# Practical Options for Deploying Small Server Rooms and Micro Data Centers

## White Paper 174

Revision 1

by Victor Avelar


## > Executive summary

Small server rooms and branch offices are typically unorganized, unsecure, hot, unmonitored, and space constrained. These conditions can lead to system downtime or, at the very least, lead to "close calls" that get management's attention. Practical experience with these problems reveals a short list of effective methods to improve the availability of IT operations within small server rooms and branch offices. This paper discusses making realistic improvements to power, cooling, racks, physical security, monitoring, and lighting. The focus of this paper is on small server rooms and branch offices with up to 10kW of IT load.


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# Introduction

IT deployments for small businesses or branch offices are typically relegated to small confined rooms, closets, or even on the office floor. A common explanation for this, whether from a small business owner or branch office manager, is that "we only had a few pieces of IT equipment so we just put them in here". This reasoning is often justified when there is little criticality to the larger business if that IT equipment goes down. However, as businesses grow, their reliance and dependence on IT increases which makes them much more sensitive to IT downtime.

An interview with a small food distributor exemplifies this sensitivity. As this food distributor gained more customers they realized it wasn't possible to fulfill orders on time and accurately without their IT systems. Downtime of these systems would not only interrupt their distribution schedules, but would cause restaurants to place last minute orders. Restaurants need only a few missed deliveries to have a good reason to seek a new distributor. The following are some examples of downtime that were uncovered in this research:

- The wrong server was unplugged. The IT admin thought he had traced the correct power cord to the tower server. The "rat's nest" of power and network cabling significantly increased the likelihood of this error. Dual-power supplies later became a standard specification for critical IT gear to avoid this type of human error.
- Random equipment failures and reboots due to high temperatures in the room.
- A server error for high temperature forced a shutdown of the system.
- A few pieces of IT gear turned off during a brief power outage. It was later discovered that the equipment was never plugged into the installed UPS. This was most likely due to the disorganized cabling behind the rack.
- A cleaning person unplugged a server to plug in the vacuum cleaner.
- A power outage caused all the systems in a branch office IT rack to go down. The IT admin arrived later to discover that the UPS had been signaling for some time that it had a bad battery that required replacement.

Micro data centers address these and other issues. A Micro Data Center is a self contained, secure computing environment that includes all the storage, processing and networking necessary to run the customer applications. They ship in one enclosure and include all necessary power, cooling, security, and associated management tools (DCIM). Micro data centers are assembled and tested in a factory environment. They can range in size from 1 - 100kW in IT load. The benefits of distributing micro data centers are that they scale as needed, reduce computing latency, and reduce the risk of bringing down the entire data center operation (i.e. reduce single points of failure). Similar to a distributed IT architecture, if more capacity is needed in the future, another Micro Data Center is added. Standardizing these Micro Data Centers results in further benefits including reduced deployment time, simplified management, and lower maintenance and capital costs.

Some trends that have made micro data centers feasible include:

- Compaction – Virtualized IT equipment in cloud architectures that used to require 10 IT racks, can now fit into one.
- IT convergence and integration – Servers, storage, networking equipment, and software is being integrated together in factories for more of an "out of the box" experience.
- Reduced latency – there is a strong desire, business need, or even life-critical need to reduce latency between centralized data centers (e.g. cloud) and applications.
- Speed to deployment – to either gain a competitive advantage or secure business.
- Cost – in many cases, micro data centers can utilize "sunk costs" in facility power (e.g. switchgear) and cooling (e.g. chillers) to be less capital intensive than building a new data center.

Micro Data Centers are currently used for applications with real time or near real time data processing needs. For example, factory automation (e.g. robots), and industrial automation (e.g. cranes). There are applications where the sheer amount of data requires that the processing be on-site to avoid the latency through multiple hubs, for example, oil and gas drilling and exploration, construction sites, and also large mining sites. The highest volume application on the horizon is a massive distributed network of Micro Data Centers that form a content distribution network. For more information on micro data center see White Paper, *Cost Advantages of Micro Data Centers*.

