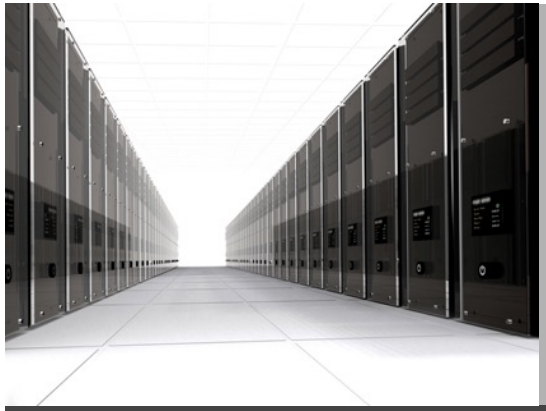

DC INFRASTRUCTURES II: PHYSICAL ELEMENTS + SECURITY

David López
V.2.1
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UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

Raised floor

- Provide an elevated structural floor above a solid substrate to create a hidden void for the passage of wiring, electrical supply or under floor air distribution
- Conditioned air is provided under the floor and dispersed upward into the room through regularly spaced diffuser tiles and blowers
- Usually wiring on ceiling trays

Raised floor

Diffuser tiles (cold air 20ºC)

Wiring entering the racks through holes beneath them

Raised floor details

- Minimum 50 mm high, can be raised enough for a person to crawl or even walk beneath
- Sometimes provide lighting and smoke detectors
- Rarely cleaned!
- Must be designed to support the weight of racks and people working in the DC (taking into account future equipment)

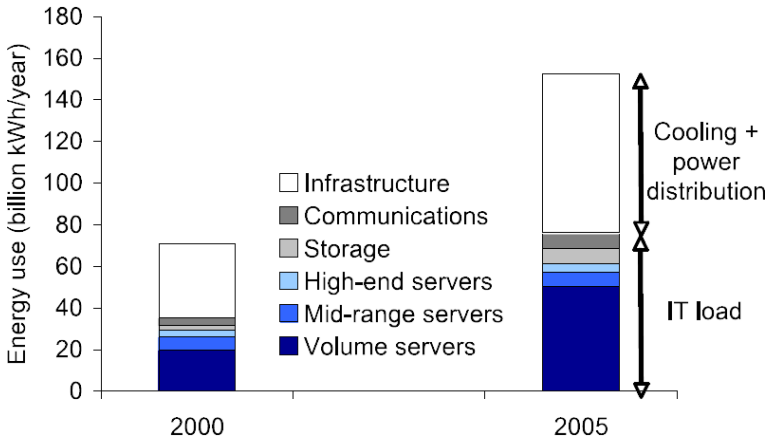
HVCA (Heating, Ventilation & Air Conditioning)

Basic ideas:

- The electrical power used by the electronic equipment is converted to heat
- Unless the heat is removed, it can result in hardware malfunction
- When designing the DC, you must know the peak HVAC consumption
  - Measured in kWh or BTU/h (British Thermal Units/hour)
  - 1 kWh = 3413 BTU/h
- Important idea: air flow
- Humidity is important!
- Not all points in the room have the same requirements!
- An important part of the final DC consumption

HVCA (Heating, Ventilation & Air Conditioning)

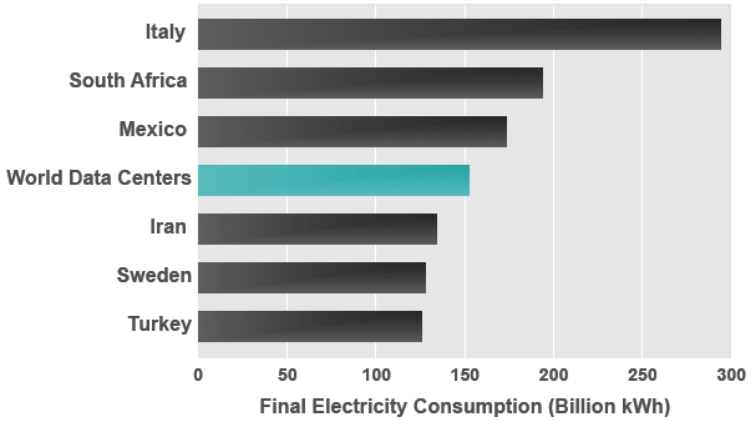
- A very important issue!



