POLITECNICO DI MILANO

Computing Infrastructures

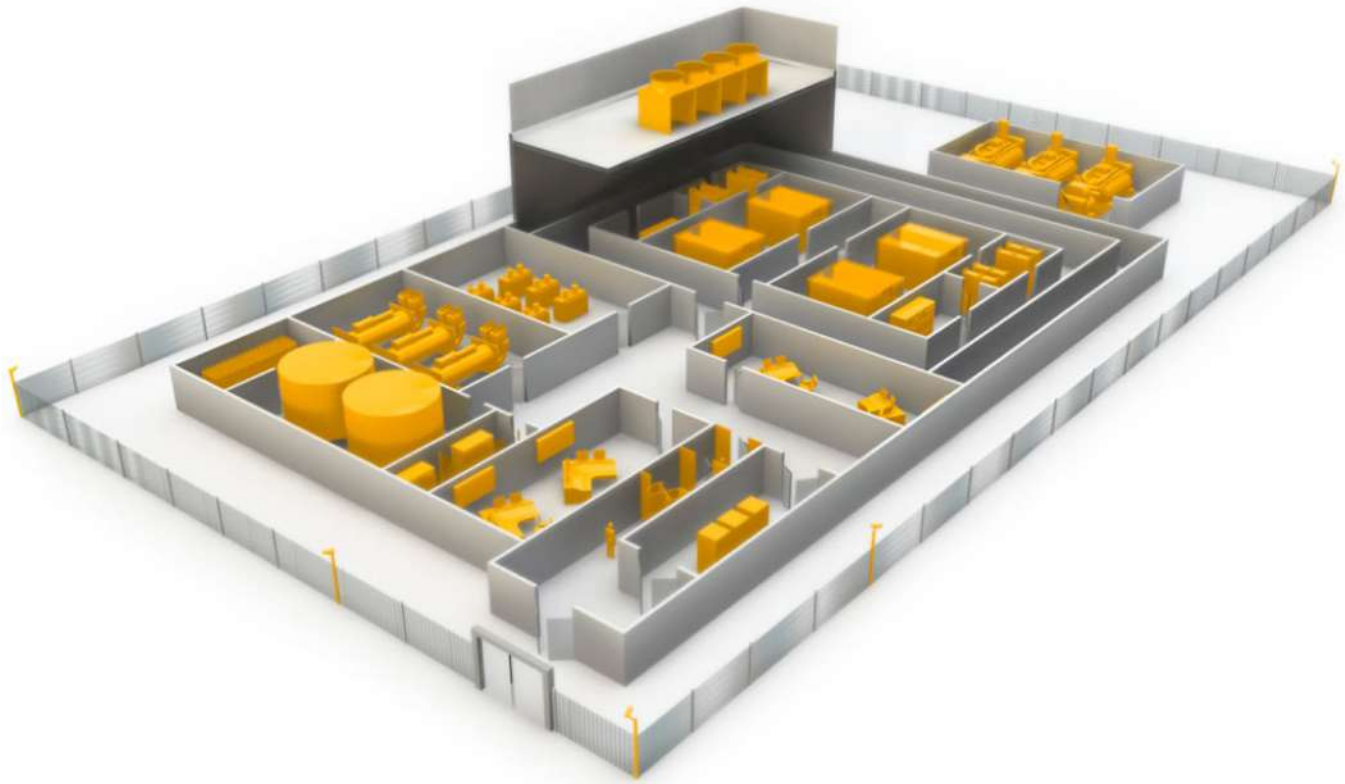




Introduction to data centers

Data-center architecture

Beside the IT equipment, a data-center must have several physical characteristics to ensure connectivity, reliability, security and safety.



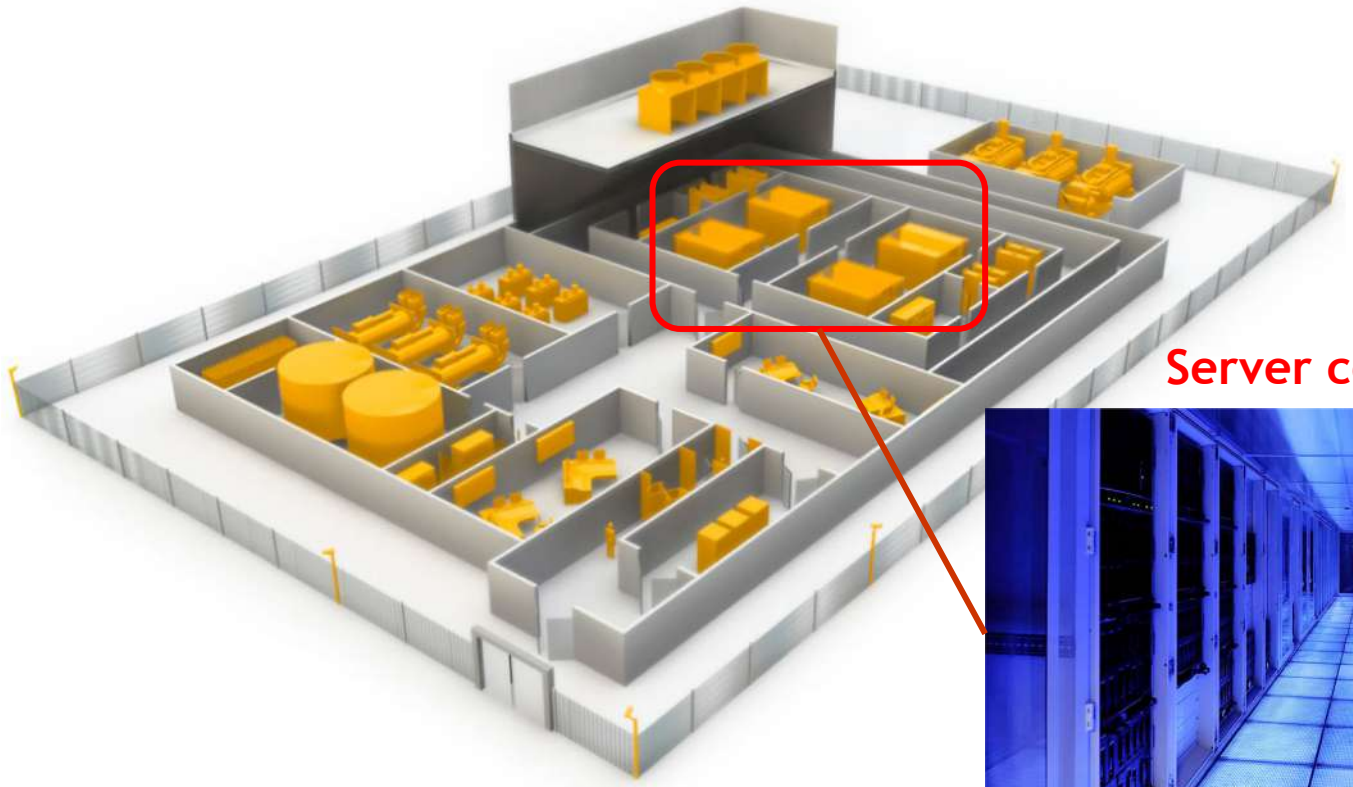
Source: *www.sapdatacenter.com*


F1 R7 CASS 4 SX G/ L


EMC
SYMMETRIX
VMAX

Data-center architecture

The IT equipment is stored into corridors, and organized into racks.
We will return on this later.

