Abstract
When considering the deployment of servers and network switches in a Small or Medium Business (SMB), as the main IT hub, or in a Branch office, as a remote hub, it has been traditional to deploy the equipment in a dedicated room along with the associated infrastructure. However, with the increasing growth in virtualization and cloud computing the equipment required to provide the associated service is shrinking. With this reduction in physical hardware it is now practical to potentially install all the equipment in a normal office environment using a soundproofed NetShelter CX solution rather than a dedicated room.

This application note looks at what needs to be considered when using a NetShelter CX solution to accommodate server or network switch as a main IT hub in an SMB or as a remote IT hub in a Branch office.

Table of Content

<table>
<thead>
<tr>
<th>NetShelter CX solutions</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>NetShelter CX solutions in the office environment</td>
<td>2</td>
</tr>
<tr>
<td>Electric Power considerations</td>
<td>3</td>
</tr>
<tr>
<td>UPS selection</td>
<td>5</td>
</tr>
<tr>
<td>UPS and system management</td>
<td>5</td>
</tr>
<tr>
<td>Meeting system availability</td>
<td>6</td>
</tr>
<tr>
<td>System power connections</td>
<td>7</td>
</tr>
<tr>
<td>Cooling considerations</td>
<td>8</td>
</tr>
<tr>
<td>Noise considerations</td>
<td>9</td>
</tr>
<tr>
<td>Conclusion</td>
<td>11</td>
</tr>
<tr>
<td>Further reading</td>
<td>13</td>
</tr>
</tbody>
</table>
NetShelter CX solutions

The NetShelter CX being a self contained cabinet offers a very flexible and portable solution for today’s ever changing business needs when deploying network and or server equipment in a SMB or branch office environment. The flexibility allows for relocation within an office or indeed to a different office without the core cost of installing a dedicated network and server room. It also provides an ideal solution for deploying identical systems in a number of branch offices, thus simplifying support and maintenance. In addition they are also ideally suited for deployment as part of a disaster recovery plan or at summits and major sporting events.

The NetShelter CX cabinets, as shown in Fig 1, are available in four sizes with 12U, 18U, 24U and 38U of available rack space respectively.

![Fig 1: NetShelter CX cabinets (12U – 38U)](image)

As most Netshelter CX products are regional specific, please check for the SKU’s available in your region at [www.apc.com](http://www.apc.com).

The units each contain one, two or three fan units respectively to pull in cool air and exhaust the warm air. The fan units are the only elements within the cabinets that consume power other than the installed network and server equipment and the associated Uninterruptable Power Supply (UPS) supporting the equipment, so the running costs are minimal. The fan power consumption in each rack is as shown in Table 1 below.

![Fig 2: NetShelter CX fan module](image)

<table>
<thead>
<tr>
<th>NetShelter CX</th>
<th>Total fan power consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>AR4038, AR4038A, AR4038I &amp; AR4038IA</td>
<td>101W</td>
</tr>
<tr>
<td>AR4024, AR2024A, AR4024I &amp; AR4024IA</td>
<td>68W</td>
</tr>
<tr>
<td>AR4018, AR4018A, AR4018I &amp; AR4018IA</td>
<td>39W</td>
</tr>
<tr>
<td>AR4000MV</td>
<td>30W</td>
</tr>
</tbody>
</table>

The AR4000MV uses a fan tray whilst all other models employ a common fan module.
NetShelter CX solutions in the office environment

The Netshelter CX solution is essentially a small network / server room with fan-assisted ventilation. Being a self contained cabinet, that is movable, means it can be easily positioned in an office environment or indeed moved from one location to another if required. The heat generated within the cabinet, by the installed equipment, is exhausted into the local environment. The four different size cabinets each have a maximum thermal loading capacity, for both critical and non-critical loads, as shown in Table 2 below.

