

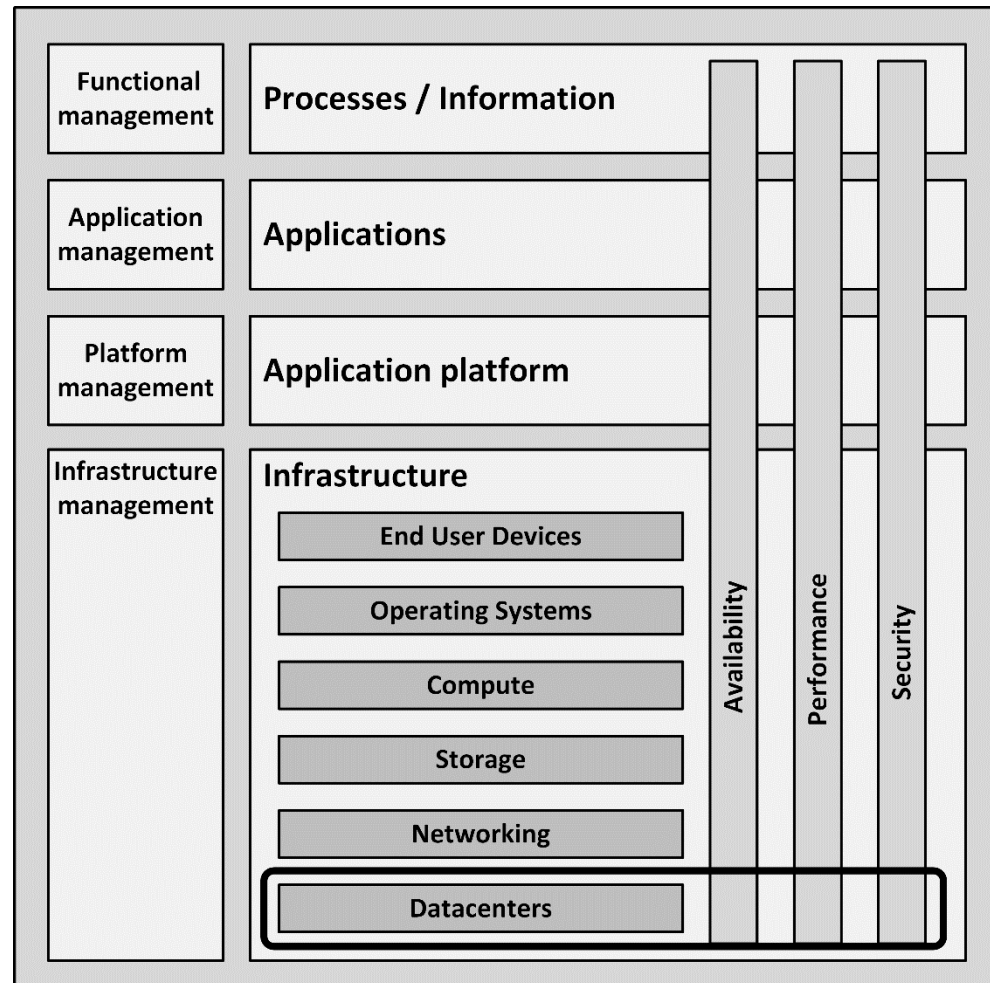
# IT Infrastructure Architecture

Infrastructure Building Blocks  
and Concepts

Datacenters

# Introduction

- Most IT infrastructure hardware, except for end user devices, are hosted in datacenters
- A datacenter provides:
  - Power supply
  - Cooling
  - Fire prevention and detection
  - Equipment racks



# History

- Early datacenters (computer rooms) were designed and built for large mainframe systems
- A mainframe, together with its peripheral systems easily filled up a large computer room



# Today's datacenters

- Today's datacenters are equipped with standardized 19" racks
  - They house servers, storage devices, and network equipment
  - They are installed in rows forming corridors between them
- Very large datacenters today contain shipping containers packed with thousands of servers each
  - When repairs or upgrades are needed, entire containers are replaced



# Datacenter building blocks

# Datacenter categories

- Typical datacenter categories:
  - **Sub Equipment Room (SER)** – a SER is also known as a patch closet
  - **Main Equipment Room (MER)** – a MER is a small datacenter in the organization's subsidiaries or buildings
  - **Organization owned datacenter** – a datacenter that contains all central IT equipment for the organization
  - **Multi-tenant datacenter** – used by service providers that provide services for multiple other organizations. These datacenters are typically the largest