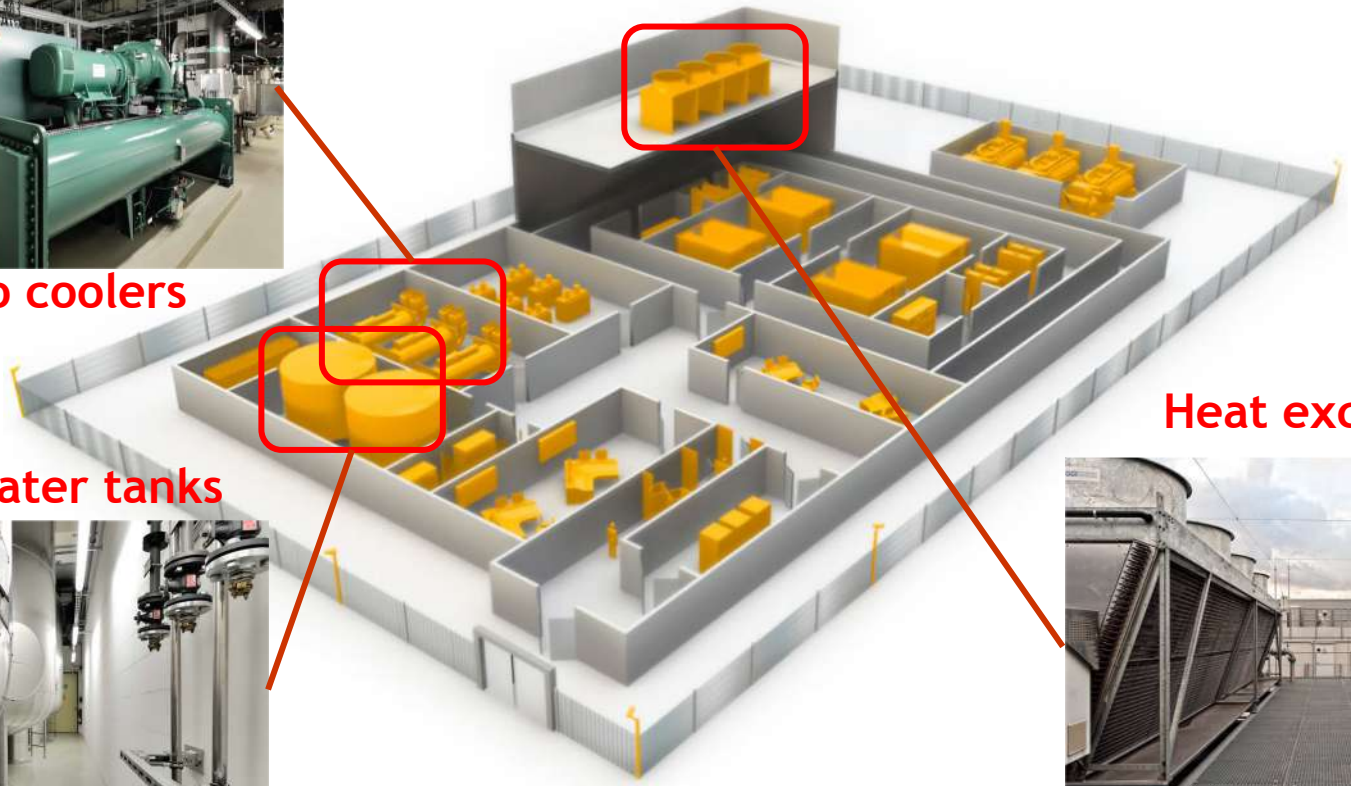


Server corridors

Data-center architecture

IT equipment generates **a lot of heat**: the **cooling system** is usually a very expensive component of the datacenter, and it is composed by coolers, heat-exchangers and cold water tanks.

