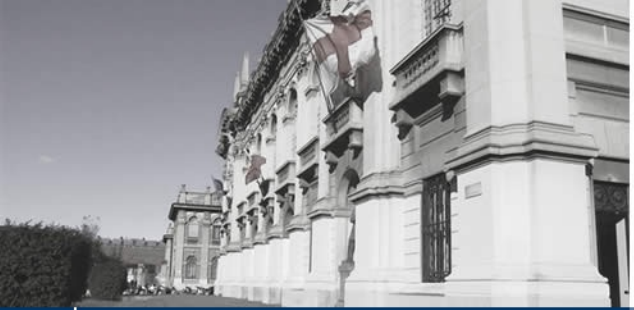


POLITECNICO DI MILANO





1) Computing Infrastructures

Prof. Manuel Roveri

The topics of the course: what are we going to see today?

A. HW Infrastructures:
- **System-level**: Computing Infrastructures and Data Center Architectures, Rack/Structure;
- **Node-level**: Server (computation, HW accelerators), Storage (Type, technology), Networking (architecture and technology);
- **Building-level**: Cooling systems, power supply, failure recovery

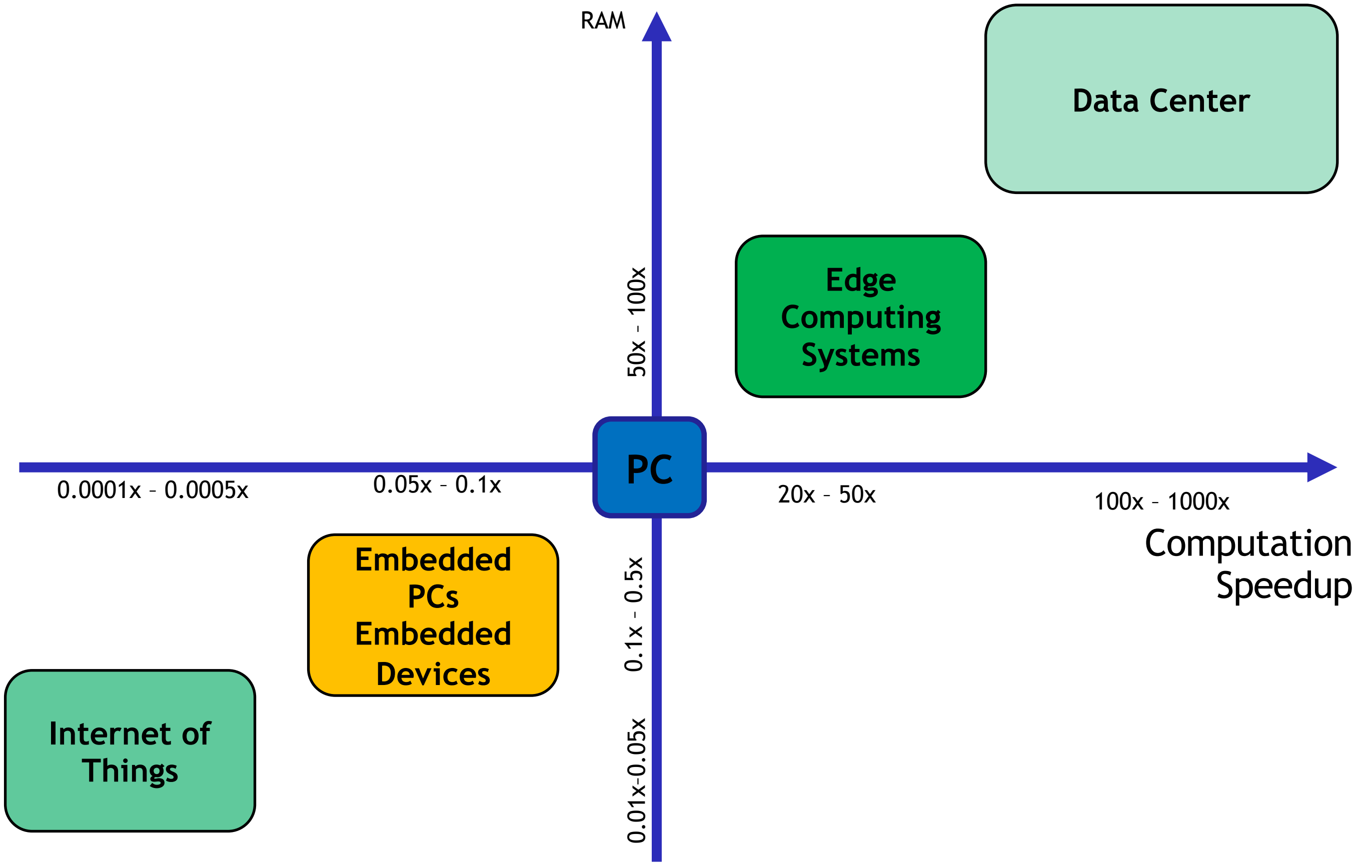
B. SW Infrastructures:
- **Virtualization**: Process/System VM, Virtualization Mechanisms (Hypervisor, Para/Full virtualization)
- **Computing Architectures**: Cloud Computing (types, characteristics), Edge/Fog Computing, X-as-a service
- **Machine and deep learning-as-a-service**