# Datacenter location

- Many variables should be considered to determine where a datacenter could be installed
- Examples:
  - Environment of the datacenter
  - Visibility of the datacenter
  - Utilities available to the datacenter
  - Datacenters located in foreign countries

# Physical structure

- The physical structure of a datacenter includes components that need special attention:
  - Floors
  - Walls
  - Windows
  - Doors
  - Water and gas pipes



# Floors

- In a typical datacenter, the floor must be able to carry 1500 to 2000 kg/m<sup>2</sup>
  - One fully filled 19" computer rack weighs up to 700 kg
  - The footprint of a rack is about 60x100 cm, leading to a floor load of 1166 kg/m<sup>2</sup>
  - In office buildings typically the floor can carry approximately 500 kg/m<sup>2</sup>

# Floors

- Raised floors consist of a metal framework carrying removable floor tiles
- Tiles are usually 60×60 cm
- Tiles can be lifted individually to reach cables installed under the raised floor
- Vents provide cool air flow to the racks placed on the floor
- Under the raised floor, data and power cables are installed
  - As alternative, overhead cable trays can be used



# Floors

- Raised floors have the following disadvantages:
  - They are expensive
  - The total available height in the datacenter is decreased
  - The maximum floor load is limited
  - Doors and equipment loading slopes are hard to install due to the difference in floor height
  - Under the raised floor, a fire could easily spread through the entire datacenter