Turbo coolers



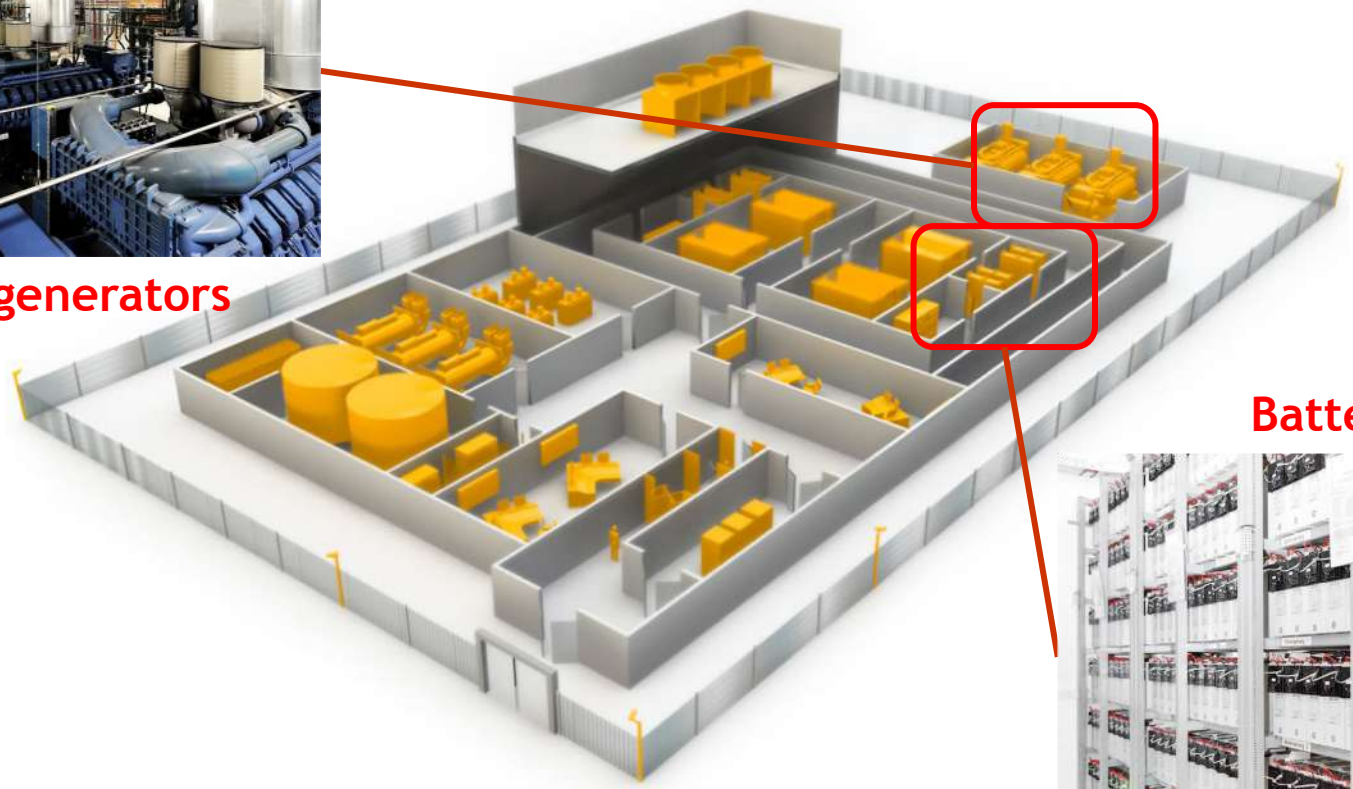
Cold water tanks

Heat exchangers

Data-center architecture

In order to protect against power failure, battery and diesel generators are used to backup the external supply.

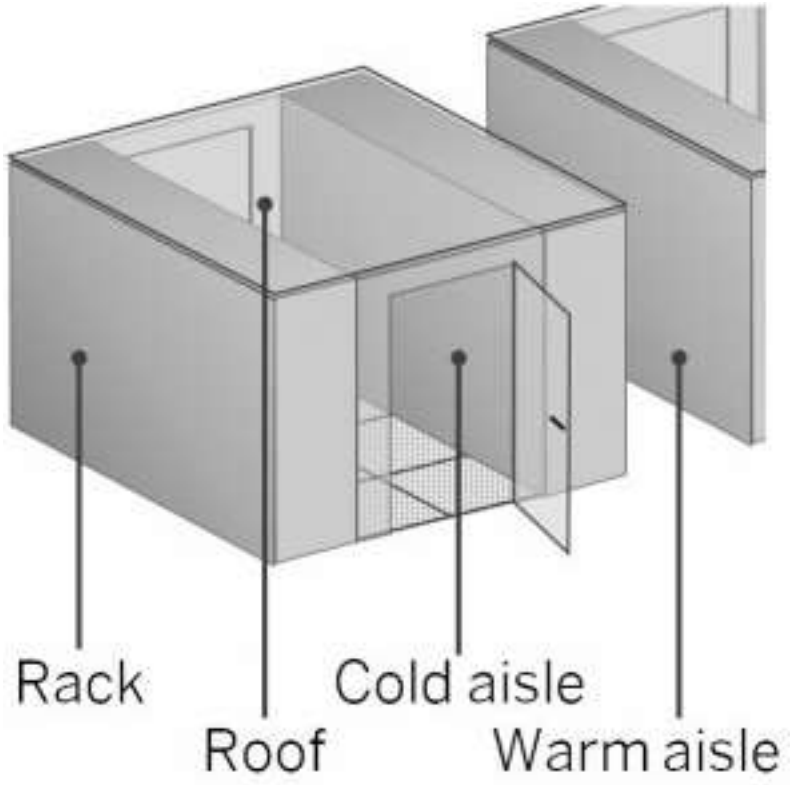
Diesel generators



Batteries

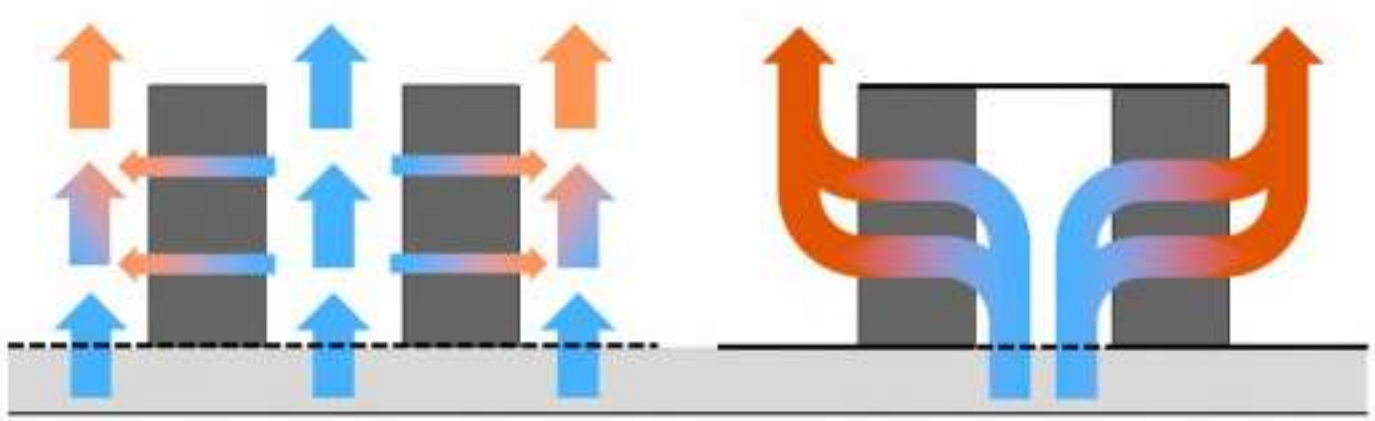
Data-center corridors

Corridors where servers are located are split into *cold aisle*, where the front panels of the equipment is reachable, and *warm aisle*, where the back connections are located.



Data-center corridors

Cold air flows from the front (cool aisle), cools down the equipment, and leave the room from the back (warm aisle).

