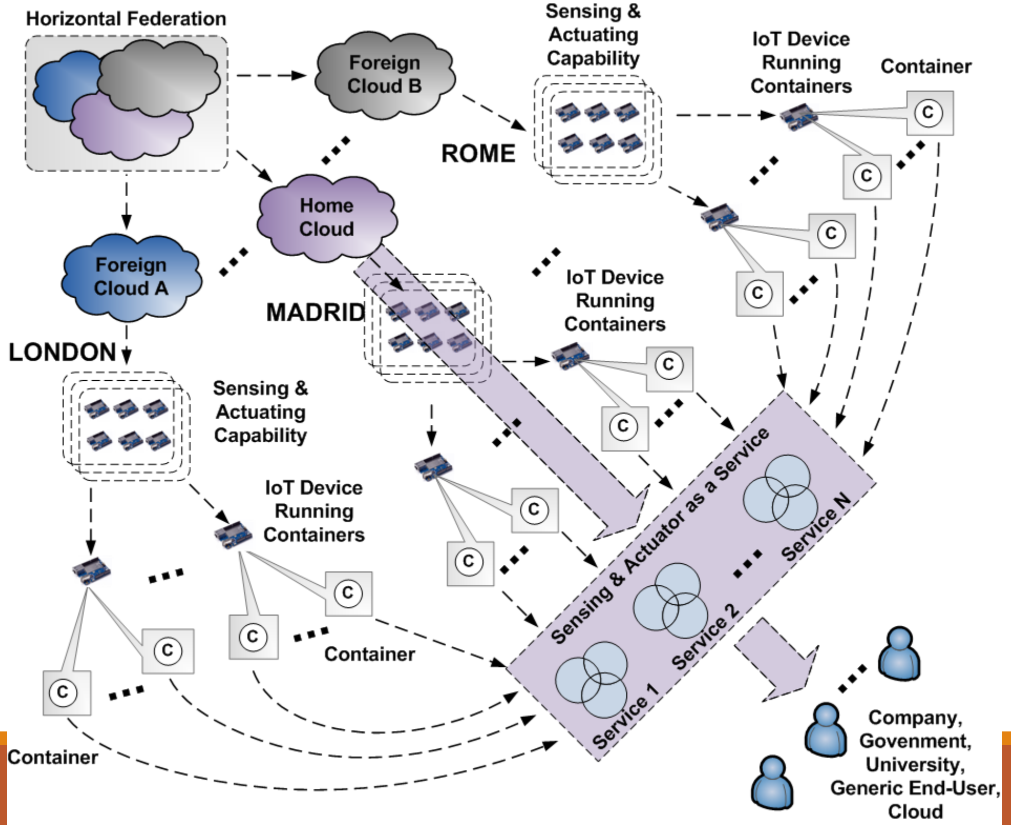


From Smart to Osmotic Cities

Natural Extension of **Federation** among Users and Service - Utility Providers

MicroElements Oriented

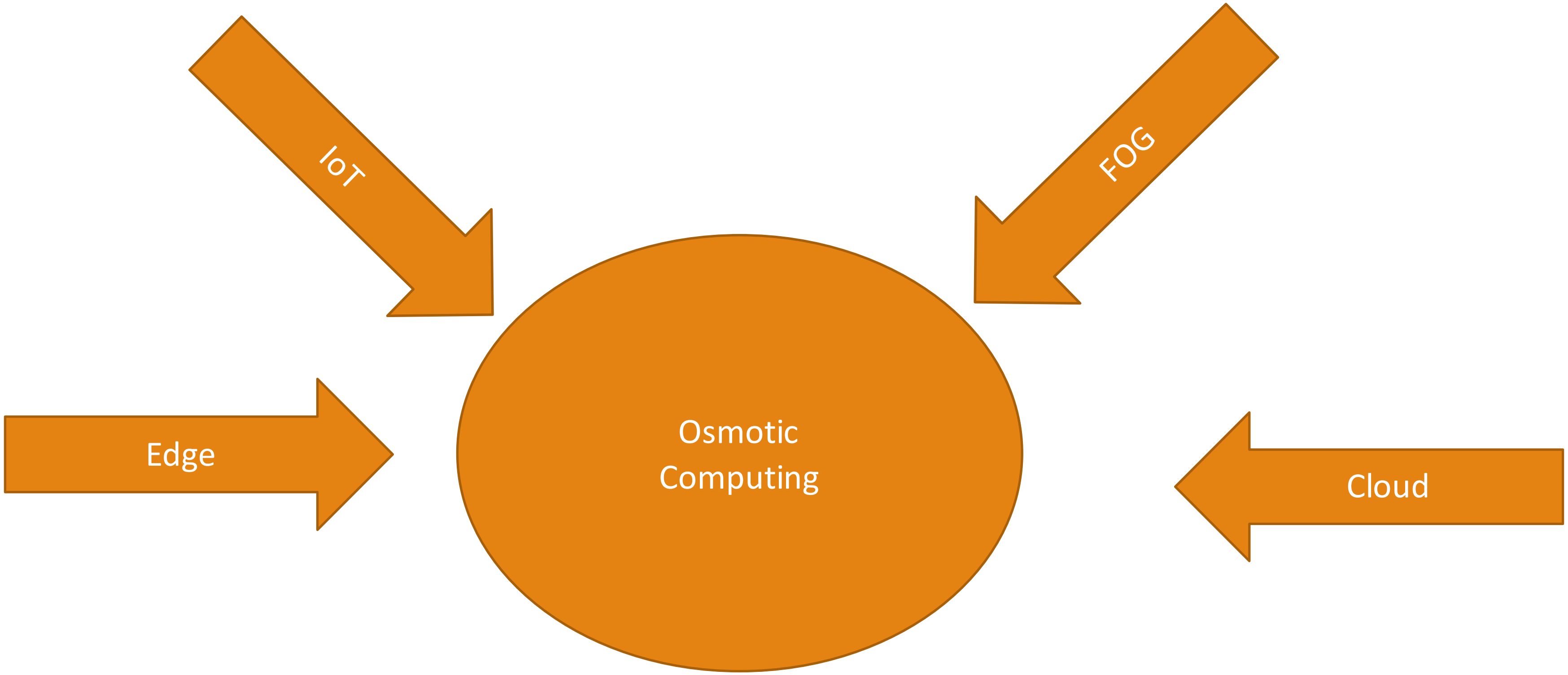
Osmotic Based


Horizontal Federation
Foreign Cloud B
Sensing & Actuating Capability
IoT Device Running Containers
Container
ROME
Home Cloud
Foreign Cloud A
MADRID
IoT Device Running Containers
LONDON
Sensing & Actuating Capability
IoT Device Running Containers
Container
Container
Sensing & Actuator as a Service
Service 1
Service 2
Service N
C
Company, Govenment, University, Generic End-User, Cloud

