How to Choose an IT Rack

by Pearl Hu and Wei Zhou

Executive summary

In data centers with 1-3kW/rack, the most popular IT racks have been 600 mm (24 inches) wide, 1070 mm (42 inches) deep, and 42U tall. However, most data centers today support a wide variety of IT equipment densities and form factors that require appropriate racks and accessories. For example, in racks housing 5 kW and above, the most popular rack size is no longer optimal as deeper equipment, higher density rack-mounted power distribution units (rack PDUs), and increased cable loads crowd the inside of the IT rack. This paper discusses the key size and feature options for IT racks and criteria for selection.

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Introduction

An information technology (IT) rack is available in three forms; two-post rack, four-post rack, or a cabinet or enclosure. Two-post racks typically support telecommunications equipment, four-post racks typically support networking equipment, and cabinets or enclosures typically support compute and storage equipment (see **Figure 1**). IT racks not only save floor space by allowing the stacking of IT equipment, but they also play a role in mounting heavy IT equipment, providing an organized environment for power distribution, air flow distribution for better cooling performance, network cable management, rack environmental monitoring, security, etc. A populated rack can weigh several thousands of kilograms.

To avoid confusion and follow common language, we will use the term "IT rack" in this paper to refer to the IT rack frame and enclosure. This white paper introduces rack components, describes the decision criteria, and recommends a practical selection process.
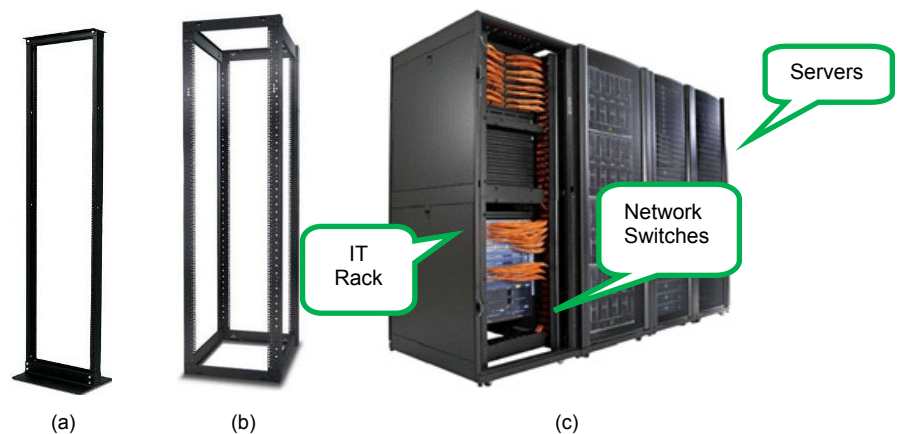
Figure 1a

Two-post rack

Figure 1b

Four-post rack

Figure 1c

Four IT racks (cabinets/ enclosures)

(a)   (b)   (c)

Rack components

Figure 2 shows an exploded view of a typical IT rack. It consists of frame with vertical mounting rails and a zero-U accessory channel, front and rear door, side panels, roof with cable penetrations, castors, leveling feet, etc.

IT equipment and accessories are mounted upon the vertical mounting rails while the frame also provides space to mount some non-IT equipment and accessories to provide power, cooling, and cable management. The perforated front and rear doors provide access to mount the equipment in a lockable secure environment without limiting the airflow though the IT equipment. Side panels can optimize the rack air flow and eliminate mixing of air between racks. The rack roof provides two key functions; one is to protect the IT equipment from falling debris and the other is to provide an entry point for power and network cabling. Rack roofs should provide wide cable penetrations that allow full cable bundles to pass through. Also, roofs should have brush strip around cable penetrations to prevent air leakage. Some rack roofs also serve as a mounting point for overhead cable troughs. The weight rating of the castors and leveling feet is verified to ensure they can support the specified loading of the rack.

Accessories also play an important role in IT racks. **Table 1** lists some common accessories and their main functions. IT rack suppliers provide more accessories for specific applications. Note that, depending on specific requirements, some IT rack components may not be required and are purposely excluded from an IT rack solution. For example, rear doors are commonly excluded for racks used in a hot aisle containment system. In some specific applications, IT racks must be anchored to the floor for stabilization, therefore ensure castors and leveling feet can be removed.