Source: Koomey, Jonathan. 2008.
"Worldwide electricity used in data centers."
Environmental Research Letters. vol. 3, no. 034008.

HVCA (Heating, Ventilation & Air Conditioning)

- How much is 152.000.000.000 kWh?



Source for country data in 2005:
International Energy Agency, World Energy.
Balances (2007 edition) (Koomey, Jonathan)

Some recommendations about HVAC

The maximum temperature must not exceed the limits given by the manufacturer of servers

- Between 20 º and 24 º C in the room
- More than 30 degrees reduces the life of electronic components
- Many units include temperature sensors with automatic shutoff

The optimum relative humidity should be around 45% to 55%

- Dry air influences the occurrence of electrostatic discharge (ESD)
- Excessive moisture condenses on internal components increasing energy consumption
- The relative humidity depends on air temperature

The flow must meet manufacturer's specifications

- The computer must be able to absorb a minimum amount of air per minute in m^3 / s
- The temperature inside the equipment depends on the external temperature and the air flow

The room must be clean of dust and particles

- Use anti-dust paint
- Vacuum cleaning before the DC start working
- Prevent dust

… but, there are not precise models and studies on the relationship between temperature, humidity and malfunction

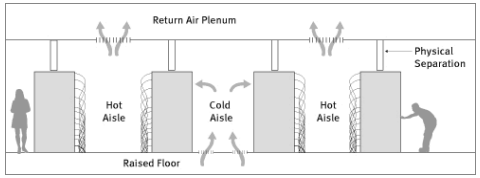
Cooling Systems

Small / domestic refrigeration equipment

- For small DC (with low power dissipation and low air flow)
- Relative humidity is not controlled
- It can not provide cold air flow where needed
  - It cools the room, not the servers

Raised floor room

- The coolers take hot air from the top of the room and push cold air into the raised floor
- The ground pressure is higher than in the room and cold air comes out where there is a hole or grid
- Racks draw air from the front and expel it from behind
  - Ground grids are placed in front of the racks
  - Two rows of racks must be faced to aspire cold air from the cold aisle
  - There are hot aisles
  - The flow is not perfectly predictable (but there are models)



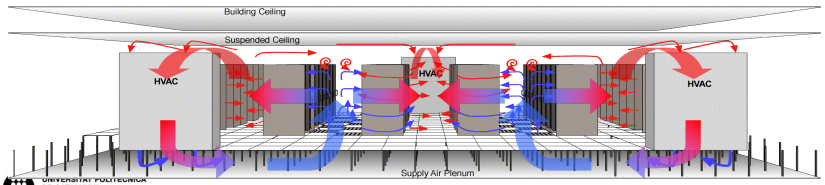
Source:hightech.lbl.gov

Hot aisle / cold aisle

Arrange the IT equipment so that all heat is exhaust into hot aisles, and all air intakes draw from cool aisles. Cool air is supplied only into the cold aisle, with return air being drawn directly from the hot aisle.

Good practices:

- Build rigid enclosures to fully separate the heat rejected from the rear of IT equipment from the cool air intakes on the front
- Use flexible strip curtains to improve the separation by blocking open space above the racks
- Blank unused rack positions to prevent hot air recirculation



Source: Guillermo Pérez

UPS (Uninterruptable Power System)

Sistema d'alimentació ininterrompuda (SAI)

Three functions:

- Contains a transfer switch that chooses the active power unit (utility power or generator power)
  - A generator can take about 10-15 seconds to start and assume full rated load
  - Usually diesel generators (for 48 MW?)
  - Utility power usually have redundancy accepting two independent power sources (typically called "A side" and "B side")
- Contains batteries or flywheels to bridge the time between the utility failure and the availability of generator power
  - AC-DC-AC double conversion
- UPS conditions the incoming power feeds
  - Removing voltage spikes or sags
  - Harmonic distortions in the AC feed

Going green: flywheels

Flywheel energy storage (FES) works by accelerating a rotor (flywheel) to a very high speed and maintaining the energy in the system as rotational energy. When energy is extracted from the system, the flywheel's rotational speed is reduced

PROS:

- Flywheels can operate at a much wider temperature range, and are not subject to many of the common failures of chemical rechargeable batteries
- Made of inert or benign material (no environmental damage)
- Costs of a fully installed flywheel UPS are about $330 per 15 seconds at one kilowatt (one half of a chemical battery)
- Consumes 75% less space
- 20 year design life (against 3 years)

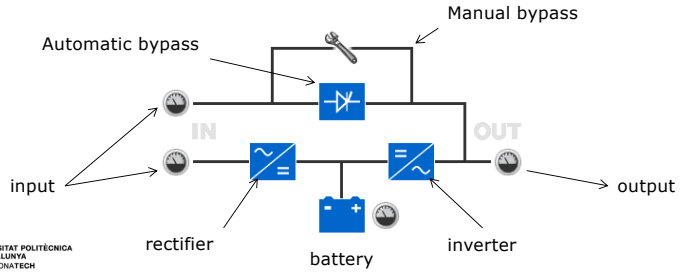
CONS:

- Use of flywheel accumulators is currently hampered by the danger of explosive shattering of the massive wheel due to overload

From wikipedia

UPS scheme

1. Input: Monofasic or trifasic
2. Output: Monofasic or trifasic, with an electronic controlled interrupter
3. Rectifier
   - Transform AC in DC
   - Battery charge
   - Feeds the inverter that generates stabilized AC
4. Battery
   - Can be a chemical battery, modern ones based on flywheels
   - Autonomy depends on the battery capacity (in kWh)
5. Inverter
   - Generates AC from DC
   - Generated power must have stable voltage and frequency
   - It feeds from rectifier or from batteries
6. Automatic Bypass
   - Feeds directly input from output in case of UPS malfunction
7. Manual Bypass
   - Direct connection for UPS maintenance



Additional features

UPS MUST communicate with systems to shut down them in case of battery discharging

- Monitoring units in UPS
- Daemon in the O.S
- Communication system
- Control message protocol

Less critical in case of having a generator power system

Real-world data centers usually include "paralleling" of generators of UPS units: multiple devices feed a shared bus so that the load of a failed device can be picked up by other devices

Typical configurations

- N+1: allows one failure or maintenance
- N+2: allows one failure even when one unit is offline for maintenance
- 2N: redundant pairs

UPS pros and cons

PROS

- Protection against power failures
- Stable voltage and frequency

CONS

- Costs: acquisition and maintenance
- Usually three years lifetime
- Difficult to scale (overestimation for the future?)
- Automatic operation complexity (for automatic shutdown)

FUTURE?

- Some companies are thinking about non-UPS DC
  - http://www.datacenterknowledge.com/archives/2010/07/14/data-centers-with-no-ups-or-generator/
  - http://www.datacenterknowledge.com/archives/2010/06/24/blue-waters-awesome-power-awesome-efficiency/
- Based on data and operations redundancy (only available for huge companies, like Yahoo!)

UPS: from small ones (up to 8 kVA)

To big ones (>8kVA)

More datacenter power and HVAC system elements

- Power Distribution Units (**PDUs**): the UPS output is routed to PDUs, that sit on the datacenter floor. They take higher-voltage feed (typically 240V, 30A) and break it up into many 110- 220-V, 15A circuits that feed the servers
- **CRAC** units (computer room air conditioning): pressurized the raised floor plenum by blowing cold air. Hot air produced by the servers recirculated back to the intakes of the CRAC that cool them
- **Heat rejection devices**: cooling towers outside the building, radiators, water-water heat exchangers
  - More problems: cooling equipment is also backed up by generators (and sometimes UPS units) because the data center cannot operate without cooling for more than a few minutes
  - According to Barroso & Hözler, in a typical datacenter chillers and pumpers can add 40% or more to the critical load that needs to be supported by generators
- **Emergency diesel generators**
  - Have you think about the fuel storage tanks?
  - And the fuel provision?