<table>
<thead>
<tr>
<th>NetShelter CX Cabinet</th>
<th>Maximum thermal loading for critical loads</th>
<th>Maximum thermal loading for non-critical loads</th>
</tr>
</thead>
<tbody>
<tr>
<td>AR4038, AR4038A, AR4038I &amp; AR4038IA</td>
<td>~1500W</td>
<td>~3600W</td>
</tr>
<tr>
<td>AR4024, AR4024A, AR4024I &amp; AR4024IA</td>
<td>~1000W</td>
<td>~2400W</td>
</tr>
<tr>
<td>AR4018, AR4018A, AR4018I &amp; AR4018IA</td>
<td>~500W</td>
<td>~1200W</td>
</tr>
<tr>
<td>AR4000MV</td>
<td>~400W</td>
<td>~800W</td>
</tr>
</tbody>
</table>

Table 2: Maximum thermal loading for critical and non-critical loads.

In many cases the thermal loading limits will equate to the power being drawn by the equipment installed in the cabinet, however, this is not true when Power over Ethernet (PoE) equipment is installed and used, as discussed in the “Power considerations” section later in this document.

The AR4038, AR4038A, AR4038I and AR4038IA all have three fan modules installed, so in the event of a fan module failure the system can still function, however, the maximum loading should be reduced to 2400W whilst the system is awaiting repair. In the unlikely event of a second fan module failure the loading needs to be reduced further, down to 1200W. Similarly with the AR4024, AR4024A, AR4024I and AR4024IA, which all have two fan modules, the failure of one means the loading should be reduced to a maximum of 1200W.

The AR4018, AR4018A, AR4018I and AR4018IA all have one fan module and the AR4000MV has one fan tray, failure of any of these means the system should be either shutdown or operated on minimum load with the cabinet doors open until the system is repaired.

The size of the office in which the cabinet is deployed, and whether any form of heat removal is available in that room, such as comfort cooling, will also influence the maximum potential loading capabilities of the cabinet. Essentially it is the ability of the room to absorb and dissipate the heat exhausted by the cabinet. The larger the room the more effective it is at absorbing the heat generated and the slower any potential temperature rise in the room as a result. Table 3 below provides general guidelines on the performance in different environments.
In a normal office environment each person generates heat equivalent to approximately 100W, so to put the heat exhausted by the cabinet into perspective, an AR4024(A) or AR4024I(A) cabinet supporting 2400W of load dissipates heat equivalent to 24 people. This additional heat generated needs to be considered in terms of the rooms ability to absorb and disperse the heat, all be that through natural dispersion or with the aid of comfort cooling. If the room is unable to affectively absorb and disperse the heat the room temperature and consequently the equipment temperature in the rack will rise proportionately. Further more consideration also needs to be given to the actual people in the room and the affect of any potential rise in ambient temperature that may result from the additional heat if not effectively absorbed and dissipated.

As well as considering the effects on temperature, both in the office and the NetShelter CX itself during normal office hour’s consideration should also be given to the temperature changes at night and at weekends if the office is not used or the temperature is not controlled in anyway.

The positioning of a cabinet within an office can also influence the power level that can be managed within the cabinet, so a few simple things should be taken into consideration when positioning the cabinet, as listed below.

1. Ensure the cabinet is not positioned near a heat source.
2. Ensure the cabinet is not positioned next to a window in direct sunlight.
3. Ensure the cabinet is not in a confined area that will restrict the air intake and or exhaust, with a minimum of 200mm (8") gap to the sides.
4. If practical, consideration can also be given to exhausting the heated air from the cabinet out of the main room using appropriate ducting. Positioning the cabinet in such a way to allow this.
5. Ensure there is a gap between Netshelter CX cabinets if more than one is being used.
6. Where multiple Netshelter CX cabinets are being used ensure the load is split proportionately.