Figure 2

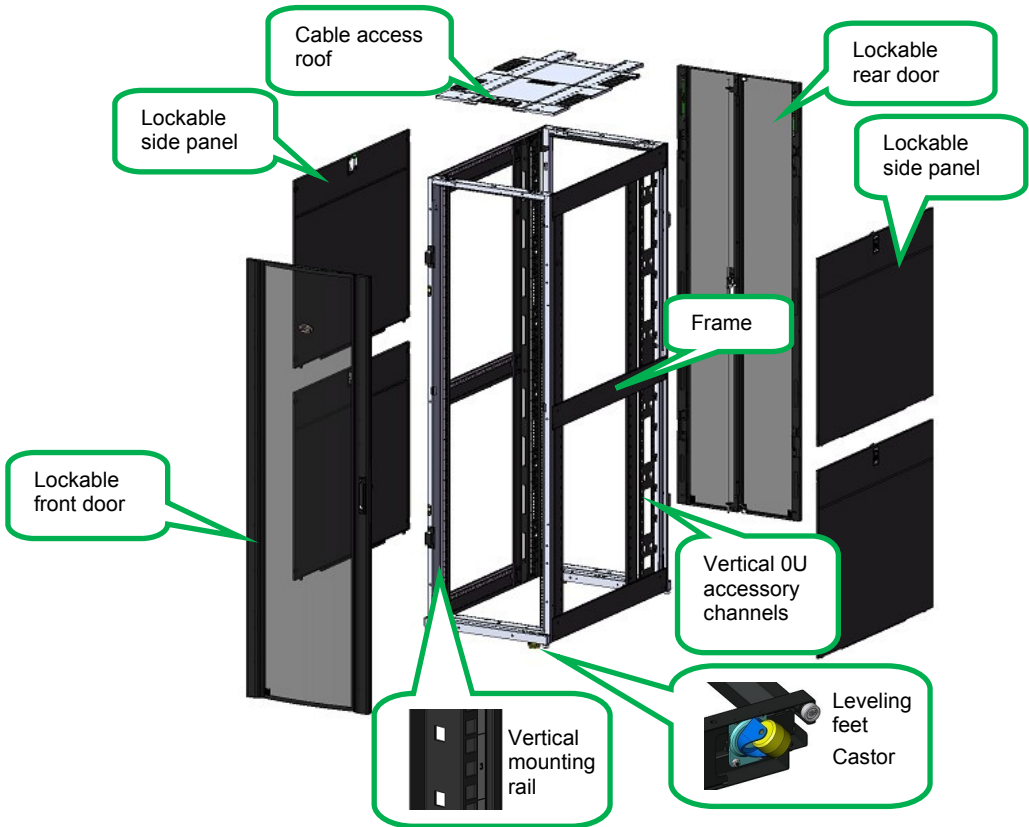*Three dimensional exploded view of a typical IT rack*

Cable access roof

Lockable rear door

Lockable side panel

Lockable side panel

Frame

Lockable front door

Vertical 0U accessory channels

Leveling feet

Castor

Vertical mounting rail

Table 1

Rack accessories and functions

Category	Name	Functions
Mounting hardware	Shelving	Enable the mounting of tower units, monitors, and other equipment into the rack environment Fixed or sliding version can be selected
	Stabilization hardware	Prevent tip-over and meet specific anchoring and seismic requirements
Power management	Rack power distribution unit (rPDU)	Distribute the power at the rack level Real-time remote load monitoring and individual output power control if needed
Airflow management	Blank panel	Cover open rack space to prevent air recirculation and reduce bypass airflow, improving cooling efficiency
	Air containment	Cooling options that can increase the efficiency of the rack-level cooling system[1]
Cable management	Vertical or horizontal cable organizer	Keep power cords and cables organized to facilitate power and data cable tracking which lowers the likelihood of human error by disconnecting the wrong cable. Protect the cables from kinking and bindings, etc.
	overhead cable troughs and partitions	Route power cords and data cables across the top of the rack and reduce the need for expensive suspended cable tray system
Security and monitoring	Environmental monitoring	Monitor the temperature, relative humidity, airflow, smoke etc. environmental parameters.
	Rack access HID system	Control and manage rack access privileges by HID proximity card
	Surveillance	Monitor valuable IT assets remotely

[1] For more information on containment see White Paper 153, *Implementing Hot and Cold Air Containment in Existing Data Centers*

Decision criteria

Before a rack is selected, some decision criteria should be considered, such as dimensions, operational design, structural design, material, and color. Racks are closely tied to the operation of a data center and as such have a significant effect on how long it takes complete rack-based work orders. In general, the lowest-cost racks require more time for things like cable management and mounting which, in large quantities, can have a material impact on operational costs.

