

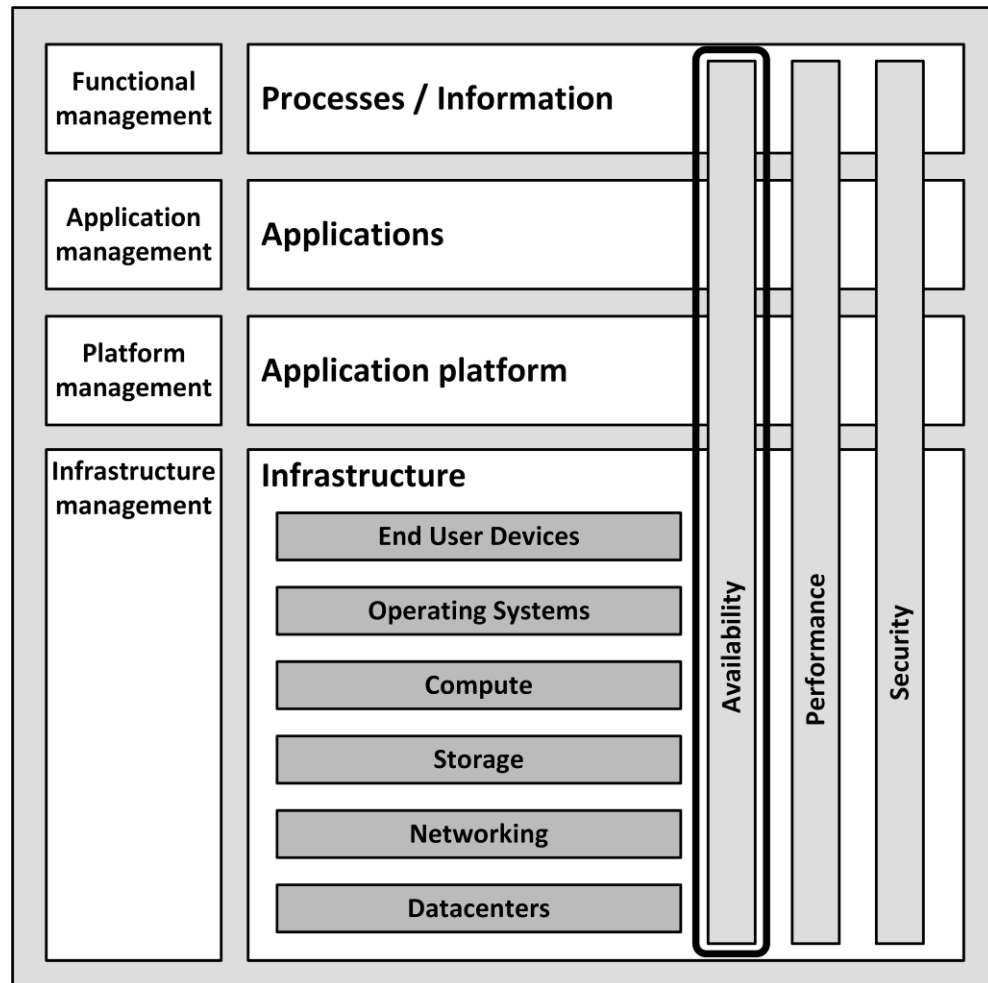
# IT Infrastructure Architecture

Infrastructure Building Blocks  
and Concepts

Availability Concepts

# Introduction

- Everyone expects their infrastructure to be available all the time
- A 100% guaranteed availability of an infrastructure is impossible



# Calculating availability

- Availability can neither be calculated, nor guaranteed upfront
  - It can only be reported on afterwards, when a system has run for some years
- Over the years, much knowledge and experience is gained on how to design high available systems
  - Failover
  - Redundancy
  - Structured programming
  - Avoiding Single Points of Failures (SPOFs)
  - Implementing systems management

# Calculating availability

- The availability of a system is usually expressed as a percentage of uptime in a given time period
  - Usually one year or one month
- Example for downtime expressed as a percentage per year:

<b>Availability %</b>	<b>Downtime per year</b>	<b>Downtime per month</b>	<b>Downtime per week</b>
99.8%	17.5 hours	86.2 minutes	20.2 minutes
99.9% ("three nines")	8.8 hours	43.2 minutes	10.1 minutes
99.99% ("four nines")	52.6 minutes	4.3 minutes	1.0 minutes
99.999% ("five nines")	5.3 minutes	25.9 seconds	6.1 seconds

# Calculating availability

- Typical requirements used in service level agreements today are 99.8% or 99.9% availability per month for a full IT system
- The availability of the infrastructure must be much higher
  - Typically in the range of 99.99% or higher
- 99.999% uptime is also known as carrier grade availability
  - For one component
  - Higher availability levels for a complete system are very uncommon, as they are almost impossible to reach