In addition spreading the network and or server equipment within the cabinet also helps, such that equipment which is heat generating is not next to similar equipment, but interspersed by non-heat generating equipment such as patch panels or blanking panels. The blanking panels also prevent recirculation of warm air so should always be used to minimize any large gaps between equipment.
**Electrical power considerations**

The actual power drawn by the equipment in the cabinet, in many cases, will be directly converted into heat developed by the installed equipment, which has to be removed from the cabinet. The key exception to this, as previously mentioned, is network equipment that is providing Power over Ethernet (PoE), as much of that power can be dissipated, as heat, outside of the cabinet at the Powered Device (PD). Examples of a PD are Voice over Internet Protocol (VoIP) phones, security cameras or wireless access points. Where PoE is being used the actual electrical power going into the cabinet will be greater than the associated thermal loading in the cabinet, but that which is dissipated as heat in the cabinet must not exceed the limits shown in Table 1.

Further details and discussion on powering and cooling when deploying PoE equipment can be found in Schneider Electric White Paper #88 "Power and Cooling Considerations for Power-over-Ethernet (PoE)".

With the flexibility and transportability of the NetShelter CX cabinets consideration has to be given to how the power into the cabinet is to be connected and that the appropriate power outlet is available adjacent to the cabinet. In many countries the maximum UPS size that can be supported from a standard wall outlet is 3kVA, typically units above this size need to be hardwired and installed by a qualified electrical engineer. In all cases local and international wiring codes must be observed when installing a NetShelter CX cabinet.

**UPS selection**

Given the thermal loading limits of the NetShelter CX cabinets and taking into account potential PoE installations the largest UPS that will likely be required in a NetShelter CX cabinet installation is 5kVA. Whilst there are various UPS topologies the most common types used to support network and server equipment are Line Interactive or Double Conversion On-Line.

Further details and discussion on different UPS topologies can be found in Schneider Electric White Paper #1 “The Different Types of UPS Systems”.

The UPS should be sized to support the total power draw from the installed equipment, this should be the actual power draw rather than the rating label of the equipment which will typically be much higher. Details of which can normally be found in the equipment manufacturer's documentation, alternatively the APC web based UPS Product Selector can assist with this. As a guide the total normal loading on the UPS should not exceed 80% of its nominal capacity.

In addition to the power rating of the UPS the runtime, battery backup, required in the event of a line failure needs to be considered. The runtime included needs to be long enough to allow an orderly shutdown of the supported equipment, via the UPS PowerChute software, or to allow for a transition to an alternative line supply, typically a diesel generator.
Whilst the fans in the NetShelter CX cabinets consume relatively little power they do need to be included within the overall power requirements to ensure they continue to run in the event of a line failure. The power consumption by the fans in each cabinet is given in Table 1.

Full details of the available UPS units can be found at www.apc.com. The key product families are Smart-UPS, offering support for loads up to 5kVA and Smart-UPS On-Line, offering support for loads up to 20kVA. Products are available in both ranges which allow additional battery packs to be added to meet extended runtime requirements.

UPS & system management

All the Smart-UPS products, bar the Smart-UPS SC range, have a SmartSlot into which a Network Management Card (NMC) can be installed and all units’ 5kVA and above have an NMC pre-installed. With a NMC card installed it is possible to remotely manage and monitor the UPS itself and other parameters associated with the NetShelter CX cabinet.

There are two alternative NMC that can be installed, AP9630 and AP9631, the AP9630 offering management of the UPS and AP9631 offering this and monitoring of the local environmental.

With the AP9631, up to two AP9810 Relay I/O accessories can be attached to the two universal I/O ports to provide a total of four alarm inputs and two alarm outputs.

The inputs can be connected to such devices as door switch sensors, as available under SKU number NBES0303, this provides two door switch sensors to enable alarms to be raised if either the front or rear doors are opened.
Alternatively one or both of the AP9631 universal I/O ports can be used to connect a temperature sensor (AP9335T) or a
temperature and humidity sensor (AP9335TH) to monitor temperature and or humidity in the cabinet.

With a NMC installed the UPS and potentially its environment can be monitored both locally and remotely including through
StruxureWare Central. StruxureWare Central is a vendor-neutral, scalable monitoring system which collects, organizes, and
distributes critical alerts, surveillance video and key information, providing a unified view of complex physical infrastructure
environments from anywhere on the network.