Dimensions

The vast majority of IT equipment has a standard width of 482.6mm (19 inches), including the edges or ears which allow for mounting in 19-inch racks. The current 19-inch rack standard was established by the Electronic Industry Alliance (EIA). The specific standards are the EIA-310-D, *Cabinet, racks, panels and associated equipment standard*, and the equivalent IEC 60297-3-100, *Mechanical structures for electronic equipment – dimensions of mechanical structures of the 482.6mm (19 in) series - Part 3-100: Basic dimensions of front panels, sub-racks, chassis, racks and cabinets*.

The usable vertical mounting grid is often specified in "U". 1U is equal to 44.45mm (1.75 inches). If a rack is described to be 42U, it means that there is a physical interior vertical space of 1.87m (73.5 inches) available for equipment mounting. Some racks are specified with customized U heights for specialized applications.

The most prevalent IT rack dimensions have been 600 mm (24 inches) wide, 1070 mm (42 inches) deep, and 42U tall. However, deeper IT equipment, higher cable densities, and higher power densities are driving the need for deeper, wider and taller IT racks along with a wider array of rack accessories. **Table 2** describes the benefits of alternative IT rack dimensions compared to typical rack dimensions, to help with the decision-making process.

Table 2

Benefits of alternative IT rack dimensions (height, width, and depth) compared to benefits of typical rack dimensions

Typical dimensions	Benefits of typical dimensions	Alternative dimensions	Benefits of alternative dimensions
Height 42U	1. Lower cost than taller racks ($/rack) 2. Easier to reach all U positions without the need for a step ladder 3. Fits through all standard door openings, i.e. trucks, entrance doors, openings, and elevators 4. Less likely to interfere with overhead fire suppression sprinklers	**Height 45U, 48U, 52U up to 58U;**	1. More U space to mount equipment increases available space in the same rack footprint
Width 600mm (24 in)	1. Lower cost ($/rack) than wider racks 2. Decreased rack footprint than wider racks	**Width 750mm (29.5 in) 800mm (31.5 in)**	1. More space for high-capacity cable management and power distribution 2. More space for wider IT equipment, like blade servers or network equipment which uses side-to-side cooling instead of front-to-back cooling[2]
Depth 1070mm (42 in)	1. Lower cost ($/rack) than deeper racks 2. Decreased rack footprint than deeper racks	**Depth 1100mm (43 in) 1200mm (47.2 in)**	1. Accommodates deeper servers 2. More space for data and power cable management 3. More positions for zero-U accessories, such as rPDUs for redundancy or ultra-high density

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[2] White paper 50, *Cooling Solutions for Rack Equipment with Side-to-Side Airflow*

Wide Vertical rails

Top View
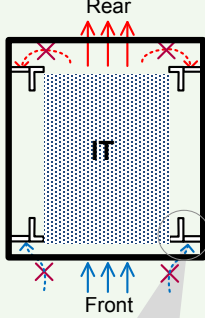
Front View

In general, networking racks should be 750 mm (29.5 in) **wide** by 1070 mm (42 in) deep to accommodate the network cabling trunks. Server racks should be 600mm (24 in) wide by 1200 mm (47.2 in) **deep** to accommodate deeper servers and provide room for cable management at the back of the rack. When choosing a wide rack, ensure that the rack vendor provides wide vertical rails that prevent cold air leakage and hot air recirculation (see side bar). Racks should be no taller than the lowest door dimension to simplify transportation and installation. 42U racks should be specified. Finally, if racks pre-configured with IT equipment are being moved, ensure that the vendor offers shock packaging to avoid damage to the IT equipment and rack during transportation.

Operational design

In addition to the attributes discussed above, some attributes increase data center operations efficiency such as speed of the deployment, easy maintenance, etc. These attributes include, but are not limited to, the following:

- Tool-less mounting decreases time required to assemble doors, side panels, roof, and accessories during installation and maintenance
- Adjustable vertical, tool-less mounting rails save time
- Numbered U positions assist in mounting IT equipment and assist in identifying server locations when creating work orders or creating an asset database
- Half-height removable side panels make handling easier and safer
- Pre-installed leveling feet allow fast adjustment with a cordless screw gun on unlevel surfaces such as a concrete slab
- Pre-installed castors help to move IT racks without the need for a pallet jack