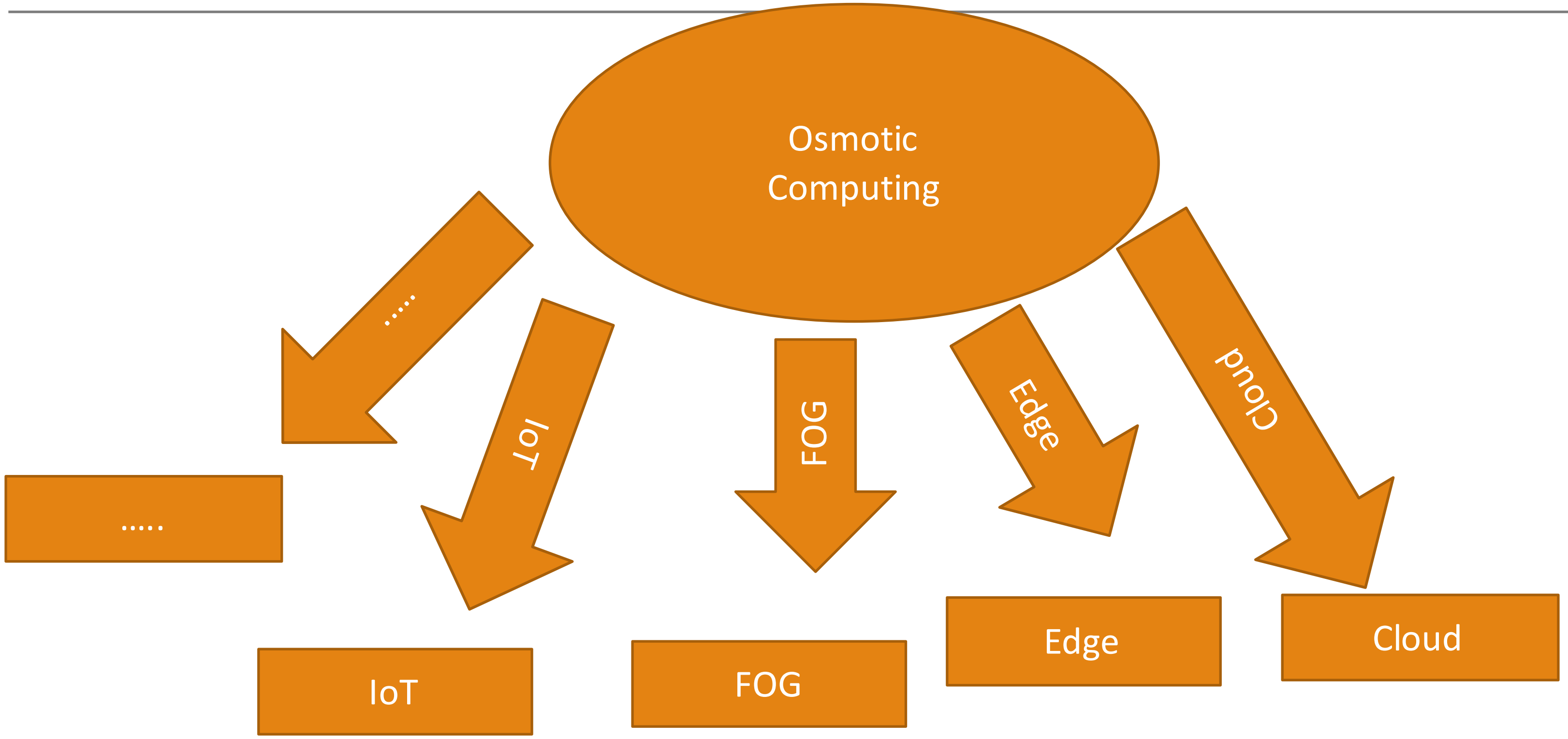
From Smart to Osmotic Cities

Where People and Devices Osmotically Behave

In Conclusion we can...