For the ability to monitor additional parameters both inside and outside the Netshelter CX cabinet, a NetBotz Rack Monitor
200 can be installed. This provides a facility to directly connect up to six APC sensors or third party dry contact sensors, via
a NetBotz Dry Contact Cable (NBES0304), further sensor ports can be added by cascading NetBotz Rack Sensor Pod 150
units. Communications with the unit are the through the RS-232 consol port, Modbus RS-485 port or the 10/100 Base-T
Network Port, providing a web interface and Simple Network Management Protocol (SNMP).

Fig 6: NetBotz 200 (NBRK0201)

In addition when a Smart-UPS SMX or SMT unit has been selected, except SMT750 and SMT750I, there is also the ability to
remotely control some of the outlet groups to enable connected equipment to be rebooted and indeed turned On and or Off
as and when required.

Further details on controlling Controlled Outlet Groups on Smart-UPS units can be found in the Schneider Electric
Application Note #165 “Switched Outlet Groups on SMT and SMX Smart-UPS”.

Meeting system availability

Quite commonly today Network and Server equipment is either supplied with dual power supply units or has the option to fit
a second power supply unit in order to provide power redundancy. Whilst the two power supply units can be supplied from a
single UPS the availability can be enhanced by adding a second UPS providing two separate power paths.

With dual redundant power supplies and a single UPS the temptation may be to feed one via the UPS and the other directly
from the AC supply, this is not recommended. With one power supply connected directly to the AC supply the system once
again becomes vulnerable to line borne disturbance, a key problem a UPS is deployed to guard against.

Further details on power quality issues can be found in the Schneider Electric White Paper #18 “The Seven Types of Power
Problems”.
If the equipment being supported only has a single power supply, the availability can still be enhanced by using two UPS units in conjunction with an Automatic Transfer Switch (ATS), such as the APC Rack-mount Transfer Switch AP7723.

Fig 7: Rack-mount Transfer Switch (AP7723) - front and rear views.

As well as enhancing the availability of power to the system, it is equally important to ensure that the heat removal system within the cabinet is maintained, to this end each fan module has three fans to provide resilience. The AR4018 & AR4018I (18U) have one fan unit the AR4024 & AR4024I (24U) have two and the AR4038 & AR4038I (38U) have three. The AR4000MV has a single fan tray. Although the failure of a fan within a fan unit or a complete fan unit in the 24U and 38U cabinets will reduce the heat removal efficiency it will still allow the system to operate temporarily at a lower capacity.

Increasing Availability

Fig 8: Diagram highlighting methods of increasing system availability.

IT equipment with dual redundant power supply units each being supported by a separate UPS unit, each with their own utility supply connection.

IT equipment with a single power supply unit being supported via an ATS fed from two UPS units, each with their own utility supply connection.

IT equipment with a single power supply unit being supported by a UPS fed from the utility supply.

System power connections

The Netshelter CX cabinets are each supplied with a “Basic Rack” Power Distribution Unit (PDU), an AP9567 providing NEMA outlets and the AP9568 providing IEC 320 outlets, the number of outlets available to the user, in each system, are as
detailed below in Table 4. Although the supplied PDU, in each case, has a greater number of outlets some are used to connect the NetShelter CX fan modules or tray, this is reflected in Table 4.

Table 4: NetShelter CX user power outlets

<table>
<thead>
<tr>
<th></th>
<th>AR4038</th>
<th>AR4038A</th>
<th>AR 4038l</th>
<th>AR 4038lA</th>
<th>AR4024</th>
<th>AR4024A</th>
<th>AR4024l</th>
<th>AR4024lA</th>
<th>AR4018</th>
<th>AR4018A</th>
<th>AR4018l</th>
<th>AR4018lA</th>
<th>AR4000MV</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Qty) NEMA outlets</td>
<td>(11) 5-15R</td>
<td>None</td>
<td>(12) 5-15R</td>
<td>None</td>
<td>(13) 5-15R</td>
<td>None</td>
<td>(3) 5-15R</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Qty) IEC320 outlets</td>
<td>None</td>
<td>(12) C13</td>
<td>None</td>
<td>(13) C13</td>
<td>None</td>
<td>(14) C13</td>
<td>(3) C13</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Additional “Basic Rack” “Switched Rack” or “Metered Rack” PDU can be installed if further outlets, control or monitoring is required.