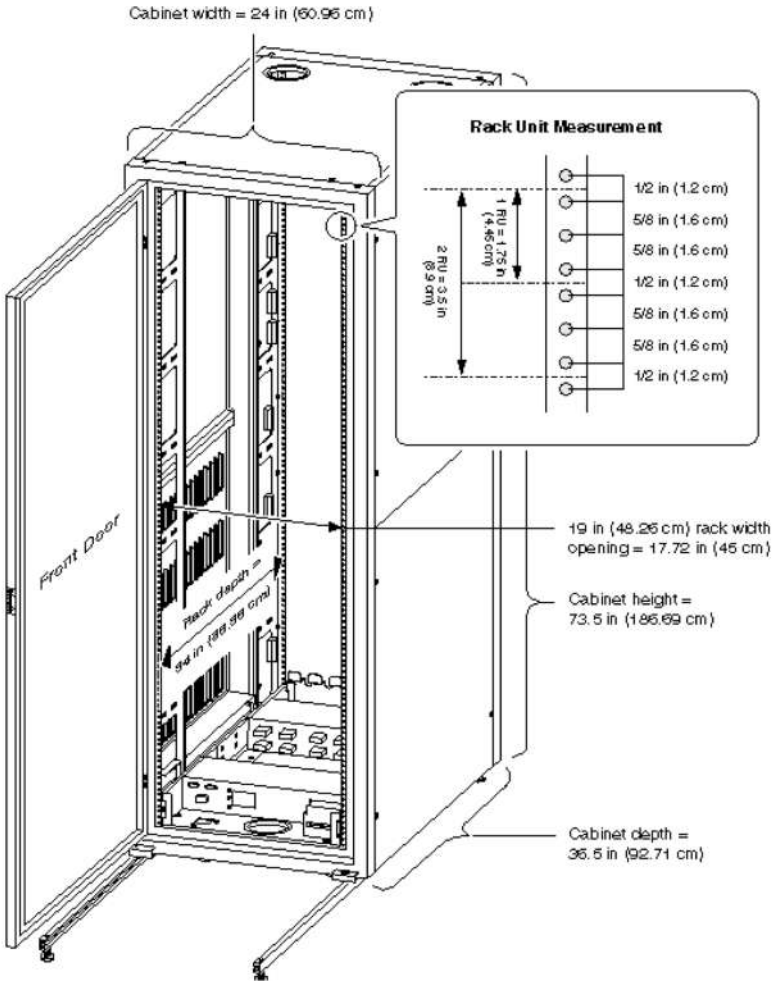


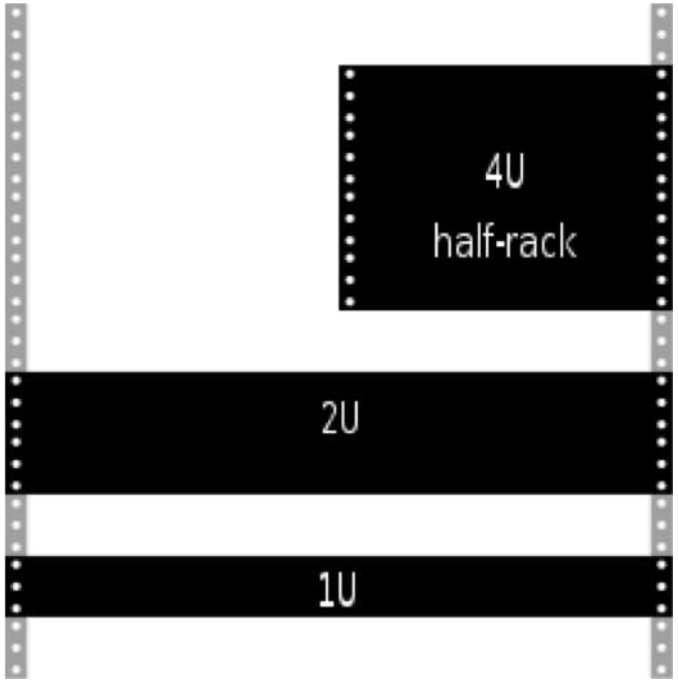
Data-center racks

Racks are special shelves that accommodate all the IT equipment and allow their interconnection.

Data-center racks

IT equipment must conform to specific sizes to fit into the rack shelves.





Rack modules

Four types of equipment are usually present into racks:

- Servers
- Communication equipment
- Storage units
- Power distribution units

Rack modules

Servers are the main processing equipment.

They are like ordinary PC, but with a form factor that allows to fit them into the racks.

They may differ in:

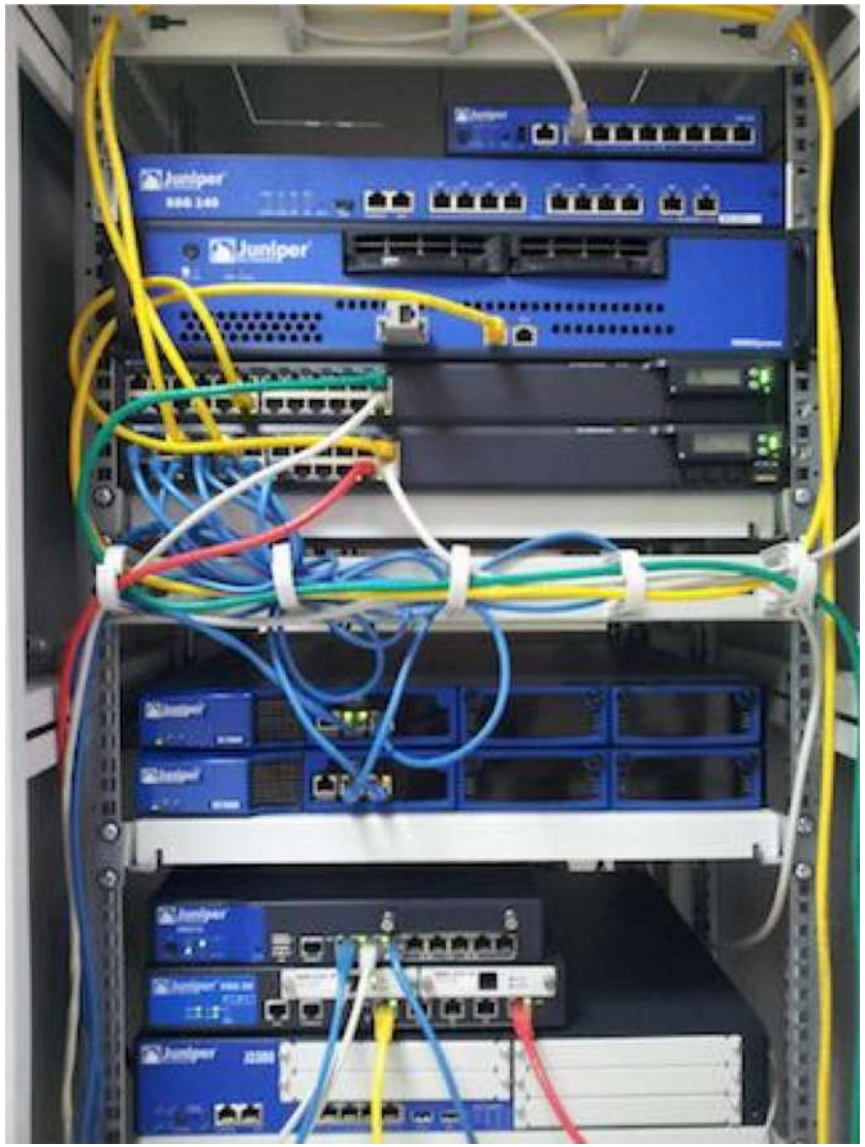
- Number and type of CPUs
- Available RAM
- Locally attached disks (HDD, SSD or not installed)
- Other special purpose devices (like GPUs, DSPs and coprocessors)

Rack modules

Communication equipment allows network interconnections among the devices.