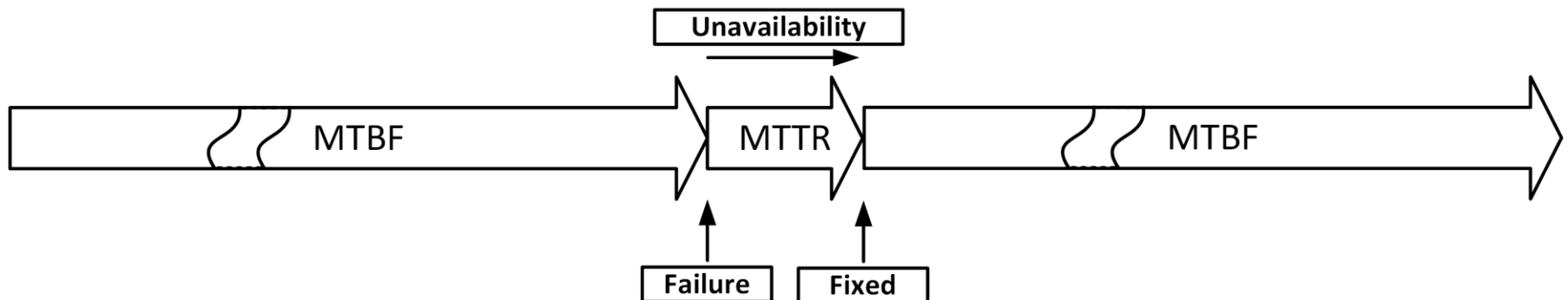
# Calculating availability

- It is good practice to agree on the maximum frequency of unavailability

<b>Unavailability (minutes)</b>	<b>Number of events (per year)</b>
0 – 5	$\leq 35$
5 – 10	$\leq 10$
10 – 20	$\leq 5$
20 – 30	$\leq 2$
$> 30$	$\leq 1$

# MTBF and MTTR

- Mean Time Between Failures (MTBF)
  - The average time that passes between failures
- Mean Time To Repair (MTTR)
  - The time it takes to recover from a failure



# MTBF and MTTR

- Some components have higher MTBF than others
- Some typical MTB's:

Component	MTBF (hours)
Hard disk	750,000
Power supply	100,000
Fan	100,000
Ethernet Network Switch	350,000
RAM	1,000,000



# MTTR

- MTTR can be kept low by:
  - Having a service contract with the supplier
  - Having spare parts on-site
  - Automated redundancy and failover

# MTTR

- Steps to complete repairs:
  - Notification of the fault (time before seeing an alarm message)
  - Processing the alarm
  - Finding the root cause of the error
  - Looking up repair information
  - Getting spare components from storage
  - Having technician come to the datacenter with the spare component
  - Physically repairing the fault
  - Restarting and testing the component

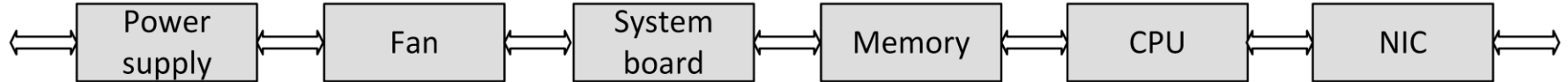
# Calculation examples

$$\text{Availability} = \frac{\text{MTBF}}{(\text{MTBF} + \text{MTTR})} \times 100\%$$

<b>Component</b>	<b>MTBF (h)</b>	<b>MTTR (h)</b>	<b>Availability</b>	<b>in %</b>
Power supply	100,000	8	0.9999200	99.99200
Fan	100,000	8	0.9999200	99.99200
System board	300,000	8	0.9999733	99.99733
Memory	1,000,000	8	0,9999920	99.99920
CPU	500,000	8	0.9999840	99.99840
Network Interface Controller (NIC)	250,000	8	0.9999680	99.99680

# Calculation examples

- Serial components: One defect leads to downtime



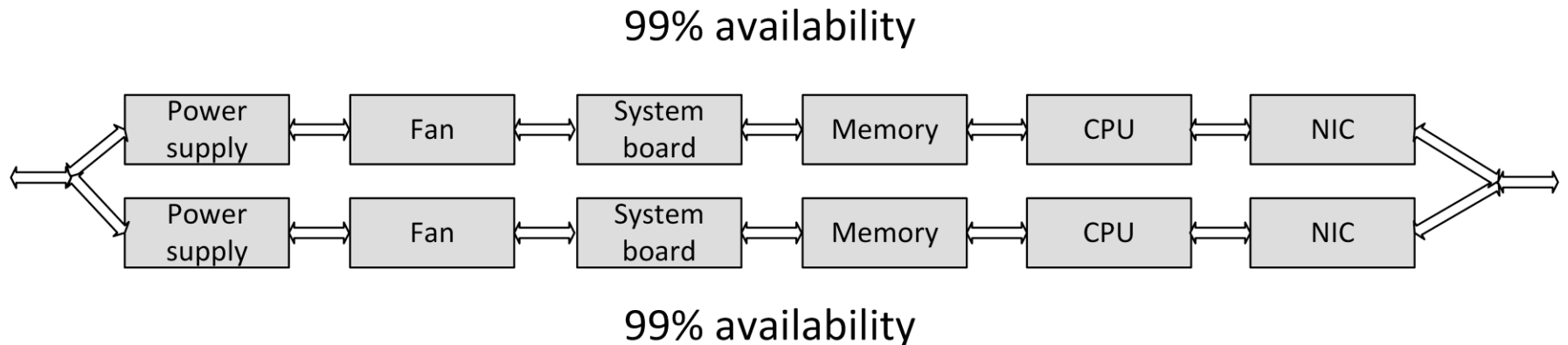
- Example: the above system's availability is:

$$\begin{aligned} &0.9999200 \times 0.9999200 \times 0.9999733 \\ &\times 0.9999920 \times 0.9999840 \times 0.9999680 \\ &= 0.99977 = \mathbf{99.977\%} \end{aligned}$$

(each components' availability is at least 99.99%)

# Calculation examples

- Parallel components: One defect: no downtime!
- But beware of SPOFs!



- Calculate availability:

$$A = 1 - (1 - A_1)^n$$

- Total availability =  $1 - (1 - 0.99)^2 = 99.99\%$