**Basic Rack PDU** - Provides basic power distribution to multiple loads either directly from the incoming supply or via an installed UPS.

**Switched Rack PDU** - Provides advanced load monitoring combined with remote on/off switching control of individual outlets for power cycling, delayed power sequencing, and outlet use management.

**Metered Rack PDU** - Provides real-time remote monitoring of connected loads. User-defined alarms providing warning of potential circuit overloads before critical IT failures occur.

Alternatively, as previously mentioned, if a Smart-UPS SMT or SMX is used then these also provide a number of controlled outlet groups. Additionally they also provide information regarding the system power draw, both in real time and cumulatively over the life span of the installation. The number of controlled outlet groups varies between units so selection of the appropriate product to meet system needs is required.

**Cooling considerations**

As the NetShelter CX cabinet draws air in from the environment in which it sits, and has no means of reducing the temperature, the average air temperature within the cabinet will always be equal to or more likely slightly greater than the incoming air temperature. The flow of air through the NetShelter CX cabinet is optimized to ensure the heat, generated by the installed equipment, is removed as effectively as possible. However, how the equipment is installed in the cabinet and the total thermal loading by the equipment within the cabinet are two key factors in determining the temperature rise that will be seen within the cabinet and ultimately by the IT equipment itself.

The importance of minimizing the temperature rise within the cabinet is that, as with all electronic equipment, the life expectancy of equipment reduces with increasing operating temperature above a nominal +20°C to +25°C (+68°F to +77°F).
Positioning of installed equipment –

Avoid clustering hot-running equipment such as servers, dense Redundant Arrays of Independent Disks (RAID), and large Voice-over-Internet-Protocol (VoIP) switches in one part of the enclosure. Distribute the thermal load evenly up and down the enclosure such that each fan module supports an equal amount of the thermal load.

Fig 9: Highlights how equipment should be positioned in a NetShelter CX cabinet.

Each fan module has a triangular metal section protruding slightly into the enclosure. This does not create an issue for installation of most equipment, but to allow for ample cabling space to the rear of the enclosure, deep servers should be installed in the enclosure space above and below these triangular metal protrusions.

Fig 10: Highlights how equipment should be positioned around the fan modules in a NetShelter CX cabinet.

Thermal loading of equipment - The type and quantity of equipment installed in the NetShelter CX cabinet will determine the actual thermal loading, so it is important to note the limits, as shown in Table 2 earlier in this document. In addition, as previously mentioned, if a network device is installed that provides Power over Ethernet (PoE) the actual electrical power being drawn will likely be higher than the power dissipated in the cabinet, in the form of heat, as some of the power is fed through the cabinet to PoE Power Devices outside the cabinet, where the power is dissipated.

Like the air intake to the cabinet, which comes from the environment in which it sits, the exhausted air is also returned into that environment, at a slightly higher temperature, unless ducted away. When the air is exhausted back into the local environment the heat in that area increases, which unless dissipated naturally or removed via a heat removal system will increase the temperature of the associated room and the equipment in the cabinet.
**Temperature rise on installed IT equipment** – Although the Netshelter CX is very effective at removing heat from the cabinet, there will typically still be a level of temperature rise within the installed equipment.

Testing has shown that for a typical system with three industrial standard rack servers and three network switches, supported by a 3kVA UPS, the average temperature rise in the server CPU’s was 3.2°C compared with the same equipment operating in an open rack. The test conditions were as follows.