C. Methods:
- **Reliability and availability of datacenters** (definition, fundamental laws, RBDs)
- **Disk performance** (Type, Performance, RAID)
- **Scalability and performance of datacenters** (definitions, fundamental laws, queuing network theory)

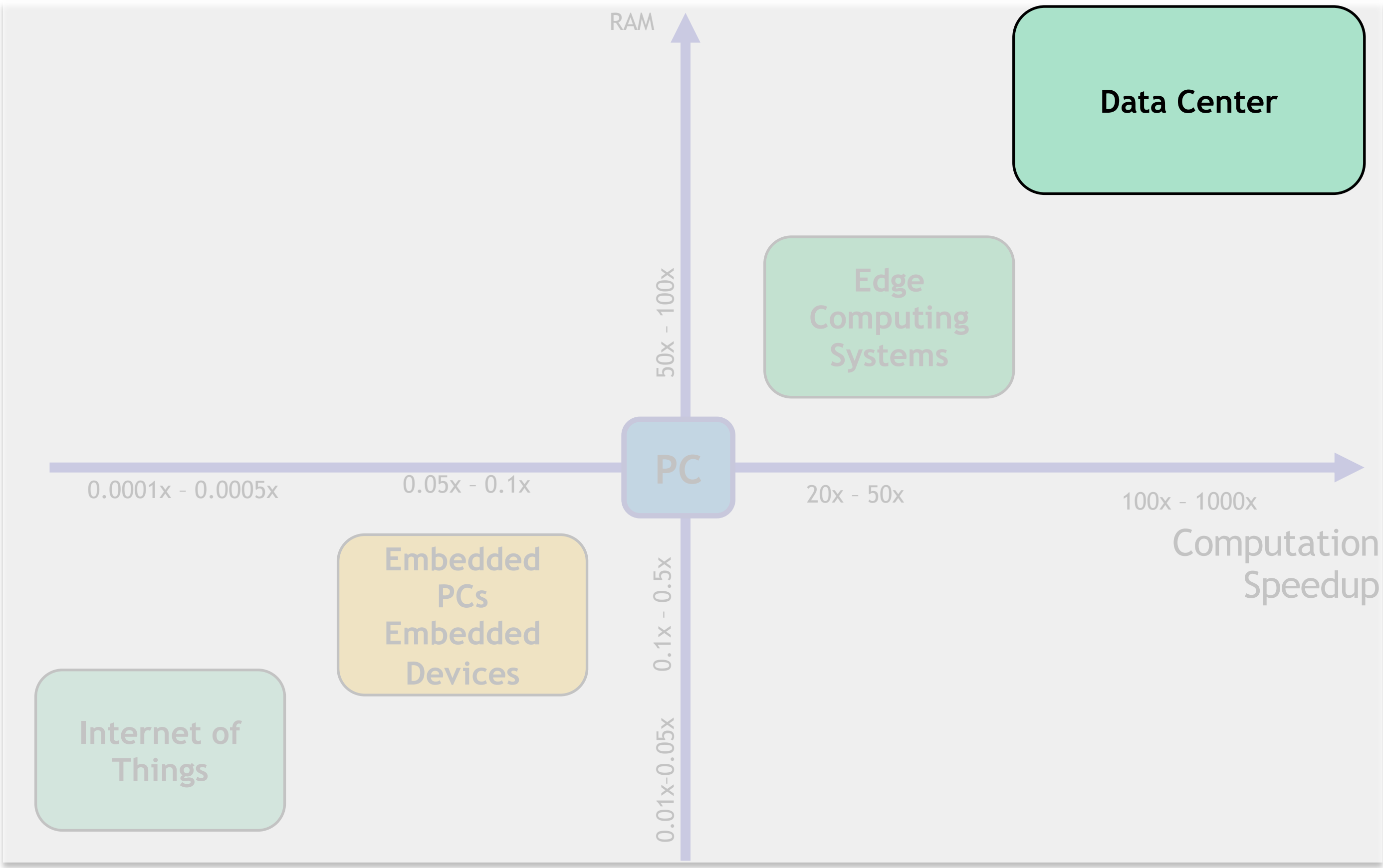
What is a computing infrastructure?