They can be:

- Hubs
- Routers
- DNS or DHCP servers
- Load balancers
- Technology switches
- Firewalls
- ... and many more other type of devices!



Rack modules

Storage units holds large amount of data.

They be:

- JBOD (Just a Bunch Of Disks)
- RAID controllers
- NAS heads

They can use:

- HDD
- SSD
- Ram disks

We will return on storage devices later.

Rack modules

Power Distribution Units (PDUs) are the last type of devices that can be fit into racks.

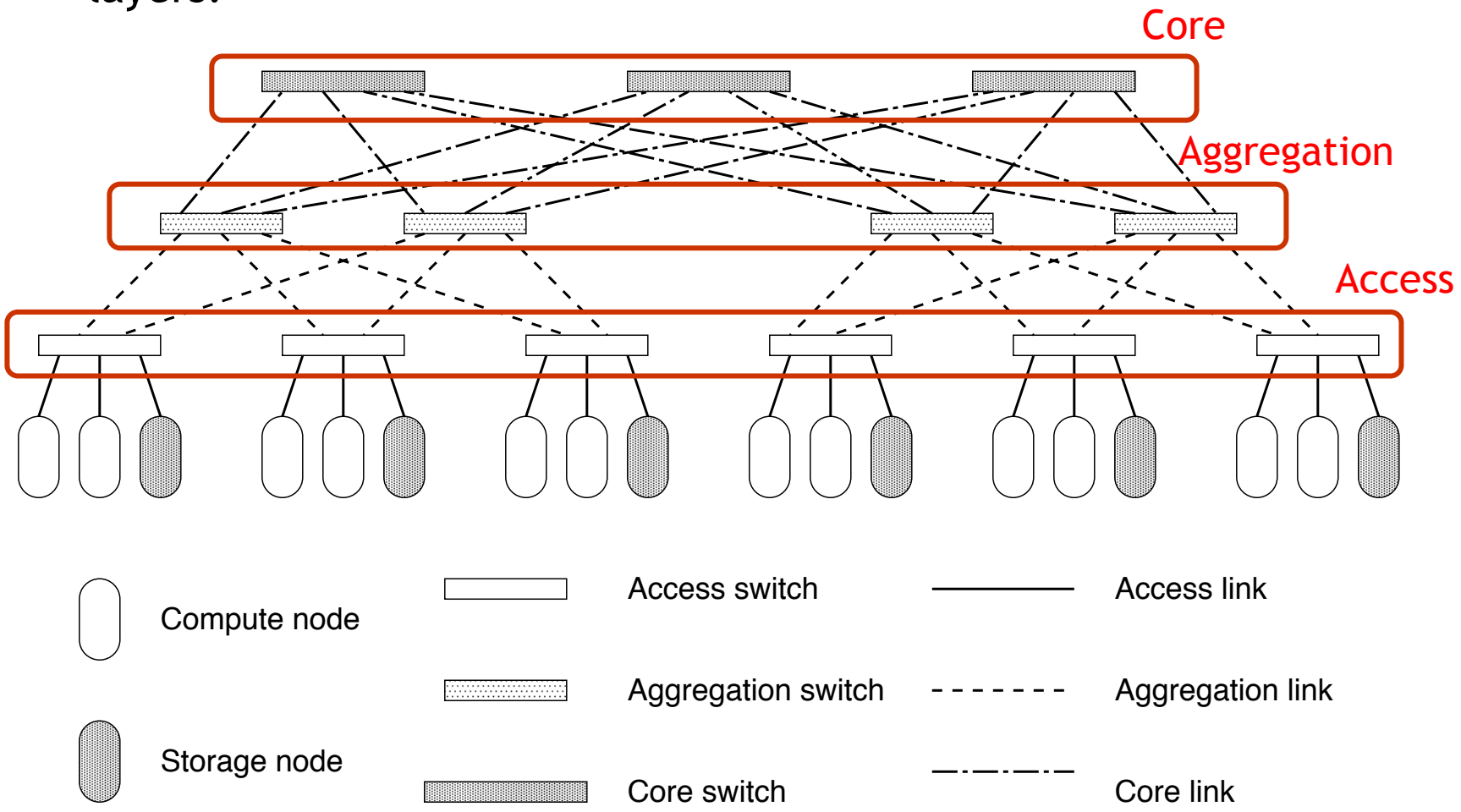
They are usually not consider as IT equipment, but they consume rack units.

The distribute the energy to the devices inside the rack.

They can provide additional feature such as energy consumption monitoring and remote turn on/off.

Data-center network architectures

Three layer architecture configures the network in three different layers:



