MODULE 10 · STUDY NOTES

# Data Center Racks

*Cabinets versus racks, rack units and standard dimensions, open-frame and enclosed types, sizing and layout considerations, and the heat, power, and cooling challenges of modern rack systems*

A rack is the basic building block of a data center — the physical unit that houses servers, switches, routers, and everything else, and the object the entire room layout is planned around. This module starts by pinning down a distinction that trips up newcomers: racks are *open* frames while cabinets are *enclosed*, and that single difference cascades into airflow, security, dust, cost, and maintenance. From there it builds the vocabulary of rack sizing — the rack unit, the half and full heights, the standardized width and depth, and the `EIA-310-E` standard — and the types you will actually deploy: rack-mount and wall-mount cabinets, open-frame 2-post and 4-post racks. It then moves from the single rack to the room, laying out the physical considerations for an optimal layout (type, size, tool-free installation, power, doors, weight, cooling, placement, storage, density) and the three individual-rack concerns of airflow, cable management, and video surveillance. Finally it confronts the pressure modern high-density servers put on racks — heat, power distribution, and cooling — and the design changes that keep a facility running.

LEARNING OBJECTIVES

- Recognize the differences between cabinets and racks
- Identify the types of cabinets and racks along with their advantages and disadvantages
- Recognize key factors that go into selecting the right cabinet and rack
- Identify the characteristics and considerations of a rack when building a data center
- Determine the various physical considerations for an optimal rack layout in a data center
- Identify the different types of racks
- Identify the system challenges for racks

## 10.1 Cabinets versus racks – the basics

Cabinets and racks are the equipment that hold IT gear in a data center, and they are similar in exactly one important way: both can **store multiple modules of IT equipment**. The differences are what matter. **Racks are open — they have no side walls, and they do not have doors. Cabinets are enclosed with side walls, and most have doors** (typically lockable). That structural difference is the root of every later trade-off in the module: security, airflow, dust protection, cost, and ease of maintenance all follow from whether the unit is open or closed.

Both come in the same height classes. A standard **half** rack or half cabinet is around `20U` or `24U`; a **full-size** rack or full cabinet is around `42U` or `48U`. The unit of measure is the **rack unit**: `1U` equals **1.75 inches** (about 44.5 mm). Multiplying it out, `24U` is roughly 42 inches (1,067 mm) of vertical mounting space, and a `42U` rack stands about 73.5 inches tall.

**RACK VERSUS CABINET – THE DISTINGUISHING FEATURES**

- **Both** hold multiple modules of IT equipment — that is the similarity.
- **Racks** are open, have **no side walls**, and have **no doors**.
- **Cabinets** are enclosed with **side walls** and **most have doors** (usually lockable).
- **Half** unit = `20U` or `24U`; **full-size** unit = `42U` or `48U`.
- `1U` = **1.75 in** (44.5 mm), so `24U` ≈ 42 in (1,067 mm).

A rack is also called a **network cabinet**, and it is one of the **first considerations** when designing a data center or server room — the entire layout is based on how the racks are placed, because that is where all the IT equipment goes. Racks typically house **switches, routers, servers, and audio/video equipment**, plus any other essentials. You will find network racks and cabinets not only in **server rooms** but also in **audio installation centers** and **video installation rooms**.

**COMMON PITFALL**

Do not treat “rack” and “cabinet” as interchangeable words. On the knowledge check, the defining split is open versus enclosed: racks are open with no doors or side walls; cabinets are enclosed and usually lockable. The physical-security and airflow-containment benefits belong to the cabinet, not the open rack.

## 10.2 Types of cabinets and racks

Depending on their structure, **cabinets** come in two forms. A **rack mount enclosure** has removable doors at the front and rear, and its side panels and mounting rails are removable and adjustable; it is popular in data centers that hold **heavier equipment**. A **wall mount rack cabinet**, as the name says, usually attaches to the wall — its benefit is **better space management**, it fits easily into tight spaces where a full rack would not, and it can be either enclosed or open.