Technological infrastructure that provides hardware and software for computation to other systems and services

Examples of Computing Infrastructures



Examples of Computing Infrastructures



Data Centers: a technological perspective

The Pionen White Mountains is a Swedish data center. This center is located in Stockholm and is one of the largest data centers in the world.

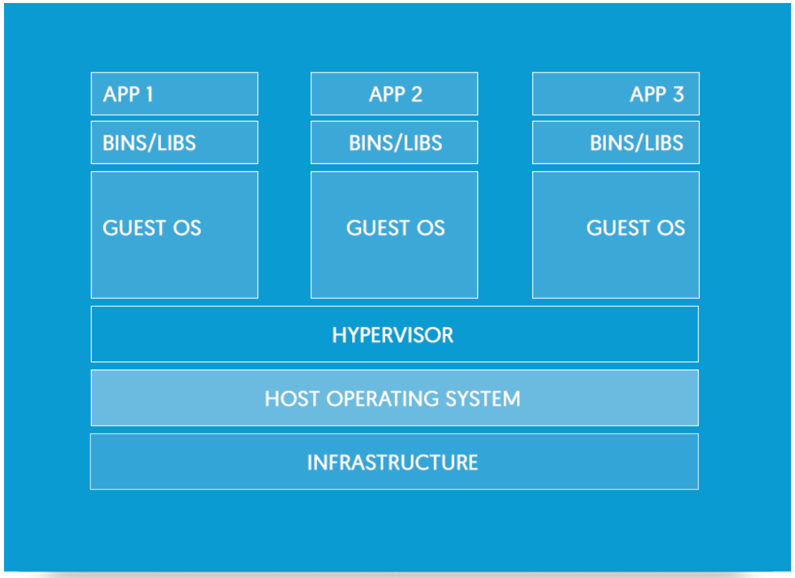
Server for Processing

Server for Storage

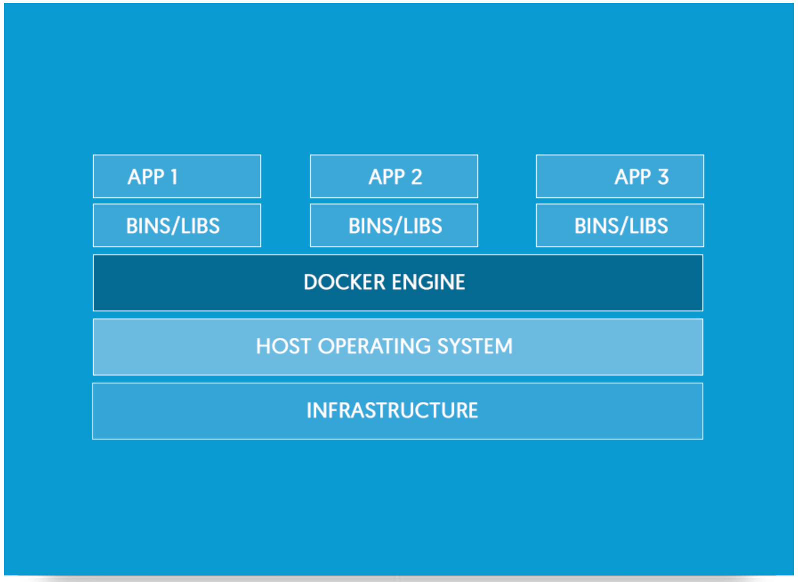
Server for Communication

Virtual Machines and Containers

VMMs
Provide the full stack (OS, LIB, APP).
Applications depend on guest OS.



Containers
Applications are packaged with all their dependencies into a standardized unit for software development/deployment.



Data Centers: advantages and disadvantages

- ✓ Lower IT costs
- ✓ High performance
- ✓ Instant software updates
- ✓ "Unlimited" storage capacity