<table>
<thead>
<tr>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Room ambient</td>
<td>24°C / 75°C (+/-0.5°C).</td>
</tr>
<tr>
<td>Server utilization</td>
<td>Idle, 20%, 40%, 69%, 80% and 100%.</td>
</tr>
<tr>
<td>Temperature measurements</td>
<td>System was allowed to stabilize for 1 hour at each CPU utilization level before temperature readings were taken. The CPU temperatures were taken from the server manufacturer’s management software.</td>
</tr>
<tr>
<td>Reference system</td>
<td>The open rack used as a test reference was the Netshelter CX cabinet without any side panels, fan modules or front and rear doors.</td>
</tr>
<tr>
<td>UPS loading</td>
<td>The UPS was loaded to 1076W when all CPU’s were at 100% utilization.</td>
</tr>
</tbody>
</table>

![Graph showing CPU temperature measurements](image)

*Fig 11: Shows an example of the CPU temperature measurements taken during testing.*

**Noise considerations**

Whilst just installing IT equipment in an open rack within a room may be beneficial from a heat removal perspective it would in general be unacceptable from a noise perspective if in an office environment. For this reason the Netshelter CX is designed to minimize the noise and maximize the heat removal from any installed IT equipment to make it suitable for installation in an office environment.
In order to appreciate the level of noise reduction provided by the NetShelter CX it is important to put the sound levels into perspective against common references, such as those listed below:

- 50 dBA background noise in an average office, without speech
- 55 dBA background noise in a busy office, without speech
- 60 dBA normal conversational speech
- 45 to 50 dBA typical noise from fully integrated or cassette-type building air conditioning
- 55 dBA + typical noise from portable air conditioners

In figure 12 below it shows the respective sound levels of four and eight servers in an open frame rack compared to the same servers installed in a NetShelter CX cabinet. The sound levels were measured at a distance of 1m (39in) and are referenced against the common noise levels. These results show an 18.5 dBA reduction in broadband noise level from the servers when installed in the NetShelter CX cabinet compared to operating under the same condition in an open rack. This is the equivalent to a 98.5% reduction in server noise.

*Fig 12: Comparative noise levels of identical IT systems operated in an open rack or in a NetShelter CX cabinet.*
Conclusions

The NetShelter CX is effectively a “Server Room in a Box” solution which provides a unique, cost effective, space efficient and flexible solution for deploying IT equipment quickly and efficiently in an office or similar environment.

Although a dedicated Network or Server room can potentially support a higher total electrical and thermal load, especially with dedicated heat removal, it lacks the ultimate flexibility of the “Server Room in a Box” solution. With a dedicated room both the installation and running costs are typically considerably higher especially if that room uses valuable office space.

For a Small to Medium Business the NetShelter CX solution allows the installation of IT equipment within a small area of the office without the need for a dedicated room, so saving space, time to deployment and cost. The flexibility of the system also allows easy expansion either within the cabinet, by migrating to a larger cabinet or by adding further cabinets, within the limitations of the office environment.

For a Branch office of a corporate organization the NetShelter CX allows a standard solution to be deployed on multiple sites, simplifying maintenance and reducing deployment costs. Such solutions can also be part of a disaster recovery plan allowing rapid deployment of configured systems to the required location or locations. The installation of network enabled power devices within in the cabinet, such as the UPS, allows for complete remote management of the equipment.

Further reading:

- Schneider Electric White Paper #1 “The Different Types of UPS Systems"
- Schneider Electric White Paper #18 “The Seven Types of Power Problems”.
- Schneider Electric White Paper #88 “Power and Cooling Considerations for Power-over-Ethernet (PoE)"
- Schneider Electric Application Note #165 “Switched Outlet Groups on SMT and SMX Smart-UPS”.

About the Author:

Neil Whiting is a Product Manager with Schneider Electric based in the UK, just north of London. He has worked in the power solution industry for over 37 years starting with AC/DC power supply design through to DC power systems for the Telecommunications industry and more recently AC power solutions for the converging IT and Telecommunications industry. He has a HND in Electrical, Electronic and Control Engineering and joined APC, now Schneider Electric, in April 2000, when APC acquired Advance Power Systems, during which time he has fulfilled both product management and application engineering roles.