POLITECNICO
MILANO 1863

# Computing Infrastructures
# -
# System Dependability Overview

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

## 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

## 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

## 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)

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  …from a microwave oven up to an airplane and a large datacenter!
- The ability of a system to perform its functionality while exposing:
  - Reliability

    Continuity of correct service
  - Availability

    Readiness for correct service
  - Maintainability

    Ability for easy maintainance
  - Safety

    Absence of catastrophic consequences
  - Security

    Confidentiality and integrity of data

# Why dependability?

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Functional Verification

A lot of effort is devoted to make sure the implementation

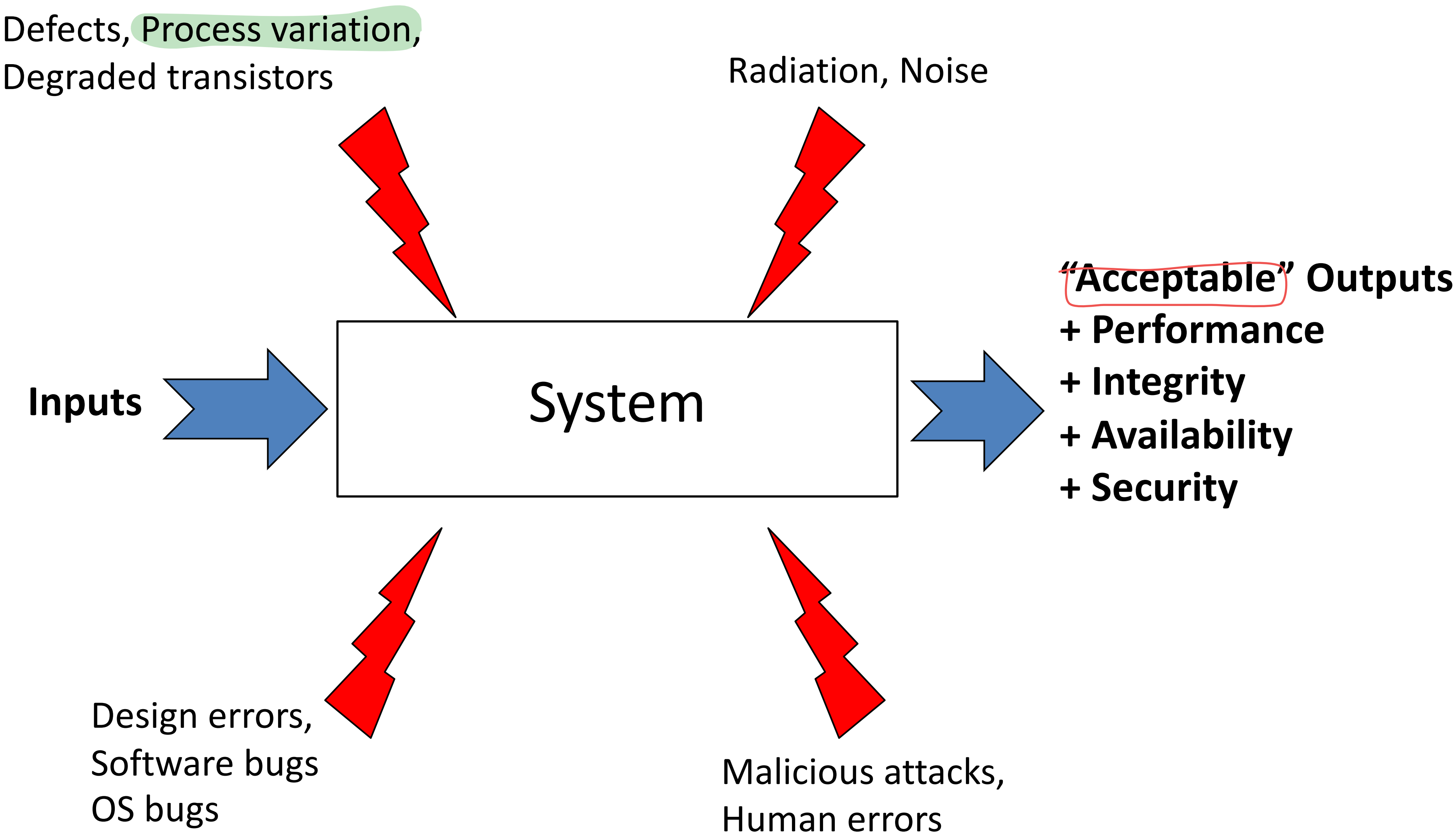
- matches specifications
- fulfills requirements
- meets constraints
- optimizes selected parameters (performance, energy, …)

Nevertheless, even if all above aspects are satisfied … things may go wrong

➧ systems fail

systems fail … because something broke

# Why dependability?



# Failure effects

Why dependability?