Data-center network architectures

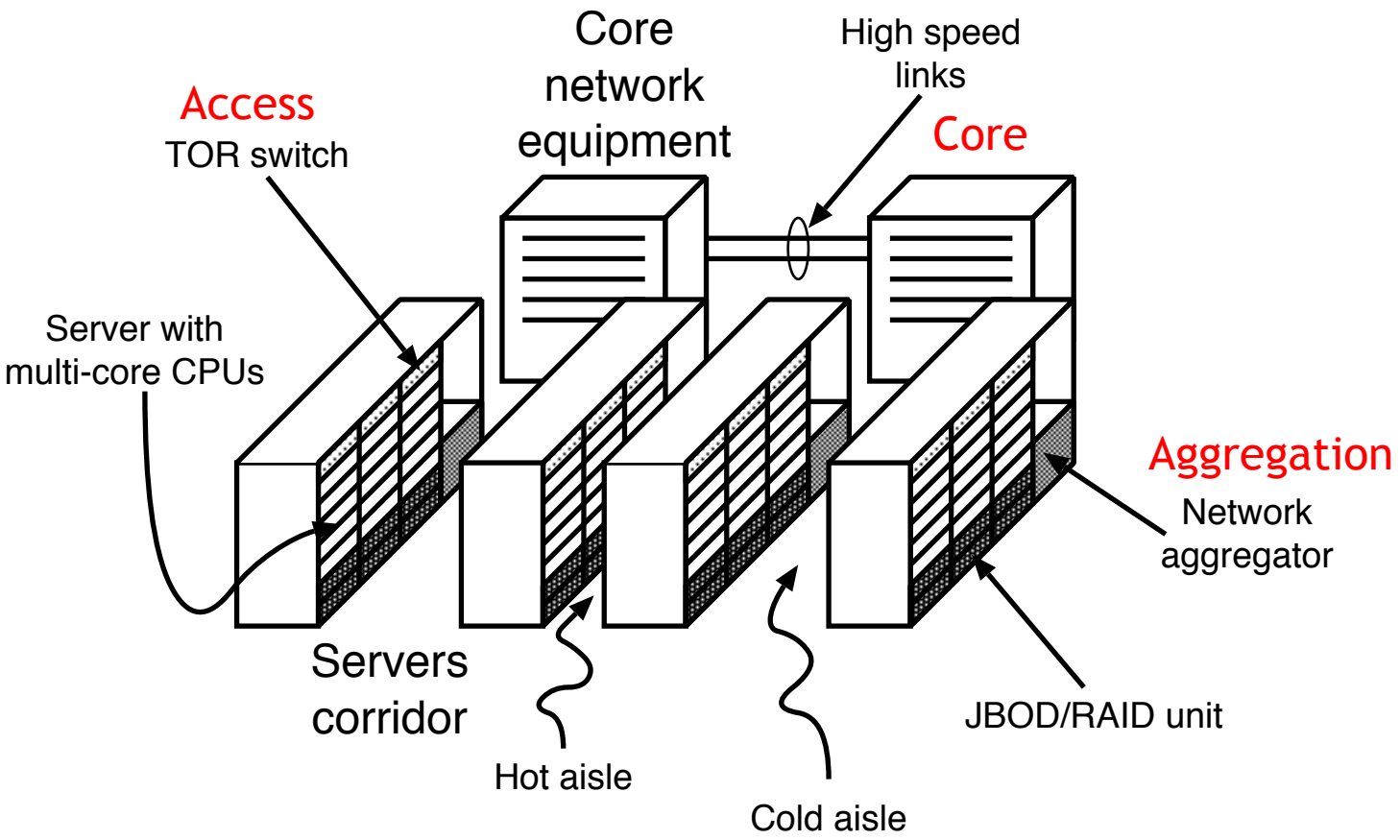
Switches at the access layer can be put into two positions:

- *Top-Of-the-Rack (**TOR**)*: Access switches are put at the top of each rack. The number of cables is limited. The number of ports per switch is also limited (lower costs). However the scalability is also limited.

- *End-Of-the-Line (**EOL**)*: Switches are positioned one per corridor, at the end of a line of rack. Switches must have a larger number of ports, and longer cables are required (higher costs). However the system can scale to have a larger number of machines.

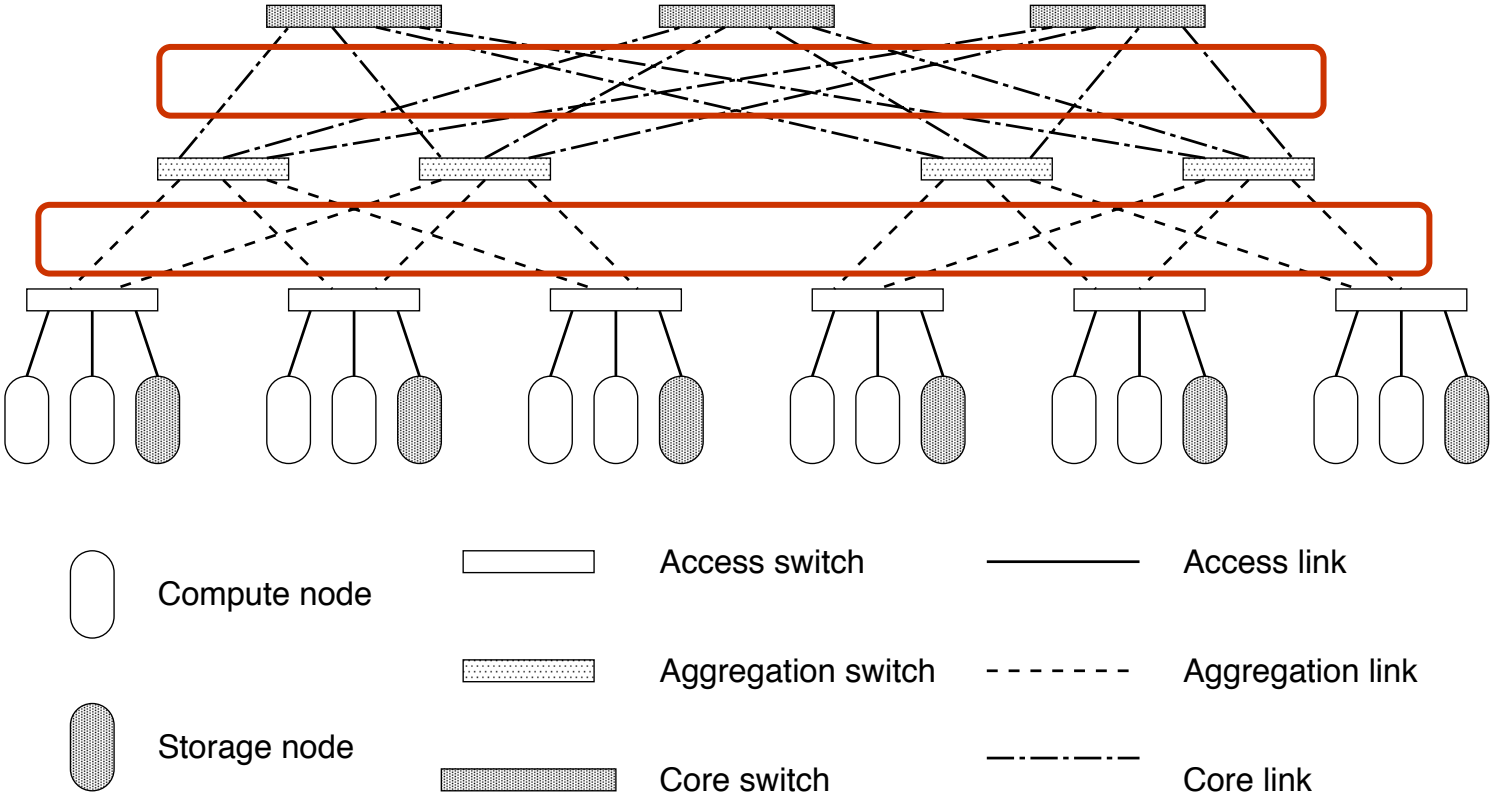
Data-center network architectures

Three layer architecture reflects the topology of the data center:



Data-center network architectures

Bandwidth can be increased by increasing the switches at the core and aggregation layers, and by using routing protocols such as Equal Cost Multiple Path (ECMP) that equally shares the traffic among different routes.