But we also can …



In Conclusion

we can state

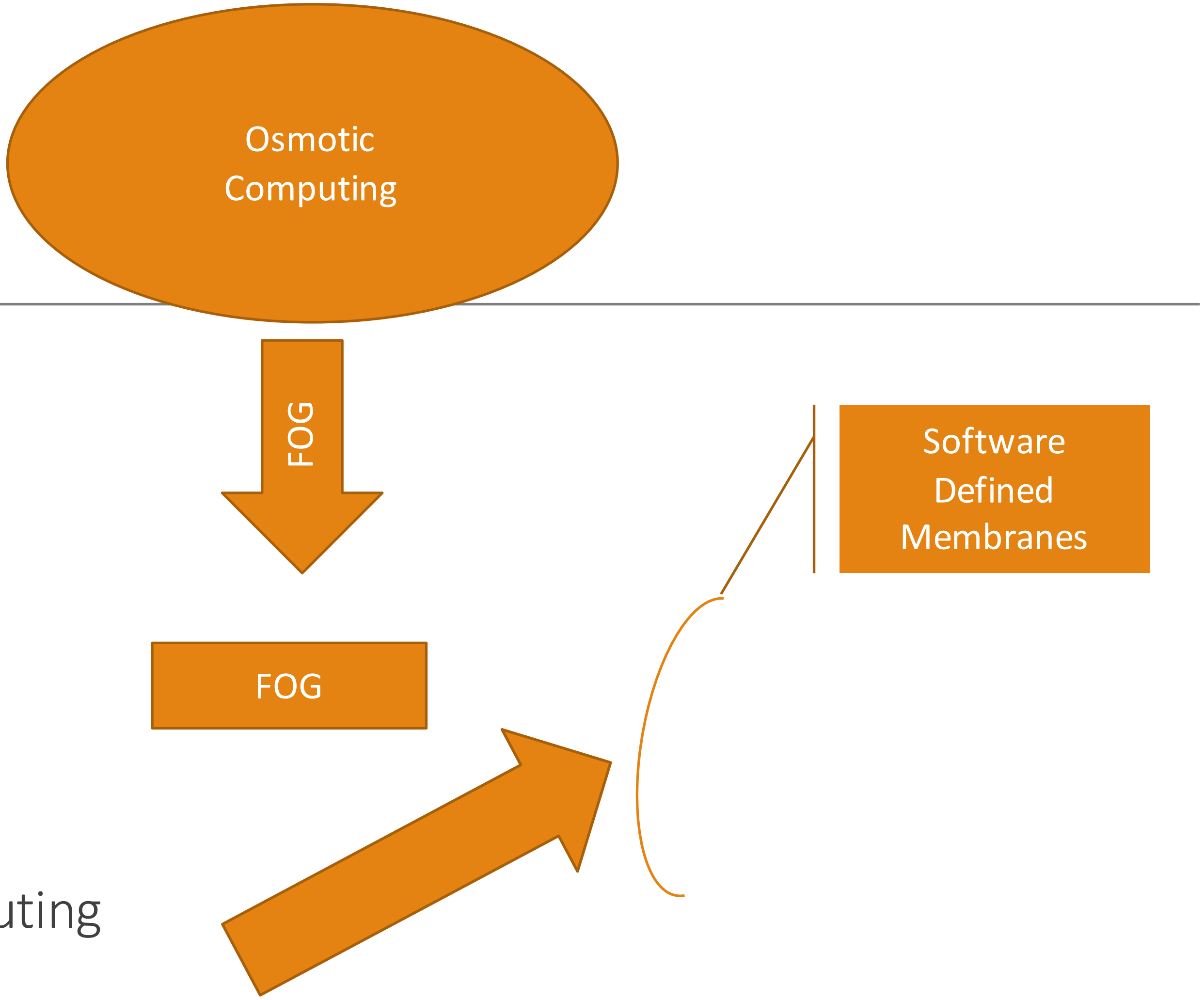
Osmotic Computing

is an

Abstraction of

.. existing Something Computing

And more ….



рахмат
danke
謝謝
ngiyabonga
spas
teşekkür ederim
Баярлалаа
mersi
kia ora
barka
welalin
tack
mahalo
tapadh leat
спасибо
faafetai lava
vinaka
спасибі
blagodaram
dank je
misaotra
matondo
paldies
grazzi
kiitos
dankie
nanni
nandri
dhanyavad
thank you
gracias
хвала
asante
manana
tenki
obrigada
murakoze
bedankt
bayarlalaa
gràçie
hvala
mauruuru
köszönöm
dankon
ačiū
akun
enkosi
djiere dieuf
tau
mochchakkeram
дякую
mamnun
chokrane
dziękuję
chnorakaloutioun
gratias ago
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sulpáy
go raibh maith agat
sobodi
děkuji
obrigado
sagolun
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taiku
arigatô
takk
dakujem
trugarez
mèsi
didi madloba
ありがとう
najis tuke
tanemirt
rahmet
grazie
shukriya
mercé
мерси
kam sah hamnida
rahmat
terima kasih
ευχαριστώ
diolch
dhanyavadagalu
তোমাকে ধন্যবাদ
감사합니다
xièxie
merci

PROF. MASSIMO VILLARI

FCRLAB - UNIVERSITÀ DI MESSINA, ITALIA

MVILLARI@UNIME.IT

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