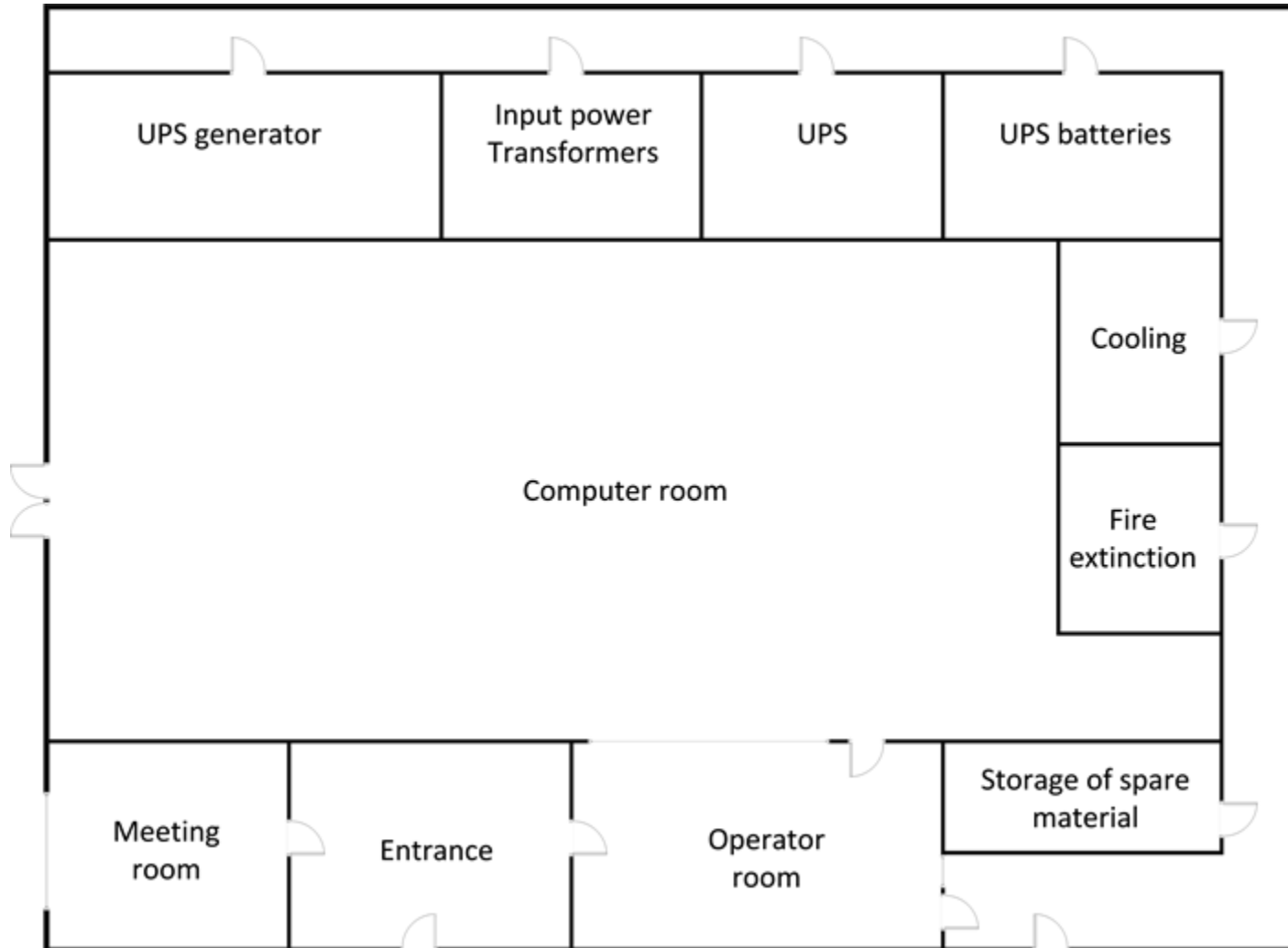
# Walls, windows, and doors

- Walls should reach from the floor to the building's ceiling
  - Because of fire safety and physical intrusion prevention
  - Adequate fire rating is needed to serve as a physical firewall
- Windows are not desirable in a datacenter
- Windows must be:
  - Translucent
  - Shatterproof
  - Impossible to open
- Doors should be large enough to have equipment brought in
- Doors must resist forced entry

# Water and gas pipes

- Water or gas pipes may have been installed:
  - Under the floor
  - In the walls
  - Above the ceiling of the datacenter
- Leakage from water pipes in the ceiling of a datacenter could lead to damage of equipment
- Datacenter operators should know where the shutoff valves are

# Datacenter layout



# Power supply

- Energy usage is a key issue for datacenters
- Power drawn by datacenters:
  - A few kilowatts (kW) for one rack of servers
  - Dozens of megawatts (MW) for large facilities
- The amount of power available in a datacenter is expressed as the number of kilowatts per  $\text{m}^2$ 
  - Known as power density
- Normal-density datacentre: between 2 to 6  $\text{kW}/\text{m}^2$
- High-density datacentre: between 10 and 20  $\text{kW}/\text{m}^2$

# Power supply

- Example:
  - If a HP DL380 server uses 250W power
  - A rack could physically hold 40 servers
  - Available energy density is 2 to 6 kW/m<sup>2</sup>
  - Only between 8 and 24 servers can be placed in the rack
- In practice most server racks cannot be fully equipped
- A high-density datacentre allows racks to be filled with approximately 40 to 80 servers

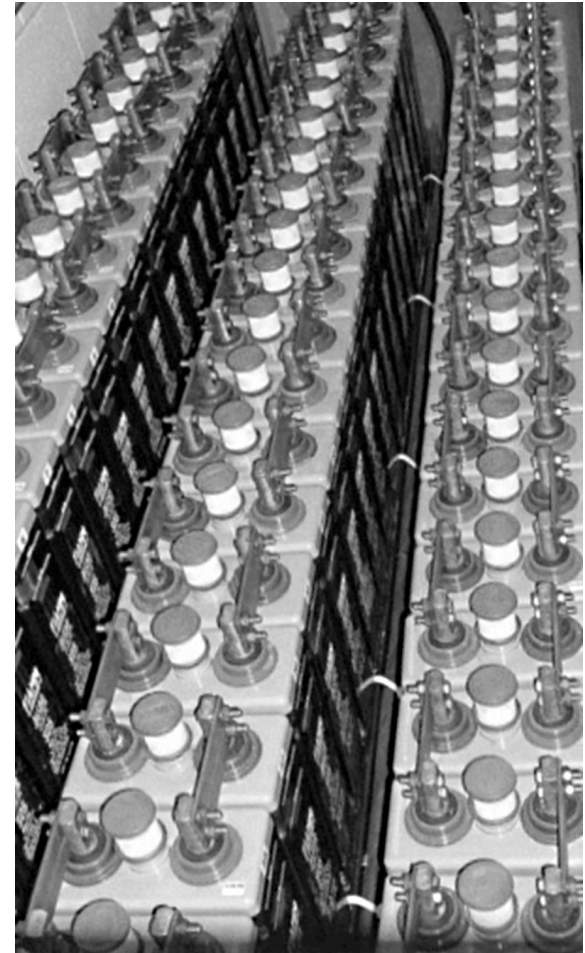


# Uninterruptable Power Supply (UPS)

- Power issues can occur in the utility power supply
- Possibly leading to:
  - Downtime
  - Damage to equipment
- Types of power issues:
  - Blackout
  - Surge
  - Spike
  - Brownout
  - Waveform issues
- An Uninterruptable Power Supply (UPS):
  - Is independent of the utility power supply
  - Provides high quality electrical power