**Racks (frames)** are represented by the **open-frame rack**, which is commonly used in data centers. Unlike a cabinet, it has **no doors or side panels** — it uses open frames and rails for mounting instead. That design makes open-frame racks suitable for applications where the rack does **not** need to control airflow, but because they are open and exposed they are susceptible to theft and **require physical-security support**.

| 2-POST RACKS | 4-POST RACKS |
|---|---|
| *also called telco or relay racks*<br>▪ Two vertical upright support beams<br>▪ For equipment that is not very heavy — patch panels, switches<br>▪ May need bolting into the floor for stability and support<br>▪ Cooling: simple, un-enclosed design lets fans dissipate heat easily<br>▪ Size: minimal footprint — good where floor space is tight<br>▪ Access: easy to reach for maintenance<br>▪ Cost-effective: often about half the cost of other rack types | *more stable, heavier capacity*<br>▪ Four posts; may add screened front and rear doors for ventilation and access<br>▪ More stable than 2-post racks and holds heavier weight<br>▪ Protection: better shielding of equipment, less accidental damage<br>▪ Support: rails and supports distribute equipment weight equitably<br>▪ Versatility: fits almost all equipment; eases planning for growth<br>▪ Cables: run and protected easily, reducing the risk of outage-causing breaks |

Both 2-post and 4-post racks are *types of open-frame racks* — the split above is about how many uprights they have and, therefore, how much weight and protection they offer. A 2-post rack keeps things simple, cheap, and airy for light gear; a 4-post rack trades some of that simplicity for stability, capacity, and cleaner cable runs.

## 10.3 Choosing between open-frame racks and enclosed cabinets

You select the right cabinet or frame after analyzing your data center requirements, but several factors favor **open-frame racks** specifically. **Easy access** — open frames give a major benefit in reaching the IT equipment they house, which makes them ideal for a data center or workstation hardware that needs frequent access. **Easy maintenance** follows directly from that accessibility — servicing is hassle-free. And **better performance**: overheating is a major roadblock to data-center efficiency, and because open-frame racks provide better airflow, they help deliver better performance.

| OPEN-FRAME RACKS – PROS AND CONS | ENCLOSED CABINETS – PROS AND CONS |
|---|---|
| *cheap, airy, exposed*<br>▪ Pro: less expensive — about **one-third the cost** of an enclosed cabinet<br>▪ Pro: low cost lets a facility fit more servers for less money<br>▪ Pro: unimpeded airflow and easy access to equipment<br>▪ Con: easy access also means they are **less secure**<br>▪ Con: dust builds up in the open frame and can damage equipment over time | *secure, protected, pricier*<br>▪ Pro: better security than open racks — they can be **locked**<br>▪ Pro: more cooling flexibility via **active and passive airflow management**<br>▪ Pro: better protection against dust and other particulate matter<br>▪ Con: more expensive because of the complex structure<br>▪ Con: maintenance is complicated by the **limited access** |

**COMMON PITFALL**

Enclosed does not automatically mean cooler, and open does not automatically mean insecure-and-done. Open-frame racks win on airflow, cost, and access; enclosed cabinets win on security, dust protection, and cooling *flexibility*. Match the unit to the priority the scenario names — and remember that for **high-density cabling**, the open-frame rack is the right answer because cable management needs the extra room.

## 10.4 Choosing the right rack or cabinet size

Four measurements decide the right size. Get them wrong and equipment will not fit, the floor may not hold, or you will run out of room to grow.

**TABLE 10.1** The four sizing factors

| FACTOR | WHAT IT CONTROLS | STANDARD VALUES |
|---|---|---|
| **Height** | The number of rack spaces available for equipment — leave space for future expansion | 42U, 45U, 48U; custom sizes up to 58U |
| **Width** | Standardized spacing between equipment; extra width for PDUs, high-density cabling, and cable managers | 24 in (600 mm) standard; 30 in (750 mm) extra-wide; follow EIA-310-E |
| **Depth** | Whether the rack is deep enough to house the equipment | ~42 in (1,066 mm); 48 in (1,219 mm) for deep servers and blade chassis |
| **Load rating** | The weight capacity the rack can safely support | Verify the floor's weight-bearing capacity too |

A note on **width** numbers, because the deck cites two: the **external enclosure width** is standardized at 24 inches (600 mm), with extra-wide enclosures at 30 inches (750 mm) to house PDUs and dense cabling without impeding airflow. The **mounting width** of the rack itself — the rail-to-rail dimension of a full-size rack — is **19 or 23 inches**. The `EIA-310-E` standard is what makes width predictable; it outlines the design specifications for racks and cabinets so equipment from different vendors fits.