Data-center network architectures

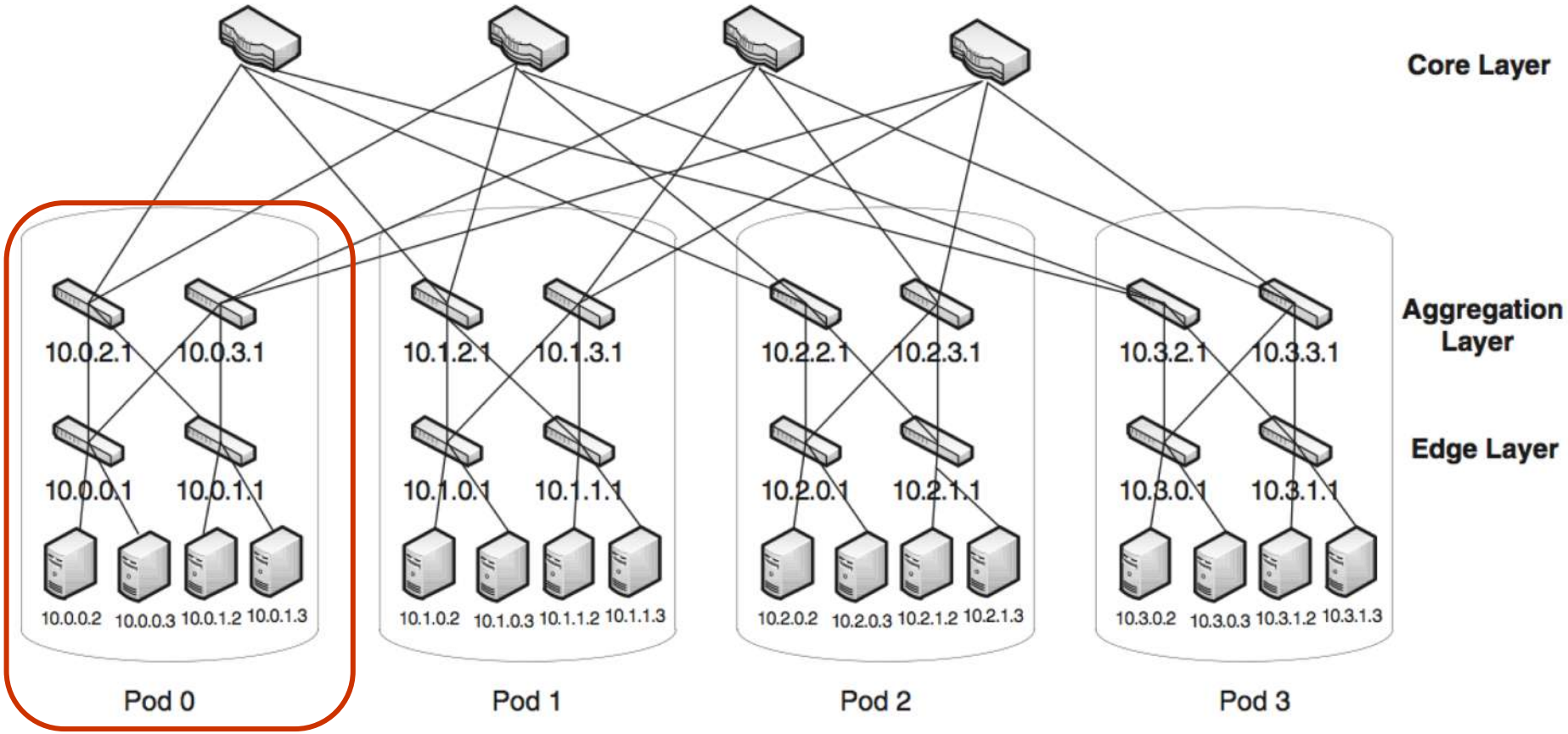
This solution is very simple, but can be very expensive in large data-centers since:

- Upper layers require faster network equipments. For example:
  - 1 GB Ethernet at the access layer
  - 10 GB Ethernet at the aggregation layer
  - 25 GB Optical connections at the core layer

- The cost in term of acquisition and energy consumption can be very high.