# Uninterruptible Power Supply (UPS)

- A UPS installation consists of:
  - Filters
  - A diesel power generator
  - A set of batteries or a flywheel system



# Uninterruptable Power Supply (UPS)

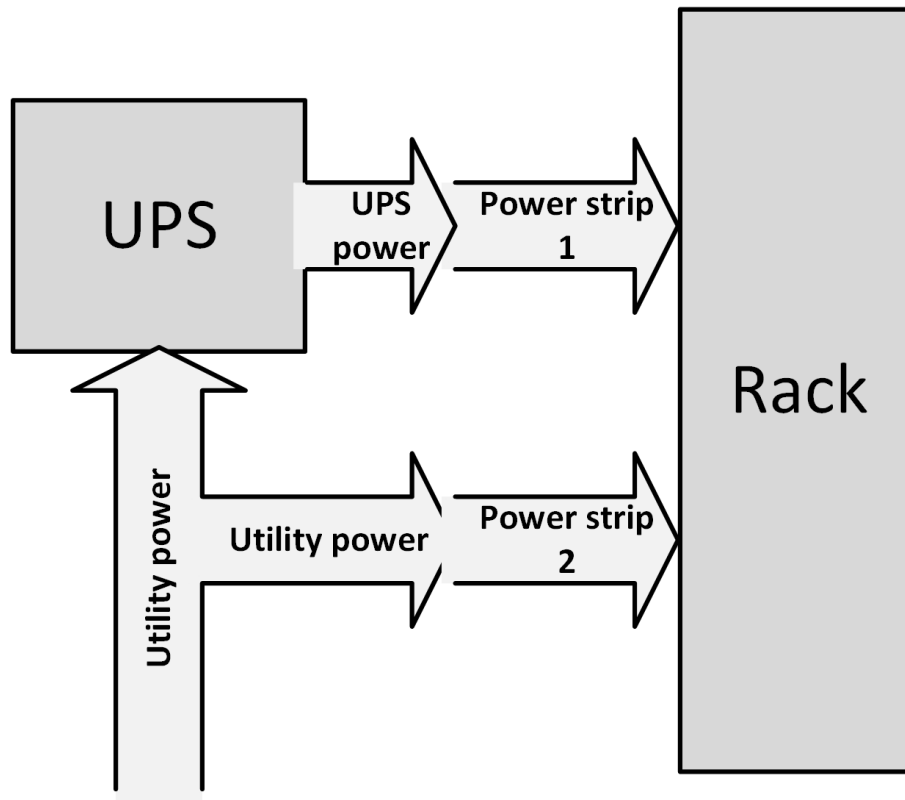
- Battery powered UPSs:
  - Standby UPS systems (also known as off-line systems)
    - Used in small setups (a few workstations or servers)
  - Line interactive UPS systems
    - Use a transformer between the utility power and the IT equipment
    - Works as a filter for many of the power issues
  - Double conversion UPS systems
    - Convert the AC utility power to DC power and then back to high quality AC power

# Power distribution

- A power distribution unit (PDU) is a device with multiple power outlets
  - Distributes power to equipment located in the datacenter
- Two types of PDUs:
  - Large floor mounted PDUs take main feeds (usually 3 phase power) and distribute it into multiple smaller feeds to computer racks
  - Power Strips that feed equipment in racks
- Most Infrastructure components can be equipped with two power supplies for redundancy
- For availability reasons at least two power strips are needed to power equipment in a rack
  - Each feeds one of the two power supplies in the equipment

# Uninterruptible Power Supply (UPS)

- Two independent power feeds to racks
- UPS should not be a Single Point of Failure



# Cooling

- > 90% of all power used by IT infrastructure components is converted into heat
- All heat has to be dissipated by a cooling system
- Two types of cooling systems:
  - Computer Room Air Conditioners (**CRAC**)
    - Refrigerant-based units connected to outside condensing units
  - Computer Room Air Handlers (**CRAH**)
    - Chilled water based and connected to outside chillers
    - A chiller produces chilled water via a refrigeration process