- A failure may have high costs if it **impacts economic losses** or physical damage
- A single **system failure may affect a large number of people**
- ***Systems that are not dependable are likely not be used or adopted***
- Undependable systems may cause information loss with a high consequent recovery cost
- …

# When to think about dependability?

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Both at design-time and at runtime

# Always!!!

# When to think about dependability?

Both at design-time and at runtime

- Analyse the system under design
- Measure dependability properties
- Modify the design if required

# When to think about dependability?

Both at design-time and at runtime

- Detect malfunctions
- Understand causes
- React

# When to think about dependability?

- Failures occur in development & operation
  - Failures in development *should* be avoided
  - Failures in operation *cannot* be avoided (things break), they must be dealt with

- Design should take failures into account and guarantee that control and safety are achieved when failures occur

- Effects of such failures should be predictable and deterministic … not catastrophic

# Where to apply dependability?

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Why dependability ?

Once upon a time …

…dependability has been a relevant aspect only for safety-critical and mission-critical application environments

- Space
- Nuclear
- Avionics

Huge costs, acceptable only when mandatory …

# Mission-critical

Mission-critical systems: a failure during operation can have serious or irreversible effects on the mission the system is carrying out

- Satellites
- Surveillance drones
- Unmanned vehicles
- Automatic Weather Stations (and more in general sensors) in harsh environments

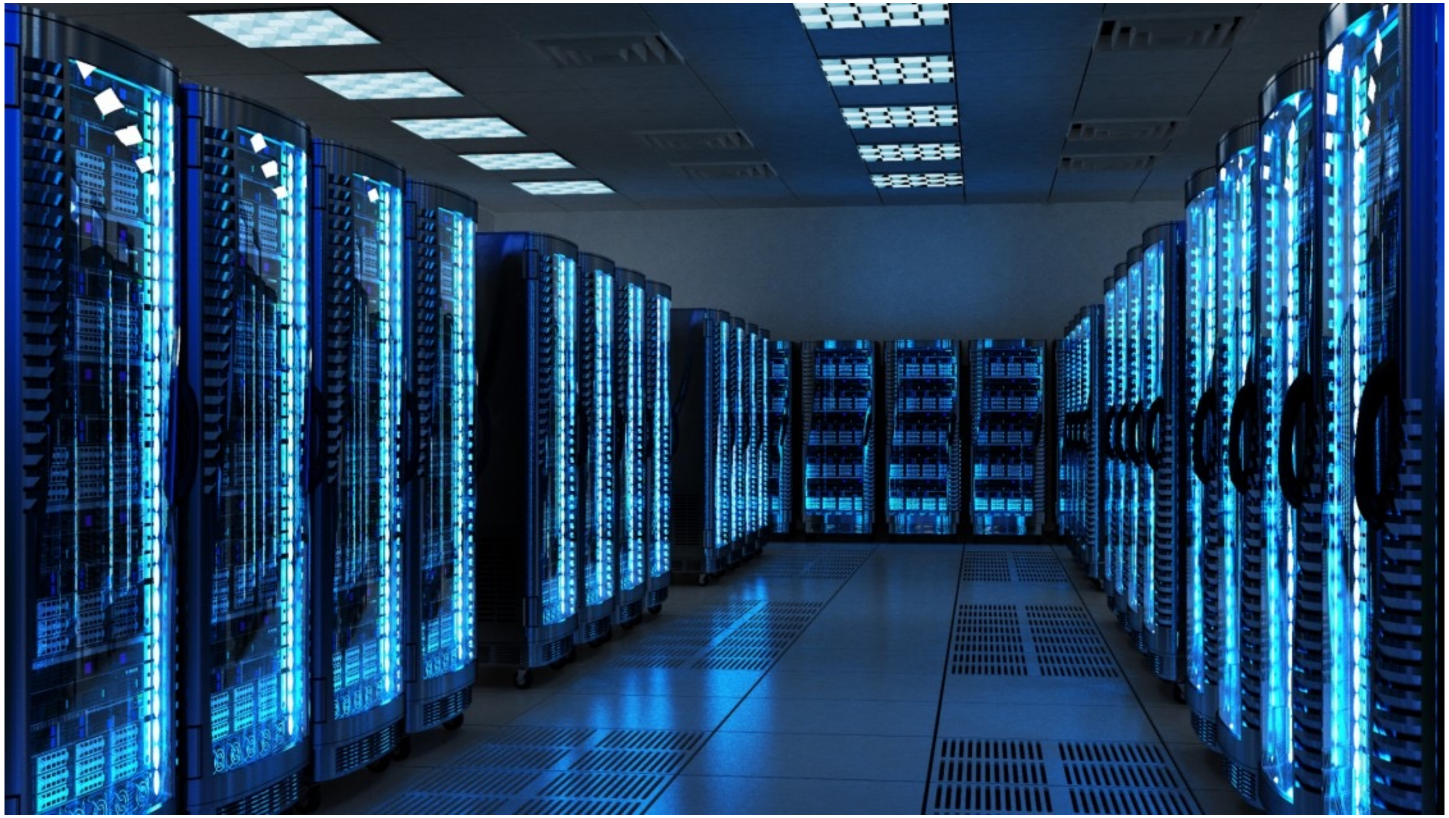
# Safety-critical systems

Safety-critical systems: a failure during operation can present a direct threat to human life