Structural design

Static and dynamic[3] load capacities are critical parameters for the rack frame. Different manufacturing techniques, such as the formed or folded sheet, tubular sheet with continuous seam welding, or stitch welding yield different capacities. Each technique has its own strengths and weaknesses. For example, the folded sheet technique is used in the majority of industrial racks with a relatively low cost and high static load capacity. However, this technique is not recommended for IT applications because of its weak dynamic load capacity which limits the movement of IT racks around the data center. Another example is in the type of welding technique used on seams. Robot welding is preferred over human welding due to reduced human error and more consistent quality. There are many more examples of manufacturing techniques, but ultimately what is important for specifying a rack's structural design is the static and dynamic load capacity, the higher the capacity the stronger the rack. Note that for seismic zones there are seismic-rated racks available that conform to the NEBS GR-63-CORE standard.

All rack components (i.e. door, frame, mounting rails) should be bonded to ground for human safety. The simplest way is to connect the components to electrical wires, usually by screws. Some racks can attain continuous grounding without screws through their structural design; which increases speed of deployment and lowers human-error during installation and maintenance.

Doors provide both physical security and airflow for mounted IT equipment. Therefore, the basic requirements for doors are structural strength and door perforations which can some-

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[3] A static load is fixed (i.e. 10 servers mounted in a stationary rack), a dynamic load occurs when the rack is moved / rolled across a floor due to vibrations, torsion, moments, etc.

times conflict with each other. For example, some structural design may be required to achieve 85% perforation or more. Fortunately, studies have shown that perforations of 64 percent do not impact airflow and cooling performance even with loads of 30 kW/rack or higher.[4]

Material

Considering the increase in average rack power density over the years, more IT equipment is mounted in a given rack. Therefore, a rack's load bearing capacity should be evaluated and confirmed in advance. The required load bearing capacity of a rack can be from several tens to thousands of kilograms. IT racks are commonly made of metallic material, like steel and aluminum depending on cost, strength, and corrosion resistance requirements. Steel construction represents the majority of racks due to its high strength and low cost. Electrogalvanized steel (Zinc coating) has good corrosion resistance but is **NOT** recommended for racks because it is prone to Zinc-whiskers[5]. Zinc-whiskers are prone to dislodging and becoming entrained in a data center's strong air flow. This increases the risk of Zinc whiskers creating a short circuit on printed circuit boards of IT equipment and other electronics. Occasionally composite wood IT racks can be found in an office environment to meet requirements such as security, noise reduction, and mobility. For more information on IT racks for office environments see White Paper 174, *Practical Options for Deploying IT Equipment in Small Server Rooms and Branch Offices*.

Color

The surface of cabinets or accessories can be finished to suit an end user's color requirements such as black, white, grey, or even matching the company's colors. Typical colors are black and white. In general, dirt and touch-up repairs are less noticeable on black racks than white racks, lowering the cleaning lifecycle cost. White racks tend to fade in color after about two years with high-temperature air flow. Differences in white shading are also easier to notice compared to black racks. However, white racks reflect more light than black racks and provide more contrast to IT equipment and cabling, making it easier to see when working in the rack. Because of the increased reflection, lighting may be operated at a slightly lower power level. For lighting that is always on, this may result in a measurable lighting power savings, but is less so when lighting management is used.

In a recent case study, one large data center using LED lighting compared the lighting demands in two separate areas. A legacy area with black cabinets, crowded servers, and poor cable management required 65% power from the lighting. A newer area with white racks and well planned server and cable management layout required only 50% power to provide the same workability level inside the rack.

Recommended rack selection process

Based on the IT rack components and decision criteria discussed above, the following rack selection process is recommended:

- Identify the attributes of IT and non-IT equipment to be mounted
- Select IT rack dimensions and load capacity based on the attributes of equipment
- Select IT rack preferences
- Select IT rack accessories for power, airflow, cabling management, and monitoring

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[4] Travis North, Understanding How Cabinet Door Perforation Impacts Airflow, BICSI News Magazine, Sep, 2011,

[5] http://nepp.nasa.gov/whisker/other_whisker/index.htm

Identify the attributes of equipment to be mounted

Depending on the IT equipment mounted inside the IT rack, it would be categorized as either a server rack or a network rack. Network racks are usually wider than server racks due to extra space required for cabling. Therefore identifying the attributes of the IT equipment will help establish some basic rack parameters, such as dimensions and load capacity. The attributes of non-IT equipment should be considered as well, such as rack PDU, automatic transfer switch (ATS), rack-mounted UPS, etc.