# Cooling

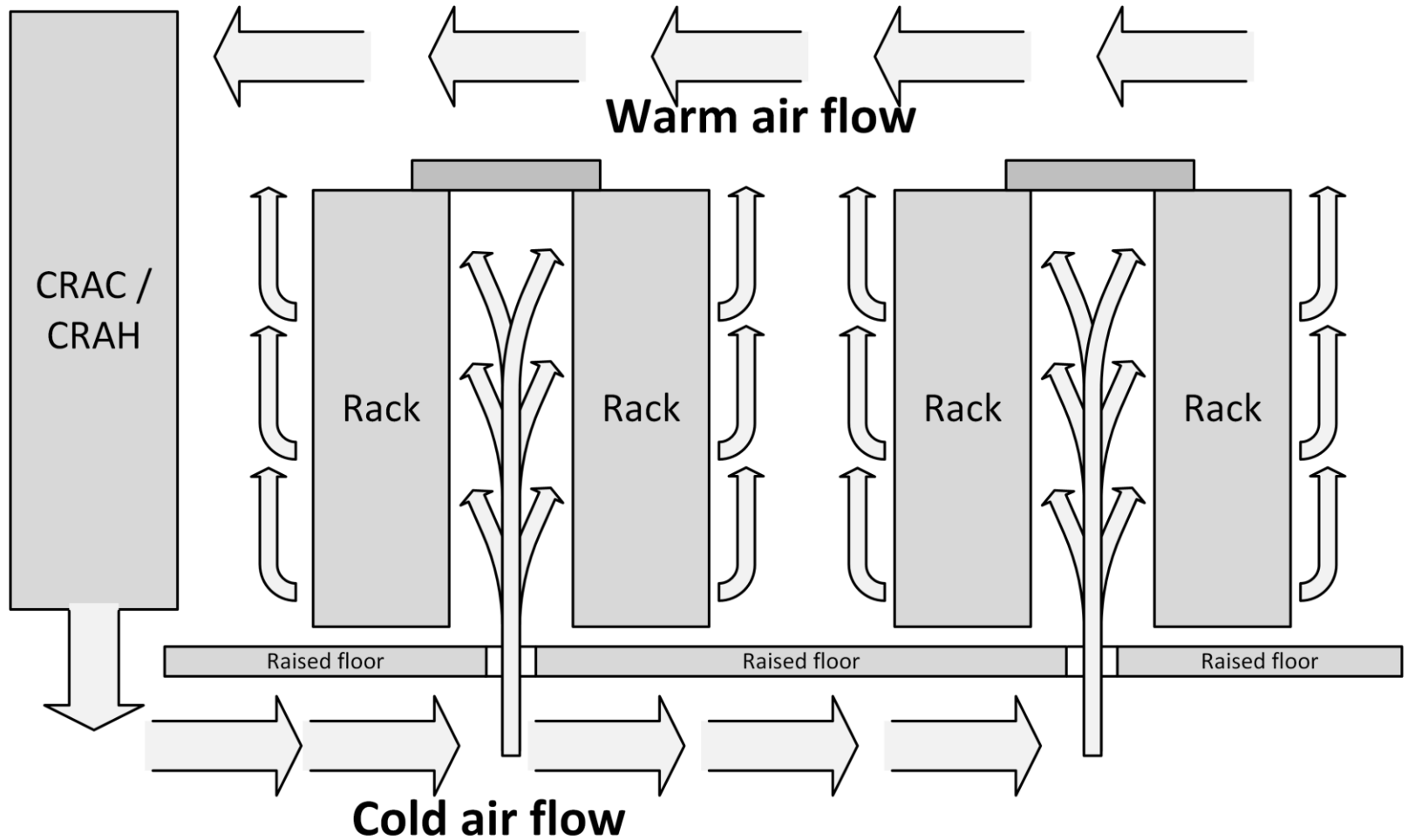
- The efficiency of a cooling system is specified in:
  - **EER** - Energy Efficiency Ratio
    - The measure of efficiency at maximum air conditioning load
    - The ratio between output cooling in BTU per hour and the electric energy input in Watts at a given operating point
  - **SEER** - Seasonal Energy Efficiency Ratio
    - Same as EER, but seasonal data is used for the measurement
    - The time of year the cooling system is used most (typically in the summer)
  - **COP** - Coefficient Of Performance
    - The ratio between cooling load in kW and the electric energy input in kW
    - Normal values are between 3 and 10

# Operating temperatures

- Infrastructure components have maximum operating temperatures
  - Servers shut themselves down at an air inlet temperature of 40 degrees Celsius
- The air temperature in the datacenter usually ranges from 18 degrees to 27 degrees Celsius
- Using higher temperatures saves cooling capacity and power
  - Raising the temperature in a datacenter with one degree Celsius lowers the cost for cooling by approximately 5%