- ✓ Increased data reliability
- ✓ Universal document access
- ✓ Device Independence

- ➢ Require a constant Internet connection
- ➢ Do not work well with low-speed connections
- ➢ Hardware Features might be limited
- ➢ Privacy and security issues
- ➢ High Power Consumption
- ➢ Latency in making decision

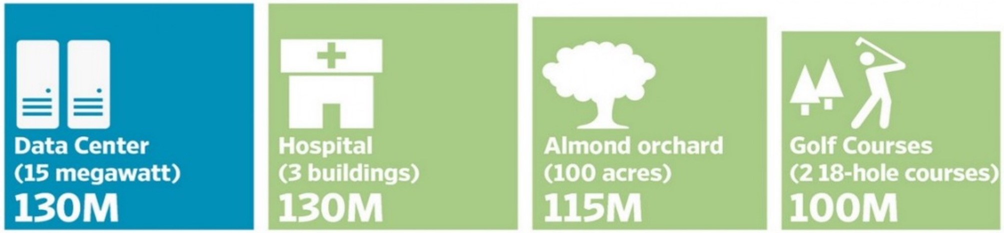
Data Centers: advantages and disadvantages

WATER

Waterlogged

A midsize data center uses roughly as much water as about 100 acres of almond trees or three average hospitals, and more than two 18-hole golf courses.

Approximate annual water usage, in gallons*

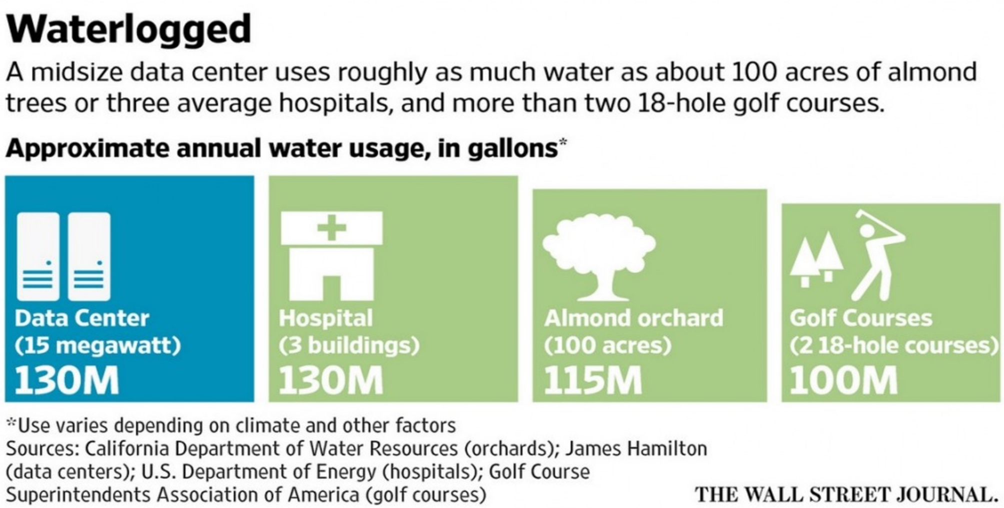


*Use varies depending on climate and other factors
Sources: California Department of Water Resources (orchards); James Hamilton (data centers); U.S. Department of Energy (hospitals); Golf Course Superintendents Association of America (golf courses)

THE WALL STREET JOURNAL.