The following key attributes effect the choice of rack:
- Number of power cords (affects cable management in the rack)
- Cooling requirement including side-to-side or front-to-rear airflow, CFM, etc.
- Rack unit (RU) spaces to be occupied
- Width and depth dimensions of IT and non-IT equipment
- Total IT and non-IT equipment weight
- Network ports required – how many cables are entering the rack

Select IT rack dimensions and load capacity

Based on the attributes of IT and non-IT equipment, the minimum requirement for the IT rack width and depth dimensions and load capacity can be determined. However, three factors should be considered before selecting IT rack dimensions and load capacity.

One is the growth plan of the IT equipment. An IT rack generally has more than an eight-year life cycle which will support multiple generations of IT equipment. As we mentioned on the dimension attribute above, most IT equipment is standardized to be mounted into a 19-inch rack. If the data center will use standard homogeneous IT equipment, oversizing the rack may not be required. However, if future equipment needs are unknown, oversizing the width and depth may be the right approach. **Table 3** provides recommended rack dimensions for different IT equipment. In some cases, administrators or data center designers want to maximize the number of racks in their data center but also want racks with extra room for cabling. In these cases, multiple rack layouts (horizontal and vertical directions) are created to compare the rack quantities between wide racks and deep racks. For example, certain data center dimensions may allow you to add 10 more wide racks compared to deep racks.

Table 3

IT rack size recommendations per IT equipment type

IT equipment	Recommended IT rack dimension
1U servers	600 mm (24 in) by 1200 mm (48 in)
2U/4U servers, mixed environment	600 mm (24 in) by 1070 mm (42 in)
Blade servers	750 mm (30 in) by 1070 mm (42 in)
High density networking	750 mm (30 in) by 1070 mm (42 in)
Deep, high density networking	750 mm (30 in) by 1200 mm (48 in)
Network storage	600 mm (24 in) by 1070 mm (42 in)
Converged IT infrastructure	750 mm (30 in) by 1070 mm (42 in)

The second factor is the rack density (kW/rack). Higher rack densities generally translate into higher rack weight. Ensure that the rack is capable of supporting the weight load at the maximum rack density.

Finally, IT rack vendors typically offer standard IT rack models based on market analysis. Selecting from standard rack models is generally lower cost compared to non-standard racks. Standard, vendor-neutral racks almost always guarantee universal compatibility and allow for greater flexibility when purchasing and mounting equipment.

Select IT rack preferences

Some preferences include color, door style (curved, angled), type of door lock, seismic bracing, etc. Regardless of preferences chosen, design criteria should be achieved. For example, any change to the front or rear door should not restrict the required IT airflow.

Select IT rack accessories

Selecting an IT rack is obviously critical to data center availability; however selecting rack accessories improves operational efficiency. **Table 1** provides a list of accessories to select from. The following white papers provide additional information on rack accessories:
- White paper 44, *Improving Rack Cooling Performance Using Airflow Management Blanking Panels*
- White Paper 102, *Monitoring Physical Threats in the Data Center*
- White Paper 103, *How Monitoring Systems Reduce Human Error in Distributed Server Rooms and Remote Wiring Closets*
- White Paper 202, How to Choose IT Rack Power Distribution
- White Paper 203, *Planning Effective Power and Data Cable Management in IT Racks*

Conclusion

As the building blocks of a data center, IT rack plays an important role to service multiplier generations of IT equipment to maximum the business value. Less than 5% of the capital cost of data center physical infrastructure, IT racks affect the availability, serviceability, flexibility, and manageability of the data center for years. Only IT racks and their attributes are well known, the right rack solutions can be recommended, evaluated and managed considering the growth plan, rack performance and user preference before the installation.

✎ About the authors

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Resources

Improving Rack Cooling Performance Using Airflow Management Blanking Panels
White Paper 44

Cooling Solutions for Rack Equipment with Side-to-Side Airflow
White Paper 50

Monitoring Physical Threats in the Data Center
White Paper 102

How Monitoring Systems Reduce Human Error in Distributed Server Rooms and Remote Wiring Closets
White Paper 103

Implementing Hot and Cold Air Containment in Existing Data Centers
White Paper 153

Practical Options for Deploying IT Equipment in Small Server Rooms and Branch Offices
White Paper 174

How to Choose IT Rack Power Distribution
White Paper 202

Planning Effective Power and Data Cable Management in IT Racks
White Paper 203

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