**WORKED EXAMPLE – HOW TALL IS A 42U RACK?**

Rack height is quoted in rack units, but equipment clearances and ceiling heights are in inches. Convert with the constant `1U` = 1.75 inches. A `42U` rack is 42 × 1.75 = **73.5 inches** (about 1,867 mm) of vertical mounting space. The same math explains the deck's figure that `24U` ≈ 42 inches (1,067 mm): 24 × 1.75 = 42 inches exactly. When you plan a room, remember height decides the *number of rack spaces*, so budget some empty U for future expansion rather than filling every slot on day one.

**LOAD RATING – A CLOSER LOOK**

- Load rating is the **weight capacity** of the rack — how much it can safely support once fully loaded.
- A **static load rating** applies when the rack is installed and stationary.
- A **dynamic load rating** applies when the rack is on the move using casters.
- Always check the **floor's** weight-bearing capacity against the combined rack-plus-equipment weight.

## 10.5 Physical considerations for rack layout

A rack is the physical unit of a data center that houses equipment of varying shapes and sizes, and a suitable layout is critical to make sure the racks accommodate all of it. Ten **physical considerations** shape a rack layout: **type, size, tool-free installation, power supplies, door type, weight (load rating), cooling type, rack placement, storage, and density**. Deciding the layout means weighing the type of rack, its placement, airflow, security, and more.

Three rack **types** appear in the layout discussion. **Open-frame racks** are doorless racks with only frames, preferred for server rooms; they have no physical security or airflow control. **Rack enclosures or cabinets** have removable front, back, and side doors, adjust to suit the equipment type, are preferred when you want to save space, are used for switches and fiber patch panels, and house servers that need physical security at the rack level. **Wall mount racks** mount on walls, are shorter than cabinets, and house switches, routers, and modems.

**TABLE 10.2** The physical considerations for a rack layout

| CONSIDERATION | WHAT IT MEANS |
|---|---|
| **Size** | Determined by the equipment planned to go in the rack; dimensions are in rack units (1U = 1.75 in). A full-size rack is 42U tall by 19 or 23 in wide |
| **Tool-free installation** | A design that requires minimal drilling and fastening of racks in the data center |
| **Power supplies** | The number and type of power strips for the racks — single-sided or double-sided |
| **Door type** | Front-and-back doors, or even doorless installation, are all possible |
| **Weight / load rating** | Select racks on point-load considerations, once fully loaded, to avoid instability on false flooring |
| **Cooling type** | Racks need cooling — often fans, but building infrastructure such as HVAC may help |
| **Rack placement** | Wall mount per the floor plan; spread out high-density racks for better cooling and to remove heat loading at the hot aisle |
| **Storage** | Plan for the future expansion placement of equipment |
| **Density** | The population of servers in the racks — leave free space inside for airflow |

> **COMMON PITFALL**
>
> Match each consideration to its own definition — the knowledge check swaps them. **Tool-free installation** is specifically about minimal drilling and fastening (not power, not doors). **Height** determines rack spaces; **density** is the server population and the reason to leave airflow gaps; **rack placement** is about spreading high-density racks so the hot aisle sheds heat.

## 10.6 Key considerations for an individual rack

Beyond the room-level layout, three key areas matter for each **individual** rack: **airflow, cable management, and video surveillance**. Rack cabinets have more airflow control than open-frame racks, but every rack must accommodate airflow between the aisles and inside the rack at all times.

**AIRFLOW MANAGEMENT – THREE METHODS**

- **Side panels** — ventilated side panels ensure appropriate cooling; preferred for **wall mount racks**, which have no airflow system of their own.
- **Ventilation fans** — added to the top of a cabinet to remove heat; best for floor-stand or wall mount racks.
- **Close coupled cooling** — air-conditioning units positioned near the racks; a precise, efficient solution that integrates with an existing cooling system.

**Cable management** prevents heat traps caused by bulky overhead cable trays. Cables should be stored in **appropriately sized cable trays underneath the racks**, and the cables converging inside a rack must not stop the airflow — if they do, they create heat within the rack. Good cable management is as much a cooling measure as a tidiness measure.