As with many businesses, especially small businesses, it takes a downtime event or a series of close calls to finally invest in improving the availability of IT operations. In many cases, this spurs new IT upgrade projects. An upgrade project is the optimum opportunity to assess the physical infrastructure required to support IT, however, our research suggests that IT managers often lack the time to research and specify an appropriate solution. This paper is written to comprehend this time constraint and summarizes the most practical improvements to power, cooling, racks, physical security, monitoring, and lighting for small server rooms and micro data centers with up to 10kW of IT load. The next two sections provide guidance on each of these support systems and describe how configuration tools reduce the time required to configure and order physical infrastructure solutions.

## Support systems

This section summarizes the best practices for applying these physical infrastructure subsystems:

- Power
- Cooling
- Racks
- Physical security
- Monitoring
- Lighting

### Power

Power for small server rooms consists of a UPS and power distribution. UPS systems for this application are typically line-interactive for loads up to 5KVA and double-conversion for loads above 5kVA. Note that UPS capacities greater than approximately 2,200VA cannot be plugged into a 5-20 receptacle (i.e. household plug). For example, a 3kVA system typically requires an L5-30 and a 5kVA system typically requires an L6-30. The “L” represents a “locking” plug, the first number represents the voltage, and the second number represents the amp rating. UPS systems greater than approximately 6kVA are typically hardwired from an electrical panel. Installing a new receptacle or hardwiring requires an electrical contractor. If this is not a possibility, an alternative approach is to use multiple lower-capacity UPS systems. For more information on UPS topology, see White Paper 1, *The Different Types of UPS Systems*.

There are two basic power distribution methods:

- Plug IT gear into the receptacles on the back of the UPS
- Plug IT gear into a rack power distribution unit (rack PDU) which is plugged into the UPS. This method requires that IT gear be mounted in a rack

When used with a rack, power cable management is easier and more organized with rack PDUs because power cords don’t have to cross over each other as shown in **Figure 1**. Another advantage is that the back of the rack remains free of power cabling which improves

front to back airflow for cooling the IT equipment. In cases where remote management of outlets is required, some rack PDUs are metered and have switchable outlets that can be used to remotely reboot hung servers.

**Figure 1**

*Rack power distribution unit mounted in a rack enclosure*

Redundant UPS systems are recommended for critical dual-corded gear, such as servers and domain controller(s). Ensure that the redundant power cords are plugged into a separate UPS or rack PDU. Reliability increases if each UPS is plugged into a separate circuit where each circuit is fed from its own circuit breaker. UPS systems with an integrated network management web card are recommended because they allow critical remote UPS monitoring such as low battery, bad battery, on battery, overload, low runtime, etc. Alarms can be sent via email or a network management system such as HP Openview. Also look for the same management card to provide environmental monitoring. Look for at least one air temperature sensor to track the supply air temperature at the front of the rack or IT equipment. Additional sensors include a single probe that measure both temperature and humidity. In cases where entry into the server room is required, look for a dry contact I/O sensor which will notify admins when the server room door is opened. Other dry contact sensors include water detection **Figure 2** shows an example of a UPS with these features.