Data Centers: advantages and disadvantages

WATER



1%

Overall worldwide total energy consumption due to datacenters

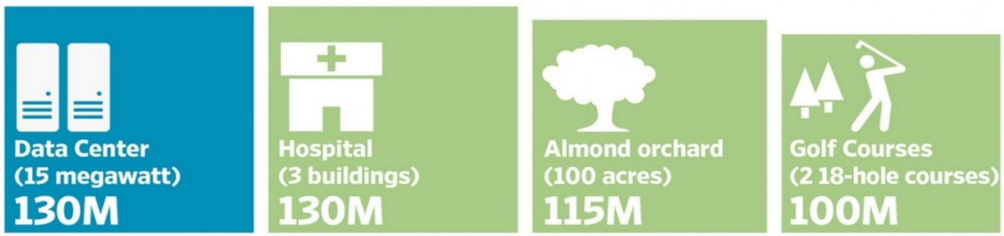
Data Centers: advantages and disadvantages

WATER

Waterlogged

A midsize data center uses roughly as much water as about 100 acres of almond trees or three average hospitals, and more than two 18-hole golf courses.

Approximate annual water usage, in gallons*



*Use varies depending on climate and other factors
Sources: California Department of Water Resources (orchards); James Hamilton (data centers); U.S. Department of Energy (hospitals); Golf Course Superintendents Association of America (golf courses)

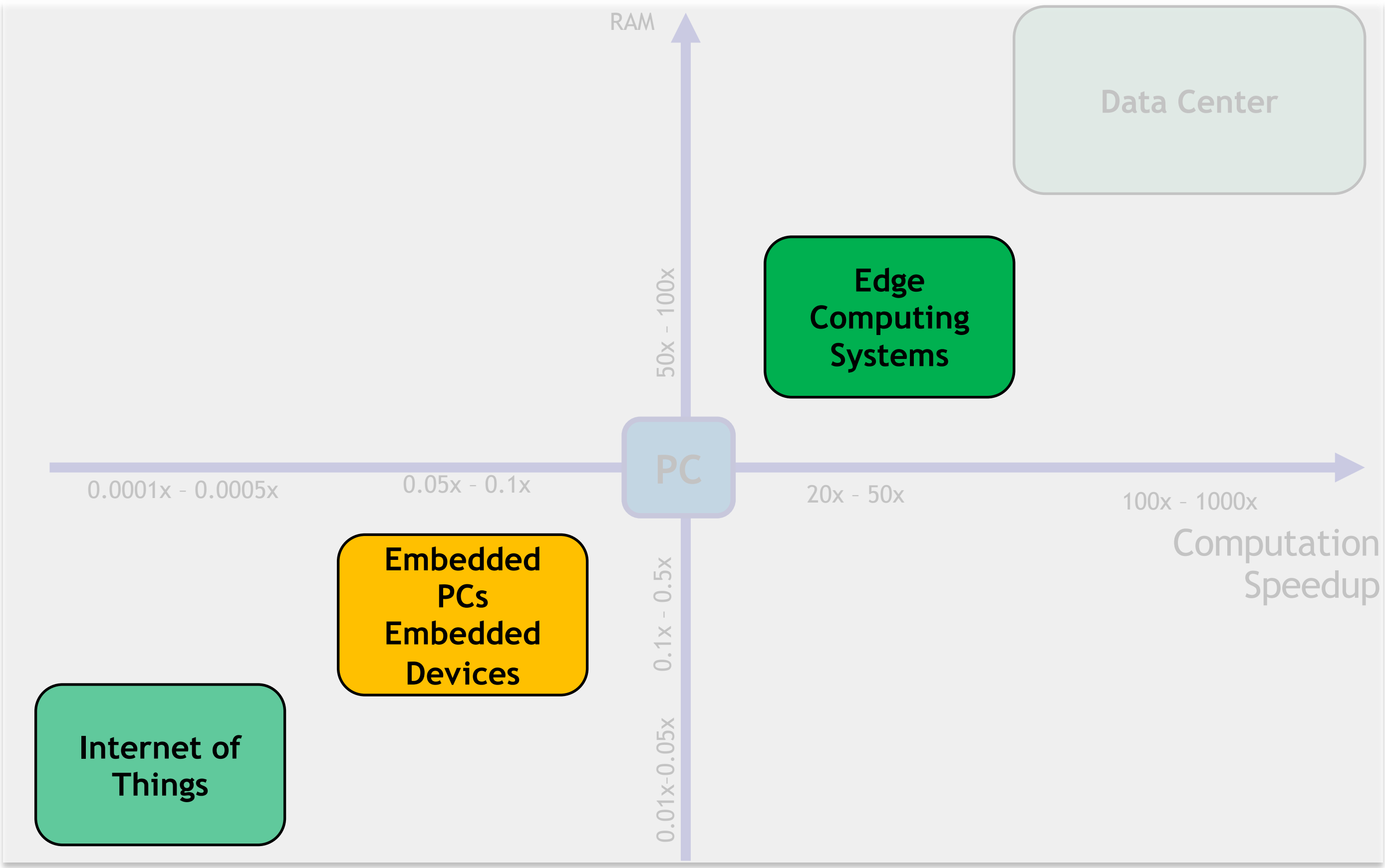
THE WALL STREET JOURNAL.