**Video surveillance** provides physical security that protects the data center building's perimeter walls against trespassers and other threats. The main tool is **closed-circuit television (CCTV)**, which records the activity of trespassers or unwanted intrusion. Most cameras can **pan, zoom, capture images, and keep a documented record** of the recordings, and CCTV is best used when controlled remotely, monitoring areas such as the main gate, parking lot, lobby, utility rooms, and server rooms.

**COMMON PITFALL**

When a scenario chooses **wall mount racks to save floor space**, the ventilation answer is **side panels** — not a rotating fan or a close-coupled system — because a wall mount unit has no internal airflow system. Ventilation fans and close coupled cooling are alternatives used in other rack styles.

## 10.7 System challenges for rack systems

Modern servers **consume large amounts of electricity** and **emit a considerable amount of heat**, and both facts drive rack design. Servers now use **long, deep cabinets** — deeper cabinets allow more adequate airflow, and wider cabinets ease cable routing. High-density data centers often use customized solutions to handle this advanced equipment. Across all of it, three primary rack varieties recur: **floor mount rack enclosures (cabinets), open-frame racks, and wall mount racks**.

An **inefficient rack selection and deployment** has real consequences: it can generate heat beyond the tolerance level, make it difficult for cooling systems to mitigate that heat, waste energy through underutilized servers, reduce airflow through the cabinet, and cause performance issues — and if the inefficiencies are not solved, unexpected downtime. Facility managers must pick the correct rack types for the servers and accessories. The challenges themselves relate to three things: **high-density racks, power distribution, and cooling**.

**TABLE 10.3** Rack system challenges and how to overcome them

| CHALLENGE AREA | THE PROBLEMS | HOW TO OVERCOME |
|---|---|---|
| **High-power density racks** | Hard to monitor and operate power attributes as power needs rise unpredictably; human errors from rack complexity; varying power, voltage, outlet, and DC needs; more branch circuits from dual-pathway systems | Change the rack design and verify appropriate height, width, and depth |
| **Power distribution** | Rising power density and rack temperatures from power surges; controlling power usage; identifying hotspots | Select the right rack PDU by its power rating and technology (primary, metered, or managed/switched distribution) |
| **Cooling** | Recirculating hot expelled air; overheating from overloaded servers; airflow blocked by dense cabling | Manage basic airflow, install side panels, use cable management, install thermal ducts, apply active heat removal, use close-coupled cooling |

#### HELPFUL RACK-DESIGN VALUES THAT AVERT THESE CHALLENGES

- **Rack height**: 42U, 45U, and 48U, and can be customized to 58U — height decides the number of rack spaces available.
- **Rack width**: 24 inches; extra-wide enclosures house PDUs, dense cabling, and cable managers without blocking airflow.
- **Rack depth**: about 42 inches, or 48 inches for deeper servers and blade chassis — the extra depth leaves room for cabling and accessories without hindering airflow.
- **Load rating**: a static rating when installed and a dynamic rating when the rack moves on casters.

#### WORKED EXAMPLE – A HIGH-DENSITY ROW RUNS HOT

A row of fully loaded, high-power-density cabinets keeps tripping thermal alarms. Work the three challenge areas in order. **High-density racks:** confirm the racks are the right height, width, and depth for the gear, since an ill-fitting rack is a common root cause. **Power distribution:** the PDUs may be stressed by the power surge — select rack PDUs rated for higher temperatures and matched to the load (metered or managed PDUs help you watch usage and spot hotspots). **Cooling:** stop hot air from recirculating — spread the high-density racks out rather than clustering them, install ventilated side panels, tidy the cabling so it does not block fans, and add thermal ducts, active heat removal, or close-coupled cooling. The fix is rarely one change; it is design, power, and cooling together.

## Module summary

- Both racks and cabinets hold IT equipment, but a rack is open (no side walls, no doors) while a cabinet is enclosed with side walls and usually lockable doors — so only the cabinet gives physical security and airflow containment. A rack is also called a network cabinet and is one of the first considerations in a data-center design.
- The rack unit is the measure of vertical space: 1U = 1.75 in (44.5 mm). A half rack or cabinet is 20U or 24U; a full-size unit is 42U or 48U.