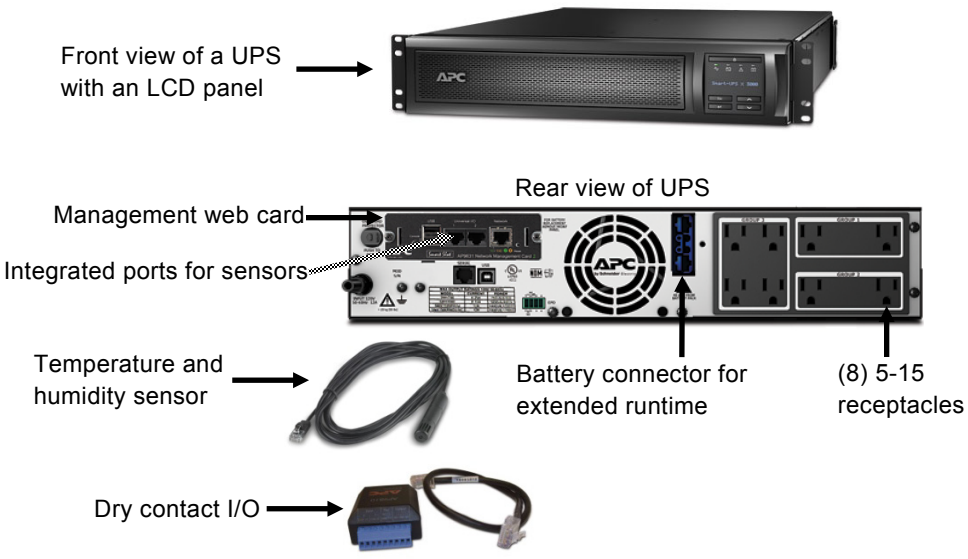



**Figure 2**

*Example of a 1,500VA UPS that plugs into a 5-15 outlet and has integrated management web card (Click figure for more data)*

## Cooling

The American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) TC 9.9 publishes both recommended and allowable operating temperatures for IT equipment.

The intent is to provide better guidance to ensure reliability and performance of equipment while maximizing the efficiency of the cooling system. These 2011 *ASHRAE Thermal Guidelines* values for class 1 equipment are provided in **Table 1**.

**Table 1**

*Operating temperature limits per ASHRAE TC9.9*

| Operating temperature | Temperature range |
|---|---|
| Recommended | 64.4-80.6°F (18-27°C) |
| Allowable | 59-89.6°F (15-32°C) |

Heat can leave a small room or office space in five different ways. These are:

**Conduction**: Heat can flow through the walls of the space
**Passive ventilation:** Heat can flow into cooler air via a vent or grille, without a fan
**Fan-assisted ventilation:** Heat can flow into cooler air via a vent or grille that has a fan
**Comfort cooling:** Heat can be removed by a building's comfort cooling system
**Dedicated cooling:** Heat can be removed by a dedicated air conditioner

### > Building comfort cooling system

Ideally the building's comfort cooling system would cool the IT equipment all year round, but this is not the case in colder climates when the heating system is turned on and the air conditioning is turned off. Furthermore, the server room or IT closet temperature is rarely controlled by its own thermostat so lowering the zone temperature to help cool overheating IT gear would adversely affect people in the surrounding area.

The five methods listed above differ in performance, limitations, and cost. The optimum cooling solution is strongly dependent on the location of the IT equipment and how much IT load (kW). There are three basic questions to answer:

1. Does adjacent space have building AC to maintain target temperature continuously?
2. Does a wall, ceiling, or floor abut a space with significant heat? (e.g. solar gain from outside wall)
3. How much power is consumed by equipment in the room?

The answer to question 1 is likely to be "No" in buildings located in warmer climates because the building's air conditioning system is reset to a higher temperature during the weekends and holidays to conserve energy. If this is the case, dedicated cooling system is recommended. However, if the answer is "Yes", move to question 2.
If the answer to question 2 is "Yes", then dedicated cooling system is recommended. If the answer is "No", then move to questions 3.

There are four recommended cooling solutions, depending on the answer to question 3. If the IT load is **less than 400 watts**, conduction will suffice as the means to cool and no cooling device is necessary. If the IT load is **between 400 and 700 watts**, passive ventilation is sufficient only if it's possible to mount vents in the room. Sometimes this is not possible if the door or wall is designated as a fire-rated. If the IT load is **between 700 and 2,000 watts**, fan assisted ventilation is sufficient but again only if it's possible to mount vents in the room. If the IT load is **greater than 2,000 watts**, dedicated cooling is recommended.

Dedicated cooling solutions include air-cooled self-contained units (**Figure 3**) used when a return plenum is available such as a dropped ceiling. If there's access to the building's chilled water, condenser water, or glycol loop, a dedicated system can be used that uses one of these cooling fluids (**Figure 4**). If an outside wall or roof is within 100ft (30m) of the IT space, and air-cooled system is recommended.