# Airflow



# Humidity and dust

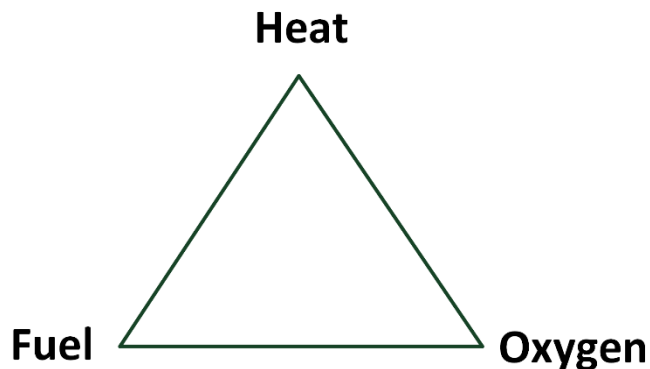
- The humidity of the air in a datacenter is critical for the IT infrastructure components
  - Air humidity should be between 40% and 60%
- The number of dust particles in a datacenter should be minimized
  - Don't allow visitors in the datacenter
  - People should wear dust-free clothing (like white coats) and protective sleeves around their shoes

# Fire prevention, detection, and suppression

- Fire is one of the main enemies of a datacenter
  - A short circuit in a cable
  - Defect equipment
- Fires can spread around very quickly
  - Because of the air flow in the datacenter and the frequent use of raised floors
- Smoke could damage equipment in the datacenter
  - Even if a fire starts outside of the datacenter's computer room

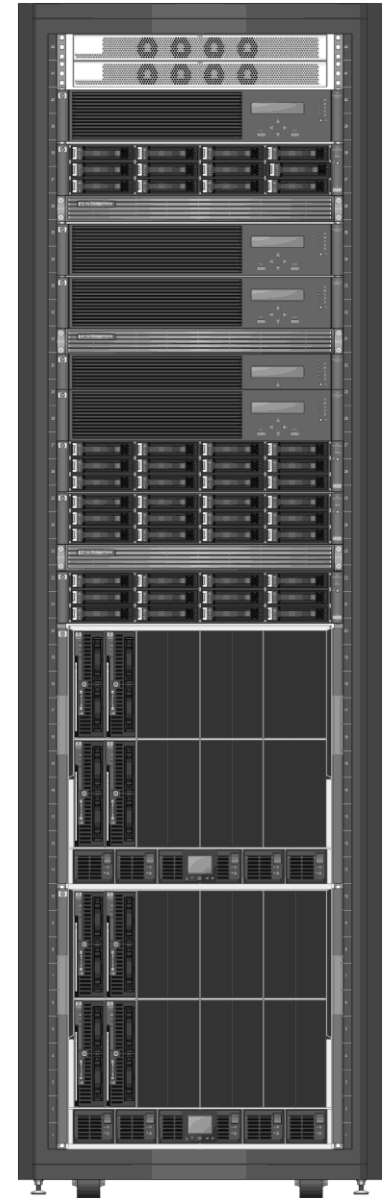
# Fire prevention, detection, and suppression

- Suppressing fire in a datacenter consists of four levels:
  - Fire prevention – Avoid a fire
  - Passive fire protection – Limit the exposure of the fire once it has started
  - Fire detection systems – Detect smoke and fire
  - Fire suppression systems – Extinguish the fire once it is detected



# Equipment racks

- A 19" rack is a standardized metal enclosure to house IT infrastructure components
- The height of a rack is measured in rack unit or 'U'
  - One U is 44.5 mm
- A typical rack is 42U high



# Datacenter energy efficiency

- IT accounts for approximately 2% of all the world's CO<sub>2</sub> emissions
- During the lifetime of a server the amount of money spent on electricity can be much higher than the cost of the server itself
- The datacenter itself uses power as well
  - Cooling system
  - Lighting
  - Heating of the operator rooms
  - Etc.

# Datacenter energy efficiency

- The Power Usage Effectiveness (PUE) metric measures the power used by the datacenter
- The PUE is calculated by dividing the amount of power used by the datacenter, by the power used to run the IT equipment in it
- Typical PUE value of a datacenter is between 1.1 and 2.0
  - Running a datacenter with a PUE of 1.5 means that for each watt of power used by the IT equipment an extra half watt is used by the rest of the datacenter