1%

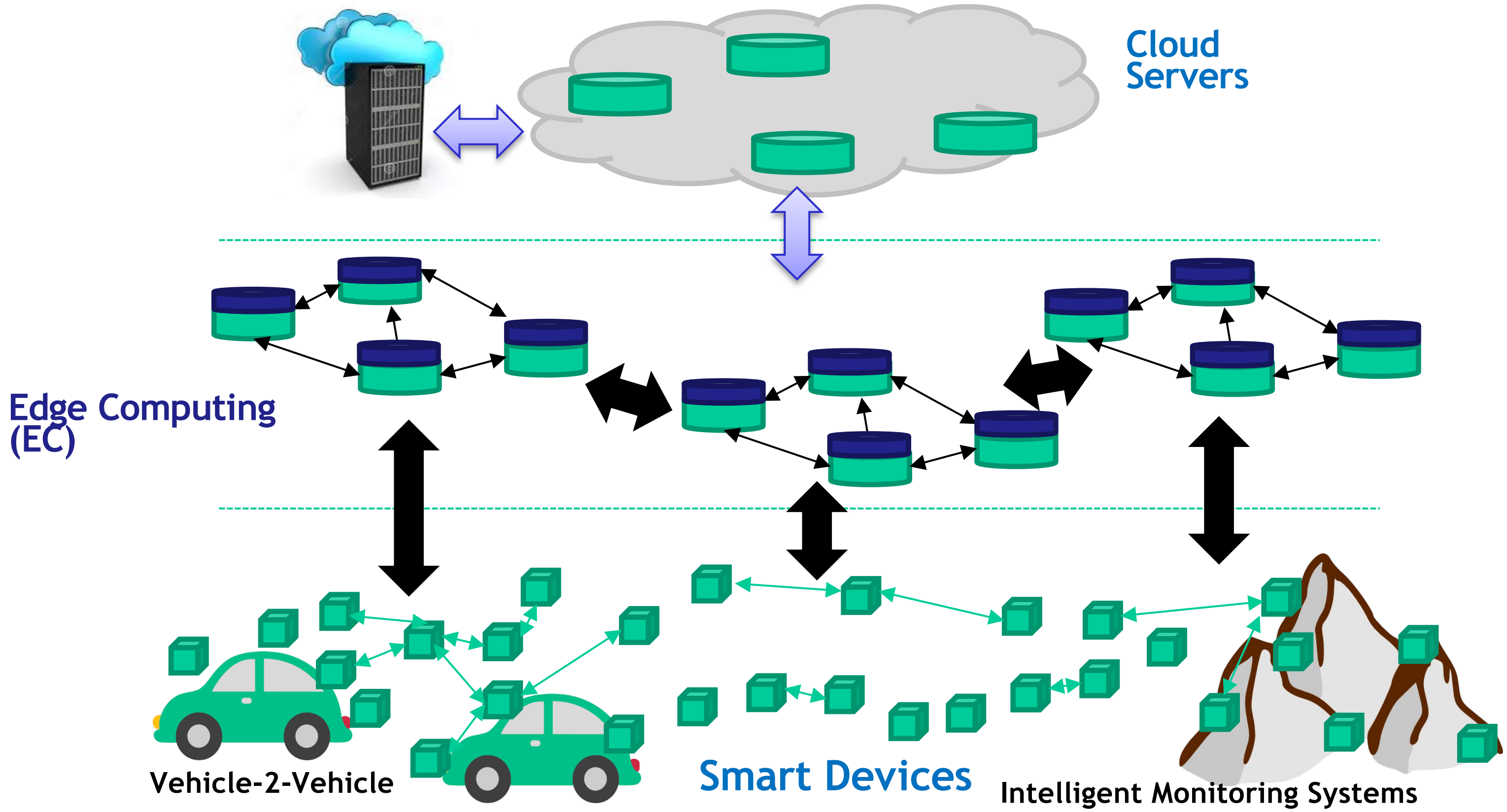
Overall worldwide total energy consumption due to datacenters