**Figure 3**

*Example of an air-cooled self-contained cooling unit*

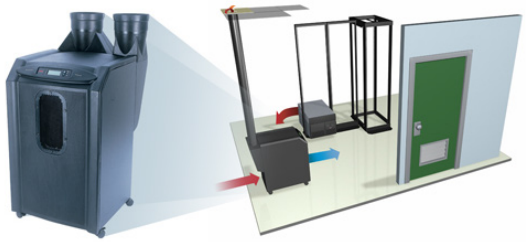


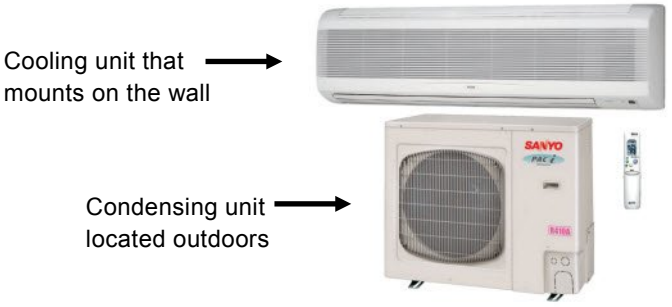
**Figure 4**

*Example of a ceiling-mounted chilled water cooling unit*

An air-cooled system has two pieces, the "cooling unit" that is usually hung high on the wall and the "condensing unit" that sits on the roof or on the side of the building. This type of installation requires drilling holes through walls for running refrigeration piping. There are distance limitations to using this solution but in most cases it provides a low-cost solution ranging from $0.30 to $0.40 per watt for the unit. A rule of thumb for installation is that it costs about the same as the materials, therefore the total cost is about $0.60 to $0.80 per watt. **Figure 5** shows an example of a so-called "mini split" system. In cases where the refrigeration piping distance is exceeded, a glycol-cooled system is required. Mini-splits can cool between 2kW and 10kW and are a common and effective solution for small rooms.

**Figure 5**

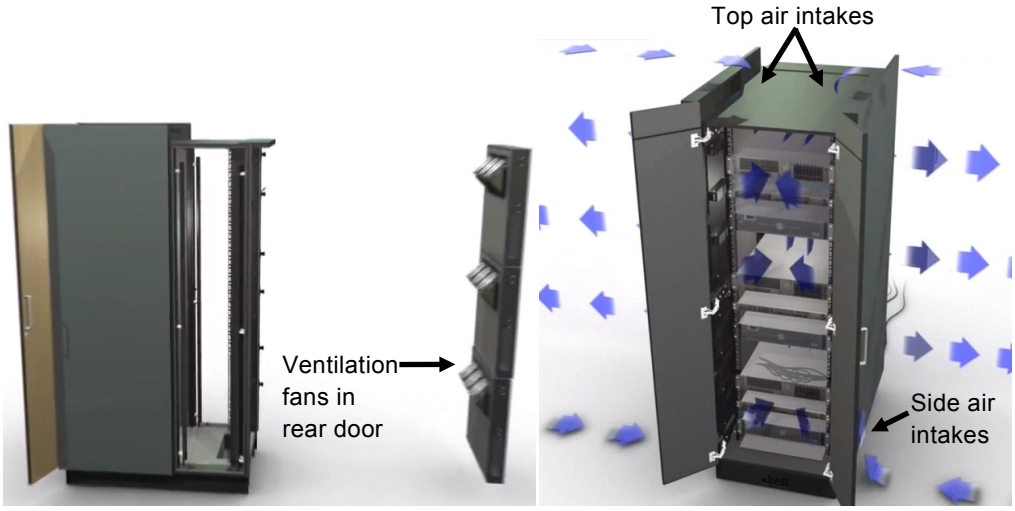
*Example of a mini split air conditioning system*




There are instances when the only choice is to locate IT equipment in the occupied office space such as in branch offices. In these cases the recommended solution is to install the IT equipment within a secure enclosure with specially designed integrated ventilation, noise dampening, and power distribution. These types of enclosures can ventilate equipment up to about 4kW and are discussed later in the "Racks" subsection. **Figure 6** illustrates an example of the ventilation air flow for such a system.

**Figure 6**

*Example of ventilation airflow for IT enclosure for office environments*




A good practice for reliable cooling is to organize IT equipment in a rack (air intakes are all facing the front of the rack) and use blanking panels to fill in the gaps where there is no equipment. This practice helps prevent thermal shutdown events and reduces the need to overcool the space with oversized air conditioners. Not placing IT equipment in a rack, often allows the hot exhaust air of one chassis to blow into the intake of another.