Power and HVCA summary

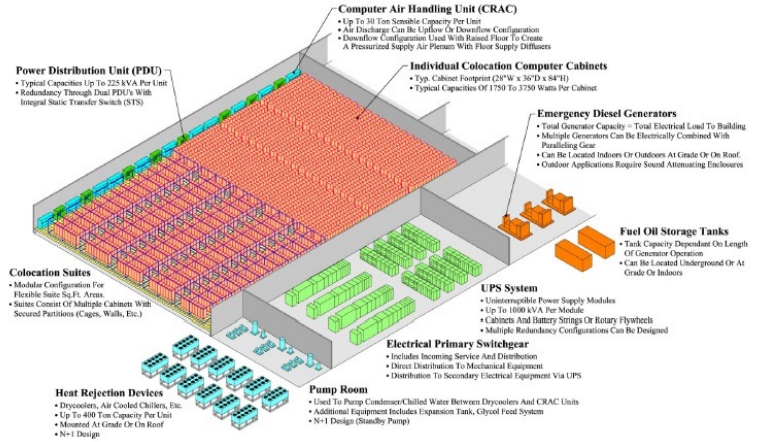


FIGURE 4.1: The main components of a typical datacenter (image courtesy of DLB Associates [23]).

Image from Barroso and Hölzle, The Datacenter as a Computer

Physical access control

Access to the computer room must be restricted

- Locked doors, with electronic access control system (ACS)
  - Access card readers or biometric sensors (e.g. fingerprint reader)
- Video camera surveillance
  - In particular, pointing to the computer room doors
- Permanent security guards?
- Mantraps

Inside the computer room

- Chassis opening sensor (alarm)
  - Avoid data theft about subtracting discs

Fire protection system

A fire can mean the total destruction of the equipment

Early detection = minimal damage

- Heat sensors
  - Detect high temperatures (fire)
- Early Warning Smoke Detector (EWSD)
  - Detects the first signs of smoke
  - Automatic sensors on the ceiling and cooling ducts
  - Disconnect the cooling equipment at the first sign of smoke
- Very Early Warning Smoke Detector (VEWSD)
  - Detects overheating hours or days before the fire
  - Vacuum system for sampling the air in the room searching for smoke particles
- Several sensors placed separately
  - 1 active sensor triggers the alarm
  - 2 active sensors triggers the extinction

Fire protection system

Extinction with inadequate means (water, foam or powder extinguishers) may involve the destruction of equipment

Based on water (sprinklers on roof)

- Can leak! Normal system in office buildings
- Solutions
  - The pipes are not filled until the alarm
  - Sprinklers are opened by fusion of a heat-seal
  - Dense fog: absorb heat with microscopic droplets (100-120 microns) that do not damage the equipment

Based on gas

- Leave no residue on equipment or in the room
- Reduction of oxygen:
  - Lower the oxygen concentration available with inert gas (argon or nitrogen).
- Heat removal
  - Different HCFCs (*hydrochlorofluorocarbon*) absorb heat from the environment by eliminating combustion

Hybrids

- First you use a gas system and if it fails to activate the water to save the lives of people and the building

Appropriate extinguishing = no need to stop operation

Routing wiring and cables

Installed during construction phase

- Power wiring form *breakers* to *outlets* (under raised floor)
- Network cable from **PODs** (points of distribution) under raised floor to the network room

Available to connect by data center personnel

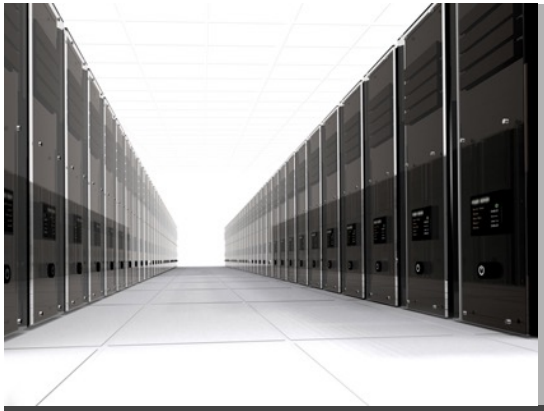
- Power wiring from outlets to racks
- Network cables form PODs to devices

Important idea:

- LABEL ALL YOUR CABLES!

(Not so) minor details

- Don’t forget ramps and lifts (scaled for new equipment)
- Weight is important!
- When scaling your UPS, don’t forget basic security elements (like emergency lighting or electronic equipment required for DC access –like access card readers), and reserve power enough for them before battery is exhausted
- Avoid unnecessary loads from the datacenter power source (like elevators)



DATA CENTER INFRASTRUCTURES

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