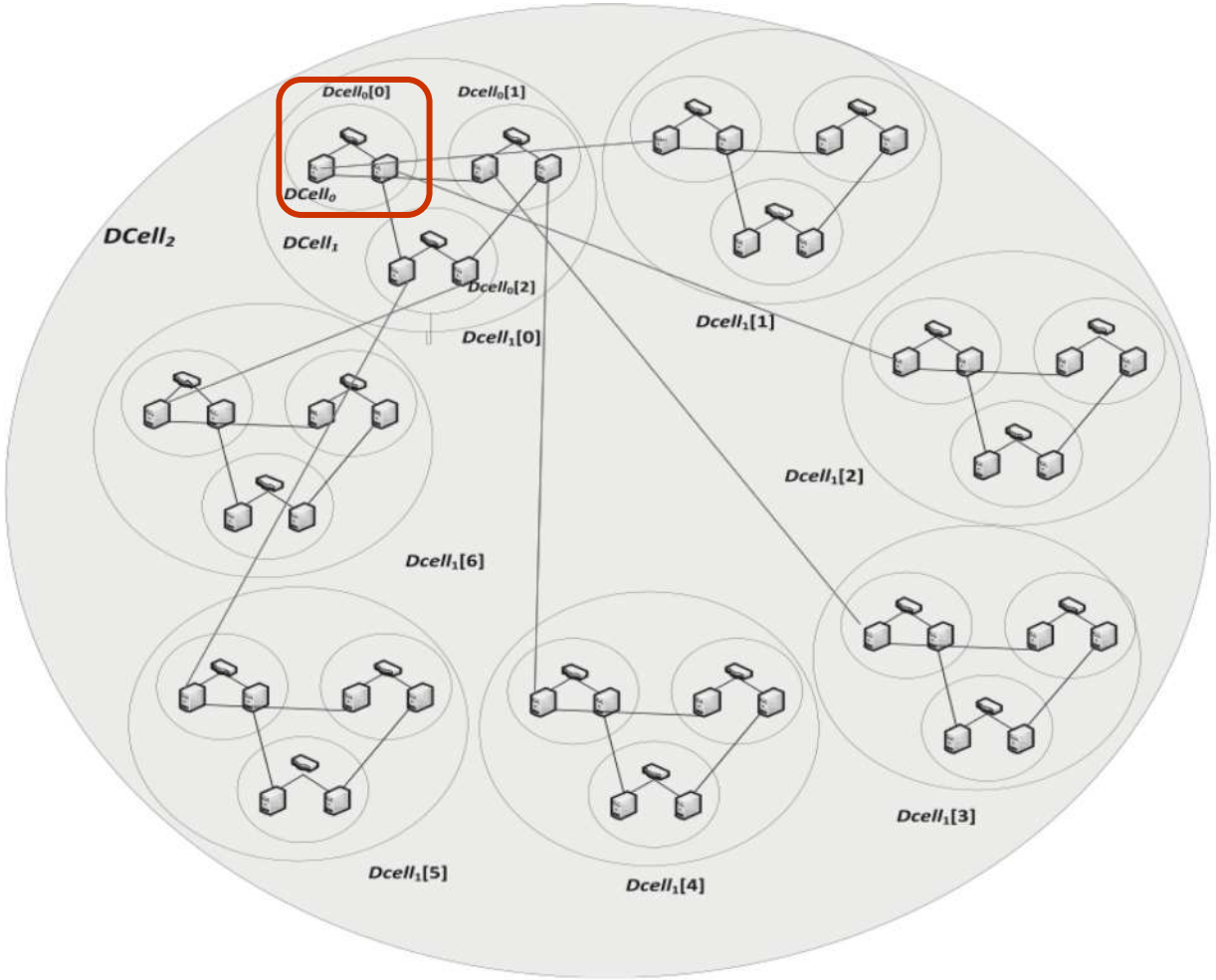
Data-center network architectures

Fat-tree topologies use a larger number of slower speed switches and connections. In particular, nodes are divided into pods characterized by the same number of nodes and switches.



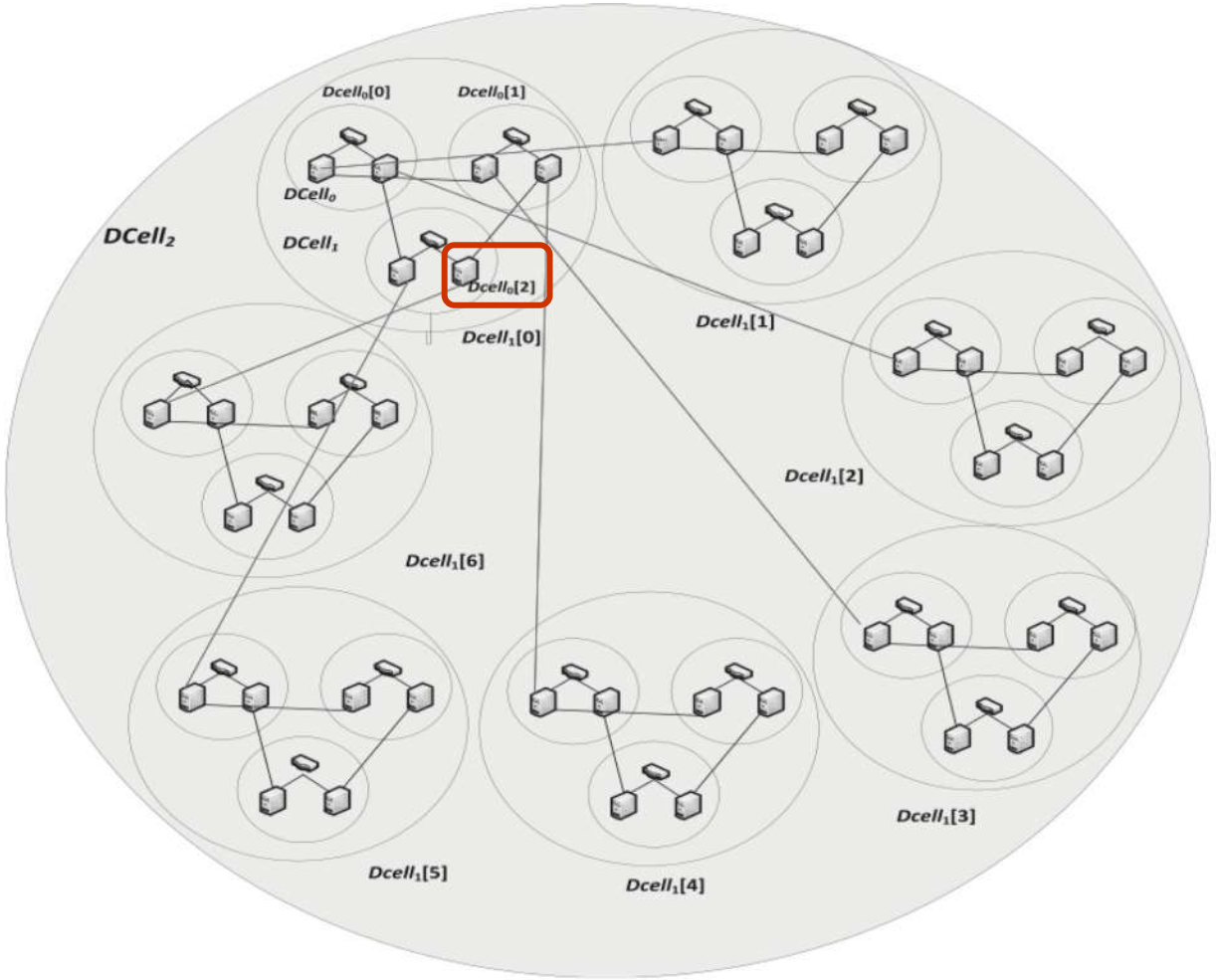
Data-center network architectures

D-Cell topology, defines the network in recursive way. Cells are organized in levels. Switches connects nodes at the lower level.



Data-center network architectures

Some nodes belong to different cells: they perform routing among them to create a higher level cell.



Data-center power consumption

Data-center power consumption is an issue, since it can reach several MWs.

Cooling usually requires about half the energy required by the IT equipment (servers + network + disks).

Energy transformation creates also a large amount of energy wasted for running a datacenter.

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

Data-center tiers

Data-center availability is defined by in four different tier level. Each one has its own requirements.

Tier Level	Requirements
1	• Single non-redundant distribution path serving the IT equipment • Non-redundant capacity components • Basic site infrastructure with expected availability of 99.671%
2	• Meets or exceeds all Tier 1 requirements • Redundant site infrastructure capacity components with expected availability of 99.741%
3	• Meets or exceeds all Tier 2 requirements • Multiple independent distribution paths serving the IT equipment • All IT equipment must be dual-powered and fully compatible with the topology of a site's architecture • Concurrently maintainable site infrastructure with expected availability of 99.982%
4	• Meets or exceeds all Tier 3 requirements • All cooling equipment is independently dual-powered, including chillers and heating, ventilating and air-conditioning (HVAC) systems • Fault-tolerant site infrastructure with electrical power storage and distribution facilities with expected availability of 99.995%