Overall, the more organized the IT environment is, the easier it is to cool the equipment by separating the hot and cold air streams. For more information on cooling, see White Paper 68, *Cooling Strategies for IT Wiring Closets and Small Rooms*.

## Racks

It's difficult for small businesses to justify the extra cost of an enclosure, but when the decision is part of an overall upgrade project, it becomes easier to "do it right". Objectives like availability, organization, cable management, physical security, cooling effectiveness, ease of power distribution, and professionalism are all offered by a well-designed rack enclosure. A rack is the fundamental structure for IT gear that enables organization which can decrease the instances of human error when troubleshooting a problem. For example, cable management becomes easier with integrated accessories so that wiring doesn't turn into a rat's nest. Removable side panels also improve the ease of cable management.

Rack enclosures are recommended with loads greater than 2kW because they help isolate the hot and cold air streams which means the IT equipment are breathing in cooler air (blanking panels are also key to improved air flow). Without the side panels or doors, enclosures become a 4-post rack which does nothing to separate the air streams. However, if 4-post racks are used, blanking panels are recommended as well. An enclosure's locking doors also provide physical security which is obviously important in open office areas or unlocked server rooms. This is a big problem in cases where the door is purposely left open to cool the room. **Figure 7** shows an example of a rack enclosure with removable panels.

As discussed in the cooling section, IT equipment in open office areas should be installed in a specially designed secure enclosure with integrated ventilation, noise dampening, and power distribution. Noise dampening helps with the fan noise from IT equipment which can be distracting for office workers. **Figure 8** illustrates an enclosure with a noise dampening design. With integrated power distribution, power cabling is easier to trace reducing the likelihood of unplugging the wrong cable.

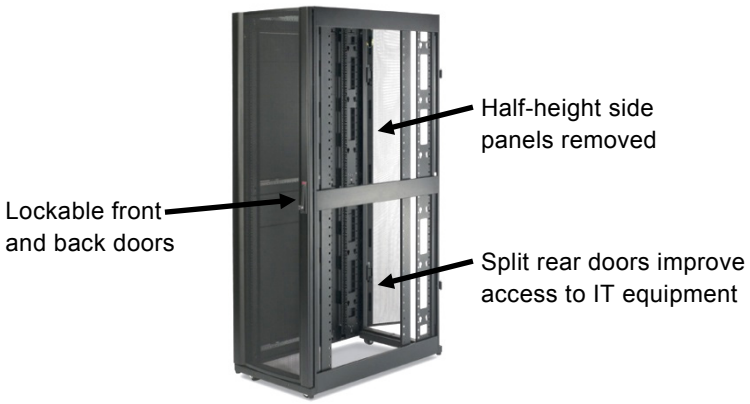



**Figure 7**

*Example of a rack enclosure with removable side panels*

**Figure 8**

*Example of an enclosure with noise dampening material inside*

## Physical security

People are essential to the operation of IT, yet studies consistently show that people are directly responsible for much of the downtime through accidents and mistakes — improper procedures, mislabeled equipment, things dropped or spilled, and other unforeseen mishaps. If the cost of downtime is significant, then physical security is important even for a small business or branch office. Locking a server room or rack enclosure is a must if the cost of downtime is high. If an IT space is considered critical, security cameras are recommended. Some cameras have integrated environmental sensors and additional ports for various sensor types including dry contacts, smoke detector, fluid detector, and door switch. Integrated sensors should include temperature, humidity and motion detection.

Cameras with motion detection can automatically detect and record motion, allowing a visual record to be paired with an access or environmental alert, which speeds root cause analysis. For example, an IT admin can be alerted via SMS or email upon access by unauthorized personnel via door switch or motion detection. Cameras should allow access via smart phone to view images and environmental data.