Amortized Cost	Component	Sub-Components
~45%	Servers	CPU, memory, disk
~25%	Infrastructure	UPS, cooling, power distribution
~15%	Power draw	Electrical utility costs
~15%	Network	Switches, links, transit

Edge Computing, PC Embedded and IoT



Edge/Fog Computing Systems



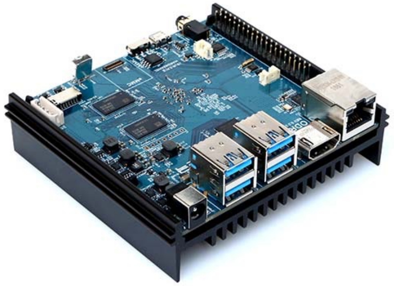
IoT Gateways	SYS-E50-9AP-WIFI	SYS-E100-9S-E	SYS-E300-8D	SYS-5018D-FN8T
				
Processor/Cache				
CPU	**Intel® Atom® processor E3940** Single socket FCBGA 1296 9.5W, 4C	**7th Generation Intel® Core i5-7300U Processor** Single Socket FCBGA 1356 System-on-Chip CPU TDP support 15W	**Intel® processor D-1518,** 2.2GHz; CPU TDP support 35W FCBGA 1667: 4 Cores, 8 Threads / 6MB	**Intel® Xeon® processor D-1518** 2.2GHz; CPU TDP support 35W FCBGA 1667: 4 Cores, 8 Threads / 6MB
System Memory				
Memory Capacity	Up to 8GB Unbuffered non-ECC SO-DIMM DDR3L-1866MHz, in 1 DIMM socket	Up to 32GB Unbuffered non-ECC SO-DIMM, DDR4-2133MHz, in 2 DIMM slots	4x DDR4 DIMM sockets Supports up to 128GB DDR4 ECC RDIMM Supports up to 64GB DDR4 ECC/non-ECC UDIMM	4x DDR4 DIMM sockets Supports up to 128GB DDR4 ECC RDIMM Supports up to 64GB DDR4 ECC/non-ECC UDIMM
Memory Type	DDR3L up to 1866MHz	DDR4 up to 2133MHz	2133/1866/1600MHz ECC DR4 ECC RDIMM and ECC/Non-ECC UDIMM	2133/1866/1600MHz ECC DDR4 ECC RDIMM and ECC/Non-ECC UDIMM
DIMM Sizes	8GB, 4GB, 2GB	16GB, 8GB, 4GB	32GB, 16GB, 8GB, 4GB	32GB, 16GB, 8GB, 4GB
Memory Voltage	1.35 V	1.2 V	1.2 V	1.2 V

- ✓ High computational capacity
- ✓ Distributed computing
- ✓ Privacy and security
- ✓ Reduced Latency in making a decision