- aircraft control systems
- medical instrumentation
- railway signaling
- nuclear reactor control systems

# Computing Infrastructures:

Datacenters



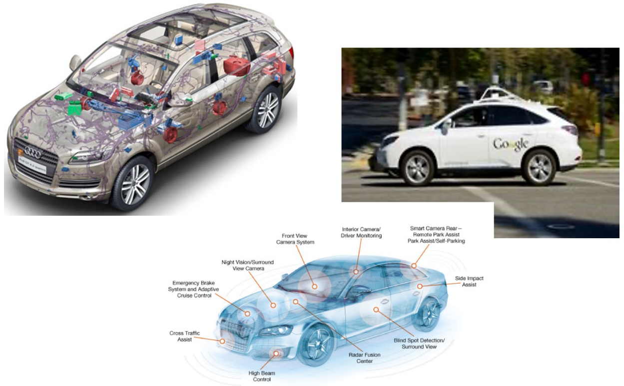
Downtime is the enemy of every data center.

Aberdeen Research reports the following downtimes and incidents:

- "Average" performing facilities, 60 minutes with 2.3 incidents per year.
- Best-in-class organizations, 6 minutes with 0.3 incidents per year.

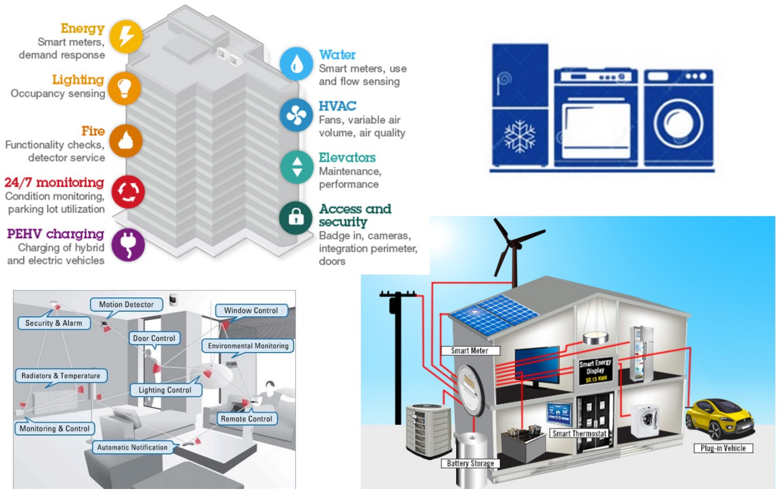
# Computing Infrastructures

Other scenarios…

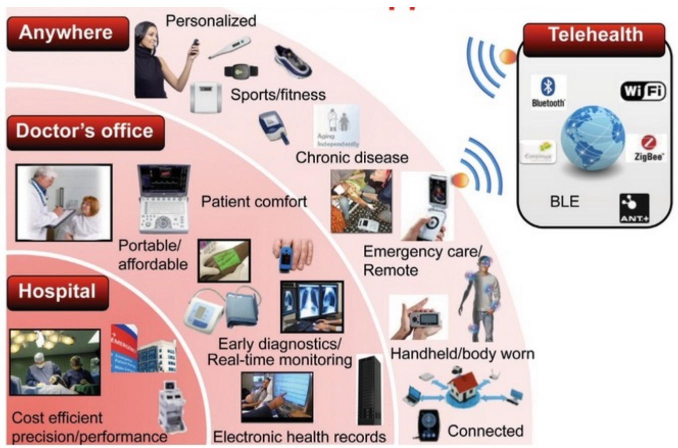


Automotive

Telecommunication




Smart Spaces




eHealth

# Anatomy of the scenarios: an example…

the nodes

- computing systems
- sensors and actuators

the communication

- network

the cloud

- data storage
- data manipulation

**Everything has to work properly for the overall system to be working**

# How to provide dependability?

# Failure avoidance vs tolerance paradigm

robust (computing) systems

**AVOIDANCE**

- Conservative design
- Design validation
- Detailed test
  - Hardware
  - Software
- Infant mortality screen
- Error avoidance

**TOLLERANCE**

- Error detection / error masking during system operation
- On-line monitoring
- Diagnostics
- Self-recovery & self-repair

# Where to work

Technological level

- design and manufacture by employing reliable/robust components
  - *Highest dependability*
  - *High cost*
  - *Bad performance (generally devices from old generation)*

# Where to work

Technological level

- design and manufacture by employing reliable/robust components

Architectural level

- integrate normal components using solutions that allow to manage the occurrence of failures
  - *High dependability*
  - *High cost*
  - *Reduced performance*

# Where to work

Technological level

- design and manufacture by employing reliable/robust components

Architectural level

- integrate normal components using solutions that allow to manage the occurrence of failures

Software/application level

- develop solutions in the algorithms or in the operating systems that mask and recover from the occurrence of failures
  - *High dependability*
  - *High cost*
  - *Reduced performance*

# Where to work

What do all solutions have in common?

- Cost
- Reduced performance

**You have to pay for dependability**