**Figure 9**

*Single security camera with integrated temp, humidity, dew point , air flow, and motion sensors*


## Monitoring

Small server rooms should have two types of monitoring; UPS monitoring and environmental monitoring. The cost of basic UPS monitoring has decreased so much over that last several years that it should always be included with the UPS system. UPS and environmental monitoring is especially valuable to small businesses with small IT teams and branch offices that have no local IT person. In these cases, admins are remotely alerted, via email, to critical UPS alarms such as on-battery, replace battery, and overload as well as environmental events such as high temperature, water-sensor, etc. **Figure 10** shows an example of a web page from a UPS network management card.

Another important part of UPS management is the shutdown software that safely shuts down the operating system(s) of critical servers. In most cases, the software included with the UPS system allows for basic power monitoring which is frequently used to show evidence of voltage abnormalities. In addition to UPS monitoring, IT admins should insist on environmental monitoring especially in server rooms with no air conditioning. UPS systems that ship with a management web card, such as the one shown in **Figure 2**, are recommended for UPS monitoring and basic environmental monitoring. For more critical environments, at least one security camera with motion detection is recommended, as shown in **Figure 9**, which also provides more advanced environmental monitoring as discussed in the “Physical security” sub-section. Ensure that the security cameras allow remote monitoring via smart phone and can alert via email and SMS.

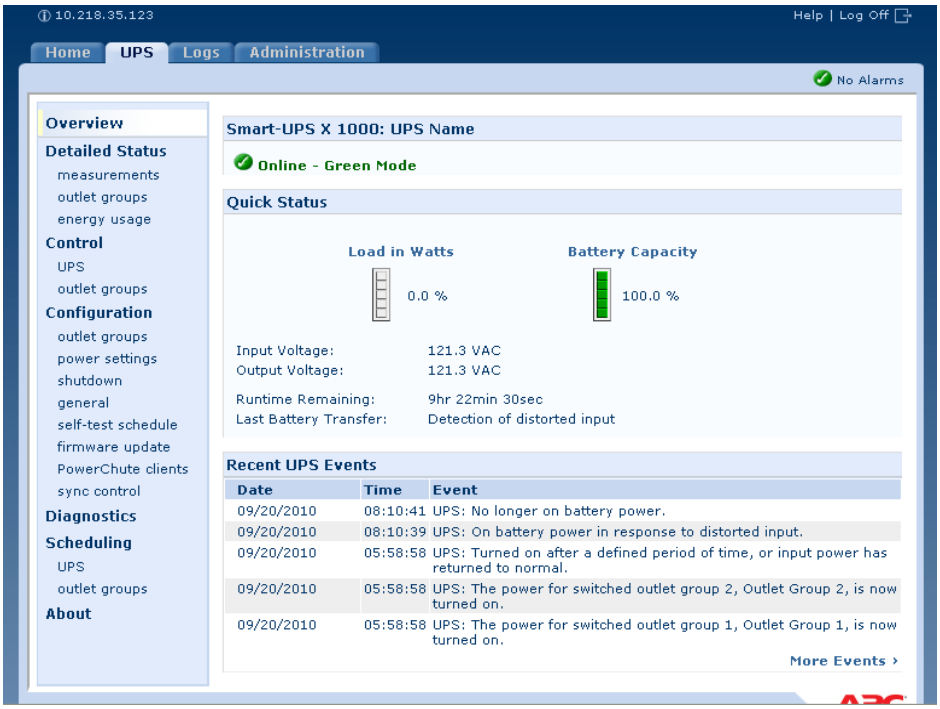



**Figure 10**

*Example of a web page from an integrated UPS network management card*

### Lighting

In smaller environments lighting is not planned for IT equipment, and IT equipment frequently ends up in locations with poor lighting. Many problems are the result of not being able to properly see labels and connections to IT equipment, particularly when mounted in cabinets or closets. Even if an investment is made in having special lights installed, there is frequently no suitable location that properly illuminates the IT equipment. One very effective solution to this problem is to provide a low cost headlamp, which allows hands-free visibility into cramped IT installations. Typically such a lamp is hung from a hook inside the back of the closed IT cabinet so it is present where needed and does not get inadvertently removed. An example a headlamp is shown in **Figure 11**.