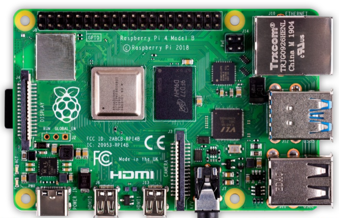
- ➢ Require a power connection
- ➢ Require connection with the Cloud

Embedded PCs

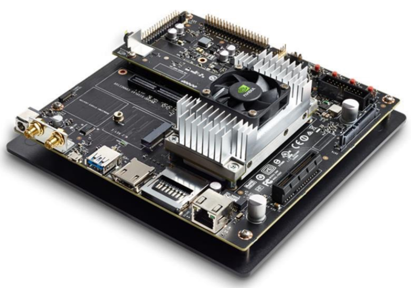
Ordoid



Raspberry



Platform	Raspberry Pi 3B
CPU	ARM11 @ 1.2 GHz
RAM	1024 MB



Jetson TX2

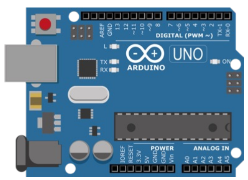
Google Coral

- ✓ Pervasive computing
- ✓ High performance unit
- ✓ Availability of development boards
- ✓ Programmed as PC
- ✓ Large community

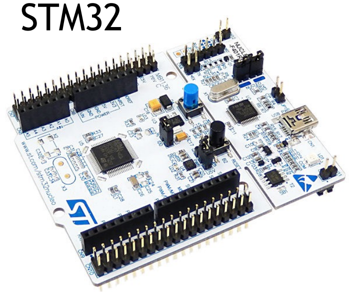
- ➢ Pretty high power consumption
- ➢ (Some) HW design has to done

Internet-of-Things

Arduino



STM32



	STM32 L1 Series	STM32F4 Series
Domain	Ultra Low-Power	High-Performance
Flash Memory (kB)	32 to 512	64 to 2048
RAM Memory (kB)	4 to 80	32 to 320
CPU	ARM® Cortex®-M3	ARM® Cortex®-M4
Frequency (MHz)	32	84 to 180
Supply Voltage (V)	1.65 to 3.6	1.71 to 3.6
Supply Current (μA)	0.28 (0.28) to 230	1.1 (140) to 282

- ✓ Highly Pervasive
- ✓ Wireless connection
- ✓ Battery Powered
- ✓ Low costs
- ✓ Sensing and actuating

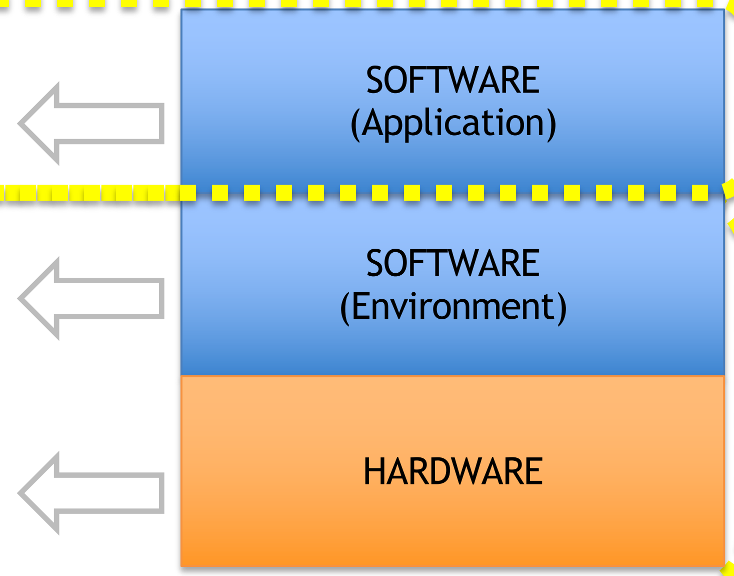
- ➢ Low computing ability
- ➢ Constraints on energy
- ➢ Constraints on memory (RAM/FLASH)
- ➢ Difficulties in programming

An IT perspective for Computing Infrastructures

The application, i.e., the reason why this system exists

Programs and libraries to control the physical resources and provide tools to build applications

Physical resources of the system (computation, storage, input/output, etc..)



An IT perspective for Computing Infrastructures