- Cabinets come as rack-mount enclosures (removable doors, adjustable rails, heavier equipment) and wall-mount cabinets (attach to the wall, save space, enclosed or open). Open-frame racks use frames and rails with no doors, split into 2-post (light gear, telco/relay, cheap and airy) and 4-post (stable, heavier loads, better cable protection).
- Open-frame racks cost about one-third of a cabinet, give unimpeded airflow and easy access, and are best for high-density cabling — but are less secure and dust-prone. Enclosed cabinets add lockable security, dust protection, and cooling flexibility, at higher cost and harder maintenance.
- Size a rack on four factors: height (number of rack spaces; 42/45/48U, custom 58U), width (standardized 24 in / 600 mm, extra-wide 30 in; mounting width 19 or 23 in; EIA-310-E), depth (~42 in, or 48 in for deep servers and blade chassis), and load rating (static and dynamic; check the floor).
- A rack layout weighs ten considerations — type, size, tool-free installation, power supplies, door type, weight/load rating, cooling type, rack placement, storage, and density — across the three rack types (open-frame, cabinet, wall mount).
- Each individual rack needs airflow (side panels, ventilation fans, close-coupled cooling), cable management (trays beneath the racks; do not block airflow), and video surveillance (CCTV that pans, zooms, and records).
- Modern high-power-density servers stress racks with heat and power; inefficient selection causes excess heat, energy waste, reduced airflow, performance issues, and downtime. The challenges cluster in high-density racks, power distribution (choose the right PDU: primary, metered, or managed/switched), and cooling.

## Review questions

**1. What are the key differences between an open-frame rack and an enclosed cabinet, and what does each do best?**

*Answer:* A rack is open — no side walls, no doors — giving unimpeded airflow, easy access, about one-third the cost, and the best fit for high-density cabling, but it is less secure and collects dust. A cabinet is enclosed with side walls and usually lockable doors, adding physical security, dust protection, and active/passive cooling flexibility, at a higher cost and with harder maintenance.

**2. How do you convert a rack's U height to inches, and how tall is a 42U rack?**

*Answer:* Multiply the number of rack units by 1.75 inches (the size of 1U, ≈44.5 mm). A 42U rack is 42 × 1.75 = 73.5 inches; likewise 24U = 42 inches (1,067 mm).

**3. What are the four factors for choosing the right rack or cabinet size, and what does each address?**

*Answer:* Height determines the number of rack spaces (42/45/48U, custom to 58U — leave room to grow); width is standardized at 24 in (600 mm), 30 in extra-wide, per EIA-310-E; depth must fit the equipment (~42 in, or 48 in for deep servers and blade chassis); load rating is the weight capacity the rack can safely bear (and verify the floor).

**4. Compare 2-post and 4-post open-frame racks.**

*Answer:* A 2-post rack has two vertical uprights (a telco or relay rack) for lighter equipment such as patch panels and switches, may be bolted to the floor, and benefits from good airflow, minimal footprint, easy access, and roughly half the cost. A 4-post rack has four posts (optionally with screened doors), is more stable, holds heavier weight, protects equipment better, distributes weight via rails, is versatile for almost any gear, and eases cable routing.

**5. What are the three key considerations for an individual rack, and what are the three airflow methods?**

*Answer:* Airflow, cable management, and video surveillance. Airflow is achieved through ventilated side panels (preferred for wall mount racks), ventilation fans on top of a cabinet, and close coupled cooling (AC units positioned near the racks).

**6. A team uses wall mount racks to save floor space. What ventilation will they most likely have, and why?**

*Answer:* Ventilated side panels, because a wall mount rack has no internal airflow system of its own — so side panels supply the cooling rather than ventilation fans or a close-coupled system.

**7. What problems result from inefficient rack selection and deployment, and into which three areas do the challenges group?**

*Answer:* It can generate heat beyond tolerance, make cooling harder, waste energy on underutilized servers, reduce airflow through the cabinet, cause performance issues, and lead to downtime. The challenges group into high-density racks, power distribution, and cooling.

**8. How does cable management affect cooling, and what is the difference between a static and a dynamic load rating?**

*Answer:* Cable management prevents heat traps from bulky overhead trays; cables go in appropriately sized trays beneath the racks and must not block airflow inside the rack, or they create heat. A static load rating is the capacity when the rack is installed and stationary; a dynamic load rating is the capacity when the rack is moving on casters.