**Figure 11**

*Example of a headlamp for use inside a small server room or rack*


## Configuration tools

Our research suggests that IT managers lack the time to research and specify an appropriate solution. Configuration tools address this challenge by allowing IT resellers to pick and choose from a menu of options without having to research which accessories, services, screws, brackets, etc. are required for a particular solution. Buying a UPS, rack, software, management cards, services, and extended warranties separately will always take more time. Configuration tools understand the interoperability of all parts, services, and warranties and create a bill of materials required for a particular solution. There are two basic methods of shipment after placing an order through these types of tools; everything can ship as individual

boxes or it can ship with the various components mounted inside of the rack. Choosing from standardized, pre-configured solutions also speeds up delivery time because these types of solutions tend to be in stock. An example of a configuration tool is shown in **Figure 5**.

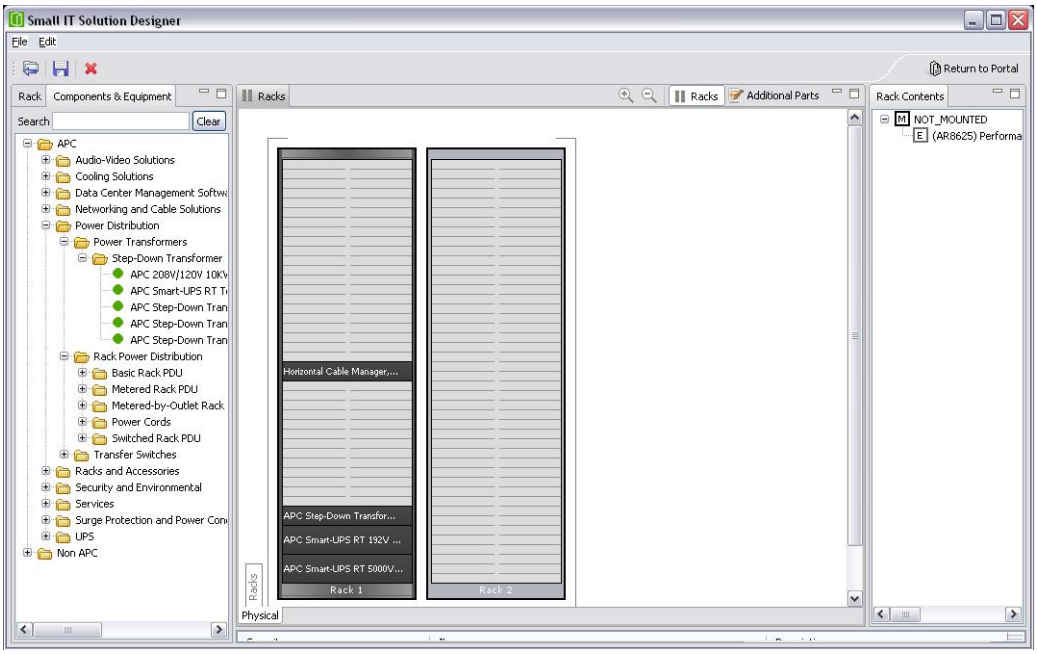



**Figure 5**

*Example of a physical infrastructure configuration tool*

## Conclusion

Our experience with thousands of data rooms of small businesses and branch offices reveals that most of them are unorganized, unsecure, hot, unmonitored, and space constrained. It is also clear that these situations often result in avoidable downtime and inconvenience. IT managers in these environments have little time to research physical infrastructure best practices. This paper is written to comprehend this time constraint and summarizes the most practical improvements to power, cooling, racks, physical security, monitoring, and lighting for small data rooms and micro data centers with up to 10kW of IT load.

## About the author

**Victor Avelar** is a Senior Research Analyst at Schneider Electric's Data Center Science Center. He is responsible for data center design and operations research, and consults with clients on risk assessment and design practices to optimize the availability and efficiency of their data center environments. Victor holds a bachelor's degree in mechanical engineering from Rensselaer Polytechnic Institute and an MBA from Babson College. He is a member of AFCOM and the American Society for Quality.

# Resources

**The Different Types of UPS Systems**
White Paper 1

**Cooling Strategies for IT Wiring Closets and Small Rooms**
White Paper 68

**Cost Advantages of Micro Data Centers**
White Paper 223

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